5 WATER DEMAND

REGIONAL WATER PLAN • RIO CHAMA WATERSHED

CHAPTER 5

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CURRENT WATER USES

As shown in Figure 5-1, about 90 percent of all the water that originates in the Rio Chama watershed flows out of the region, either as surface flow in the Rio Chama or subsurface flow of ground water. Of the approximately 42,600 acre-feet per year average depletion within the region, about 25,100 is used by agriculture, over 15,000 goes for reservoir, lake, and river evaporation (including riparian evapotranspiration), and about 1,600 is used for all our domestic, community, and commercial water uses. However, even though domestic or community water use makes up a very small part of the total, most of that domestic water supply comes from ground water sources that are barely adequate to meet current demand, and likely to be inadequate for growing future demand.

WATER RIGHTS

In the Rio Chama Region, water rights are held by a large number of relatively small holders, almost all of them parciantes on acequias. Irrigated agriculture accounts for the majority of all water rights and water used (excluding reservoir evaporation) in the Planning Region. Right holders are listed in the hydrographic surveys conducted by the Office of the State Engineer (OSE), that include subfiles listing all right holders of record, along with irrigated acreage with water rights, fallow acres determined to have water rights, and land irrigated but considered not to have associated water rights. Fourteen hydrographic surveys have been conducted in the watershed from the 1950's through 2003 (refer to OSE hydrographic survey references in the ***Reference*** section of this chapter). An adjudication lawsuit (*State of New Mexico vs. Aragon)* is pending in Federal District Court for the Rio Chama below El Vado Dam, and although several partial final decrees have been entered, water rights claims for the Region have not been fully quantified nor have priority dates been settled.

It is important to recognize the physical fact that acequia water use varies dramatically from year to year, and acequias have a valid and generally senior right to use the additional flows that occur in wet years. The aggregate total of valid water rights held within the region is significantly greater than reported average water use. As our region was settled, acequias were built and land brought under irrigation in a way that permitted flexible use of the highly variable runoff. Our field and acequia system evolved to allow farmers to take advantage of relatively high runoff to grow more food on more land in wet years, but still permit the system to work on a smaller total acreage in dry years. Accordingly, the total acreage irrigated and total water use varies with the weather and available streamflow. Acequias and parciantes hold valid water rights to irrigate the land that can be irrigated in

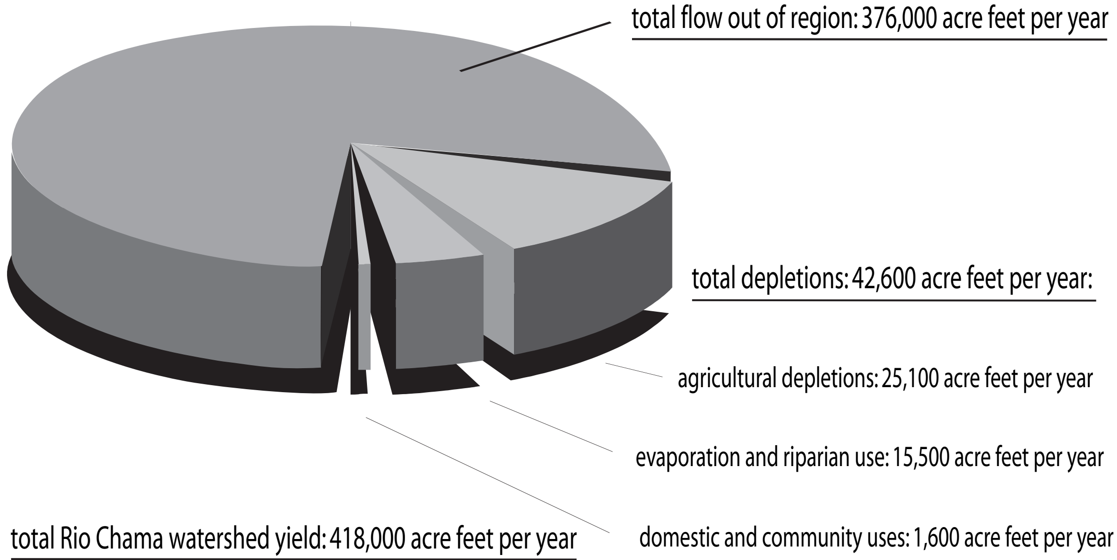

Figure 5-1: Current Water Uses

times of adequate streamflow, even though not all that land is irrigated every year. Reported average water use figures take the diminished water use during dry years into account, and understate the quantity of water needed and used in periods of higher streamflow. In other words, even if reported average irrigation use within the region is 24,000 acre-feet per year, irrigators have a right to use significantly more water than that and water planning must recognize the larger need and use during wetter years.

Rights to the water stored in the three reservoirs in the region – Heron, El Vado, and Abiquiu – are almost totally owned and used outside the region. El Vado Reservoir is owned by the Middle Rio Grande Conservancy District, and water stored in it is used below Cochiti Dam. Heron Reservoir is owned by the Bureau of Reclamation, and is used to store San Juan-Chama Project water diverted into the Chama from the San Juan Basin. A number of entities contract with the Bureau to lease rights to this water, including principally the City of Albuquerque, the City and County of Santa Fe, and the Middle Rio Grande Conservancy District. The water stored in these reservoirs flows down the Rio Chama but irrigators in the Chama Valley do not have rights to use it. Chama Valley right holders are entitled to make use of the natural flow of the river, or the amount of water that would be in the river if the reservoirs and San Juan-Chama diversion did not exist. Abiquiu Reservoir was not originally authorized by Congress to store any water; it was for flood and sediment control only. In 1981 it was authorized to store up to 200,000 acre-feet of San Juan-Chama water for the City of Albuquerque and other contractors. Since 1988 up to 200,000 acre-feet of native Rio Chama water can be stored also, provided the space is not needed for San Juan-Chama water.

It has not been possible to assemble an accurate and complete inventory of all water rights in the region, because adjudication is incomplete and the amount, to say nothing of the priority date, of many rights is still unknown. The vast majority of the rights claimed are for agricultural use in acequias, and the information currently available on agricultural water rights from the hydrographic surveys completed to date is summarized on page 5-9. It also emphasizes the point made above that acequias were designed and built to accommodate highly variable streamflows, and have valid rights to greater quantities of water in wet years than their average use. It should also be noted that water rights for community water systems, while they are a very small percentage of the total water rights in the region, are critically important for the welfare of the communities they serve. These water rights need to be carefully examined, and perhaps augmented, on a community-by-community basis in the same way that the physical infrastructure of community water systems should be carefully examined for leaks and possible opportunities for greater efficiency.

DIVERSIONS AND DEPLETIONS BY CATEGORY OF USE

A note on terminology may be appropriate here. **Diversions** or **withdrawals** refer to water diverted from a stream (for instance into an acequia), or pumped from a well and taken out of the water system to be applied to a beneficial use. This might seem to be the quantity of water that is used, but in fact in our region most of the water diverted from a stream for irrigation returns to the hydrologic system it came from and is not used by the crop. Water that does not soak into a field runs off the lower end, and may be available for use on another field or may flow back into the stream. Water that does soak into the ground may percolate below the crop root zone and recharge the ground water beneath the field. The OSE estimates that about 70 percent of the water diverted from streams in the Rio Chama Valley eventually returns to surface or ground water – in other words, the overall efficiency of the entire irrigation system, or "project efficiency", is about 30 percent (Wilson et al., 2003). Some of the factors that affect irrigation efficiency are discussed in more detail below in the section on **Irrigation Practices.**

The water that seeps into the ground below an acequia, for example, percolates below a crop root zone, returns to the stream as runoff from fields, or infiltrates into the ground below a leach field, is the **return flow**. The fraction of the diverted or withdrawn water that does not return to the stream or aquifer is the **depletion**. To express it differently, diversion minus return flow equals depletion. Depletion is the amount of water that is evaporated, used by plants, or otherwise removed from the local hydrologic system.

Just as with irrigation return flows, some of the water pumped from a well for household use usually returns to the aquifer, either as effluent from a septic tank or as deep percolation below the root zone of garden or landscaping plants. The OSE estimates that between 55 and 72 percent of the domestic water used in the Rio Chama watershed returns to the aquifer system, although they also maintain that return flows from individual septic tanks should be considered zero when water tables are deep (Wilson et al, 2003). In most places in our Region, however, septic tank return flows are considerable because water tables are shallow, and the issue is the contamination in septic tank return flow because of inadequate treatment in the shallow vadose zone.

The New Mexico OSE publishes an estimate of water use by category in New Mexico counties every five years. These estimates are the only published primary source for water use statistics in the Planning Region. The Bureau of Reclamation and the U.S. Geological Survey (USGS) publish water use statistics independently of the OSE and in different formats (USGS uses millions of gallons used per day, for instance), but both organizations ultimately derive their figures from those collected and estimated by the OSE.

The most recent data compiled by Wilson et al (2003) is detailed below. Table 5-1 shows water use by category for 2000 in Rio Arriba County. Return flow is the difference between withdrawals and depletions.

Table 5-2 on the following page presents estimated withdrawals and depletions for the Rio Chama planning region, within Rio Arriba County. It is important to recognize that few of the reported withdrawal and depletion figures are directly measured – almost all of them are estimated. Sources of the reported estimates are described in the table notes.

TABLE 5-1: WATER USE BY CATEGORY IN RIO ARRIBA COUNTY, 2000
All quantities are in acre-feet per year

CATEGORY	WITHDRAWALS			DEPLETIONS		
	Surface Water	Ground Water	TOTAL	Surface Water	Ground Water	TOTAL
PUBLIC WATER SUPPLY	722.0	1,718.7	2,440.6	315.5	545.6	861.2
SELF-SUPPLIED DOMESTIC	0.0	1,950.6	1,950.6	0.0	1,950.6	1,950.6
IRRIGATED AGRICULTURE	110,595.0	1,258.0	111,853.0	40,615.0	679.0	41,294.0
SELF-SUPPPLIED LIVESTOCK	167.1	177.5	344.6	167.1	177.5	344.6
SELF-SUPPLIED COMMERCIAL	215.9	279.7	495.6	68.1	190.0	258.1
SELF-SUPPLIED INDUSTRIAL	0.0	136.9	136.9	0.0	131.3	131.3
SELF-SUPPLIED MINING	0.0	96.6	96.6	0.0	12.4	12.4
POWER GENERATION	0.0	0.0	0.0	0.0	0.0	0.0
RESERVOIR EVAPORATION	25,535.5	0.0	25,535.5	25,535.5	0.0	25,535.5
COUNTY TOTALS	137,235.5	5,618.0	142,853.4	66,701.2	3,686.4	70,387.7

Source: Water use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 2000, by Brian C. Wilson, Lucero A.A., Romero, J.T., and Romero, P.J., (New Mexico State Engineer Office Technical Report 51, 2003).

NOTE: Figures for irrigated agriculture are from 1999, because of the severe drought in 2000.

