8. Analysis of Alternatives for Meeting Future Demand

Once the region has studied their water supply and projected future demand for water, the next key component of the regional water plan is to develop alternatives for meeting the projected water demand. Alternatives are actions that the region can take to increase supply, reduce demand, protect or improve water quality, or better manage water resources so that the water supply of the region continues to be viable. This section provides information on the process used to identify and screen alternatives and analyzes the feasibility of priority alternatives selected by the Steering Committee. The purpose of this alternative analysis is to provide decision makers an overview of the technical, legal, environmental, and political issues with regard to each alternative. This section does not rank the alternatives nor compare their relative merits, for it is likely that combinations of multiple alternatives will be implemented, and each governmental entity will ultimately make the decision on the degree to which each alternative is implemented.

8.1 Identification and Selection of Alternatives

The region initiated the current phase of regional water planning in January 2004. A complete list of potential alternatives for addressing water supply needs was developed at Steering Committee meetings, which were advertised and open to the public, held in the winter and spring of 2004. In developing the potential alternatives, the Steering Committee also considered input from public meetings held in 2003. Public participation during this planning process is outlined in Appendix B.

To help determine which of the alternatives were the most important to identify and analyze in the regional water plan, the Steering Committee requested that DBS&A assist in developing a formal decision analysis process. The decision analysis process is a structured way of thinking about the ramifications of actions taken as a result of a specific decision and provides a structured way to consider diverse values in making the decision (Spradlin, 1997). The intent is to provide a group of stakeholders with insight into their preferences and values, as well as their attitudes toward risk, as they relate to the potential alternatives. In the absence of complete "hard data" regarding some of the water supply choices to be made, particularly regarding intangibles such as public/institutional and regulatory acceptability, the evaluation and ranking of alternatives in this manner incorporates judgments from those knowledgeable about or affected by the alternatives. The decision making process followed by DBS&A and the Steering Committee allowed consideration of the issues and values that are most important to the region's stakeholders in order to logically evaluate, compare, and rank alternative options.

To assist with the decision-making process, the Steering Committee identified the following criteria:

- Economic feasibility
  - Local costs
  - Project costs

- Institutional feasibility
  - Equity of cost/benefit
  - Regional political and stakeholder support
  - Technical feasibility
  - Legal feasibility

- Water resources enhancement
  - Water quality
  - Water quantity

- Quality of life enhancement
  - Environment
  - Social and cultural impacts
  - Economic vitality of the region

These criteria were used to score all of the alternatives as an initial evaluation. Scores for technical, financial (economic), legal, and water resources enhancement criteria were prepared by DBS&A and were reviewed and revised by the Steering Committee. Scores for quality of life enhancement, equity of costs/benefits, and regional political and stakeholder support criteria were prepared by the Steering Committee.

In April 2004, the Steering Committee, which includes representatives from all four counties, participated in ranking more than 25 water use alternatives using the decision matrix. Meeting participants scored the alternatives on the criteria listed above, decided what weight each criterion should have, and in some cases made adjustments to project team scores. Scores were then added by computer, and the top alternatives were presented to the group. At a subsequent meeting, attendees further refined the list to include the top priorities for each county and arrived at a final list for evaluation. Participants then had the opportunity to discuss and remove from mention in the plan alternatives that received lower scores.

In an August 2004 Steering Committee meeting and in October 2004 Steering Committee and public meetings, participants discussed the potential water savings and implications of each alternative, including social or public welfare implications, political feasibility, potential environmental impacts, and implementation issues.

In accordance with the ISC template, the alternatives defined by the Steering Committee fall into the categories of water resource management, water conservation, water and infrastructure development, and water quality management. The alternatives were also categorized separately by the Steering Committee. Based on the scoring and review processes described above, the Steering Committee identified the following subset of these alternatives for analysis within this Regional Water Plan:

- Municipal conservation and management
- Agricultural water conservation
- Watershed management
- Enhancement of surface recharge
- Provide water for natural riparian and aquatic habitat on the Gila and San Francisco Rivers
- Aquifer storage and recovery of Gila River flows
- Water banking
- Groundwater development

In accordance with the ISC template, these priority alternatives were evaluated with regard to their technical feasibility, political feasibility, social and cultural impacts, financial feasibility, and hydrologic and environmental impacts (Sections 8.2 through 8.9). Physical impacts, if relevant to the alternative, are discussed in the hydrologic impacts subsections of Sections 8.2 through 8.9.

In addition to the priority alternatives that are analyzed in this document, the Steering Committee identified several other alternatives to be included as part of the long-term water plan, including:

- Water quality protection
- Groundwater management planning
- Border groundwater management
- Rain harvesting
- Industrial conservation
- Restrictions on domestic wells

Though a full analysis of these alternatives was not included in the work plan for the region, the region nevertheless wanted to present a description of these alternatives along with the key issues and implementation strategies. Accordingly, these alternatives are discussed in Sections 8.10 through 8.15.

Finally, recommendations and an implementation schedule for all alternatives considered in the regional water plan are included in Section 8.16.

8.2 Municipal Conservation and Management

Water conservation is an important aspect of regional water planning, as it allows the region to make efficient use of and extend existing resources, thereby avoiding costly development of new supplies. Given that the largest supplies in the Southwest Region are in groundwater reservoirs, many of which have very low natural recharge rates, a reliable long-term supply projection depends on using these resources wisely. As discussed in Section 5.3.6.1 and 5.3.6.2, groundwater resources are currently being depleted at an unsustainable rate, such that the communities of Santa Clara, Bayard, Deming, and Silver City will not be capable of meeting demands through 2040 with existing wells. By decreasing demand through water conservation, existing supplies can be extended to meet growing demands, and the development of costly infrastructure to tap new water supplies can be delayed.

Because the agricultural sector is the largest water user in the Southwest Region, the greatest conservation opportunity for increasing the overall available supply is probably agricultural conservation, which is discussed in Section 8.3. The rural nature of much of the area makes municipal demand a smaller part of total demand (Section 6), and municipal conservation will not greatly affect the overall water budget in the region. However, controlling municipal demand is important for reasons other than balancing the overall regional water budget:

- Unlike other water uses, where beneficial use is necessary (at least theoretically) to maintain a water right, municipalities can hold water in reserve for growth and economic development if they develop 40-year municipal water plans, and those plans require consideration of municipal conservation.

- After December 2005, Water Trust Board and other state and federal water supply infrastructure funding programs will also require that all funding applications include an adequate municipal water conservation plan. Section 72-14-3.2 of the NMSA 1978 states that any public supply system with diversions of “at least 500 acre-feet annually for domestic, commercial, industrial, or government customers for other than agricultural purposes, may develop, adopt and submit to the State Engineer, by December 31, 2005, a comprehensive water conservation plan, including a drought management plan, and that after December 31, 2005, neither the Water Trust Board nor the New Mexico Finance Authority shall accept an application from a covered entity for financial assistance in the construction of any water diversion, storage, conveyance, water treatment or wastewater treatment facility unless the covered entity includes a copy of its water conservation plan.”

- In addition to these water right and funding considerations, municipal conservation programs can provide benefits to individual systems and raise public awareness of the importance of controlling excessive water use.

This section focuses on methods of addressing municipal water conservation and management, including water rate structures, ordinances that restrict water use, graywater recycling, treated wastewater reuse, reduction in water system losses and leaks, and encouraging voluntary conservation through public education programs. Implementation of water conservation programs is both technically and legally feasible and has been done throughout the Southwest.

8.2.1 Technical Feasibility

Developing successful municipal conservation programs requires the use of many different tools, from regulations, policies, and programs to changes in technology. Each water supplier in the region will be required to develop its own conservation plan, which should identify the tools and measures that will best address their situation. Small water suppliers with limited outdoor water use and no industrial use may choose to focus on customer education and creating incentives to install low-water-use appliances as first steps toward reducing water use. Larger suppliers and users may require a broader suite of measures to achieve water conservation goals, including equipment replacement or technology improvement. This section outlines some of these tools: conservation ordinances (including rate structures), public education programs, graywater reuse, and municipal wastewater reuse.

Conservation plans developed by suppliers should also include a drought management plan. Appendix G contains a copy of the OSE model drought management plan as guidance for regional water suppliers. A complete list of water conservation plan requirements and potential water conservation measures, such as indoor plumbing fixture replacements and landscape design ordinances, is available on the OSE website (http://www.ose.state.nm.us/water-info/conservation/index.html). Section 8.2.1.1.1 provides other references to municipal conservation guidance information that managers in the Southwest Region could use to develop or expand conservation programs.

8.2.1.1 Ordinances

Water conservation ordinances are a clear way to engage the public in water conservation activities. The primary topics covered by conservation ordinances, in separate or combined legislation, include:

- Prohibiting outdoor water waste and/or requiring or encouraging low-water-use landscapes

- Changing water rate structures to encourage conservation and reduce water use by residential, industrial, commercial, and institutional customers

These types of ordinances are discussed in Sections 8.4.1.1.1 and 8.4.1.1.2; Section 8.4.1.1.3 discusses the use of water meters to support enforcement of these ordinances. Some of the ordinance provisions discussed in this section are already at least partially implemented in several Southwestern New Mexico regional communities.

8.2.1.1.1 Water Waste. Many of the main conservation issues can be addressed in an ordinance addressing water waste. The OSE (2001) suggests that water waste can be defined in an ordinance as water that flows or is discharged from a residence or place of business onto an adjacent property. Such discharges occur most often from landscape irrigation or leaking water pipes. In addition to the loss of potable water, these events have safety and maintenance impacts. Water running onto streets, especially when it freezes, can cause vehicle accidents and, if it pools, damage road surfaces.

A prototype for a water waste ordinance is included in OSE's guidance for municipal water systems (NM OSE, 2001). This ordinance template provides measures applying to both normal operations and water emergencies and includes the following main elements:

- Types of prohibited water waste:
  - Water running off an area during landscape irrigation
  - Washing of impervious surfaces with a hose (except in cases where it is needed to protect public health and safety)
  - Water leaks not fixed within eight hours
  - Landscape watering outside prescribed hours (e.g., before 10 a.m. and after 6 p.m.)

- Fines and penalties for violations that increase with the number of citations assessed to a property, including:
  - Imposition of a water waste surcharge to any customer in violation
  - Temporary or permanent restriction or discontinuance of flow to a property with recurring violations

- Exceptions, cure of violations, and refunds of surcharge

- Administrative appeal process for customers (e.g., appeal to administrative hearing officer, water utility's general manager, or the board of directors)

An emergency water ordinance can include additional measures such as:

- Emergency rationing (water allotment to different customer classes)
- Prioritization of water service according to customer class

The OSE prototype ordinance assumes implementation and enforcement by the utility general manager and board of directors. If a county-wide enforcement system is developed, a certain amount of coordination is needed to develop and enforce the ordinance.

Examples of municipal water conservation ordinances enacted by other municipalities in New Mexico are discussed below.

- The City of Albuquerque adopted water conservation through a resolution and two or more ordinances (COA, 2004):
  - In 1995, the City adopted the Water Conservation Plan Resolution, which outlines the comprehensive water conservation program.
  - The Water Conservation Landscaping and Water Waste Ordinance also passed in 1995 (amended in 1998 and 2001). This law defines restrictions and creates the basis to enforce penalties for violations.
  - An ordinance outlining water conservation guidelines for large users (industrial, commercial, and institutional) was also passed.

- In 2001, the City of Las Cruces passed a water conservation ordinance (2001). Major features of the ordinance are:
  - Watering restrictions regarding time of day and odd/even day designations
  - Prohibition of water waste and requirement for use of hose nozzles
  - Mandatory time frame for leak repairs (within five days)

  Las Cruces has had an inclining block rate structure since 1975. In 1996, the steepness of consumption-based rate steps was increased in accordance with its water conservation ordinance.

- The City of Santa Fe has implemented a conservation ordinance associated with its water emergency declarations (City of Santa Fe, 2004). Because of the real limits to their water supply, the restrictions are more severe and less voluntary than other case examples. However, by implementing conservation ordinances that restrict watering to three days a week during drought periods, the City of Santa Fe has reduced demand by 22 percent on a per capita basis since 1995.

Although outside New Mexico, the nearby City of El Paso provides a good example of the potential for consumption reduction through conservation. El Paso is probably the second most aggressive city in the Southwest (after Tucson, Arizona) in implementing conservation and xeriscaping programs and currently has a per capita per day municipal and municipal-supplied industrial consumption rate of 140 gpcd (Padilla, 2004; Balliew, 2004). El Paso is a very good source of conservation information and a key player in the Texas Water Conservation Implementation Task Force, which has recently published a set of conservation best management practices that provides an up-to-date compendium of conservation tools (TWDB, 2004).

Another good source of up-to-date conservation information was recently published by the Pacific Institute (Gleick et al., 2003), and the EPA and American Water Works Association both provide conservation information on their web sites (http://www.epa.gov/OW-OWM.html/water-efficiency/index.htm and http://www.awwa.org/waterwiser, respectively).

Although the conservation ordinances outlined above are all for larger municipalities, the same concepts can be and are applied to the smaller municipalities in the Southwest Region.

- Silver City has a water conservation ordinance that prohibits “water waste” and specifically identifies excess flow from landscape watering as waste. The ordinance includes enforcement provisions starting with warning notices and escalating to a series of graduated fines and ultimately to shutting off the connection (Silver City Ordinance No. 1038, Article VI, Water Conservation).

- Deming‘s conservation ordinance requires low flow plumbing fixtures and appliances in new construction and recommends conservation features on evaporative coolers (Ordinance No. 1087) Deming also designates odd/even days for outdoor residential and commercial turf and landscape irrigation and prohibits watering during the hours of 10 a.m. to 6 p.m. This same ordinance prohibits home car washing by hose without using a shut-off nozzle or alternatively allows transfer of the water in a pail of 5 gallons or less. Commercial car washes are limited to 50 gallons or less per vehicle. The ordinance includes numerous other provisions to prohibit water waste through leaks or excessive landscape watering (Ordinance No. 1088). Deming also regulates new subdivisions, requiring drainage plans to prevent off-site migration of water and use of low-water-use plants (Ordinance No. 1089).

Both Silver City and Deming have more severe restrictions triggered by drought and/or the relationship between demand and the available water supply. In the case of Silver City, there are three levels of restriction (Silver City Ordinance No. 1038, Article VI, Water Conservation):

- Level I is voluntary and is triggered by lower-than-normal precipitation. At this level of restriction, water users are encouraged to minimize landscape irrigation and other activities that consume water.

- Level II is triggered by demand that is greater than available production for two consecutive weeks. It allows outdoor watering on only odd or even days outside of the 10 a.m. to 6 p.m. time bracket, limits refilling of swimming pools, and places restrictions on car washing and other water consuming activity.

- Level III is called a “water crisis” and is again triggered by the relationship between demand and available supply on the system. It is instituted by a declaration from the Town Manager when an emergency exists in his/her judgment. The level III condition eliminates all outdoor watering and allows the Town Manager to impose other restrictions as s/he deems necessary.

Deming also has provisions for declaring a “water emergency” by the City Council on the advice of the City Administrator and the Director of Public Works. This declaration is triggered by severe drought or “any condition that interrupts the ability of the city to supply water” and allows restrictions or prohibition of outdoor irrigation and other water uses (Ordinance No. 1088).

The City of Lordsburg has a conservation ordinance that restricts use only during shortage events. It is triggered by “severe drought,” in the judgment of the utility, and imposes outdoor watering limitations (Castillo, 2004). Reserve is currently working on enacting a drought management ordinance (Martinez, 2004).

8.2.1.1.2 Water Conservation Incentives Through Rate Structuring. Nationally, and in the Southwest Region, many utilities are using price as a demand management tool. According to a 1992 American Water Works Association (AWWA) survey, approximately 60 percent of the utilities in the United States use a conservation rate structure (NH DES, 2001). Four different types of rate structures can generally be classified as conservation oriented:

- Uniform commodity rates: All usage is charged at the same unit rate. Although not often viewed as being a water efficiency-oriented rate, uniform rates are an improvement over declining-block rate structures in which the price of water decreases as the volume of water used increases.

- Flat seasonal rates: This rate structure incorporates two or more different uniform volume charges for different seasons during the year. Generally, a higher rate is charged during the peak water usage season than is charged during the off-peak season.

- Inverted block rates: An inverted-block rate structure (also called inclining block) involves the use of increasing rates for units of water consumption at higher levels of usage. (In addition to encouraging water conservation, this rate structure could help balance the impact of conservation on loss of revenue to the utility.)

- Excess use rates: An excess use rate structure involves establishing an average base water usage volume during the non-peak period and a corresponding base water usage rate. During the peak period or season, water usage above this base level is charged at the base rate plus an excess use rate. Several variations of the excess use rate structure exist. Some utilities provide an allowance above the base usage during the peak season to recognize an increase in non-discretionary use during peak periods.

More information about these types of rate structuring is provided by the New Hampshire Department of Environmental Services (2001).

The OSE recommends that an inclining (inverted) block rate be favored. However, utilities should analyze whether this structure can achieve conservation effects in the local community. If such a structure is implemented, the amount of water required for “basic human needs” can be determined and kept at an affordable rate for low-income households; thereafter, rates can increase. Some municipalities, such as Albuquerque, provide for an administrative waiver for low-income households that have more members than the number allowed for in the "basic human needs" assumptions.

Conservation rate structures may result in uncertainty in forecasting revenue, as these pricing policies usually do not exhibit the high minimum charge that standard rate structures incorporate. A utility must assess the interrelationships among rates, consumption, and costs and the effect that these issues will have on the revenue requirements of the utility.

The larger municipalities in the Southwest Region already have either inverted block or excess use rate structures:

- Silver City has an inverted block rate structure that charges
  - $7.49 for the first 3,000 gallons per month
  - $2.22 per thousand gallons from 3,000 to 13,000 gallons
  - $2.50 per thousand gallons above 13,000 gallons.

  Due to the higher service cost, water rates outside the town limits are doubled (Town of Silver City, 2004).

- Lordsburg has a similar inverted block rate (Castillo, 2004):
  - $7.50 for the first 1,000 gallons per month
  - $1.70 per thousand gallons from 1,000 to 12,000 gallons
  - $1.80 per thousand gallons from 12,000 to 20,000 gallons
  - $1.90 per thousand gallons from 20,000 to 50,000 gallons
  - $2.00 per thousand gallons from 50,000 to 100,000 gallons
  - $2.10 per thousand gallons over 100,000 gallons

- Deming has a base rate of $9 plus $0.80 per 100 cubic feet over 600 cubic feet, with higher rates outside the city limits and higher commercial rates (100 cubic feet is equivalent to 748 gallons).

- Reserve charges a base rate of $12 for service and $1 per 1,000 gallons with a 5 percent conservation fee and higher rates outside the city limits (Martinez, 2004).

8.2.1.1.3 Metering. Metering is an essential element in water conservation. Metering of both production and individual user consumption is the only way to track water use and assure that conservation goals are being achieved. Comparison of production metering to meter readings for customer water accounts allows determination of "unaccounted-for" water. This unaccounted-for water can result from inaccurate customer water meters, leakage in water mains and distribution lines, and failure to meter all the demands. Many utilities track unaccounted-for water to look for water system problems. A figure below 10 percent is desirable and achievable.

A regulation, resolution, or ordinance should be in place to require the installation and regular reading of meters at all water sources, including import or export points, customer service connections, and public landscape sites. All water provided free of charge for public use, including construction water from fire hydrants, should also be metered to allow the utility to more accurately account for water use. The City of El Paso provides portable fire hydrant metering of construction water use (Padilla, 2004).

The larger communities in the Southwest region (i.e., Deming, Silver City, and Lordsburg) all have metering of both production and customer accounts.

- Deming had a 1997 per capita per day gross (including all uses) production rate on the order of 250 gpcd (LHI and JS&A, 1997), and an unmetered use (unaccounted-for water) of 4.8 percent. In 2000, Deming's per capita demand was estimated to be 227 gpcd based on diversion estimates shown in Table E2-4, which shows a population of 16,000.

- Silver City had a per capita demand of about 155 gpcd in the 1993 to 1997 period (Gordon et al., 1997), including an unaccounted-for water demand in the 13 percent range. Silver City's per capita demand increased to 235 gpcd, including system losses of 16.6 percent (Robert Esqueda, Silver City Utility Director, personal communication with Amy Lewis, May 3, 2005). The increased demand in 2000 is most likely due to the lower amounts of precipitation that fell in 2000 compared to the relatively wet years from 1993 to 1997.

- Lordsburg had a 241-gpcd demand in 1994 (Gordon, 1994), and unaccounted-for water made up 22 percent of this demand. In 2000, Lordsburg had a per capita demand of 205 gpcd, based on the information presented in Table E2-4.

The higher per capita use rates in Deming and Lordsburg, as compared to Silver City, are probably at least partially due to more turf grass watering by both metered customers and the municipalities due to the drier climate and more demand from the Interstate 10 transient population. Much of the unaccounted-for water use in Lordsburg goes to unmetered water use at parks, cemeteries, and other municipally maintained turf grass areas (Gordon, 1994). Therefore, if there is any room for improvement in this area, it would be more metering in small communities and more metering of normally unbilled consumption (e.g., construction water and city landscape water uses) in larger Southwest Region communities.

8.2.1.2 Public Education

Public education and community outreach are an important part of any water conservation effort. Individuals must know why water conservation is essential and what they can do to save water. The OSE manual *A Water Conservation Guide for Public Utilities* (NM OSE, 2001) recommends two main aspects of the program:

- To reach the public, the entity in charge of the water conservation program (either the local government or local utility) should use a wide range of avenues including:
  - News media
  - Speakers programs
  - Public information materials
  - Exhibition, tours or special events
  - Web site

  Assigning staff to implement various aspects of public information campaign is essential.

- Outreach in the public schools should be included in the program. Children who learn about conservation in the classroom will take that information home and educate their own families.

Numerous materials available for all types of public education programs and school outreach are available on the OSE water conservation website (http://www.ose.state.nm.us/water-info/conservation/index.html).

The Grant County Water Collaborative Group is an example of public education already underway in the Southwest Region. This group, which is funded by the State of New Mexico, consists of 21 private and public water users. The group will have a total of 8 facilitated meetings to discuss water issues, with the potential for participating water users to commit to local resolutions.

Other websites currently offer interactive water calculators to help users understand how much water they use and where they use it:

- http://www.h2ouse.org/
- http://www.tampagov.net/dept_water/conservation_education/Customers/Water_use_calculator.asp

These web calculators provide a simple method for doing a "home water check-up" and allow individuals to compare their home use with the average use.

8.2.1.3 Indoor Conservation

To gain water demand reductions, it is important to ensure that efficient water use appliances are distributed and installed. The potential water savings can be realized from upgrading the plumbing in existing homes and businesses. A single low-flow toilet (1.6-gallon flush) will save 12,000 to 16,000 gallons of water in a single year when compared to toilets that are more than 10 years old (Ash et al., 2002).

Water audits can be conducted to evaluate the water savings potential on a site. These can be made mandatory for all or selected groups of users. A time period should be established for audits to be completed, commercial and industrial sites should be required to use a certified water auditor, and a report should be submitted to the local and state water authorities. Audits can identify where rebate programs (such as rebates for installing low-flow toilets) can have the most impact.

Retrofits can be required through "retrofit on resale" requirements that mandate the installation of low-flow plumbing devices in residences (with the cost borne by the seller or buyer) as a condition of sale. In addition, financial incentives for installing retrofits and implementing other water-saving measures can be provided through rebates, such as rebates for low-flow plumbing devices for homes and apartments, rebates and/or tax incentives to install rainwater harvesting systems (residential and commercial), or rebates and/or tax incentives for businesses to upgrade plumbing and process water systems.

In addition to retrofitting, planning and design guidelines are needed to ensure that all new development uses water efficiently. Standards for low-flow plumbing devices should be included in all local building codes. Requirements for installation of metering devices should also be included in building codes.

8.2.1.4 Graywater Recycling

Graywater reuse refers to either residential or commercial reuse of water that does not contain blackwater (from toilets) or kitchen wastes. Water from sinks (excluding kitchens), laundries, bathtubs, or showers is considered to be graywater.

Recycling of graywater at individual residences has received a lot of recent attention in New Mexico. New Mexico allows individual residences to apply up to 250 gallons of graywater per day to household gardening and landscape irrigation without a discharge permit (Sections 74-6-2 and 74-6-4, NMSA 1978).

The City of Deming implicitly allows and encourages residential graywater reuse by including the State law provisions allowing it in City Ordinance No. 1087. Other Southwest Region communities and rural suburban areas could consider encouraging it also. This may be a partial solution to restrictions on outdoor watering in the Gila and San Francisco basins.

Advantages of reusing graywater are:

- Replaces potable water use and therefore lowers water bills and possibly sewer bills for municipal customers
- Increases the life and/or improved performance of on-site septic systems

- When used for outdoor irrigation, may support plant growth (due to the nutrients in graywater)
- Reduces energy and chemical use
- Possibly decreases the need to expand wastewater treatment facilities

Reusing graywater also has some disadvantages:

- May spread disease if system is not properly operated
- May develop odors if stored more than 24 hours
- May adversely impact soil (salt buildup)
- Decreases the amount of wastewater going to treatment plant, which may affect the overall wastewater system
- Lowers availability of reclaimed water for return flow credits (where applicable) or other uses

The standard components of a graywater system include (Little, 2003):

- Conveyance piping to collect water from a source and deliver it to the graywater system
- Surge tank to hold flows (e.g., plastic trash barrel)
- Filter to remove particles such as lint and hair (e.g., sock, sand filter)
- Storage tank to hold water until ready to use
- Three-way valve to allow graywater to go to sewer or septic system
- Pump to move water to distribution point such as irrigation system

A permit is required by NMED for use of more than 250 gallons of graywater per day. The permit needed is the same type of permit required for a septic system (Duttle, 1994). In issuing the permit, NMED considers treatment, storage, and disposal of the water (underground leach field versus surface disposal for irrigation).