TABLE 5-2: WATER USE BY CATEGORY IN RIO CHAMA WATERSHED, 1999

All quantities are in acre-feet per year

CATEGORY	WITHDRAWALS			DEPLETIONS		
	Surface Water	Ground Water	TOTAL	Surface Water	Ground Water	TOTAL
PUBLIC WATER SUPPLY	248.0	800.0	1,048.0	124.0	400.0	524.0
SELF-SUPPLIED DOMESTIC	0.0	541.3	541.3	0.0	541.3	541.3
IRRIGATED AGRICULTURE	75,898.0	1,222.0	77,120.0	27,854.6	659.5	28,514.1
SELF-SUPPPLIED LIVESTOCK	93.6	99.4	193.0	93.6	99.4	193.0
SELF-SUPPLIED COMMERCIAL	120.9	156.6	277.5	38.1	106.4	144.5
SELF-SUPPLIED INDUSTRIAL	0.0	76.7	76.7	0.0	73.5	73.5
SELF-SUPPLIED MINING	0.0	54.1	54.1	0.0	7.0	7.0
POWER GENERATION	0.0	0.0	0.0	0.0	0.0	0.0
RESERVOIR EVAPORATION	25,535.5	0.0	25,535.5	25,535.5	0.0	25,535.5
REGION TOTALS	101,896.0	2,950.1	104,846.1	53,645.8	1,886.4	55,532.9

Source: Water use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 2000, by Brian C. Wilson, Lucero A.A., Romero, J.T., and Romero, P.J., (New Mexico State Engineer Office Technical Report 51, 2003), modified as noted on next page.

Notes to Table 5-2:

Figures for irrigated agriculture are from 1999, because of the severe drought in 2000.

Public water supply: *Volume of water withdrawn by public water supply systems was estimated by summing the estimates for individual systems reported in the OSE water use summary (Wilson et al., 2003) and adding to that an estimate for withdrawals made by systems existing in the region and not included in the OSE inventory. For these systems (as for self-supplied domestic consumption), withdrawal was estimated by multiplying the population served by the OSE estimate of 80 gallons per person per day and the result converted to acre-feet per year. This calculation can be summarized with the following equation:*

W = (POP) x (gallons/day) x (acre-ft./325,851) x 365 days

W is annual withdrawal of water in acre-feet. POP represents the population served by the public water supply systems (population figures were taken from New Mexico Environment Department public water supply system reports). Gallons/day is assumed to be 80 gallons per day, as calculated in the OSE water use report. The total surface water withdrawal and ground water withdrawal in the table represent the sums of the individual water systems.

Depletions were estimated by assuming that Rio Chama watershed depletions were the same fraction of withdrawals as reported for Rio Arriba County as a whole (50% for public water supply systems, with the one exception of the Chama Water system, where 71% of water withdrawn is depleted).

More details on the individual public water supply systems are provided in Tables 5-5 and 5-6 in ***Public Water Supply Systems*** *section below.*

Self-supplied domestic water: *Self-supplied domestic withdrawal was estimated using the equation for withdrawal shown above. Population was estimated as the difference between residents served by community water supply systems and the total population in the watershed (12,247 - 6206 = 6041) (refer to Tables 5-5 and 5-6 in Public water supply systems section below). For this calculation, the population served by community water systems (and subtracted from the total population) does not include non-residents served by non-community public water supply systems, as detailed in Table 5-6.*

Irrigated agriculture: *The total volume of water withdrawn for irrigated agriculture within the Rio Chama watershed was taken from (Wilson et al., 2003). Depletion amounts were not reported as such in the OSE reports, but were estimated to be the same percentage of withdrawal (36.7%) as reported for the county as a whole.*

Livestock, commercial, industrial, and mining water uses: *Ground water and surface water values were estimated by multiplying Rio Arriba County values (from Table 5-1) by 0.56. This is the percentage of county land area comprised by Rio Chama planning region.*

Reservoir evaporation: *The figures are unchanged from the countywide total since all three reservoirs in the county are located in the planning region.*

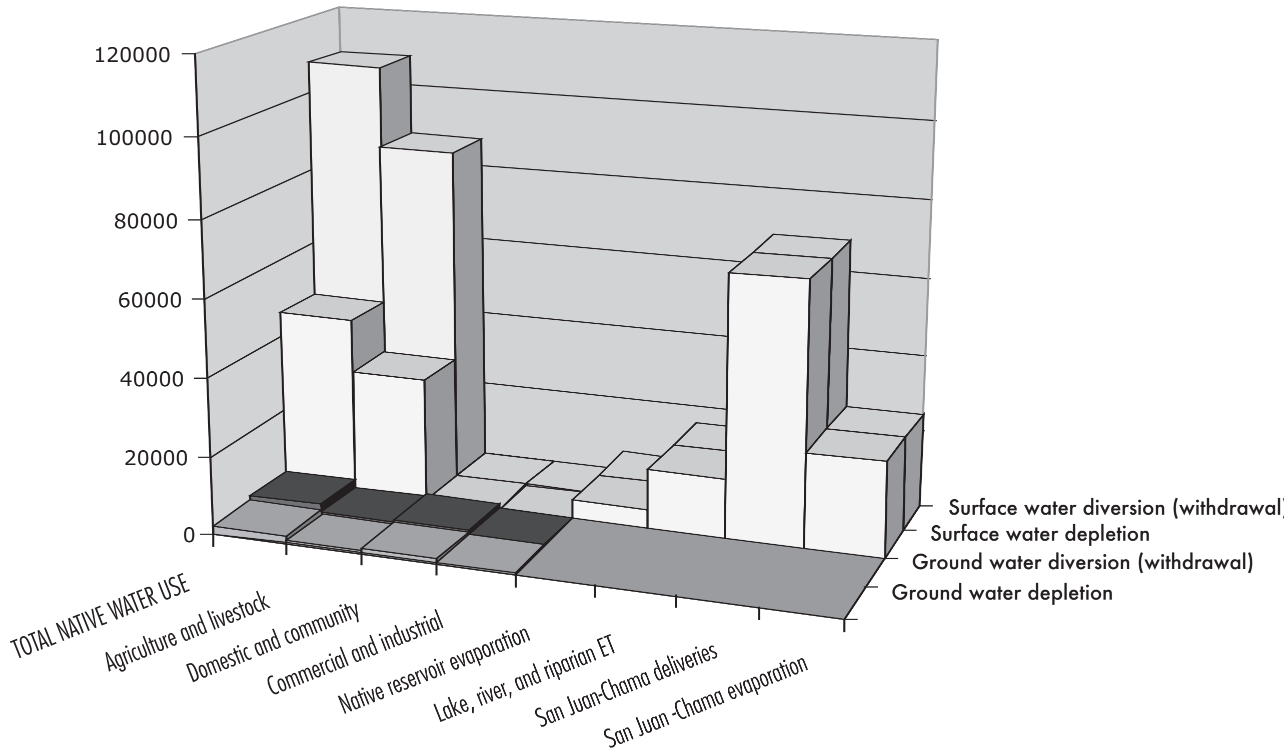

Figure 5-2: Diversions-depletions bar chart

Table 5-2 shows that irrigated agriculture is by far the largest component of intentional water use in the Rio Chama watershed, accounting for approximately 94 percent of these depletions, with the total of all other domestic and commercial uses making up the remaining 6 percent. However, it is worth noting that total reservoir evaporation is almost equal to irrigation depletion, although more than 80 percent of the total reservoir evaporation is attributed to storage of San Juan–Chama water that would not be in the Rio Chama system at all except for transbasin diversion. It is also worth noting that, even though domestic and community consumption may be a small fraction of our total water use, a shortage of drinking water will be felt much more acutely than a shortage of irrigation water. Ground water resources are especially important since nearly 90 percent of domestic water used in the region comes from ground water.

Figure 5-2 illustrates graphically the relative magnitude of both diversions and depletions that take place within the Rio Chama watershed. San Juan-Chama water that flows into the region, and San Juan-Chama depletions within the region (i.e. reservoir evaporation) are shown separately, and neither surface nor subsurface outflows are shown on the chart.

IRRIGATION PRACTICES, CONVEYANCE LOSSES, AND RETURN FLOWS

Virtually all irrigation in the planning region takes place in traditional surface-water acequia systems, by flooding fields using water diverted from the Rio Chama and its tributaries. There is essentially no ground water irrigation in the area (500 acres are reported to be irrigated with ground water). Irrigation efficiencies undoubtedly vary depending on the types of soil being cultivated, the skill of the irrigator, the length of acequia needed to supply the field, and perhaps most importantly, on the degree of land leveling and other investments in water management that have been made.

Almost all the acequias in the Chama valley are hand-dug, unlined ditches. Some of the oldest still existing were originally constructed in the early 18th if not 17th Centuries. While the acequia system as we know it took shape rapidly during the 1700s, and much of it may be unchanged since then, many minor relocations of diversion dams, headgates, and ditch courses have been made over the years in response to flood damage, changes in the river channel, and legal disputes (Baxter, 1994; Hordes, 1996).

In an effort to better understand the flow of water through an acequia system, the hydrographic survey of the Rio Chama from Española to Abiquiu measured the capacity of the acequias in that reach using portable flumes, and found the maximum diversion rate of the ditches to range from 0.04 cfs (18 gpm) for a ditch that served a single field of 0.14 acre, to 15 cfs (almost 7,000 gpm) serving approximately 700 acres. This size range is typical of the region (OSE, 1961).

The same hydrographic survey estimated seepage losses from 7 of the 24 acequias. Seepage losses from unlined ditches are one component, usually assumed to be the major component, of what are called "conveyance losses" – the losses of irrigation water between the stream diversion and the point where water enters a field. These seven acequias were considered to be representative of conditions in the rest. Seepage rates were measured using the temporary flumes, first at the beginning of the ditch near the diversion, and then just above the first diversion into a field. Estimated seepage rates varied from a slight gain in one ditch that ran below the level of some other irrigated fields, to an obviously leaky stretch where water was lost at the rate of about 6 ccfs per mile. The average loss rate was 0.42 cfs per mile, or 0.51 cfs per mile in the ditches that were losing water, and the report recommended assuming an average loss of 0.5 cfs per mile. However, as mentioned above the capacities of the ditches vary widely, and the various loss rates represent a total loss of 5 to 46 percent of the flow in the ditches, if they were carrying maximum capacity. Multiplying the loss rate for each ditch by the length of the ditch, and assuming maximum flows, the overall loss rate was about 10.4 percent of the flow.

Although this is the only systematic study of seepage losses or other details of irrigation efficiency known in the region, the 10 percent loss that seems to be indicated by the hydrographic survey study is generally considered low. For instance, the State Engineer estimates conveyance losses for the Chama Valley as a whole to average about 40 percent. Another way of expressing this is that conveyance efficiency is 0.60, or 60 percent of the water diverted from the river makes it to the farm headgate. Of course, this average masks a great deal of individual variation, and for long ditches the lower on the ditch a field is the lower the percentage of the original diversion likely to arrive at the field. Other potential sources of water loss include evaporation, use by plants along the ditch bank, and damage to ditches by burrowing animals.