No permit is required for less than 250 gallons per day if the following conditions are met:

- System overflow is directed to an existing wastewater system.
- Storage tank is enclosed and access is restricted.
- System is outside the floodway.

- The vertical distance between graywater and the groundwater table is at least 5 feet.
- Pipes for graywater system are marked as nonpotable water.
- Graywater does not leave the property.
- Standing water is minimized and prohibited for more than 24 hours.
- Graywater is never applied by spraying.
- Graywater use complies with local ordinances.

8.2.1.5 Reuse of Municipal Wastewater

Wastewater reclamation and reuse is being practiced successfully in many locations in the western United States as a means of increasing or supplementing the available supply of water and preserving potable water for drinking water uses. Treated wastewater has been successfully used throughout the United States for agriculture, recreation, landscape watering, aquifer recharge, manufacturing and industry, and return flow credits. Each of these types of uses requires that the wastewater be treated prior to use and comply with applicable regulatory standards. The degree of treatment and the standards to be met depend upon the end use of the reclaimed water:

- For all reuse options where human contact with the treated wastewater is likely (i.e., irrigation and recreational use), wastewater treatment must include secondary and tertiary (filtration and disinfection) treatment.

- For all reuse options where treated wastewater is likely to come in contact with groundwater (e.g., irrigation, landscaping, and aquifer recharge), a New Mexico Groundwater Discharge Permit is necessary.

- Returning water to a river for return flow credits requires treatment to meet the standards required by a Region 6 U.S. EPA written and enforced NPDES permit.

NMED has “certification” review rights on NPDES permits and may require additional permit limits as long as they are at least as protective as those required by EPA. NMED is currently in the process of public review of their desire to assume “primacy” over the NPDES program, which would eliminate EPA responsibility except in an oversight role. The discharge standards in NPDES permits must, at a minimum, meet uniform, nationwide secondary treatment requirements.

Treated wastewater discharges to streams may also be further limited by receiving water quality standards established to meet the designated uses of that particular stream segment as established by the NMWQCC. These further limitations result when the receiving water quality standards would be exceeded after the introduction of secondary treated effluent from that discharger without additional treatment. When that segment is listed as "impaired" on the 303d list, which must be maintained by NMED and is based on periodic stream sampling results or other indications of problems from a particular pollutant or pollutants, a TMDL determination must be performed (Section 5.4). The TMDL allocates maximum waste load discharges of each pollutant contributing to impairment by each point source discharger on that stream segment. These standards lead to further discharge limitations. All of these limitations influence the type and level of wastewater treatment necessary.

The primary technical challenge in reusing wastewater is treatment of the water to bring it to an acceptable level of quality. Treatment of wastewater for reuse has been practiced at some locations within the U.S. for more than 25 years and the technological feasibility is thus well known. The treatment standards for a surface water discharge, as outlined above, are well defined. However, the applicable standards that would have to be met for some (non-discharge) reuse applications are not as well defined.

Current NMED guidelines for irrigation and landscaping reuse are unclear or are relatively lenient in comparison to guidelines that exist elsewhere. NMED's existing policy covering use of treated wastewater effluent for irrigation was issued in 1985. These guidelines are intended to be used in conjunction with a groundwater discharge permit for any applications of the reuse water that can result in percolation to an underlying aquifer. This permit, which describes the reuse application (use, flows, etc.) and specifies a water quality monitoring program, must be filed with NMED for each reuse site. NMED guidelines do not allow for reuse of wastewater for potable applications.

NMED has recently issued (March 2003) updated draft guidelines for irrigation using treated wastewater, which should be carefully considered as the draft moves toward implementation of new guidelines.

To date, no federal regulations have been proposed for either nonpotable or potable reuse (Pontius et al., 2002). In 1992, the EPA published guidelines for water reuse, defining a broad range of reuse applications and presenting guidelines for treatment water quality and implementation; however, these guidelines are not legally binding. Generally, where overlap occurs, EPA's guidelines are similar to or more conservative than NMED's guidelines.

In 1998, Camp Dresser & McKee (CDM) developed a treated effluent management plan for the City of Santa Fe (CDM, 1998) that reviews the significant reuse standards current at that time. The most extensive of those are in the State of California, which since 1978 has regulated nonpotable reuse under Title 22 of the California Administrative Code. In addition, California drafted proposed regulations in 1993 for intentional recharge of potable aquifers with treated wastewater. However, considerable disagreement still exists within the water industry, and particularly in California, on how such indirect potable reuse should be regulated.

Recent attempts in the San Diego area to authorize intentional indirect potable reuse, by discharge of relatively small amounts of highly treated municipal wastewater to a relatively large natural reservoir that serves as the source for a water treatment plant, resulted in failure due to opposition generated during the public education process. Other attempts, in earlier times and locations where public opinion is less opposed, have been more successful. For example, the City of El Paso, Texas has injected tertiary treated wastewater effluent from the Fred Hervey Wastewater Reclamation Plant into their primary groundwater aquifer, the Hueco Bolson, for more than 20 years (Balliew, 2004). The injected reuse water travels from injection to production wells in approximately 2 years. This project was permitted by an NPDES permit issued by the predecessor agency to what is now the Texas Commission on Environmental Quality (TCEQ), which has NPDES primacy. Current policy would require an underground injection control (UIC) program permit from that same agency.

In 2000 NMED, in conjunction with the New Mexico Department of Health (NMDH), issued a revised draft of its guidelines for reuse, following the approach of California Title 22. Significant adverse comment was received on this proposed revision. Stakeholders thought that following the approach of Title 22 was not appropriate, in particular because changes would be imposed on existing New Mexico reuse practices without providing needed financial support. Reuse of wastewater for irrigating parks, school yards, and certain other areas is currently practiced throughout New Mexico, and objections were raised concerning additional treatment and monitoring that might be required for these activities.

NMED and NMDH are reviewing the comments received on the draft revisions and are considering options. NMED has reviewed the approaches taken by other states and is considering regulation based on classes of reuse. A workgroup formed by NMED to address this issue has proposed updated guidelines for public comment.

Tables 8-1 through 8-3 summarize possible classes of reuse and associated treatment standards and monitoring requirements that might constitute regulations for nonpotable reuse in the future. These tables were developed based on discussions with NMED prior to the March 2003 release of the new draft guidelines. These latest draft guidelines and subsequent revisions may alter final reuse standards.

Reuse classes A, B, and C are possibilities put forth by NMED and are defined by the quality limits indicated in Tables 8-1 and 8-2. The classes are intended to define the level of water quality and thus the degree of treatment required for various uses of reclaimed water.

Current regulations generally require secondary treatment of wastewater in order to meet NMED discharge standards. The degree of wastewater treatment necessary beyond secondary treatment (and thus the cost of the treatment) will depend on the quality standards required for the use of the water. A higher-quality effluent can be provided by applying tertiary treatment with additional treatment processes. The effectiveness of tertiary processes for treating wastewater to a high quality is well documented.

8.2.1.5.1 Use of Treated Wastewater to Supplement Agricultural Needs. Treated wastewater may be pumped directly to agricultural areas for irrigation. As an example, the City of Roswell, New Mexico uses all of its treated effluent for irrigation by selling it to nearby farmers during nine months out of the year. In New Mexico, treated effluent is most commonly used for non-food crops, such as alfalfa.

Land application of wastewater for irrigation purposes would require a groundwater discharge plan under the NMWQCC regulations. These regulations limit the amount of nitrogen that can be applied to fields to 200 pounds per acre per year, with a higher rate applied for crops with higher nitrogen uptakes. Thus the degree of treatment required is variable depending on the types of crops grown.

Table 8-1. Conceptual Use Classes for Reclaimed Wastewater

Use	Reuse Class [a]		
	A	B	C
Irrigation uses			
Fiber, seed, forage, and similar crops	■	■	■
Silviculture	■	■	■
Orchard or vineyard flood irrigation	■	■	
Orchard or vineyard spray irrigation	■		
Sod farms	■	■	■
Pasture for milking cows	■	■	
Pasture for non-dairy animals	■	■	
Unrestricted access golf course	■		
Unrestricted access landscape	■		
Restricted access golf course	■	■	
Freeway landscape	■	■	
Residential landscape	■		
Parks and playgrounds	■		
School yards	■		
Construction uses			
Dust control	■	■	
Backfill consolidation around portable water pipes	■		
Backfill consolidation around non-potable piping	■	■	
Soil compaction	■	■	
Mixing concrete	■	■	
Other uses			
Livestock watering (non-dairy animals)	■	■	■
Livestock watering (dairy animals)	■	■	
Toilet and urinal flushing	■		
Fire protection systems	■		
Street cleaning	■	■	
Snowmaking	■		
Commercial laundries	■		
Landscape impoundment	■	■	
Recreational impoundment (no significant dilution)	■		
Vehicle and equipment washing (does not include self-service vehicle washes)	■		
Irrigation and other non-potable uses at wastewater treatment plants	■	■	

[a] See Table 8-3 for treatment standards associated with each reuse class.

Table 8-2. Conceptual Reuse Treatment Standards

Category	Reuse Class A	Reuse Class B	Reuse Class C
Treatment required	Secondary, filtration, and disinfection	Secondary with disinfection	Secondary with disinfection
Turbidity limit	3 NTU monthly average, not to exceed 5 NTU in more than 5 percent of monthly samples	None	None
Disinfection limit	Nondetection of fecal coliform in 4 of last 6 daily samples; maximum 23 cfu/100 mL in any single sample	*E. coli* of 126 cfu/100 mL monthly geometric mean; maximum 235 cfu/100 mL in any single sample	Fecal coliform less than or equal to 1,000 CFU/100mL at all times.
Other	---	BOD 30 mg/L; TSS 45 mg/L	BOD 30 mg/L; TSS 45 mg/L

NTU = Nephelometric turbidity units
cfu/100 mL = Colony-forming units per 100 milliliters
BOD = Biological oxygen demand
TSS = Total suspended solids
mg/L = Milligrams per liter

Table 8-3. Conceptual Reuse Monitoring Requirements

Parameter	Reuse Class A	Reuse Class B	Reuse Class C
Turbidity	Continuous	None	None
Pathogen	Fecal coliform, daily	*E. coli,* weekly	Fecal coliform, monthly
BOD5	None	Monthly	Monthly
TSS	None	Monthly	Monthly

BOD5 = Biological oxygen demand (5-day)
TSS = Total suspended solids

In instances where water will be discharged to a natural waterbody, the water must be dechlorinated prior to discharge. For wastewater treatment plants (WWTPs) that discharge solely to waterbodies, alternative disinfection methods such as UV radiation or ozone injection may be practical.

This option is only practical if the point from which the treated wastewater is being pumped is within a reasonable distance of the point of return. Long return pipelines are generally costly and may not always be feasible because of terrain, permits, or other considerations.

8.2.1.5.2 Use Treated Wastewater for Recreational Uses (Landscape Irrigation). The primary recreational use of treated wastewater is for landscape irrigation, such as at parks, schools, and athletic fields, as other recreational uses involve bodily contact and potential human ingestion. Because of the small acreages normally involved, treated wastewater is usually not economically practical for irrigation if long pipelines must be constructed. As with agricultural uses, therefore, reusing wastewater for landscape irrigation is feasible only if the source of treated wastewater is within a reasonable distance of the reuse point. In addition, the wastewater would require treatment to conceptual reuse class A standards, which would likely consist of secondary treatment, filtration, and disinfection.

8.2.1.5.3 Inject Treated Wastewater as Artificial Recharge. Because of regional reliance on groundwater, treated wastewater might be used as a source of recharge to the underlying aquifers. Treating wastewater and injecting it as artificial recharge is straightforward technologically. Treated effluent may be recharged to groundwater by pumping it into the ground through injection wells or by percolation from surface recharge basins. Artificial recharge of groundwater is regulated under the OSE Underground Storage and Recovery Regulations (19.25.8 NMAC, effective January 31, 2001). The OSE determines whether the recharged water is fully recoverable using recovery wells or whether an unrecoverable loss occurs.

Unfortunately, determining the treatment requirements for artificial recharge is difficult. Because groundwater is widely used as a drinking water source in New Mexico, injection or percolation of treated wastewater into the ground is considered indirect potable reuse, and the State of New Mexico has not enacted guidelines or regulations regarding acceptable quality for effluent recharge for indirect potable reuse. NMED requirements would typically be expected for recharge effluent quality, depth to groundwater, and minimum setback distance from existing drinking water wells. Any discharge of effluent to an aquifer, however, will require a groundwater discharge plan permit to ensure that groundwater standards are not violated.