Not all the water diverted onto a field is used by the crop, either. Since inevitably the water enters the field at a high point and flows across it to a low point, there will be more time for the water to soak in at the entry end than at the exit end. By the time the crop is adequately watered at the downstream end of the field or furrow, a surplus of water will have soaked into the upstream end, and the extra will percolate down to the water table. Frequently the flow rate and field arrangement is such that water needs to flow over the downstream end of the field for some period of time before enough has soaked into the ground to water the crop, and the water that flows past the low end of the field is obviously lost to that field (although it will probably be available for use on another field, or else returned to the stream as a return flow). Irregularities in the field, resulting in high spots that are not watered efficiently, and soil that is either too sandy for good water retention or too impermeable for good water absorption, will also reduce efficiency. In some cases, water in excess of crop requirements must be applied to fields to leach accumulated salts below the root zone, although this is not a major problem in our area. For flood irrigation, a farm irrigation efficiency of 65 percent would be pretty good (Jensen et al., ASCE Manual 70, p. 70) and efficiencies of about 50 percent are usually assumed for farms in the Chama Valley (Lucero, personal communication, March 6, 1997; and Rio Chama hydrographic survey reports).

The conveyance efficiency multiplied by the farm efficiency gives the "project efficiency", or overall efficiency of the entire irrigation system. Overall irrigation efficiency estimates range from about 0.25 to 0.5 – in other words, from two to four times the amount of water actually needed by the crop must be diverted from the stream to adequately irrigate the field. OSE water use estimates generally consider Chama Valley conveyance efficiencies to be 60 percent and farm efficiencies to be 50 percent. Doing the arithmetic, $0.6 \times 0.5 = 0.3$, or 30 percent of the irrigation water withdrawn is actually depleted by the crops. Hydrographic surveys in the region more often consider on-farm efficiency to be 40 percent and conveyance efficiency to be 60 percent, for a project efficiency of 24 percent. Most of the excess is, however, return flow either to the stream or to the aquifer system.

The Natural Resources Conservation Service estimates that the total return flow that makes it back into the Rio Chama in the Tierra Amarilla – Chama area is at least 50 percent of the total diversion (Treadway, personal communication, 1996). The State Engineer assumes total return flows – into both surface and ground water systems, not necessarily directly back into a river – to equal the difference between withdrawals and depletions in Tables 5-2 above and 5-3 below.

Nowhere in the Chama Valley is it possible to directly measure the amount of water used on fields and returned to the river system. Ditches and headgates are irregularly shaped and not calibrated for determining flows (even though some are equipped with height gages). Flows in the ditches are highly variable, and there are no return flow gages, to say nothing of ways to measure water seeping below crop root zones. As a result, irrigation water use has to be estimated. This process starts with determining the total acreage to be irrigated. To date hydrographic surveys have been completed for the Village of Chama, Rutheron & Plaza Blanca, Rio Brazos, Rito de Tierra Amarilla, Rio Nutrias, Rio Cebolla, Rio Canjilon, Rio Gallina, Rio Puerco de Chama, Canones and Polvadera, Lower Chama valley, Ojo Caliente, Rio Galina, El Rito, Rio Puerco de Chama, Canñones and Polvadera, Lower Chama, and Ojo Caliente, Vallecitos, and Tusas (refer to OSE hydrographic survey references in ***References*** section).

The other major source of information on irrigated acreage are technical reports by New Mexico State University entitled Sources of Irrigation Water and Cropland Acreages in New Mexico, compiled periodically. These publications estimate actual irrigated acreage year by year, taking into account factors such as weather and federal farm programs. They are, however, only estimates and are not directly measured or field checked.

Once irrigated acreage has been established, it is necessary to know how much water has to be applied to crops growing on it. Consumptive use (CU) is the volume of water per unit area that is consumed by crops in transpiration, building of plant tissue, and evaporation. This also is estimated, and there are many different methods for doing so. They all involve equations (of varying complexity) that relate the amount of water needed by different crops to various environmental factors such as temperature, humidity, vapor pressure, wind speed, solar radiation, and crop yield. Some of the more complex equations are considered to give more accurate results but require data that may not be available in real-life locations. For various reasons, not least consistency among hydrographic surveys and adjudication proceedings, the OSE uses the original Blaney-Criddle method for estimating crop water needs and these estimates are used in the Water Plan, although other, more recent methods are widely accepted among irrigation professionals and almost all of them tend to come up with higher CU estimates than the Blaney-Criddle method.

Once the amount of water needed by the crop is estimated using an appropriate method, the amount of water available from natural precipitation has to be subtracted to arrive at the amount of irrigation water needed. The resulting figure is called the crop irrigation requirement, or CIR. This is the amount of water that needs to be applied to the plant root zone to permit maximum plant growth in the ambient conditions. However, as discussed above, more water has to be applied to a field than the CIR in order to make sure the plants themselves actually receive the CIR. What must be applied to the field is the CIR divided by the farm irrigation efficiency, and this is termed the

TABLE 5-3: SURFACE WATER DEPLETIONS FOR AGRICULTURE, RIO CHAMA 1980-1999

Year	Reported depletion *(acre-ft/yr)*	Source
1980	33,090	*Sorensen, 1982*
1985	25,931	*Wilson, 1986 (withdrawal * w/d ratio for 1980)*
1990	19,269	*Wilson, 1992 (project withdrawal * .30)*
1994	20,925	*Wilson and Lucero, 1998 (farm withdrawal * .50)*
1995	18,462	*Wilson and Lucero, 1997*
1999	27,854	*Wilson et al., 2003 (Chama withdrawal * w/d ratio for Rio Arriba County)*
Average	**24,255**	

farm delivery requirement or FDR. The farm delivery requirement must be divided by the conveyance efficiency to arrive at the quantity of water that has to be diverted from the river to make sure enough water is available at farm headgates – this is the project delivery requirement or PDR. As an example, if the CIR for pasture is 1 foot of water per growing season (as it is estimated to be in higher-altitude parts of the region), each acre of pasture grass would need 1 acre-foot of water every year. If the farm efficiency is 50 percent, 1.0/0.5 or 2 acre-feet per acre would have to be delivered to the high end of the field. If conveyance efficiency is 60% (as estimated by the State Engineer), 2.0/0.6 or 3.33 acre-feet per acre per year would have to be diverted from the river, but 2.33 acre-feet would eventually return to the river system.

This is the process used to estimate the total depletion and withdrawal of irrigation water for OSE reporting, in our region and elsewhere (Wilson et al., 2003; and previous reports); with the additional step of a correction for estimated irrigation shortages in the area, made by reducing the composite CIR for the whole region used in calculating total depletions. For instance, the CIR used in the 1999 estimates shown above in Table 5-2 was 1.072 ft/yr, while the CIRs calculated in the hydrographic surveys or adjudication final decrees range from approximately 1.0 ft/yr near Chama or Tierra Amarilla to 2.0 ft/yr. in the lower Ojo Caliente valley. It can be seen that the composite CIR used to make the overall estimate was significantly lower than a weighted average CIR from the hydrographic surveys, suggesting that an assumption was made that significant shortages affected the region. Corrected, composite CIRs used for water use estimates in the past have ranged from approximately 0.74 ft/yr to 1.3 ft/yr. Table 5-3 shows the range of published OSE estimates for irrigation water depletions in the Rio Chama watershed.

As described above, these depletions are not measured and there are many assumptions and estimates involved in these reported figures. The principal sources of uncertainty are:

- Irrigated acreage is estimated from year to year by staff at several different agencies, including the Bureau of Indian Affairs, the Bureau of Reclamation, U.S. and New Mexico Departments of Agriculture, irrigation districts, and county extension agents. They are not actually measured by survey, aerial image analysis, or other quantitative methods.
- The composite CIR is determined by unknown methodology that presumably reflects an estimate of irrigation shortages, rather than actual measurement of local irrigation shortages or water use.
- Farm and conveyance efficiencies are estimated rather than measured.
- Withdrawals and return flows cannot be systematically measured and compared anywhere in the region, to corroborate or calibrate the estimates used.
- Depletions are calculated from the estimates of irrigable acreage, composite CIR, and incidental depletions. From that estimate and estimates of conveyance efficiency, total withdrawals are estimated – resulting in many opportunities for errors or uncertainties to compound as components are multiplied.

The methodology described above provides an estimate of actual water use by irrigated crops in particular years, on an ongoing basis. The irrigable acreage, irrigated acreage, and CIRs determined by hydrographic surveys and court files in the adjudication process provide a more definitive measure of the irrigated land area and water needs for the region – but only at one point in time. A hydrographic survey accurately measures the land area under irrigation at the time of the survey and calculates the CIR required (at least under the Blaney-Criddle formula) for normal plant growth. A hydrographic survey determines both total ***irrigable*** acreage in an area and the actual area ***irrigated*** during the survey. These figures, along with CIRs, are presented in Table 5-4 for the tributary watersheds to the Rio Chama.

As shown in Table 5-4, if all the area observed during the surveys to be irrigated and presumed to have water rights (the irrigated acreage) received its full crop irrigation requirement, the total amount of water withdrawn from Rio Chama stream systems would be 128,675 acre-feet per year, of which about 32,000 acre-feet would be depleted and almost 97,000 acre-feet would return to the stream or shallow aquifer system. It is interesting to compare these figures to the reported estimates for total surface water depletions for irrigated agriculture, restated in the last row of Table 5-4 from the figures shown in Table 5-2 (or to compare them with the range of previous estimates shown in Table 5-3).

The OSE water use estimate of actual surface water irrigation withdrawal for 1999 was 76,934 acre-feet, while the calculated withdrawal needed to satisfy crop irrigation

TABLE 5-4: IRRIGATION WATER DEMAND BY TRIBUTARY

Tributary System	Irrigable acreage	Irrigated acreage	CIR (ft/-yr)	Calc. Depl. (af/yr)	On-farm irrig. Eff.	FDR (ft/yr)	Off-farm eff.	Withdrawal for irrigated acreage (af/yr)	Maximum withdraw-al for total irrigable acreage
Village of Chama[1]	2,935	2,119	0.87	1,844	0.4	2.18	0.6	7,681	10,639
Rutheron & Plaza Blanca[2]	1,716	1,348	1.00	1,348	0.4	2.50	0.6	5,617	7,150
Canones Creek[3]	1,706	1,538	0.96	1,476	0.4	2.40	0.6	6,152	6,824
Rio Brazos[4]	3,703	3,374	0.99	3,340	0.4	2.48	0.6	13,918	15,275
Rito de Tierra Amarilla[5]	891	517	1.09	564	0.4	2.73	0.6	2,348	4,047
Rio Nutrias[6]	1,367	807	1.04	839	0.4	2.60	0.6	3,497	5,924
Rio Cebolla[7]	2,069	1,115	1.02	1,137	0.4	2.55	0.6	4,739	8,793
Rio Canjilon (Canjilon Cr)[8]	1,788	1,425	1.02	1,454	0.4	2.55	0.6	6,056	7,599
Rio Canjilon (Gost Ranch)[8]	38	27	1.92	52	0.4	4.80	0.6	216	304
Rio Gallina[9]	907	675	1.18	797	0.4	2.95	0.6	3,319	4,459
El Rito[10]	2,450	2,450	1.68	4,116	0.45	3.73	0.6	15,244	15,244
Rio Puerco de Chama[11]	1,861	1,088	1.50	1,632	0.4	3.75	0.6	6,800	11,631
Cañones and Polvadera[12]	291	291	1.24	361	0.4	3.10	0.6	1,504	1,504
Lower Chama Valley[13]	4,538	4,538	1.50	6,807	0.4	3.75	0.6	28,363	28,363
Ojo Caliente, lower Vallecitos, low. Tusas[14]	1,149	1,149	2.00	2,298	0.5	4.00	0.6	7,660	7,660
Middle Vallecitos and middle Tusas[14]	1,314	1,314	1.60	2,102	0.45	3.56	0.6	7,787	7,787
Upper Vallecitos and upper Tusas[14]	1,595	1,595	1.17	1,866	0.4	2.93	0.6	7,776	7,776
TOTALS	**30,318**	**25,370**		**32,033**				**128,675**	**150,978**
OSE estimate of water use by category in 2000[15]		*21,530*	*1.072*	27,855	*0.5*	*2.14*	*0.6*	***76,934***	

[1]Source: (OSE, 2003), [2]Source: (OSE, 2002a), [3]Source: (OSE, 2002b), [4]Source: (OSE, 2001a), [5]Source: (OSE, 2001b), [4]Source: (OSE, 2000a), [7]Source: (OSE, 2000b), [8]Source: (OSE, 2000c), [9]Source: (OSE, 2000d), [10]Source: (OSE, 1971, and adjudication subfile), [11]Source: (OSE, 1953), [12]Source: (OSE, 1974), [13]Source: (OSE, 1961), [14]Source: (OSE, 1968, and adjudication subfile). [15] 2000 Water use by category report (Wilson et al, 2003); as shown in Table 5-2 above.

Notes to Table 5-4:

Irrigable acreage: *Irrigable acreage includes all land that has shown evidence of irrigation per the hydrographic survey. This includes irrigated land with a water right, fallow land with a water right, and land that is irrigated but considered by the OSE to have no water right.*

Irrigated acreage: *Only irrigated land with a water right is considered irrigated acreage.*

Crop irrigation requirement (CIR): *CIR values were taken from the hydrographic surveys and final adjudication decrees.*

Calculated depletion: *Irrigated acreage x CIR.*

On-farm irrigation efficiency: *Values from hydrographic surveys.*

Farm delivery requirement (FDR): *FDR = CIR x on-farm irrigation efficiency.*

Off-farm conveyance efficiency: *Values from hydrographic surveys.*

Withdrawal for irrigated acreage: *= (Irrigated acreage x CIR)/(on-farm efficiency x off-farm efficiency)*

Maximum withdrawal for total irrigable acreage: *= (Irrigable acreage x CIR)/(on-farm efficiency x off-farm efficiency)* requirements for land with valid water rights based on the hydrographic surveys would be 128,675 acre-feet: in other words, the estimated actual withdrawal was less than 60 percent of the withdrawal calculated as necessary by the hydrographic surveys. The 1999 estimated depletion (calculated by multiplying the reported withdrawal by the proportion of depletion to withdrawal reported for Rio Arriba county in Wilson et al. 2003) was about 28,000 acre-feet, which is about 87.5 percent of the total depletion needed to satisfy CIRs for actual irrigated acreage. The average of the reported depletion estimates in Table 5-3 (24,255 acre-feet per year) is 75 percent of the 32,000 acre-feet needed to provide adequate water for the irrigated acreage reported in the hydrographic surveys.

Comparing the water use estimates to the hydrographic survey calculations suggests one or both of two conclusions: either there is a 12 to 25 percent long-term average shortage of irrigation water in the Rio Chama region as a whole (in other words, there is chronically less water available than needed to fully satisfy the CIRs for irrigated land); and/or the reported water use estimates may understate the amount of water actually used in the region, for some or all of the reasons discussed on page 5-8 above. It is known that shortages occur on many (perhaps all) tributaries, although the only attempt at quantifying shortages was done for the Rio Ojo Caliente below La Madera, and calculated an overall average shortage of 37 percent (in other words, 63 percent of the total CIR for the total irrigated acreage had been available for the period of record) (Barroll, 1999). This certainly suggests that the 12 to 25 percent average shortage suggested by Table 5-4 is plausible, but it is also interesting to note that the total irrigated acreage (land actually under irrigation, not counting idle or fallow land) reported in the hydrographic survey was over 25,000 acres, while the irrigated land estimate used for the water use report was only 21,530 acres. This reduced irrigated acreage, along with the lower (corrected) CIR, lowers the result of the calculation for estimated water use.

The last column in Table 5-4, *Maximum withdrawal for total irrigable acreage*, can be interpreted as the amount of water that could legitimately be diverted or withdrawn from the stream system by Rio Chama acequias during a wet year when flow durations were adequate to water all the land capable of being irrigated by the acequia system, and would presumably be accompanied by a depletion of over 50,000 acre-feet. As discussed earlier in this chapter, the acequia system was designed and built to accommodate the highly variable nature of precipitation and runoff in northern New Mexico, and acequias have rights to water available during high-flow periods and not just to mathematically average flows. To restate this concept, the existence of calculated shortages can be argued to represent over-appropriation of surface water resources, since there are more water rights extant than “wet water” available to satisfy the rights most years; but it can perhaps more accurately be seen as a pragmatic and successful adaptation to prevailing conditions that has served communities in the Rio Chama Valley well for centuries.

PUBLIC WATER SUPPLY SYSTEMS

Domestic water use is derived almost totally from ground water at present, except for the Village of Chama, and the communities of Abiquiu, Barranco, Canjilon, Cebolla, Lumberton, and Vallecitos, which use surface water from springs or infiltration galleries near the land surface. There are 57 public water supply water systems, 26 of which are mutual domestic water consumers’ associations (MDWCAs) in the planning region. Community or mutual domestic water systems, serving full-time residential users, are listed in Table 5-5. Other public (but not “community”) water supply systems are listed in Table 5-6.

As shown in Table 5-5, the community MDWCAs report serving a population of 6,206, which represents about 50 percent of the current population of 12,247 in the Rio Chama region. Community water systems withdraw about 644 acre-feet per year (also refer to Table 5-2).

TABLE 5-5: MUTUAL DOMESTIC WATER CONSUMERS ASSOCIATIONS

SYSTEM NAME	POPULATION SERVED	TYPE OF SYSTEM	TOTAL WITHDRAWAL (acre-ft/yr)
Abiquiu MDWCA	363	GW - spring	32.5
Agua Sana MDWCA	660	GW - well	59.1
Arroyo del Agua MDWCA	60	GW - well	5.4
Barranco MDWCA	50	SW – infil. gall.	2.8
Brazos Water Co-op	146	GW - well	14.3
Canjilon Water System	380	GW – spring & infil. gall.	20.8
Canon Plaza MDWCA	25	GW - well	2.2
Canones MDWCA	165	GW - well	14.8
Capulin MDWCA	165	GW - well	14.8
Cebolla MDWCA	300	GW – well & infil. gall.	21.8
Chama Water System	1,199	SW - spring	216.4
Chamita MDWCA	246	GW - well	22.0
Coyote MDWCA	53	GW - well	4.7
El Rito Canyon MDWCA	300	GW – shallow well	26.9
El Rito MDWCA	220	GW - well	10.9
Ensenada MDWCA	151	GW - well	9.6
Gallina Water System	120	GW - well	10.8
La Association de Agua de Los Brazos	46	GW - well	4.1
La Madera MDWCA	36	GW - well	3.2
Los Ojos MDWCA	125	GW - well	9.2
Lumberton MDWCA	172	SW – infil. gall.	15.4
Ojo Caliente MDWCA	110	GW - well	12.8
Placitas MDWCA	320	GW - well	27.8
Plaza Blanca Water System	43	GW - well	3.9
South Ojo Caliente MDWCA	170	GW - well	16.3
Tierra Amarilla MDWCA	400	GW - well	37.1
Vallecitos MDWCA	96	GW – infil. gall.	8.6
Youngsville MDWCA	85	GW - well	7.6
TOTAL MDWCA	**6,206**		**635.8**

Source: New Mexico Environment Department, Drinking Water Bureau database, provided by Mr. Gil Salas, August 2002.

TABLE 5-6: PUBLIC WATER SUPPLY SYSTEMS OTHER THAN MDWCAS

WATER SYSTEM NAME	POPULATION SERVED	TYPE OF WATER SUPPLY	TOTAL WATER WITHDRAWAL (acre-ft)
Abiquiu Dam	43	GW-well	
Abiquiu Elementary School	194	GW - well	17.4
Abiquiu Inn	65	GW - well	5.8
Archuleta Mobile Home Park	60	GW - well	5.4
Canjilon Lakes Campground	250		22.4
Clinica del Pueblo	40	GW - well	3.6
Christ in the Desert Monastery		SW- infil. gall.	
Corkin's Lodge	85	GW - well	7.6
Coronado High School	300	GW - well	26.9
Coyote Elementary School	94	GW - well	8.4
Coyote Ranger Station West	45	GW - spring	4.0
Echo Amphitheater	205	GW - well	18.4
El Alamo Café	65	GW - well	5.8
El Rito Elementary School	140	GW - well	12.5
El Vado Lake Resort	90	GW - well	8.1
El Vado Lake State Park	800	GW-well	71.7
Escalante High School	200	GW - well	17.9
Ghost Ranch Conference Center	15	GW - well	1.3
Ghost Ranch Museum	300	GW - well	26.9
Gordo's Café	25	GW - well	2.2
Hernandez Elementary School	292	GW - well	26.2
Heron Lake State Park	250	GW - well	22.4
Heron Lake State Park	150	SW – infil. gall.	13.4
Jemez Mountain Electric Co-op	80	GW - well	7.2
Lake Shore Inn	65		5.8
Mesa Vista High School	500	GW - well	44.8
Northern New Mexico Community College	125	SW - spring	11.2
Ojo Caliente Mineral Springs	50	GW - well	4.5
Parkview Fish Hatchery	45	GW - spring	4.0
Rio Arriba County Detention Center	60	GW - well	5.4
Stonehouse Lodge	75	GW - well	6.7
TOTAL	**4,754**		**417.9**

Source: derived from information supplied by the New Mexico Environment Department, Drinking Water Bureau database, provided by Mr. Gil Salas, August 2002.

1 Production figures are not available for many water systems.

DOMESTIC, COMMUNITY, AND COMMERCIAL WATER USE

It is often a matter of interest what fraction of total water depletions in the region is comprised of private well pumping, community water system uses, and commercial or industrial uses. Table 5-7 below itemizes these uses, whether the source of the water is originally ground or surface water. Domestic, community, and commercial water uses account for only **1,556** acre-feet per year as compared to about 24,000 acre-feet per year of irrigation depletions, or 6 percent of total intentional water depletions (not counting reservoir evaporation or river/riparian evapotranspiration). Ground water sources provide 90 percent of all domestic and commercial water used.