The NMWQCC groundwater regulations specify maximum concentrations for many constituents, and degradation of the groundwater quality up to these limits is allowed. Thus, if ambient concentrations were below the specified concentrations, treated wastewater concentrations could be higher than the specified in-ground concentrations. Conversely, if the existing concentration of any constituent in groundwater already exceeds the specified maximum, no degradation beyond the existing concentration would be allowed. A conservative approach would be to ensure that the quality of any treated effluent being used for groundwater recharge is equal to or less than the standard specified in the NMWQCC groundwater regulations.

EPA's water quality guidelines on groundwater recharge through surface application state that, after percolation through the vadose zone, all Safe Drinking Water Act maximum contaminant levels must be met, and fecal coliforms must be nondetectable. Ensuring that this will be the case is difficult, unless an underdrain system is constructed to allow sampling and testing of water that has percolated through the soil.

The most conservative and most publicly acceptable approach to indirect potable reuse involves treatment of wastewater to potable standards using advanced water treatment. This approach might require application of one or more of the following processes beyond secondary wastewater treatment: chemical clarification, reverse osmosis, granular activated carbon (GAC) adsorption, air stripping, filtration, and ion exchange. Advanced treatment should be sufficient to remove pharmaceuticals and other trace constituents that may be of concern to the public.

Another potential technology, soil-aquifer treatment (SAT), has been demonstrated in Tucson, Arizona and other areas to be effective in treating wastewater for groundwater recharge. The use of SAT requires particular geological conditions and the availability of considerable land; however, if feasible, SAT may be the most economical option for groundwater recharge.

8.2.2 Hydrological Impacts

Sections 8.2.2.1 through 8.2.2.3 discuss the hydrologic impacts of each of the four tools discussed in Section 8.2.1. Conservation ordinances and public education have been grouped together as they have similar hydrologic impacts.

8.2.2.1 Conservation Ordinances and Public Education

The success of conservation programs varies depending upon the starting per capita water use, which is a representation of water use based on the amount of municipal water that has historically been pumped or diverted divided by population. Per capita water use includes municipal-supplied commercial and industrial use, system losses, unaccounted-for water, and water used for public facilities.

Many of the larger municipalities in the Southwest Region already have good conservation ordinances and inverted rate structures in place. Silver City and Deming have measures in place to control demand in new subdivisions (Section 8.4.1.1.1). The use rates in Deming and Lordsburg are higher, but that is partially explainable by the transient population.

Because municipal water use (and wastewater generation) is relatively small in the region, reuse of wastewater will not have a large impact on the overall water situation in the region. However, it could improve efficiency in individual municipalities.

Understanding both the current community water use patterns of different types of water users and the real needs of customers is the first step in developing the best tools to conserve water. The difference between the actual use of water and the actual need is the conservation potential. The potential for water savings determines which efforts should be undertaken and when it becomes cost-effective to implement them. Once the water savings potential has been determined for a customer group, the conservation strategy comes quickly into focus.

Based on reviews of water use in the region and surrounding communities, and on program examples from around the country (i.e., those with proven track records), some communities in the planning region could achieve significant water savings—as much as 38 percent—through an integrated application of a conservation program. The success of a given conservation program will depend upon (1) the accuracy of the data, (2) the commitment of the local leaders, and (3) the thoroughness of the implementation.

Communities with conservation programs have had varying levels of success. The City of Las Vegas, New Mexico has reduced water use by 25 percent, from an average of 189 gpcd during 1985 to 1989 to an average of 142 gpcd during 2000 to 2004. Albuquerque has reduced demand by 23 percent, Tucson by 30 percent, Los Angeles by 25 percent, Austin by 27 percent, and Irvine by 54 percent (landscape use) and 12 percent (residential use). Additionally, Santa Fe has reduced demand by 22 percent on a per capita basis since 1995.

Studies show that an incentive water pricing structure significantly affects water use decision making and can determine the effectiveness of conservation programs. Approximate water savings potential is 15 to 30 percent for indoor use and 40 to 50 percent for outdoor use, depending on how wasteful the current uses are.

The projected increase in municipal demands in the Southwest Region from the year 2000 to 2040 is approximately 2,500 ac-ft/yr under the low growth scenario and 6,600 ac-ft/yr under the high growth scenario. A conservation program that uses tools such as rate structures and public education could reduce demand to 150 gpcd in cities and communities (which includes commercial uses) and to 100 gpcd in residential-only areas. A municipal per capita demand of 150 gpcd is relatively low and is based on demand in communities that have implemented a conservation program, such as the New Mexico cities of Las Vegas and Santa Fe.

For planning purposes, communities need tools, in addition to the conservation measures discussed here, that will enable them to respond to future droughts. While both Las Vegas and Santa Fe reduced demands below 150 gpcd during the drought period from 2000 to 2004, the lower level of demand represented a hardship in both of these communities. For instance, in 2002 and 2003 the City of Santa Fe had to reduce outdoor watering to one day per week to meet indoor water demands, which resulted in a per capita demand of 118 gpcd. A per capita demand of 150 gpcd is viewed as an achievable goal for a conservation program; further reduction can be pursued as needed to respond to drought emergencies. Each community will need to assess its water use patterns and set ideal goals for per capita demand.

The ideal demand in self-supplied homes is assumed to be 100 gpcd. This amount is based on indoor usage of 60 gpcd (with no evaporative cooler) and outdoor usage of 40 gpcd (Wilson, 1996). Evaporative coolers may increase the water requirements by up to 25 gpcd. Vickers (2001) indicates that indoor water use for single-family residents in Albuquerque is 95 gpcd.

To assess potential water savings from the implementation of a conservation program that includes both rate structures (for community systems) and public education, current demands were compared with the achievable goals of 150 gpcd for municipal use and 100 gpcd for self-supplied. Table 8-4 and Figure 8-1 show the projected water demand with and without conservation. Projected potential savings for various areas in the region, based on this comparison, are as follows:

- The mining district, including Bayard, Hurley and Santa Clara, has a per capita consumption of 107 gpcd, which is above the 100 gpcd for purely residential but well below the municipal goal of 150 gpcd. Because the mining district includes businesses and schools, the current per capita consumption is already below average, and therefore, no additional water savings are projected for this community.

- Silver City, with a current demand (after system losses) of 191 gpcd, can achieve significant savings (up to 21 percent) through a conservation program, reducing projected demands in 2040 by 620 ac-ft/yr under the low projection and 744 ac-ft/yr under the high projection. Current total per capita demand for Silver City is 235 gpcd including losses from leaking pipes.

- Lordsburg currently has an average demand of 205 gpcd and could reduce that by 27 percent reducing projected demands by about 200 ac-ft in the year 2040.

- Deming's current water demand is 227 gpcd, leaving room for conservation savings of 34 percent, or about 2,000 ac-ft/yr under the low projection or 3,000 ac-ft/yr under the high projection in the year 2040.

- The communities served by rural water systems have an average use of 156 gpcd in Catron County, 152 in Hidalgo, and 161 in Luna County, each of which could be reduced through conservation efforts.

- The average demand by rural public systems in Grant County is only 70 gpcd, which leaves no room for significant savings.

Table 8-4. Potential Water Demand Reductions for Public Supply Systems
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Water System	Estimated 2002 Per Capita Use (gpcd)	Per Capita Demand (ac-ft/yr)	Reduction (%)	Growth Scenario	Projected Public/Domestic Water Use (ac-ft/yr)			
					2010	2020	2030	2040
Catron County public systems								
Without conservation	156	0.17	NA	Low	154	154	154	154
				High	173	183	186	188
With conservation	100	0.11	35.9	Low	97	97	97	97
				High	109	116	117	119
Grant County total public								
Without conservation	158	0.18	NA	Low	3,687	3,944	4,158	4,352
				High	3,687	4,116	4,594	5,129
With conservation	115	0.13	27.4	Low	2,678	2,859	3,008	3,145
				High	2,678	2,979	3,313	3,686
Grant County rural public	71	0.08	NA	Low	410	423	432	442
				High	410	431	451	470
Silver City								
Without conservation	235	0.26	NA	Low	2,611	2,809	2,975	3,125
				High	2,611	2,942	3,315	3,735
With conservation	150	0.16	36.1	Low	1,602	1,723	1,825	1,917
				High	1,602	1,805	2,034	2,292
Mining District (Bayard, Hurley, Santa Clara)	107	0.12	NA	Low	666	712	751	785
				High	666	743	829	925
Hidalgo County total public								
Without conservation	196	0.22	NA	Low	857	831	794	755
				High	980	1,026	1,031	1,032
With conservation	138	0.15	29.7	Low	595	576	551	524
				High	677	708	711	712

gpcd = Gallons per capita per day ac-ft/yr = Acre-feet per year NA = Not applicable

Table 8-4. Potential Water Demand Reductions for Public Supply Systems
Page 2 of 3

Water System	Estimated 2002 Per Capita Use (gpcd)	Per Capita Demand (ac-ft/yr)	Reduction (%)	Growth Scenario	Projected Public/Domestic Water Use (ac-ft/yr) 2010	2020	2030	2040
Hidalgo County rural public								
Without conservation	152	0.17	NA	Low	93	91	87	84
				High	148	173	175	176
With conservation	100	0.11	34.1	Low	59	58	55	53
				High	94	109	111	111
Lordsburg								
Without conservation	205	0.23	NA	Low	763	740	707	672
				High	831	854	856	856
With conservation	150	0.16	26.9	Low	536	519	496	471
				High	583	599	600	601
Luna County total public								
Without conservation	211	0.24	NA	Low	4,990	5,560	6,056	6,476
				High	5,663	7,015	8,302	9,489
With conservation	134	0.15	36.4	Low	3,132	3,492	3,806	4,072
				High	3,558	4,414	5,229	5,983
Luna County rural public								
Without conservation	161	0.18	NA	Low	823	842	859	866
				High	843	855	842	810
With conservation	100	0.11	37.8	Low	492	503	513	518
				High	504	511	503	484
Deming								
Without conservation	227	0.25	NA	Low	4,167	4,718	5,197	5,610
				High	4,820	6,161	7,460	8,678
With conservation	150	0.16	34.0	Low	2,640	2,989	3,293	3,554
				High	3,054	3,903	4,727	5,498

gpcd = Gallons per capita per day   ac-ft/yr = Acre-feet per year   NA = Not applicable

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Table 8-4. Potential Water Demand Reductions for Public Supply Systems
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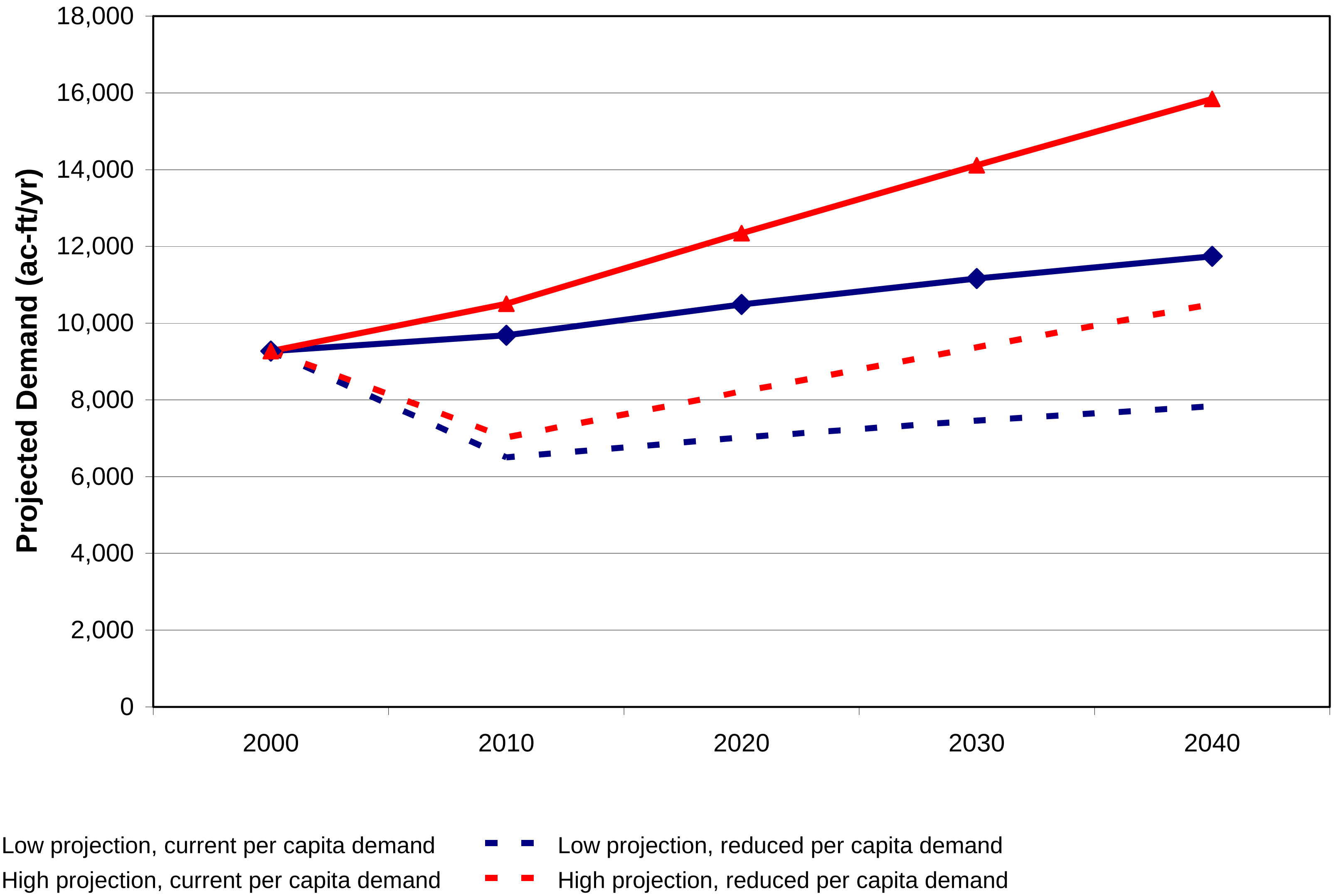
Water System	Estimated 2002 Per Capita Use (gpcd)	Per Capita Demand (ac-ft/yr)	Reduction (%)	Growth Scenario	Projected Public/Domestic Water Use (ac-ft/yr)			
					2010	2020	2030	2040
Total public water supply in Southwest Region								
Without conservation			NA	Low	9,688	10,488	11,162	11,738
				High	10,503	12,341	14,113	15,838
With conservation			32.88	Low	6,502	7,025	7,463	7,838
				High	7,022	8,217	9,372	10,500

gpcd = Gallons per capita per day   ac-ft/yr = Acre-feet per year   NA = Not applicable