TABLE 5-7: DOMESTIC, COMMUNITY, AND COMMERCIAL DEPLETIONS

CATEGORY	Reported depletion *(acre-ft/yr)*		
	Ground water	Surface water	Total
Public water supply	400.0	124.0	524.0
Self-supplied domestic	807.0	0	807.0
Self-supplied commercial	106.4	38.1	144.5
Self-supplied industrial	73.5	0	73.5
Self-supplied mining	7.0	0	7.0
REGION TOTAL	**1,393.9**	**162.1**	**1,556.0**

Source: Wilson et al., 2003

RESERVOIR EVAPORATION

Reservoir evaporation, along with other water uses, is calculated by the Bureau of Reclamation and the Corps of Engineers for the three reservoirs in the region, and is reported in the State Engineer's summary of water uses in New Mexico, published every five years. Estimates of reservoir evaporation begin with data about pan evaporation, measured daily at El Vado and Heron Dams. Reservoir evaporation is estimated from the pan data. The brief description of the procedure given below is based on information supplied by personnel from National Weather Service, Bureau of Reclamation, and Army Corps of Engineers. The general procedure for calculating reservoir evaporation is the same; however equipment, assumptions, and mathematical modeling performed by the three agencies may differ. The general procedure is as follows:

- The height of the reservoir water surface level is measured daily (the average water surface area is computed using an equation or curve that correlates gage height with reservoir surface area).
- Wind movement, precipitation, and temperature, are measured daily at the damsite weather stations.
- Evaporation pans are located at the dams, and pan measurements are taken daily in accordance with National Weather Service protocols.
- Adjustment is made for the effects of ice cover during winter months. The ice cover is estimated and monthly winter averages are used.
- The gross lake evaporation rate is computed by multiplying the observed pan evaporation by the pan coefficient (0.7 is commonly used).
- The net evaporation rate is computed by subtracting the measured rainfall from the gross evaporation.
- The net volume of water evaporated is computed by multiplying the exposed surface area by the net lake evaporation rate.

Evaporation rates are greater at lower elevations, and typically peak in June. The June average pan evaporation rates for Heron, El Vado, and Abiquiu Dam sites, respectively, are 7.5 inches, 8.7 inches, and 10.8 to 11.4 inches. The annual average pan evaporation rates for Heron, El Vado, Abiquiu Dams are 40.4 inches, 47.6 inches, and 63.5 to 76.5 inches, respectively. The two values given for Abiquiu Dam represent differing data collected by the Corps of Engineers and NMCC, respectively. Multiplying the pan evaporation rates by the usual correction factor of 0.7 suggests that about 2.3 feet of water evaporates from Heron Reservoir, 2.7 feet from El Vado Reservoir, and 3.7 to 4.4 feet from Abiquiu Reservoir per year.

Reported reservoir evaporation figures for the last five reports are shown in Table 5-8 below, and shows total reservoir evaporation including losses of both San Juan - Chama project and native water combined. The average of these five reported values is **29,962 acre-feet per year**, and the reported values include both wet and dry years, so the average seems a reasonable figure to use for water planning purposes.

The majority of the total reservoir evaporation in Rio Chama reservoirs can be attributed to the storage of San

TABLE 5-8: RESERVOIR EVAPORATION

Year	Reported evaporation *(acre-ft/yr)*
1980	45,312
1985	26,512
1990	22,862
1995	29,592
2000	25,535
Average	**29,962**

Source: U.S. Bureau of Reclamation Calculations

Juan-Chama Project water, since for the most part native water is only stored in El Vado Reservoir, while all Heron storage and most Abiquiu storage is actually Project water. The U.S. Bureau of Reclamation calculates the long-term average evaporation loss from San Juan-Chama Project water to be 23,382 acre-feet per year (Flanigan, personal communication, 20 March 2003).

LAKE EVAPORATION

The combined surface area of Stinking, Horse, Thompson, Boulder, and Enborn Lakes (mostly located on the Jicarilla Apache Reservation) was estimated at approximately 1680 acres from the USGS 1:250,000 Aztec, NM map. Lake evaporation was assumed to be approximately equal to the El Vado Reservoir pan evaporation rate of 3.97 feet per year multiplied by a lake evaporation coefficient of 0.7. Estimated lake evaporation is:

Lake evaporation = 1,680 acres x 3.97 feet x 0.7
= **4,669 acre-feet per year**

RIPARIAN EVAPOTRANSPIRATION AND RIVER SURFACE EVAPORATION

Riparian evapotranspiration was estimated by multiplying river length by width and multiplying the resulting area by evapotranspiration rate. River length was considered to be 633,279 feet (119.94 mi.), a figure provided by the New Mexico Water Resources Research Institute GIS system. For riparian evapotranspiration, river length was multiplied by an average estimated riparian area width of 100 feet. Riparian evapotranspiration was taken to be 1.5 times the alfalfa or pasture ET rate (OSE internal memorandum, 25 July 2000). Note that this earlier memorandum has been superseded by a more recent memorandum (OSE internal memorandum, 26 August 2002). An average of the alfalfa crop irrigation requirement at Española (36.2 inches per year, again per OSE internal memorandum) and the pasture crop irrigation requirement in the upper Chama area (about 11 inches per year, from hydrographic surveys) is 23.6 inches, or 1.97 feet per year. 1.5 times the average crop ET rate would be 2.95 feet per year, so total annual riparian evapotranspiration is estimated as:

Riparian ET = (633,279 x 100/43,560) acres
x 2.95 ft/yr
= 1453.8 acres x 2.95 ft/yr
= **4,289 acre-feet per year**

River surface evaporation was calculated similarly, assuming an average river width of 40 feet and an evaporation rate equal to the average of the pan evaporation at Abiquiu, El Vado, and Heron reservoirs multiplied by a river evaporation correction factor of 0.6 (OSE memo, 25 July 2002):

River surface evaporation
= (633,279 x 40/43,560) acres x 4.2 ft/yr x 0.6
= **1,465 acre-feet per year**

Total estimated lake and riparian evaporation and transpiration is about **10,423** acre-feet per year.

RIPARIAN USES AND STREAMFLOW

Protection for both instream flows and riparian corridor ecological attributes can generate a great deal of controversy, and the Rio Chama has experienced some of that contention. Fortunately, it has not been as difficult an issue here as it has in some places.

A 24.6 mile reach of the Rio Chama, roughly from El Vado Dam downstream through what is known as the Chama Canyon to the upper end of the maximum storage pool at Abiquiu Reservoir, was designated a federal Wild and Scenic River on November 7, 1988. As mentioned in the **INTRODUCTION**, this stretch of the river gets a great deal of recreational use and attention. Fortunately for fish and boaters, virtually all irrigation use of Rio Chama water is located downstream of the Wild and Scenic part of the river and under present circumstances it is difficult to envision a situation where that reach would be completely dried up. However, there are a remarkable number of overlapping treaties, interstate compacts, legislative mandates, and administrative policies that govern how streamflow is regulated on the Rio Chama, and the timing of water releases and location of water storage can strongly affect the recreational and ecological values for which the Wild and Scenic designation was made.

The Bureau of Land Management, which administers the land along the Wild and Scenic reach, has recommended a range of flows at different times of year to maximize such qualities as fish, macroinvertebrate, or eagle habitat, riparian ecology, scenic values, and boating opportunities (Fogg, et al, BLM, 1992). The details of their recommendation are too complex for presentation here, but minimum recommended flows are generally 150 cfs for most of the year, with some higher releases for boating (minimum boating flows are about 500 to 1000 cfs) and occasional even higher releases needed for riparian regeneration.

So far the whole question has been taken care of by what the authors of the BLM recommendations call "cooperative management". Some water users have been willing to slightly modify the release timing and/or storage location of water for downstream uses so that their needs to move water stored in El Vado and Heron Dams also provides water in the river for recreation and wildlife. For instance, an agreement was reached whereby the City of Albuquerque is allowed to store some of its allotment of San Juan-Chama water in Abiquiu Reservoir, and movement of that water is timed for summer weekends when flow in the river would otherwise be too low for boating. Other agreements such as these exist and more may be possible. For the foreseeable future such agreements have been effective and available mechanisms to keep minimum flows in the river.

Discussion of instream flow, river recreation, and riparian values has concentrated on the Wild and Scenic River corridor, but the rest of the Chama Valley is much noted as a beautiful place and a recreational destination and will probably continue to attract increasing attention for thesereasons in the future. In addition, environmental regulations such as Clean Water Act protection for wetlands, and protection for threatened and endangered species resident in riparian areas, already apply to reaches of the Chama both above and below the Wild and Scenic corridor.

FUTURE WATER DEMAND

The water planning goal most frequently and strongly voiced during public meetings was the preservation of agriculture and the acequia system in the Region. Future agricultural demand is expected to remain constant; in fact, we need additional irrigation water.

Domestic demand for water is increasing. The 2000 Census Data indicate that about 12,250 people live in the watershed—a population increase of 20 percent since 1990. In 1995 the New Mexico Bureau of Business and Economic Research (BBER) predicted that the population in the Region would increase by about 25 percent from 1990 through 2030. These predictions have turned out to be lower than the actual rate of growth in the region. There are significant differences in growth rates in different parts of the region, with the most rapid growth occurring along the lower Rio Chama from Abiquiu to Española.

Throughout the region, water systems are aging and many of the wells tap relatively unproductive aquifers. The majority (68 percent) of the Mutual Domestic Water Users Association wells have experienced sporadic and sometimes chronic water shortages. An increase in domestic demand will not have a large impact on overall water supplies in the region, since domestic use makes up less than 6 percent of the total demand. However, just because the region as a whole could supply additional domestic water does not mean that any individual community will be able to provide additional water. There are few institutions or large commercial users in the region at present, but consideration must be given to water availability for them in the future.

There are both practical and water rights issues involved in providing water for increased domestic and/or commercial uses. The practical issues have to do with how to provide additional water in places where aquifers and/or wells are incapable of increased production, or there are other specific local technical problems to be overcome. The water rights issues involve the challenge of finding adequate domestic and community water supplies without necessarily forcing communities to choose between acequia water supplies and drinking water. The Region as a whole has plenty of water for its future domestic and community needs, but many individual communities within the region face limited water supplies and technical or economic hurdles in providing additional water. In some areas, local water banking may offer a creative solution to community water supply needs.

DEMOGRAPHIC TRENDS

Population in the Rio Chama Planning Region has grown by over 20 percent from 1990 to 2000 according to U.S. Census figures, and about 12,250 people lived within the Planning Region in 2000. The increase in population reflects growth among long-time resident families as well as retirement and migration from other places, and has certainly been fueled by proximity to Santa Fe, Los Alamos, and Española.

Predicting future populations is a difficult task. The first difficulty is to accurately define the Planning Region in terms of census enumeration units, since the census does not report population by watershed or water planning region. Population within the Rio Chama Region was calculated by determining which census tracts and blocks were within the Region by examining 2000 census maps, and then summing the population counts from those tracts and blocks. A population count was made from 2000 Census data and from 1990 data where the enumeration units were the same, although 1990 population for the Hernandez and Chamita area had to be back-calculated from figures for 2000 since the tract boundaries were different in 1990. Projections were made for future populations to year 2040. These population estimates and projections for the Rio Chama Region were calculated first for the entire region by adding up counts for the whole and partial census county divisions (CCDs) that make up the Region (Table 5-9). Estimates were then made as closely as possible for individual communities within the region (Table 5-10). The totals in the two tables do not match precisely because zip code area boundaries do not match CCD boundaries exactly, and neither match the watershed boundaries, so some interpolation is always needed. The most difficult issues arise in the Hernandez and Chamita areas, because they are densely settled and it is difficult to conclusively define a boundary between the Rio Chama and Jemez y Sangre planning regions. The task is further complicated because the Hernandez, Salazar, and Chamita acequias all provide water from the Rio Chama to areas that are topographically in the Rio Grande watershed.