SOUTHWEST NEW MEXICO REGIONAL WATER PLAN

Projected Demand by Public Systems
With and Without Water Conservation

Daniel B. Stephens & Associates, Inc.

5/25/05

Figure 8-1

The average water use of self-supplied homes in each county is assumed to be 0.1 ac-ft/yr (89 gpcd) based on the average self-supplied use discussed by Wilson et al. (2003). Because domestic wells are not metered and reported, actual diversions may be higher and residents may be able to reduce water consumption through conservation efforts.

If all communities in the planning region reduced demand to be less than 150 gpcd for municipal and 100 gpcd for residential use, the overall reduction in demand would be about 33 percent of the municipal/public supply diversions for the region. The actual reduction potential will depend on current water use patterns (i.e., the amount used for landscape watering, tourism, etc). Figure 8-1 shows the potential reduction of projected demand for both the low- and high-growth population projections. Under the low growth scenario, demand in 2040 would be reduced by about 3,900 ac-ft/yr, from a projected 11,740 to 7,840 ac-ft/yr. Under the high growth scenario, the region could reduce water use by about 5,340 ac-ft/yr, from a projected 15,840 to 10,500 ac-ft/yr.

8.2.2.2 Graywater Recycling

This alternative has the potential to reduce demand for treated potable water by the amount of graywater that is recycled. The average person generates about 40 gallons of graywater per day (NSFC, 2002), and use of this graywater could reduce freshwater use by 20 to 25 percent (Prososki-Marsland, 1995). However, even though the amount of diversions and water passing through a central treatment plant may be reduced, the consumptive use does not change as a result of this alternative.

The graywater systems allow water that has been used internally (from laundry, sinks, etc.) to subsequently be used outside. However, consumptive uses do not change unless other adjustments are made. In fact, consumptive use may increase slightly if graywater is cheaper than other water supplies. This alternative can also affect the water supply by decreasing the amount of wastewater returned to the treatment plant by up to 60 percent (Gelt, 2002). If water rights stipulate a return flow requirement or if other users are depending on return flows, those issues must be addressed when implementing graywater reuse.

Consequently, graywater reuse will have little impact on the regional water budget overall; however, it may help provide solutions to address Gila-San Francisco Basin restrictions on outdoor water use.

8.2.2.3 Wastewater Reuse

Because municipal water (and wastewater) represents a small portion of the total regional water use, reuse will not have a large impact on the overall water situation in the region. However, it could improve efficiency in individual municipalities. When considering opportunities for reuse, the benefits that may accrue from current effluent disposal practices, such as groundwater recharge from arroyo discharge, should be considered.

8.2.3 Financial Feasibility

Sections 8.2.3.1 through 8.2.3.3 discuss the financial feasibility of each of the four tools discussed in Section 8.2.1. Conservation ordinances and public education have been grouped together as funding for these options is generally all part of one large program.

8.2.3.1 Conservation Ordinances and Public Education

The primary financial burden on local governments associated with implementing water conservation ordinances and public education programs is labor.

- Drafting and implementing a water conservation ordinance requires a staff member to oversee the process and maintain the effort.

- Utility staff would need to be trained and made available to undertake water waste enforcement duties. Existing field staff could be trained and sworn in as water waste officers if they have several hours available each week.

- Rate structuring requires staff time to develop and implement the new rate structures. Billing has to be retooled in order to bill using the new rates. Public education generally requires at least a part-time person devoted to outreach to the public and in the schools.

The larger municipalities in the Southwest Region that already have ordinances and block rate structures in place could devote resources instead to enforcement, more public education, or additional conservation measures or programs such as rebates for water-efficient household appliances and xeriscaping.

The major positive financial ramification of adequate municipal conservation ordinances and education is the necessity of demonstrating good conservation practices to be eligible for many funding programs. Conservation, conservation ordinances, conservation education, and a conservation ethic are essential to planning for the future water supply in the Southwest Region.

8.2.3.2 Graywater Reuse

The cost to implement a graywater system varies greatly depending on whether the work is done by the owner or by professionals. The cost to retrofit a graywater system where plumbing is relatively accessible is estimated to range from $135 to $2,000. Costs would be prohibitive for existing structures where plumbing is inaccessible. The cost to build a graywater system during new construction is estimated to range from $65 to $650 (Little, 2003).

The graywater filtering system needs to be cleaned on a regular basis to prevent clogging. Annual maintenance costs are estimated to be less than $100 up to $600 for residential graywater recycling units, depending on whether the work is performed by the owner or under a maintenance contract. This cost would cover disinfectant use, regular cleaning, and replacement of filters throughout the year.

8.2.3.3 Wastewater Reuse

Costs for wastewater reuse alternatives will depend on the standards to be met, the volume treated, the end use, the distance treated effluent must be pumped and/or piped, and the cost of permitting. Costs of effluent reuse fall into several categories:

- Acquisition of raw wastewater supply

- Construction and operation of treatment facilities needed to meet standards for planned end uses

- Construction and operation of storage facilities needed to ensure a reliable supply on a day-to-day basis, accounting for seasonal differences in supply of effluent and use (for instance, turf facilities have peak demand in the summer, and effluent produced in the winter may need to be stored for summer use on these facilities)

- Construction and operation of the transmission and distribution system

- Costs of resolving issues related to diminished return flows for downstream users who have relied upon effluent discharges

- End-user adaptation costs, which can include:
  - On-site hookup and replumbing to connect to the nonpotable system
  - Special equipment, such as corrosion-resistant devices
  - Additional on-site treatment for water-quality-sensitive end uses
  - Idling of other water supply facilities (e.g., groundwater wells) that will no longer be used
  - Worker safety and public health practices, as applicable
  - Higher maintenance costs (cleaning, reducing clogging) relative to those for other water sources
  - More frequent leaching and higher volume of leaching water to control salt buildup in irrigation uses

Costs are also highly dependent on the type of wastewater treatment process, which differs depending upon the reuse application. Finally, costs for treatment and reuse of wastewater effluent differ substantially from one area to another across the U.S., and a separate assessment of the cost feasibility for each town will therefore need to be made. Reuse options away from municipalities typically are limited due to a lack of locally generated wastewater and the high cost of conveying wastewater. Costs for implementing conservation efforts can often be justified by comparing them to the costs of developing new water supplies, which include design, construction, and operating costs.

8.2.4 Environmental Impacts

Sections 8.2.4.1 through 8.2.4.3 discuss the environmental impacts of each of the four tools discussed in Section 8.2.1. Conservation ordinances and public education have been grouped together as they have similar impacts.

8.2.4.1 Conservation Ordinances and Public Education

These water conservation tools can significantly reduce local demand on local water supply and treatment facilities. For significant populations to be supported in the Southwest Region without eventually depleting local groundwater resources and quality of life, municipal conservation must continue to be emphasized, thereby contributing to the long-term sustainability of water resources. If a municipality were to dedicate the amount of water conserved to the preservation of a particular species or sensitive habitat, then a conservation program could directly benefit the environment.

8.2.4.2 Graywater Reuse

Although not a general environmental concern, water quality is an issue in graywater reuse, and it should be carefully monitored by the user. Graywater should never contain wastewater from toilets, washing machine loads that contain baby diapers, or kitchen waste. Systems should be turned off when someone in the household is diagnosed with an infectious disease (Office of Arid Lands Studies, 2002). Additionally, household chemicals should never be disposed of in graywater systems.

When used for outdoor irrigation, the nutrients in graywater will support plant growth, but may cause damage to soil from the buildup of salts if graywater use is not rotated with harvested rainwater or fresh water (Prososki-Marsland, 1995). Plants can be damaged from graywater containing sodium, bleach, borax, or liquid fabric softeners (Duttle, 1994). Use of biodegradable soap low in sodium content is recommended as well as selection of plants that are salt-tolerant and not edible (Prososki-Marsland, 1995).

8.2.4.3 Wastewater Reuse

The key environmental issue related to wastewater reuse is discharging the treated wastewater to the environment. If treatment standards are sufficient, there should be no adverse environmental impact from this alternative. However, if treatment is insufficient, environmental issues could arise. Many of the environmental and public health concerns regarding wastewater reuse, such as the potential for adverse effects on aquatic organisms and/or humans due to contact with chemicals that typical wastewater plants do not provide treatment for (e.g., endocrine disrupters, hormones, and antibiotics), exist whether the effluent is reused or discharged. The key issue with reuse is the increased likelihood of human contact, which makes assurance of disinfection effectiveness and reliability very important.

8.2.5 Political Feasibility and Social/Cultural Impacts

Sections 8.2.5.1 and 8.2.5.2 discuss the political feasibility for the four conservation tools discussed in Section 8.2.1. Conservation ordinances and public education have been grouped together as they raise similar types of political, social, and cultural issues.

8.2.5.1 Conservation Ordinances and Public Education

The general public tends to support the concept of water conservation. However, individuals are generally less supportive of measures that will curtail their individual water use or increase their own water bills. The tools discussed in Section 8.2.1 will be adopted only if local governmental bodies find them politically acceptable. The public is especially aware of scarce water resource issues after a drought, and the elected officials may find more political acceptance during this period of heightened awareness. Alternatively, if additional or more restrictive ordinances are not politically acceptable, efforts can be focused on conservation education, as discussed in Section 8.2.1.2.

Other political, social, and cultural impacts with regard to water conservation, as raised in steering committee meeting discussions, include:

- Per capita demand figures may not be directly comparable to other southwestern communities due to the large non-resident transient population in and around many of the cities in the Southwest Region.

- Actual residential uses for outdoor watering and other consumptive demands most amendable to reduction from conservation programs are already fairly low.

- Stakeholders recognize that an emphasis on municipal conservation is needed as a good faith effort, regardless of its potential contribution to the regional water balance.

8.2.5.2 Graywater Use

Graywater reuse is a useful way to save water for individual homeowners facing water restrictions or having limited water available. However, graywater reuse raises issues with respect to water quality, and some individuals may not be inclined to implement such a system in their homes due to these concerns. Fact sheets and other informational materials would assist individuals in determining whether graywater use is desirable and possible for their own homes.

8.2.5.3 Wastewater Reuse

The primary social concern regarding wastewater reuse is the potential for human contact with wastewater (e.g., when parks where children play are irrigated with wastewater). If treatment is not adequate or temporarily fails, there is a genuine concern about human health impacts.

8.3 Agricultural Conservation

This alternative examines on-farm water efficiency and conservation measures that can reduce the quantity of water that must be delivered to a farm in order to satisfy crop water requirements. In 2000, agriculture accounted for 77 percent of the total depletions in the Southwest Region. Table 8-5 indicates the primary crops and acreages irrigated, by county. Additional information on irrigated lands in the Southwest Region is presented in Section 6.1.4.