TABLE 5-9: POPULATION PROJECTIONS FOR CENSUS COUNTY DIVISIONS IN THE RIO CHAMA REGION

Census Data			Projected populations, low range[1]	Projected populations, current trends[2]
Census County Division	**1990**	**2000**	**2040**	**2040**
Rio Chama CCD	2,566	3,777	*2,710*	*6,233*
Tierra Amarilla CCD	3,002	3,263	*2,343*	*5,384*
Vallecitos CCD	578	575	*413*	*949*
Coyote CCD	1,535	1,559	*1,119*	*2,573*
S. Rio Arriba CCD (part)	*1,095*	1,352	*2,038*	*3,141*
San Juan CCD (part)	*1,394*	1,721	*2,595*	*3,999*
TOTAL POPULATION	**10,170**	**12,247**	***11,218***	***22,278***

Note: S Rio Arriba CCD and San Juan CCD 1990 Populations are back calculated using BBER growth rate of 2.13 percent per year for 1990 to 2000.

[1] Low range populations are based on BBER projected growth rates of –0.83 and 1.03 percent per year for BBER-defined "Rio Chama Region" and "Santa Fe Region north of Española", respectively (BBER, 2003).

[2] High range populations are based on BBER growth rates of 1.26 and 2.13 percent per year (for period 1990 to 2000) for BBER-defined "Rio Chama Region" and "Santa Fe Region north of Española", respectively (BBER, 2003).

TABLE 5-10: POPULATION PROJECTIONS FOR RIO CHAMA WATERSHED COMMUNITIES

		Census Data		Projected population, low range[1]	Projected population, current trends[2]
Places in Rio Chama watershed	**CCD**	1990	2000	2040	2040
Abiquiu, Barranco	Rio Chama CCD	1,220	1,144	*820*	*1,888*
Cañones, Abiquiu			128	*92*	*211*
El Rito, Las Placitas		1,245	1,113	*797*	*1,837*
Medanales			841	*603*	*1,388*
Ojo Caliente		450	1,010	*724*	*1,667*
Canjilon	Tierra Amarilla CCD		309	*221*	*510*
Brazos, Los Ojos, Rutheron			393	*282*	*648*
Cebolla, Alire			94	*67*	*155*
Chama		1,145	1,604	*1,149*	*2,647*
TA, El Vado, Enseñada, La Puente, Nutrias		1,851	750	*537*	*1238*
Vallecitos, Las Tablas, Lr Ranchito	Vallecitos CCD	560	92	*66*	*152*
Tres Piedres			258	*185*	*426*
La Madera, Sevilleta Plaza		87	308	*221*	*508*
Coyote	Coyote CCD		331	*237*	*546*
Gallina		930	493	*353*	*814*
Youngsville			112	*80*	*185*
Hernandez, Chile, El Duende, Chamita	S. Rio Arriba & San Juan CCD	*2,489*	3,073	*4,630*	*7,140*
TOTAL POPULATION			**12,053**	**11,064**	**21,958**

Note: Hernandez vicinity 1990 populations are back calculated using BBER growth rate of 2.13 for 1990 to 2000.

[1]Low range populations are based on BBER projected growth rates of –0.83 and 1.03 for BBER defined Rio Chama Region and north of Española Santa Fe Region, respectively (BBER, 2003).

[2]High range populations are based on BBER growth rates of 1.26 and 2.13 (for period 1990 to 2000) for BBER defined Rio Chama Region and north of Española Santa Fe Region, respectively (BBER, 2003).

The Bureau of Business and Economic Research at the University of New Mexico released a population projection for the Region in 1995 predicting a total population growth of about 25 percent over the 50 years from 1990 to 2040. A BBER study released in 2003 (with entirely different boundaries, apparently excluding the entire lower Chama area below about Abiquiu or Medanales) suggested that population in the Region will decline, particularly in communities further from urban areas. These projections are very much at odds with observed population growth trends, since 80 percent of the 50-year population growth projected by BBER in 1995 has already occurred in the past decade alone. The conclusion reached by the more recent BBER study, that overall population everywhere in the region except Española will decline, seems untenable since it does not correspond at all with trends to date, and is emphatically not accepted as a premise of this water plan.

Because future population projections are uncertain and depend on social and economic conditions outside the region, both a low-range and higher, current-trends population projection were made for the period from 2000 to 2040. These projected populations (for both the CCDs and local communities) were estimated using growth rates proposed by BBER or observed over the past decade for different parts of the region, applied to the actual population counts developed from 2000 census data.

The low range projected populations, presented in Tables 5-9 and 5-10, are based on the BBER projected growth rates in the 2003 study, that assume a negative growth rate for communities distant from Española, and a positive but low growth rate for communities close to Española. The BBER projection presumably anticipates that lack of employment opportunities and distance from major urban areas or employment centers will cause a decline in the future population. The BBER growth rate of –0.83 percent annually (BBER, 2003) for the period between 2000 and 2040 was applied to populations in rural areas in the Rio Chama, Tierra Amarilla, Vallecitos, and Coyote CCDs. The BBER-proposed growth rate of 1.03 (BBER, 2003) for the period between 2000 and 2040 was applied to populations close to the urban areas, within portions of South Rio Arriba and San Juan CCDs (these areas lie within what the 2003 BBER study considered “Rio Arriba County within the Santa Fe Region”). The low-range projection suggests population trends dramatically different from recent experience, but is perhaps useful as an indication of what could happen given a significant economic downturn or severe lack of economic opportunity in the region.

The higher-range, “current trends” population projection in Tables 5-9 and 5-10 assumes that the observed trends from 1990 to 2000 will continue through 2040, with a positive growth rate for the entire planning region. This scenario assumes that the region close to Española will continue to attract commuters from Española, Santa Fe, and Los Alamos, and that the commuting range may extend further north in the region. In addition, retirement in the region is anticipated to continue, and more rural areas may provide an attractive alternative to urban life. The current-trend projection utilizes the actual 1990-2000 growth rate for the Rio Chama, Tierra Amarilla, Vallecitos, and Coyote CCDs, which was 1.26 percent per year (BBER, 2003). For the area closer to Española (parts of the S. Rio Arriba and San Juan CCDs), the 1990-2000 growth rate of 2.13 percent per year was used for the projection.

Using this calculation methodology, the 2040 projected population in the Rio Chama Region varies from a low-range projection of about 11,200 to a high-range projection, if current trends continue, of over 22,200 residents as shown in Table 5-9.

The same projection methodology was used for low-range and current trends projections of populations for particular communities, insofar as they could be individually estimated from the census data. The regional totals do not match exactly with those in Table 5-9 because Table 5-10 was developed from data organized by zip code while Table 5-9 was based on census maps.

The 1990 and 2000 populations, presented in Tables 5-9 and 5-10, were taken from Census web sites (venus.census.gov/cdrom/lookup, and www.census.gov/, respectively). Populations for the census county divisions, shown in Table 5-9, were estimated by adding the populations within the appropriate census tracts, block groups, and blocks from census block maps. The census tracts included in the region are: all of Census Tract 4; most of Census Tract 5; a small portion of Census Tract 3; and a small portion of Census Tract 9541. Populations for the communities, shown in Table 5-10, were estimated by counting the populations within community zip-code regions. Appendix C provides details of population counts within census tracts, block groups, blocks and zip code regions and a map showing the census tracts that define the boundary of the region. Total population in the Rio Chama Region for year 2000, using both zip code and census tract counting methods, is approximately 12,250. The increase in population in the planning region from 1990 to 2000 was 20.4 percent.

Population in areas near Española has increased even more than predicted in the past by the Census Bureau and BBER. The Agua Sana Water Users' Association was formed in 1995 to construct a community water system for several communities along the Rio Chama from the Española city limits north about fifteen miles to the community of Rio Chama. This area includes a good portion of Hernandez, Salazar, Chili, and Chamita. In the process of planning the system, the Association commissioned an independent demographic study of the service area to accurately predict water demand. The study was performed by James D. Williams, PhD., of Williams Demographics in Las Cruces, and made an intensive count of both houses and inhabitants in the area (in Leedshill-Herkenhoff and Shomaker, 1996). While the Williams study found that the 1990 census tally for their area appeared to be largely correct, a much greater population growth had occurred since 1990 than the Census Bureau and BBER had predicted. The Agua Sana service area does not correspond neatly to CCDs, but is contained within portions of the Rio Chama, San Juan, and South Rio Arriba CCDs (Hernandez/Salazar, Chili, and Chamita). The Williams study reported that the 1990 census found 2245 people in the Agua Sana service area, but by 1995 there were 4703 people in the same area – a growth of 109 percent in five years. According to Williams, the census population growth projection for the same period was 17%. Williams expects population in the Agua Sana service area to be approximately 9000 people by 2035.

Table 5-11 presents population figures assembled by the Rio Arriba County Planning Department in the process of developing a county General Plan over the past few years. County staff divided the county into watershed-based planning areas and aggregated population figures for groups of watersheds within the Rio Chama region as a whole. As mentioned previously, the Census Bureau does not tabulate census figures by watershed, so this information has to be tallied by hand from Census block counts on maps that show few natural features, which may account for the slightly different figure for 2000 population shown in Table 5-11 as compared to Table 5-9 (13,886 as compared to 12,247). Clearly, however, the two figures are comparable for 1990 and 2000 and the County's projection (which is the basis for their planning process) is higher than the current trends projection in Table 5-9 (26,150 residents in 2030 as compared to 22,278 in 2040). If the same overall regional growth rate projected from 2000 to 2030 were to continue to 2040, the total region population would be 32,529 people. County planning staff believe it is prudent to err on the side of caution, if anything, in planning for an adequate water supply as well as other infrastructure needs for future residents.

The range of overall regional population projections discussed above can be summarized briefly in Table 5-12 below.

TABLE 5-11: RIO ARRIBA COUNTY PLANNING DEPARTMENT POPULATION PROJECTIONS

Planning watershed	1990 pop.	2000 pop.	% change	2030 proj.
Lower Rio Chama	4,917	7,044	43.3	15,457
El Rito/Ojo Caliente	1,886	2,207	17.0	3,814
Upper Rio Chama	2,973	3,454	16.2	5,392
Rio Gallina/Puerco	1,204	1,181	-1.9	1,487
Totals	**10,980**	**13,886**		**26,150**

TABLE 5-12: SUMMARY OF POPULATION PROJECTIONS

Census data		2040 Projections		
1990	2000	Low-range	Current trends	High range
10,170	12,247	11,218	22,278	32,529

In addition to Census counts, BBER projections, Rio Arriba County projections, and the Agua Sana demographic study, information was collected on voter registration trends and school enrollments. This information is summarized below in Tables 5-13 and 5-14.

Table 5-13 illustrates that in many communities in the region, including some of the more rural areas like Chama, Los Ojos, or Ojo Caliente, voter registrations increased by even greater percentages than the Census-reported overall regional population increase of about 20 percent. This suggests that the observed growth in new homes in these areas are not just occupied by seasonal residents, and that not all population growth in the area is driven by commuters to the economic centers of Santa Fe, Española, and Los Alamos.

School enrollments seem to tell a somewhat different story about population growth in the region, however, with declining enrollments in all region districts except Española over the past few years. It is difficult to know what to make of these figures since they are available for only the past four school years, but they may suggest that population growth, at least in some areas, is driven more by in-migration than by growing families among current residents.

Regardless of precisely which growth rates occur in which particular communities over the next few decades, additional domestic and community water supplies will be needed throughout the region. Even some of the most remote communities in the area have experienced population growth over the past decade, and failure to plan for and provide adequate drinking water will guarantee economic disadvantage, personal hardship, and declining population.

TABLE 5-13: VOTER REGISTRATION TRENDS,1990 – 2000

Precinct No.	Location	Registered voters		Percent change
		1990	2000	
Dist. 2				
36	Hernandez	2,282	2,934	28.6
39	Rio Chama	791	1,932	144.2
41	San Juan Pueblo	1,154	1,334	15.6
Dist. 3				
5	Chamita	1,026	1,271	23.9
18	Tierra Amarilla	662	753	13.7
19	Los Ojos	428	548	28.0
20 A&B	Lumberton & Chama	1,388	1,680	21.0
22	Cebolla	108	96	-11.1
23	Canjilon	387	377	-2.6
26	Coyote	542	549	1.3
27	Canones	166	151	-9.0
30	Gallina	496	481	-3.0
31	El Rito	955	1,155	20.9
32	Ojo Caliente	393	497	26.5
33 A,B,& C	Vallecitos, Petaca, La Madera	538	596	10.8
35	Abiquiu	818	907	10.9

Source: Rio Arriba County Clerk's office

TABLE 5-14: SCHOOL ENROLLMENT TRENDS, 1999-2004

District	Year	Enrollment	% change
Chama	1999-2000	588	
	2003-2004	488	-17.0
Española	1999-2000	4,854	
	2003-2004	4,946	1.9
Jemez Mountain	1999-2000	386	
	2003-2004	377	-2.3
Mesa Vista	1999-2000	594	
	2003-2004	505	-15.0

Source: New Mexico Department of Education

AGRICULTURE: OPPORTUNITIES AND FUTURE DEVELOPMENT

As an economic sector, farming and ranching within the region has been holding its own over the past decade or two, has great potential for expansion, and is a key element in any vision of a sustainable future for the region. The total number of farms as reported by the New Mexico Department of Agriculture in Rio Arriba County has remained stable since 1987, for instance, at just under 1000 farms, that collectively brought in $17,250,000 in cash receipts in 1997 (NMDA, 2000). Similarly, water and land use for agriculture in the region has remained stable since at least the 1980's. Farming and ranching are not declining enterprises along the Rio Chama.

Rio Arriba County has made and continues to make a concerted effort to protect agricultural land and associated infrastructure from indiscriminate development pressure or other depredations. In fact, Rio Arriba is probably the most pro-active county in New Mexico and among the most active in the country in preserving agricultural land and water for future generations. Agricultural land protection, and the availability of agriculture as a way of life and community structure in the future, is a cornerstone principle in the County's General Plan, and an equally important principle in water planning. Continued sustainable agricultural development is an indispensable element in any vision for a sustainable economic future for the Rio Chama Planning Region and Rio Arriba County. There are abundant opportunities for expanding the volume and profitability of agricultural production in the Rio Chama watershed, considering the expanding market for quality farm produce in the Albuquerque, Santa Fe, and Española areas and the land and water base existing in the region. One of the most important goals of this Water Plan is to contribute to preserving, expanding and developing regional agriculture.

Beyond purely economic considerations, the agricultural and cultural infrastructure of our region are closely intertwined. The preservation of traditional communities, local hispanic culture, an agricultural lifestyle, and the historic acequia system are widely shared goals throughout the Planning Region. There are many challenges to these goals, and not all of them involve water. Many residents are strongly supportive of the idea of keeping land in agriculture and preserving the basic character of existing communities, but at the same time are anxious to avoid the fate of more nationally popular areas such as Santa Fe where real estate values and related pressures have tended to make it difficult for people to remain in their ancestral communities. Economic opportunities and incentives, community cultural values, and many other factors are all important in shaping the growth or decline of an area, and many of these factors cannot be controlled just by managing water. Nevertheless, irrigation made possible the way of life that has existed in the Chama Valley at least since the Spanish arrived, and still determines the look of the landscape and the fabric of the community. The acequia system still provides the framework for most of the day-to-day village democracy and community government in rural northern New Mexico, and its participants feel passionately about its survival. Keeping the fields green and the acequias running cannot by itself preserve the heritage and control the development of the Chama Valley, but it is an essential part of that effort.

PROJECTED WATER DEMANDS

Agricultural water needs in the region will remain at least constant for the foreseeable future, and would expand if additional water were available. It is vital to protect both the water rights and the acequia infrastructure that supports life along the Rio Chama and its tributaries. There are also alternatives that could help make better use of the water we have available, and perhaps provide modest increases in total available water supply in some circumstances. The two most promising alternatives for providing additional water when needed are:

- Additional water storage in reservoirs, of all sizes, and
- Watershed management for enhanced streamflows.

Additional reservoir storage could be as simple as finding room in Abiquiu Reservoir for storing small amounts of water for use by acequias below the dam, or it could take the form of small ponds or reservoirs along existing acequias, or on headwaters reaches of tributary streams. Additional water storage on this scale would not involve the environmental or financial considerations that would be associated with constructing new large-scale reservoirs.

Watershed management of some high-altitude watersheds in the region could include thinning or controlled burns of forest areas where trees have become extremely thick because of past fire suppression. Reduction in tree density in these areas could provide modest increases in total annual streamflow as well as reduce the risk of large-scale forest fires. At lower altitudes (and in areas where fires have occurred), enhancing grass cover and preventing erosion will also enhance infiltration and reduce flash-flood runoff. This contributes to more perennial streamflow patterns and also improves water quality. These alternatives are discussed in detail in the **PLANNING ALTERNATIVES** chapter.

While water demands for agriculture are expected to remain constant in the relatively near term, domestic demand for water is increasing and expected to continue to increase into the future. Population growth in the southern part of the Planning Region has been much more rapid than that predicted by census and BBER figures. A large and sophisticated mutual domestic water association (the Agua Sana system) is taking shape to serve that need for water. The Agua Sana service area, from Rio Chama south to the outskirts of Española, is almost certainly the fastest-growing area within the Rio Chama Region, but it is not the only one with looming domestic water shortages. During the dry spring and early summer months, sporadic if not chronic water shortages have been experienced in the Abiquiu, Arroyo del Agua, Barranco, Capulin, Cebolla, Chama, Coyote, Ensenada, El Rito Canyon, Gallina, La Madera, Los Ojos, Plaza Blanca, Vallecitos, and Youngsville community water systems and an unknown number of private wells. These communities are not necessarily the most rapidly growing in the Region, but they are growing and in general their water systems are aging and did not include a great margin of safety to begin with. Other systems or areas of domestic wells may emerge as overtaxed in the future.

There are relatively few institutions or large commercial users in the Region at present, but planning consideration must be given to water availability in the event economic development opportunities requiring such water use present themselves in the future.

Considering projected population growth as well as the existing constraints to water supplies in some communities, we as a region should plan to at least double our domestic and commercial water supplies over the next 40 years. Some communities will experience greater demand growth than others, but **we should plan to provide at least 3000 acre-feet per year within the Region as a whole by 2040**. If high-range population growth projections materialize, and/or if significant water-using economic development takes place, our total domestic and commercial demand could be higher, perhaps even reaching 5000 acre-feet per year.

The overall available water supply within the Rio Chama watershed as a whole is hardly a constraint to providing any reasonable expansion of domestic or even commercial water supplies, since these uses now make up only 6 percent of our total water use (and our total water use is less than 10 percent of the water flowing out of the watershed). However, in any particular community the local water supplies immediately available for expanding consumption may be severely limited, and the means to expand community supplies may be expensive. Alternatives that may be available to help communities meet growing demand include:

- Auditing water systems to identify and correct leaks or other inefficiencies
- Consolidate community water systems where appropriate.
- Explore alternatives for providing additional water rights where needed.
- Optimize location and depth of community wells.
- Protect existing communities from unsustainable new water demands.
- Gather basic data for informed decision making.

These are discussed further in the **PLANNING ALTERNATIVES** chapter.

Each community faced with expanding water needs will need to assess its particular situation carefully and creatively. In some cases additional new water supplies may turn out to be available. While most San Juan-Chama Project water is subject to permanent contracts, in some cases it may be possible to make arrangements for leases with Project contractors. In other cases, community members may need to re-allocate water (and water rights) from other existing uses into community water supplies. Because ours is a region of rural communities with deep agricultural roots, there is great resistance to the principle of transferring water from agricultural to other uses. It should not be assumed that transfer of acequia or other agricultural water is the only way to provide additional domestic water. However, the quantities of water needed for domestic use are generally quite small in comparison to agricultural needs, and a small percentage of most communities' agricultural water use and water rights would provide for any needed expansion of domestic or commercial supplies.

There are many possible ways to provide for additional community water rights. In most of our communities, the same acequia parciantes that collectively hold agricultural water rights are members of the community that may need more domestic water. A water banking agreement or lease, for instance, between a local acequia and Mutual Domestic water association could provide ample additional water to permit as much growth as desired by a community, without either exposing water rights to the risk of transfer outside the community or requiring the community to purchase outside water rights. It should also be possible for water banking within our Planning Region to help provide community water rights (and, given treatment and distribution infrastructure, actual "wet" water) for communities where the acequia lending water and the community needing water are not necessarily the same.

Residents of the Region, and Rio Arriba County, strongly support continuing the long-established practice of allowing transfers of water rights from individual household wells to community systems. It should be possible at least to transfer rights to the calculated actual household water use to the community system. In many instances past practice has allowed homeowners to retain their individual well for outdoor water use (with a water right reduced by the amount of the transfer to the community system for indoor use). If a well owner transfers their entire 3 acre-foot per year water right to a community system, the system should be credited with the entire 3 acre feet per year, which could help provide water rights for other users that may not have a well of their own from which to transfer rights.

Water banking and/or leasing arrangements within a carefully defined area, whether a single community, a watershed within the region like the Rio Gallina or the Ojo Caliente, or within the Rio Chama watershed as a whole, could permit flexibility in meeting our future water needs while avoiding the risk of losing water rights to entities outside the region. These arrangements could also help retain control of the extent of growth and of development patterns within the region, and would give acequia parciantes and commissioners a key decision-making role in providing for community water supplies. At the same time, it could provide a way to prevent the family hardship and economic stagnation that would likely follow if communities find themselves genuinely unable to provide water for any new residents, including family members that want to remain in the community. The Region and Rio Arriba County should work with the State Engineer and the Legislature to ensure that local water banking and leasing can play this role.