Agricultural conservation methods typically focus on changes in farming practices (on-farm improvements) and on delivery system improvements (off-farm improvements) to increase efficiencies and reduce water losses. In the Southwest Region, much of the agriculture depends on groundwater, particularly in the southern part of the region, and because groundwater systems generally involve piping water from the well directly to the irrigated field, delivery system efficiencies are not an issue. Delivery system efficiencies are of most concern when unlined ditches are used to bring water from rivers or streams for flood irrigation. Some of this type of agriculture occurs along the San Francisco and Gila Rivers, and potential improvements to delivery systems could be beneficial for those areas, although diversion points are typically either on-farm or nearby so that any inefficiencies are minimized. Nevertheless, to address agricultural conservation on a region-wide basis and to target strategies with the largest potential to save water, the focus of this alternative is to evaluate on-farm water efficiency and conservation measures that can reduce the quantity of water that must be delivered to a farm in order to satisfy crop water requirements.

Because irrigation is such a large component of the region's water budget, even very modest improvements in on-farm efficiency can translate into significant water conservation. Sections 8.3.2 through 8.3.6 evaluate the technical feasibility, hydrologic impacts, financial feasibility, environmental impacts, and political feasibility and social/cultural impacts associated with implementing known and proven measures that can increase on-farm irrigation efficiency.

8.3.1 Technical Feasibility

An important concept in understanding irrigation efficiency is the difference between depletions and diversions. Diversions represent the amount of water delivered to a farm, and depletions represent the amount of water consumed by a farm. Under OSE accounting rules, water that

Table 8-5. Irrigated Acreage in the Southwest Water Planning Region, 2002

County	Number of Farms	Total Acres Irrigated		Irrigated, Non-Harvested Pasture Land	Harvested Crops in 2002									
		OSE [a]	USDA		Wheat	Forage	Sorghum	Corn Silage	Corn	Cotton	Vegetables	Oats	Beans	Orchards
Catron	206	1,937	2,442	1,742	NR	700	NR	NR	NR	NR	NR	NR	10	31
Grant	272	3,422	4,208	3,282	NR	853	NR	NR	NR	NR	NR	NR	NR	102
Hidalgo	144	11,627	11,060	4,144	NR	1,169	213	NR	2,442	NR	2,352	NR	212	179
Luna	171	28,704	23,255	2,152	2,132	2,866	2,023	3,100	NR	2,091	9,310	106	385	1,737
Total	793	45,690	40,965	11,320	2,132	5,588	2,236	3,100	2,442	2,091	11,662	106	607	2,049

Source: USDA, 2004, unless otherwise noted
[a] Wilson et al., 2003

OSE = New Mexico Office of the State Engineer
USDA = U.S. Department of Agriculture
NR = None reported

percolates past the root zone is assumed to eventually return to the aquifer or surface water system, and because it is not consumed by the plants, it is not counted as a depletion.

A condition of even the most efficient irrigation is that significantly more water must be available for diversion than is consumed by plants (i.e., depleted). Currently in the Southwest Region, diversions are twice the anticipated depletions (ratio of 2:1). This ratio can be closer to 1.5:1 under very efficient conditions.

On-farm water efficiency is a simple ratio of the quantity of water taken up or consumed by crops, including evapotranspiration (ET), divided by the quantity of water delivered to a farm. On-farm irrigation efficiency can be further broken down into two components:

- *Application efficiency:* Ratio of water reaching the soil to water delivered to the farm
- *Consumption efficiency:* Ratio of water used by crops to water applied to the soil.

There are two general goals of on-farm conservation:

- Decrease the amount of diversions required to enable use of allotted depletions.
- Decrease the amount of depletions per amount of crop grown, or per amount of profit gained from the crop.

On-farm efficiency is affected by several factors (Kay, 1986):

- *Farm layout:* The shape and slope of the farmed areas irrigated by basin (flood) and border irrigation systems affect the farm's ability to promote efficient root zone saturation while diminishing losses to deep percolation.

- *Soil types:* Differing soil types in a farm or in multiple basins can cause uneven watering effectiveness and extremely high losses to deep percolation.

- *Land preparation practices:* Land leveling needs to be done every five to ten years to ensure that water does not pond and that it flows freely in basins.

- *Farm canal condition:* Large amounts of water can be lost to seepage in on-farm canals.

- *On-farm water management:* Supplying crops with the right amount of water at the right time can minimize water waste and save money.

- *Irrigation scheduling:* Scheduling of on-farm water deliveries can help maximize crop yields while minimizing evaporative losses.

- *Methods of irrigation:* The choice of irrigation method (e.g., flood [basin], border, furrow, or micro-irrigation) can optimize water use.

- *Crop type:* Different crops require different amounts of water. An emphasis on growing crops with a high value relative to its water consumption is desirable.

Several on-farm technologies are available to increase the efficiency of production agriculture irrigation systems. While they do save significant quantities of water, they are also expensive to implement. Some farms in the planning region are already using conservation techniques. In particular, drip or sprinkler irrigation systems have been installed in many locations in the southern groundwater basins. Other farms would be likely to install additional on-farm technologies if financial assistance was available.

The technologies identified as being the most beneficial and appropriate to the Southwest Region are summarized in Sections 8.3.2.1 through 8.3.2.7. The economic and hydrologic impacts of implementing these technologies are described in Sections 8.3.3 and 8.3.4. Further information on these irrigation methods is available in the manual *Selection of Irrigation Methods for Agriculture,* prepared by the On-Farm Irrigation Committee of the Irrigation and Drainage Division of the American Society of Civil Engineers (Burt et al., 2000). This manual also discusses other types of irrigation systems not covered in this report.

8.3.1.1 Sprinkler Systems

Most crops can be irrigated with some type of sprinkler system, although crop characteristics such as height must be considered in system selection. Sprinkler systems are well suited for germinating seed and establishing ground cover for crops like lettuce, alfalfa, and sod because they can provide the light, frequent applications that are desirable for this purpose. Most soils can be irrigated with the sprinkler method, although soils with an intake rate below 0.2 inch per hour may require special measures. Sprinkler systems are useful for irrigating soils that are too shallow to permit surface shaping or too variable for efficient surface irrigation. In general, sprinklers can be used on any topography that can be farmed, and land leveling is not normally required.

There are some disadvantages to using sprinkler systems for irrigation. Sprinklers may require more pumping energy than other irrigation methods. They also require better quality (or filtered) source water than other surface irrigation methods, except for drip/micro-irrigation (Section 8.3.2.2). Sprinkler systems can be labor-intensive, especially systems that must be moved manually. If source water is salty, sprinkler methods that apply water to leaves may be unsuitable.

Many types of sprinkler devices and sprinkler systems are available today. Sprinkler devices include rotating head sprinklers (apply water in circular pattern), low-pressure spray nozzles (often used on center pivot and linear move systems or in orchards), under-tree rotating heads that keep the spray below tree foliage, and perforated pipe that sprays water from small-diameter holes in pipes. The more common types of systems include:

- Hand-move or portable sprinkler systems consist of a lateral pipeline, typically made of aluminum, with sprinklers installed at regular intervals. The lateral is operated in one location until sufficient water has been applied and is then disassembled and moved to the next position. Initial costs for this type of system are low, but the labor costs associated with moving the lateral lines are fairly high. These systems can be used on varying terrain and for most crops, except tall crops such as corn that make moving the lateral difficult.

- Side roll systems have lateral lines mounted on wheels, with the pipe forming an axle that is high enough to clear the crop as it is moved. A drive unit is used to move the system from one irrigation position to another by rolling the wheels. These systems are vulnerable to high winds and may be damaged or pushed long distances if not staked down.

- Traveling gun systems use a high-volume, high-pressure sprinkler "gun" mounted on a trailer and are commonly operated as continuous move systems, with the gun sprinkling as the trailer moves. Although appropriate for most crops, these systems are best used on coarse, permeable soils because of the large droplets and high application rates produced.

- Center pivot systems consist of a single sprinkler lateral supported by a series of self-propelled towers that allow the lateral to rotate around a pivot point (one end of the lateral) in the center of the irrigated area. A single revolution can range from a half day to many days. The length of the lateral affects the speed at which the end of the lateral travels, as well as the size of the area irrigated by the end section. Because of this, the water application rate must increase with distance from the pivot to deliver an even application amount, and the high application rate at the outer end of the system may cause runoff on some soils. Also, because of the circular application area, the corners of the field are not irrigated unless special equipment is added to the system. Center pivots, which have moderate initial costs and low labor costs, can be used for most field crops.

- Linear move systems are similar to center pivot systems in construction except that neither end of the lateral pipeline is fixed. The whole line moves down the field in a direction perpendicular to the lateral and is designed to irrigate rectangular fields free of tall obstructions. As with the center pivot system, the linear move system is capable of very-high-efficiency water application. It requires high capital investments, but labor costs are low.

- Low energy precision application (LEPA) systems are similar to linear move irrigation systems except that the lateral line is equipped with drop tubes and very-low-pressure orifice emission devices that discharge water just above the ground surface into furrows. This distribution system is often combined with micro-basin land preparation for improved runoff control (and for retention of rainfall). High-efficiency irrigation is possible, but requires either very high soil intake rates or adequate surface storage in the furrow micro-basins to prevent runoff or non-uniformity along a furrow.

- Solid set and permanent systems are similar to the hand-move lateral sprinkler system, except that they include enough laterals placed in the field to avoid the necessity of moving pipe during the season. The solid set system requires significant labor at the beginning and end of the irrigation season, but minimal labor during the irrigation season. A permanent system is a solid set system where the main supply lines and the sprinkler laterals are buried and left in place permanently (this is usually done with PVC pipe).

Attainable irrigation efficiencies for different systems are listed in Table 8-6. More detailed descriptions of these systems are provided by Burt et al. (2000).

Table 8-6. Attainable Irrigation Efficiencies

System Type	Efficiency (%)
Flood Irrigation	30-40
Sprinkler systems	
Hand-move or portable	65-85
Side roll	65-85
Traveling gun	60-75
Center pivot	75-90
Linear move	75-90
Solid set or permanent	70-80
Low energy precision application	80-93

Source: Burt et al., 2000.

As indicated in the above descriptions, labor requirements vary depending on the degree of automation and mechanization of the equipment used. Hand-move systems require the least degree of operational skill, but the greatest amount of labor. At the other extreme, center pivot, linear move, and LEPA systems require considerable skill in operation and maintenance, but the overall amount of labor needed is low.

8.3.1.2 Drip/Micro-Irrigation Systems

Drip/micro-irrigation methods can conserve water because they deliver water directly to the root zone through emitters placed along a water delivery line (typically a polyethylene hose). Also, in contrast to most other types of irrigation systems, a properly designed and well operated drip/micro-irrigation system:

- Can be used on steep slopes
- Requires minimal land grading
- Can be installed on parcels of land of any size or shape

- Has few, if any, runoff problems or chances of excessive over-irrigation
- Has greater distribution uniformity (especially the newer system designs)
- Provides optimal soil moisture through more frequent irrigation
- Allows direct application of fertilizer to the root zone

Systems can be installed permanently (typical for orchards and vineyards) or seasonally (typical for row crops), or they may have permanent main lines with removable or disposable lateral lines. Because drip/micro-irrigation system components typically remain in place for the growing season, the systems can be automated; however, they should be monitored and shut off temporarily as appropriate during rainy periods.

Drip/micro-irrigation systems should be tailored to meet crop needs. For example, water is generally applied to plants through drip/micro-irrigation systems on a frequent basis such as daily or several times per week. However, some crops (such as lettuce) do not yield as well with irrigation that is too frequent, and the watering frequency should be adjusted accordingly. Because emitter devices typically have low flow rates (0.4 to 2.1 gallons per hour [gph]), larger plants such as trees may require multiple emitters (Burt et al., 2000).

Regional and micro-climate conditions should also be considered in the design of drip/micro-irrigation systems. For example, in arid regions emitters are often spaced so that at least 60 percent of the potential root zone volume is wet, thereby providing an adequate moisture reservoir for periods of high ET and insurance against several days of breakdowns. A lower percentage of wetted area is common in areas that receive supplemental rainfall.

Drip/micro-irrigation systems are of three main types: (1) aboveground drip systems, (2) buried drip systems, and (3) aboveground microspray and microsprinkler systems. Aboveground drip systems have been used in orchards and vineyards since the 1980s, and a variety of designs can be used depending on the crop, orchard configuration, and available water pressure. Where rows do not exceed 12 or 13 feet in width, one hose is typically used per row, with varying numbers of emitters per tree or vine. Aboveground row crop drip irrigation typically uses a thin-walled hose with built in emitters (drip tape). The drip tape can be installed under plastic, rolled up to allow cultivation and harvest, or buried just below the ground surface (maximum ½ to 2 inches deep) to protect it from the wind (Burt et al., 2000).

Buried drip systems in orchards and vineyards are a relatively new concept that is not yet widely used. However, interest in this technology is high, as it potentially reduces soil evaporation and weeds and allows workers to drive through or cultivate a field at any time, regardless of the irrigation schedule. Drawbacks include potentially extensive soil surface wetting due to low soil hydraulic conductivity or excessive emitter flow rates, pinching of the hose by roots, root intrusion into the emitters, and a high cost of installation. In addition, the proper depth and location of buried emitters with respect to plant trunks is not yet fully understood (Burt et al., 2000).