The availability of water is a critical part of domestic water planning, but not the only consideration. Water quality is another crucial concern, and a number of instances of ground water contamination are documented in the Chama Valley. The engineering study for the Agua Sana system provides lists of New Mexico Environment Department and Rio Chama Acequia Association test results demonstrating substantial areas of water contamination with nitrates (from human or animal wastes, or agricultural fertilizers) in the communities of Chamita, Chili, Corral de Piedra, El Duende, El Guache, Hernandez, and Medanales. These, with the exception of Chamita and Medanales, are located in the area to be served by the Agua Sana association and hence have been relatively extensively tested and reported. Other communities almost certainly have instances of similar nitrate contamination, since virtually all settlement in the region is along river valleys where ground water is shallow and houses are clustered increasingly close together because traditional communities, and available building land, are in the valleys.

The quickest solution to a contamination problem is for people to purchase bottled water or water treatment devices, and a longer-term solution in many places may be the construction of community water systems that tap so far unpolluted water. Another option would be to consolidate and develop larger water districts. In some places, however, consideration should be given to community sewage treatment systems as well to prevent pollution from contaminating even the community wells. Sewage treatment, given existing technology, is frequently more expensive initially than public drinking water – but in some instances it is cheaper in the long run to prevent excessive water contamination than to attempt to remedy the situation after the fact.

WATER CONSERVATION

There are many ways to use water more efficiently, and perhaps to make some available for alternative uses. Water conservation seems uncontroversial in principle, but some aspects of water conservation are complex. Most uses of water involve diverting a certain amount of water from a stream or aquifer, depleting some of it, and returning the rest to the stream or aquifer. Many practices that may be described as "conservation" are ways to reduce the amount of water diverted while leaving the amount depleted the same (the amount returned is reduced by the same amount as the reduction in diversion). Lining acequias, for instance, is frequently a prime example of this kind of "efficiency", which results in no net increase in the amount of water available in the hydrologic system for any other uses.

Changes in use that reduce the amount of water depleted can result in additional water being made available for other uses. An example of this would be changing cropping patterns to grow crops that require less water, or converting domestic or commercial landscaping from lawn to native shrubs. There is little incentive at present for a water right holder to make these kinds of changes, however, for two reasons:

- In much of the region, water rights are not yet adjudicated, so the final quantity of rights held is still uncertain. Because of this, any reduction in water use prior to adjudication may reduce a right holder's final decreed water right.
- Even if rights were finally adjudicated, there is little incentive for voluntary reduction in water depletion, and in fact some right holders may well feel a disincentive to reduce water use in their home or community if they believe the only beneficiaries will be users elsewhere.

With our existing system of water rights, perhaps the first step in encouraging water conservation would be to complete the adjudication process, in as expeditious a way as possible while protecting local water rights and handling the process in a reasonably non-adversarial way, as discussed in the **PLANNING ALTERNATIVES** chapter. In the absence of adjudicated water rights, anyone who voluntarily reduces water depletion is almost guaranteed to lose part of their original right. Once water rights are adjudicated and it is clear how much water each acequia is entitled to, it will also be essential to ensure that there are appropriate incentives for acequias to consider water conservation options and implement those that serve their interests.

If rights to any water made available by reducing depletions can stay within our communities and our region, they may be very helpful in meeting growing water needs and in sharing water in times of shortage. Where available rights are the only limit to using water, rights to water conserved by reducing depletions should be able to be banked, lent, or leased to other local users. Where actual physical water availability is also an issue, additional investment in infrastructure like wells, piping, treatment facilities, and storage will also be needed before additional water can really be used.

The incentives and possibilities for water conservation will be greater if any water saved can also be stored for later use, either physically in reservoirs or aquifers, or by water exchanges or banking arrangements that permit water saved at one time to be used at a subsequent time. The lack of physical water storage is a significant disincentive to conservation in our region.

If appropriate incentives and safeguards to water rights were in place, several options exist that would enable farmers, ranchers, and other parciantes to reduce water consumption and still maintain agricultural production and acequia integrity in some circumstances:

- Field leveling and other on-farm water management efficiencies;
- Repair of chronic or excessive leakage from certain acequia sections;
- More active water management, including soil moisture testing or additional flow measurement;
- Water banking that allows unneeded water to be used elsewhere without loss of rights, and enables greater flexibility in responding to drought;
- Agricultural research and extension outreach to assist in growing and marketing less water-consumptive crops;
- More intensive management by mayordomos to ensure that water isn't wasted or used inappropriately; and
- Making information available and/or supporting research into alternatives for water re-use and conservation, such as gray water systems, constructed wetlands, or effluent re-use from community wastewater treatment where it may be implemented.

If communities had centralized wastewater treatment plants, the treated effluent from the plants could be reused for watering non-edible crops (such as feed for animals), providing another opportunity for more efficient water use.

Since, in our region, the great majority (94 percent) of water use is for irrigation, and in general little community system water is used for landscape watering, the total potential water savings from water conservation in domestic or community systems is much smaller than in other, more urban areas. However, water saved in community systems may still be extremely valuable, especially in times of shortage. These techniques for water conservation may benefit communities here just as elsewhere:

- Leak testing and repair on water system piping as well as on individual household plumbing, including evaporative coolers;
- Low-flow shower heads, toilets, and faucets;
- Low water use appliances, especially clothes washers; and
- Gray water use where domestic water is used for landscape watering.

Water conservation can play a useful role in ensuring an adequate water supply for the future, but only when it is clear from a legal point of view that those conserving water won't simply lose the water conserved.

SUMMARY

We are fortunate in our Region that we are not faced with ever-increasing demands for water and an already unsustainable supply, as in other parts of New Mexico and the Southwest. We face three challenges: First, we must ensure that our existing supplies are protected to serve our present and future needs, which will not diminish over time. Second, we need to make better use of the water we have by providing additional storage and managing our watersheds to protect both water supply and water quality. Third, we need to make more water available where needed for domestic and commercial uses. This requires management of both water rights and physical infrastructure.

REFERENCES

Barroll, Peggy, 1999. Revised Historical Supply Calculations for the Rio Ojo Caliente, State Engineer Office Memorandum, July 15, 1999.

Baxter, John O., Irrigation in the Chama Valley, study prepared for the U. S. District Court in connection with water rights adjudication of the Rio Chama, unpublished manuscript, 1994.

BBER, 2003. Demographic and Population Study for Regional and Statewide Water Planning Population Projections for 16 Regions July 1, 2000 to July 1, 2060: Completed by Adelamar N. Alcantara and Elvira Lopez, University of New Mexico Bureau of Business and Economic Research October 2003; Prepared for the Regional Water Planning Program New Mexico Interstate Commission, October 2003, p. 97.

Flanigan, Kevin. New Mexico Interstate Stream Commission, (personal communication, 20 March 2003).

Fogg, J.L., Hanson, B.L., Mottl, H.T., Muller, D.P., Eaton, R.C., and Swanson, S., Rio Chama Instream Flow Assessment, U.S. Department of the Interior, Bureau of Land Management, 1992.

Hordes, Stanley M., Irrigation at the Confluence of the Rio Grande and Rio Chama: The Acequias de Chamita, Salazar, and Hernandez, 1600-1680, report submitted to the Rio de Chama Acequia Association, 1996

Jensen, M.E., Burman, R.D., and Allen, R.G. (eds), Evapotranspiration and Irrigation Water Requirements, (ASCE Manual No. 70), American Society of Civil Engineers, 1990.

Leedshill-Herkenhoff, Inc., and John Shomaker and Associates, Inc., Preliminary Engineering Report for the Agua Sana Water System, report to the Agua Sana Water Users' Association, 1996.

Lucero, Anthony; OSE staff, personal communication, Mar. 6, 1997

New Mexico Department of Agriculture, 2000. New Mexico Agricultural Statistics, 1999.

New Mexico Department of Health, Public Health Division, Bureau of Vital Records and Health Statistics, Rio Arriba County Health Profile, 1996.

Office of the State Engineer, 25 July 2000. Determination of Depletions of the San Juan/Chama Project Water made by the Rio de Chama Acequias Association, internal memorandum from Paul Wells to Paul Saavedra, Fred Vigil, and Buck Wells.

Office of the State Engineer, 26 July 2002. Update of Determination of Depletions of the San Juan/Chama Project Water made by the Rio de Chama Acequias Association, internal memorandum, Water Rights Division.

Office of the State Engineer (OSE), 2003. Village of Chama Hydrographic Survey, Rio Chama Stream System, Section 7, Volume 5, July 31, 2003.

Office of the State Engineer (OSE), 2002a. Rutheron & Plaza Blanca Hydrographic Survey, Rio Chama Stream System, Section 7, April 30, 2002.

Office of the State Engineer (OSE), 2002b. Canones Creek Hydrographic Survey, Rio Chama Stream System, Section 7, December 31, 2002.

Office of the State Engineer (OSE), 2001a. Rio Brazos Hydrographic Survey, Rio Chama Stream System, Section 7, December 18, 2001.

Office of the State Engineer (OSE), 2001b. Rito Tierra Amarilla Hydrographic Survey, Rio Chama Stream System, Section 7, January 12, 2001.

Office of the State Engineer (OSE), 2000a. Las Nutrias Hydrographic Survey, Rio Chama Stream System, Section 3, April 2000.

Office of the State Engineer (OSE), 2000b. Rio Cebolla Hydrographic Survey, Rio Chama Stream System, Section 3, Volume 3, August 11, 2000.

Office of the State Engineer (OSE), 2000c. Canjilon Creek Hydrographic Survey, Rio Chama Stream System, Section 3, July 14, 2000.

Office of the State Engineer (OSE), 2000.d Rio Gallina Amended Hydrographic Survey, Rio Chama Stream System, Section 5, January 14, 2000.

Office of the State Engineer (OSE), 1974. Canones and Polvadera Creeks Hydrographic Survey, Rio Chama Stream System, Section 6, 1974.

Office of the State Engineer (OSE), 1971. El Rito Hydrographic Survey, Rio Chama Stream System, Section 4, 1971.

Office of the State Engineer (OSE), 1968. Ojo Caliente, Vallecitos, and Tusas Hydrographic Survey, Rio Chama Stream System, Section 2, 1968.

Office of the State Engineer (OSE), 1961. Lower Chama Hydrographic Survey, Rio Chama Stream System, Section 1, 1961.

Office of the State Engineer (OSE), 1953. Rio Puerco de Chama Hydrographic Survey, Rio Chama Stream System, Section 8, 1953.

Resource Technology, Inc., 1993. Northern Rio Arriba County Regional Water Plan: prepared for North Central New Mexico Economic Development District, Santa Fe, New Mexico, June 1993.

Treadway, Doug (NRCS staff, Chama, NM). Personal communication, 1996.

Wilson, B. C., Lucero A. A., Romero, J.T., and Romero, P.J., 2003. Water use by Categories in New Mexico Counties and River Basins, and Irrigated Acreage in 2000: New Mexico State Engineer Office, Technical Report 51, p. 164.

U.S. Census Bureau web sites:
www.census.gov/
venus.census.gov/cdrom/lookup