Buried drip systems are used for "one-crop" row crops such as strawberries and sugar cane, where the drip can be installed before planting and removed before the plants are disked into the soil. Permanently buried systems are also used commonly in the southwestern U.S., where more than 150,000 acres of high-value crops such as tomatoes, peppers, broccoli, lettuce, and cauliflower are estimated to be irrigated with permanent drip systems (Burt et al., 2000). These systems are designed to be in place for 6 to 10 years; however, special equipment is needed during tilling to ensure that the drip tape is not damaged during removal of the old crops. Also, considerable time must be spent checking the system during the first year or two of operation to ensure proper functioning (Burt et al., 2000).

Microspray systems typically have larger hose diameters than drip because the flow rates of the emissions devices are much higher than for drip. They also tend to have smaller hose lengths than drip for the same reason. Because of the high application rates, a microspray field is often divided into six or more blocks with only one block irrigated at a time, whereas many drip fields are divided into only two blocks. The net result is that microsystems are usually more expensive than drip systems. The exception would be on widely spaced plants such as walnuts, in which case several drip hoses would be required per tree row compared to only one hose for microspray.

Microspray systems have the advantages of requiring less stringent filtration than drip because of the large and short paths of micro-nozzles. In addition, they result in a larger soil wetted volume than a single hose drip system. In situations where frost protection is important, micro-sprinkler/sprayer designs offer better climate control than do emitters.

Disadvantages of microspray as compared to drip include the higher cost in some designs, the higher evaporation losses (especially if the water is extended past the canopy), higher humidity, and inability to easily restrict the wetted area during certain times of the year. Also, some microspray systems have high sprayer flow rates (10.5 to 15.8 gph) and could be classified as low-flow permanent sprinklers rather than micro-irrigation systems (Burt et al., 2000).

The International Arid Lands Consortium (IALC) has been involved in a demonstration project in Artesia, New Mexico to determine the benefits of drip irrigation technology for alfalfa. In this study they have estimated a 40 percent water use reduction with the use of drip irrigation compared to traditional sprinkler technology without a reduction in yield (IALC, 2000).

8.3.1.3 Soil Treatments

Water available to plants depends not only on the amount of rainfall and/or irrigation, but also on the physical, chemical, and biological properties of the soil. The soil acts as an absorbent for water from precipitation and irrigation and serves as a reservoir of water for plants in the interval between water applications.

Soil structure is an important physical parameter to consider, as soil sealing and soil crusting decrease the infiltration rate of water into the soil. Structureless soil can severely restrict the downward percolation of water. A common constraint to both water filtration and root penetration in the soil is the degree of soil compactness or density. Other soil characteristics that affect water availability to plants include the extent of organic matter in the soil and the types and density of soil organisms present.

In situ moisture conservation is a form of water conservation in which all rainfall is conserved where it falls and no runoff is permitted. Measures that can be adopted by farmers to optimize the physical, chemical, and biological soil parameters with a view to increasing the water efficiency include:

- Covers or mulches laid down on the surface of the soil and along rows. This practice is very important for water and soil conservation as well as for organic matter preservation. These mulches protect soil structure by reducing the mechanical action of raindrops on soil aggregates, thus preventing runoff and erosion. Mulching dramatically decreases evaporation and improves soil moisture retention capacity and, therefore, soil water content. Soil temperature, soil strength, and soil aeration are also improved, thus increasing soil productivity and crop yield.

- Tilling or physically (manually or mechanically) breaking up the plough layer. This is a common agronomic practice that can improve the infiltration rate of rainwater, thus conserving soil moisture. Tilling also helps to control soil pests and weeds. The pests are brought up to the surface where they are then killed by radiation and/or predators. This approach therefore reduces the need for pesticides and their attendant use of fairly large quantities of water.

- Use of soil additives called polyacrylamides that bind the soil together so that water spreads more evenly and percolates less rapidly. Polyacrylamides are soil additives that are applied to the surface and then mixed into the top soil. They generally have more of a beneficial effect in sandy soils. Polyacrylamides are sold under many different trade names: Terra-Sorb, Hydrosource, Hydro-mulch, water crystals, PAM, copolymer, Moist Soil, Aquasorb, Agrosoke, Smart Soil, Aquacrystals, Bioplex, Agro-diamonds, and others.

- Planting in small depressions, known as planting pits. This practice is common in arid areas. These pits conserve and concentrate both water and nutrients.

- Contour cultivation. This technique slows down the movement of water across the soil surface and also helps to conserve water. Contour cultivation can be achieved by constructing physical barriers such as ridges, with or without ties, across the contours to prevent runoff and soil erosion. In contour cultivation, the runoff from the higher elevations is trapped in furrows in the contours, thereby increasing infiltration into the soil.

- Terracing fields. Different types of terraces can be constructed (e.g., stone terraces, earth banks, bench terraces, and contour stone) to conserve soil moisture as well as to collect water.

8.3.1.4 Laser Leveling

Laser leveling involves grading and earthmoving to eliminate variation in field gradient, that is, smoothing the field surface and often reducing field slope for fields that are flood irrigated. Laser leveling helps to control water advance and improve uniformity of soil saturation under gravity-flow systems, allowing the grower to apply only the water needed to refill the root zone. For this method to work properly, the volume of water needed for irrigation must be applied as rapidly as possible in order to allow the same time for infiltration throughout the entire field.

Laser-leveling works only in relatively short runs. If the border lengths are too long it is better to use graded border irrigation. Border distances for laser-level irrigation will depend upon soil type and water quantity, but 300 to 500 feet in length is usually recommended. Laser-level irrigation needs a minimum of 3 inches per application. Whenever a high water flow is used with a laser-leveled field, an erosion control device may be needed at the turnout.

Production farms in the Animas Valley where laser-leveling has already been done have been shown to have substantially increased on-farm efficiency. Anecdotal evidence suggests that these improvements can increase on-farm efficiency by 30 percent and reduce diversion time to 25 percent of that previously required to irrigate the same acreage. Irrigation efficiencies for laser-level irrigation can be as high as 75 to 85 percent, while irrigation efficiencies for normal flood irrigation run about 40 to 50 percent (Vickers, 2002).

8.3.1.5 Surge Valves

For some fields currently using furrow irrigation, surge valves can be added to increase application efficiencies and reduce deep percolation of irrigation water. The principle behind surge irrigation is to switch the water back and forth between irrigation sets using an automated valve. The valve may be set for different lengths of out-times, or times when water is applied to advance water through the length of row. If the out-times and cutback times are set correctly, this method of irrigation advances the water more quickly and efficiently through the field than continuous irrigation, thereby minimizing runoff (tailwater) and deep percolation. Surge valves typically improve furrow irrigation efficiency by an average of 10 to 40 percent, depending on soil type, land slope, and the length of the runs, and some growers have cut irrigation amounts by as much as 50 percent (Vickers, 2002).

Surge irrigation is a relatively inexpensive method to adopt, given its benefits of more uniform water distribution, reduced deep percolation, reduced tailwater, and reduced total irrigation.

Although surge valves cost approximately $1,000 to 1,500 per valve, a surge valve may be used on one or more fields. However, the use of surge valves requires more farmer time and daily adjustment. Laser leveled fields are also usually required, as the principle behind surge irrigation is that water applied uniformly on a given area has time to percolate before the following application. Irregularities in farm topography, which can be covered by flood irrigation, are not compatible with surge techniques.

8.3.1.6 Gated Piping

Pipeline conveyance systems are often installed to reduce labor and maintenance costs, as well as water losses to seepage, evaporation, spills, and non-crop vegetative consumption. Underground pipeline constructed of steel, plastic, or concrete is permanently installed, while aboveground pipeline generally consists of lightweight, portable aluminum, plastic, or flexible rubber-based hose that can be moved. One form of aboveground pipeline, gated pipe, distributes water to gravity-flow systems from individual gates (valves) along the pipe. One method of irrigation (commonly called “cablegation”) using gated piping involves the use of a moveable plug that passes slowly through a long section of gated pipe, with the rate of movement controlled by a cable and brake. Due to the oversizing and required slope of the pipe, water will gradually cease flowing into the first rows irrigated as the plug progresses down the pipe. Improved water management is achieved by varying the speed of the plug, which controls the timing of water flows into each furrow.

8.3.1.7 Crop Management

Crop management is an extra means of reducing water losses and optimizing water use in any farming system. Crop management considerations include crop water requirements, timing of irrigation, crop selection, crop configuration (plant density, crop mix), and cropping calendar (planting dates, rotation). With properly programmed automatic irrigation systems, efficiencies can increase to 85 to 90 percent (Vickers, 2002).

Planting density and crop mix have an effect on the hydrologic characteristics of the system. Increasing planting density increases the soil cover by crops and can lead to a decrease in evaporation losses; however, these measures can also increase water uptake from the soil. Annual crops and some perennials use moisture mainly from the top layer, whereas deep-rooted plants such as fruit and other trees tap water that is beyond the reach of the annuals. Additionally, some trees shed their leaves in winter, thereby covering the soil and creating mulch. A synergistic planting may yield more abundant crop production while protecting critical top soils. In addition, mixed cropping systems in particular combinations can help to significantly reduce pest damage. For instance, cabbages grown in alternate rows with either tomatoes or garlic or carrots have been shown to suffer fewer insect attacks.

8.3.2 Hydrological Impacts

Improvements to irrigation efficiency would decrease pumping and diversion costs, decrease the rate of groundwater decline, and potentially leave more water in surface waterbodies or make more water available for other beneficial uses in the Southwest Region at large. Tables 8-7 through 8-10 summarize estimated water savings associated with applicable on-farm water conservation measures for irrigated agriculture for each county in the Southwest Region; Table 8-11 summarizes the estimated water savings for the entire region.

To estimate the potential gains from improvements in irrigation efficiency, the current on-farm diversions for existing irrigation techniques (flood, sprinkler and drip) are identified. The potential improvement from one technique to another is calculated as the difference in irrigation efficiencies between the two methods. For example, to convert from flood irrigation, which has an irrigation efficiency of 55 percent, to an efficiency of 85 percent, a 30 percent reduction in diversions could be achieved. In Luna County, 24,700 acres are flood irrigated, 4,000 acre-feet are sprinkler irrigated, and 3,240 are irrigated with micro or drip irrigation. For the flood irrigated lands, Wilson et al. (2003) currently estimates that 71,538 acre-feet are required for on-farm diversion. If this land were converted to LEPA irrigation, the efficiency could increase to 95 percent from 55 percent, resulting in a reduced diversion requirement of 28,600 acre-feet.

As the estimates shown in Table 8-11 indicate the amount of savings that could be achieved if all of the land currently in production is converted to the new techniques, they represent the maximum possible savings. Due to financial and logistical constraints, actually achieving this amount of savings may be difficult. In addition, the savings reported on Table 8-11 represent reduced diversions (as opposed to depletions). In surface water systems, reducing diversions can be important in meeting agricultural needs during drought conditions, and in groundwater systems, diversion reductions can create significant savings in pumping costs. However, savings in depletions, or consumptive use, will be significantly less. The greatest savings in consumptive use occur by switching to micro-drip irrigation systems, which have negligible incidental depletions, or by converting to lower-water-use crops.

Table 8-7. Estimated Water Savings for Irrigated Agriculture in Catron County

Conservation Technique	Potential Reduction in Diversions by Changing from Existing Irrigation Method							Estimated Cost to Implement[b] ($/acre)
	Non-Improved Flood		Sprinkler Irrigation		Micro-irrigation		Total (ac-ft/yr)	
	(%)	(ac-ft/yr)	(%)	(ac-ft/yr)	(%)	(ac-ft/yr)		
Current irrigated acreage[a] (acres)	*1,937*		*0*		*0*		*1,937*	*NA*
Current on-farm diversion amounts[a] (ac-ft/yr)	*5,838*		*0*		*0*		*5,838*	*NA*
Current on-farm irrigation efficiencies[a] (%)	*45*		*NA*		*NA*		*NA*	*NA*
Micro-irrigation (80-95% EF[c])	50	2,919	0	0	0	0	2,919	1,800
Low-energy precision application (90-98% EF[c])	50	2,919	0	0	0	0	2,919	250
Laser leveling (75-85% EF[c])	40	2,335	0	0	0	0	2,335	250
Installation of surge valves (65-80% EF[c])	35	2,043	0	0	0	0	2,043	185
Gated piping irrigation[d]	NE	NE	0	0	0	0	NE	250
Soil treatments[e]	NE	NE	0	0	0	0	NE	500
Crop management (85-90% EF[c,e])	45	2,627	0	0	0	0	2,627	NE
Total potential reduction in diversions	NA	2,919	NA	0	NA	0	2,919	NA

[a] Wilson et al., 2003
[b] Based on an assumed 160-acre farm currently irrigated using standard non-improved flood irrigation (Vickers, 2001)
[c] Vickers, 2001
[d] No estimate of EF available
[e] Highly dependent on type of crop grown and/or current soil conditions

ac-ft/yr = Acre-feet per year
NA = Not applicable
EF = Efficiency
NE = Not estimated, highly variable

Table 8-8. Estimated Water Savings for Irrigated Agriculture in Grant County

Conservation Technique	Potential Reduction in Diversions by Changing from Existing Irrigation Method							Estimated Cost to Implement [b] ($/acre)
	Non-Improved Flood		Sprinkler Irrigation		Micro-irrigation		Total (ac-ft/yr)	
	(%)	(ac-ft/yr)	(%)	(ac-ft/yr)	(%)	(ac-ft/yr)		
Current irrigated acreage [a] (acres)	*3,312*		*110*		*0*		*3,422*	*NA*
Current on-farm diversion amounts [a] (ac-ft/yr)	*11,675*		*251*		*0*		*11,926*	*NA*
Current on-farm irrigation efficiencies [a] (%)	*47*		*65*		*NA*		*NA*	*NA*
Micro-irrigation (80-95% EF [c])	48	5,604	30	75	0	0	5,679	1,800
Low-energy precision application (90-98% EF [c])	48	5,604	30	75	0	0	5,679	250
Laser leveling (75-85% EF [c])	38	4,437	0	0	0	0	4,437	250
Installation of surge valves (65-80% EF [c])	33	3,853	0	0	0	0	3,853	185
Gated piping irrigation [d]	NE	NE	0	0	0	0	NE	250
Soil treatments [e]	NE	NE	NE	NE	0	0	NE	500
Crop management (85-90% EF [c,e])	43	5,020	25	63	0	0	5,083	NE
Total potential reduction in diversions	NA	5,604	NA	75	NA	0	5,679	NA

[a] Wilson et al., 2003
[b] Based on an assumed 160-acre farm currently irrigated using standard non-improved flood irrigation (Vickers, 2001)
[c] Vickers, 2001
[d] No estimate of EF available
[e] Highly dependent on type of crop grown and/or current soil conditions

ac-ft/yr = Acre-feet per year
NA = Not applicable
EF = Efficiency
NE = Not estimated, highly variable

Table 8-9. Estimated Water Savings for Irrigated Agriculture in Hidalgo County

Conservation Technique	Potential Reduction in Diversions by Changing from Existing Irrigation Method							Estimated Cost to Implement[b] ($/acre)
	Non-Improved Flood		Sprinkler Irrigation		Micro-irrigation		Total (ac-ft/yr)	
	(%)	(ac-ft/yr)	(%)	(ac-ft/yr)	(%)	(ac-ft/yr)		
Current irrigated acreage[a] (acres)	*9,142*		*2,485*		*0*		*11,627*	*NA*
Current on-farm diversion amounts[a] (ac-ft/yr)	*33,262*		*6,000*		*0*		*39,262*	*NA*
Current on-farm irrigation efficiencies[a] (%)	*55*		*65*		*NA*		*NA*	*NA*
Micro-irrigation (80-95% EF[c])	40	13,305	20	1,200	0	0	14,505	1,800
Low-energy precision application (90-98% EF[c])	40	13,305	30	1,800	0	0	15,105	250
Laser leveling (75-85% EF[c])	30	9,979	0	0	0	0	9,979	250
Installation of surge valves (65-80% EF[c])	20	6,652	0	0	0	0	6,652	185
Gated piping irrigation[d]	NE	NE	0	0	0	0	NE	250
Soil treatments[e]	NE	NE	NE	NE	0	0	NE	500
Crop management (85-90% EF[c,e])	35	11,642	25	1,500	0	0	13,142	NE
Total potential reduction in diversions	NA	13,305	NA	1,800	NA	0	15,105	NA

[a] Wilson et al., 2003
[b] Based on an assumed 160-acre farm currently irrigated using standard non-improved flood irrigation (Vickers, 2001)
[c] Vickers, 2001
[d] No estimate of EF available
[e] Highly dependent on type of crop grown and/or current soil conditions

ac-ft/yr = Acre-feet per year
NA = Not applicable
EF = Efficiency
NE = Not estimated, highly variable

Table 8-10. Estimated Water Savings for Irrigated Agriculture in Luna County

Conservation Technique	Potential Reduction in Diversions by Changing from Existing Irrigation Method							Estimated Cost to Implement[b] ($/acre)
	Non-Improved Flood		Sprinkler Irrigation		Micro-irrigation		Total (ac-ft/yr)	
	(%)	(ac-ft/yr)	(%)	(ac-ft/yr)	(%)	(ac-ft/yr)		
Current irrigated acreage[a] (acres)	*24,704*		*4,000*		*3,240*		*31,944*	*NA*
Current on-farm diversion amounts[a] (ac-ft/yr)	*71,538*		*11,800*		*6,000*		*89,338*	*NA*
Current on-farm irrigation efficiencies[a] (%)	*55*		*65*		*85*		*NA*	*NA*
Micro-irrigation (80-95% EF[c])	40	28,615	20	2,360	0	0	30,975	1,800
Low-energy precision application (90-98% EF[c])	40	28,615	30	3,540	10	600	32,755	250
Laser leveling (75-85% EF[c])	30	21,461	0	0	0	0	21,461	250
Installation of surge valves (65-80% EF[c])	20	14,308	0	0	0	0	14,308	185
Gated piping irrigation[d]	NE	NE	0	0	0	0	NE	250
Soil treatments[e]	NE	NE	NE	NE	NE	NE	NE	500
Crop management (85-90% EF[c,e])	35	25,038	25	2,950	5	300	28,288	NE
Total potential reduction in diversions	NA	28,615	NA	3,540	NA	600	32,755	NA

[a] Wilson et al., 2003, not including acreage irrigated with floodwater
[b] Based on an assumed 160-acre farm currently irrigated using standard non-improved flood irrigation (Vickers, 2001)
[c] Vickers, 2001
[d] No estimate of EF available
[e] Highly dependent on type of crop grown and/or current soil conditions

ac-ft/yr = Acre-feet per year
EF = Efficiency
NE = Not estimated, highly variable

Table 8-11. Estimated Water Savings for Irrigated Agriculture in the Southwest Region

Conservation Technique	Potential Reduction in Diversions by Changing from Existing Irrigation Method							Estimated Cost to Implement [b] ($/acre)
	Non-Improved Flood		Sprinkler Irrigation		Micro-irrigation		Total (ac-ft/yr)	
	(%)	(ac-ft/yr)	(%)	(ac-ft/yr)	(%)	(ac-ft/yr)		
Current irrigated acreage [a] (acres)	*39,095*		*6,595*		*3,240*		*48,930*	*NA*
Current on-farm diversion amounts [a] (ac-ft/yr)	*122,313*		*18,051*		*6,000*		*146,364*	*NA*
Current on-farm irrigation efficiencies [a] (%)	*40-55*		*65*		*85*		*NA*	*NA*
Micro-irrigation (80-95% EF [c])		50,443		3,635		0	54,078	1,800
Low-energy precision application (90-98% EF [c])		50,443		5,415		600	56,458	250
Laser leveling (75-85% EF [c])		38,212		0		0	38,212	250
Installation of surge valves (65-80% EF [c])		26,856		0		0	26,856	185
Gated piping irrigation [d]		13,983		0		0	13,983	250
Soil treatments [e]		13,983		1,805		600	16,388	500
Crop management (85-90% EF [c,e])		44,327		4,513		300	49,140	NE
Total potential reduction in diversions	NA	50,443	NA	5,415	NA	600	56,458	NA

[a] Wilson et al., 2003, not including acreage irrigated with floodwater
[b] Based on an assumed 160-acre farm currently irrigated using standard non-improved flood irrigation (Vickers, 2001)
[c] Vickers, 2001
[d] No estimate of EF available
[e] Highly dependent on type of crop grown and/or current soil conditions

ac-ft/yr = Acre-feet per year
NA = Not applicable
EF = Efficiency
NE = Not estimated, highly variable

8.3.3 Financial Feasibility

Tables 8-7 through 8-11 also summarize estimated costs associated with applicable on-farm water conservations measures for irrigated agriculture in the Southwest Region. Paying for conservation measures can be difficult or impossible for some farmers, and hence financing is important. Both federal and state funding assistance should be available for the measures described in this section. The most applicable federal program for funding on-farm activities is the Natural Resources Conservation Service Environmental Quality Incentives Program. However, this program is understaffed, which could increase the time needed to process applications and disburse funding. Federal funding sources are not available for operation and maintenance costs.

A number of additional economic assistance and incentive programs are available. One example is the Farm Security and Rural Investment Act of 2002, which provides for the Conservation Security Program. This is a national incentive program in which farmers who are implementing conservation technologies in fiscal years 2003 through 2007 can receive reimbursements (SWCS, 2003). The New Mexico State Legislature is also considering some initiatives to provide funding for agricultural conservation measures.

8.3.4 Environmental Impacts

The reduction of deep percolation and incidental losses on farms will reduce seepage, thereby affecting groundwater levels and recharge. Changes in recharge to the shallow aquifer due to changes in flows through on-farm canals may impact the bosque and the types of ecosystems that may be established in the irrigation canals and drains. However, flows in these systems are already intermittent due to the seasonal nature of irrigation. Ecosystem impacts should be minimal if on-farm projects are planned and designed to avoid impacts to on-farm ecosystems. Increased water supply management flexibility will provide more options for supporting endangered species habitat.

8.3.5 Political Feasibility and Social/Cultural Impacts

Providing that funding is available, there should not be any significant political or social cultural obstacles for implementation of this alternative. Widespread support for the alternative was expressed at public meetings held throughout the region, and the fact that conservation measures are already being implemented by some farmers illustrates regional support for the alternative. The primary concern raised is that without economic assistance, the burden on small farmers to implement conservation is too great for this alternative to be successful.

8.4 Watershed Management

Watershed management consists of a variety of activities that can contribute to the health of a watershed, including those that protect or improve water quality, enhance water supply, and/or enhance the ecosystems of the area. Another important benefit of watershed management can be reduction of fuel loads, which in turn minimizes the potential for catastrophic forest fires. Ideally, watershed management proceeds in a manner that will optimize the benefits in all of these areas.

In the past couple of decades, vegetation density at higher elevations has generally increased due to the suppression of fire and the limited amount of timber harvest. This increased density has almost certainly resulted in a decrease in water yields. Management activities such as forest harvest or thinning could potentially increase water yields. In addition, reducing vegetation density can help lower the risk of severe wildfires which, as seen in the case of the Cerro Grande and numerous other fires (Robichaud et al., 2000; Moody and Martin, 2001, as cited by MacDonald et al., 2002), can greatly increase the size of peak flows and surface erosion rates, thus increasing channel erosion, causing downstream sedimentation, and adversely affecting water quality.

In the absence of any efforts to reduce forest density, a continuing high risk or a gradual increase in risk of high-severity wildfires can be expected. High-severity fires are of considerable concern because of the potential to destroy property and greatly increase runoff and erosion rates (Robichaud et al., 2000; Moody and Martin, 2001, as cited by MacDonald et al., 2002; McCord and Winchester, 2001; Burke, 2004). These increases can then have severe effects on downstream channels, aquatic habitat, and reservoir sedimentation rates.

Examples of watershed restoration projects designed to address forest fire prevention as well as other watershed concerns such as water quality include:

- Thinning and/or prescribed burns to reduce the risk of catastrophic forest fire and to potentially increase surface water supplies at higher elevations and/or groundwater recharge at lower elevations

- Management practices for roads, culverts, or other construction projects that minimize erosion and protect water quality from increased sedimentation

- Projects that address water quality issues such as elevated stream temperatures, suspended sediment loads, and impacts from septic systems, mining, or potential contaminant sources

- Grazing practices that minimize water quality degradation, riparian impacts, and impacts to upland watersheds

Watershed restoration projects may be identified and implemented through development of a watershed restoration action strategy (WRAS) or other watershed management plan, or individual projects may be implemented to address particular areas of concern within a watershed. Ideally, watershed restoration programs integrate projects that will improve water quality, water yields, and ecological health of the watershed.

Watershed efforts often bring together entities and individuals with interests in the watershed, including local, state, and federal agencies that have some jurisdiction in the watershed, along with private landowners and interested citizens. In the Southwest Region, watershed groups already exist for the Gila, San Francisco, and Mimbres watersheds, and many watershed restoration activities are being carried out by Soil and Water Conservation Districts, the Natural Resources Conservation Service (NRCS), the U.S. Forest Service (USFS), and other agencies and individuals. Some of the primary ongoing watershed activities occurring in the region are:

- The Upper Gila Watershed Alliance (UGWA) is a nonprofit, community-based conservation organization that operates from Gila and Cliff, New Mexico. UGWA's area of focus is defined by the natural watershed boundaries of the upper Gila River, from its headwaters in the Gila National Forest and Wilderness areas, downstream through the Middle Box just above Redrock, New Mexico. All 2,832 square miles of this watershed are located within Grant and Catron Counties. About 81 percent of the watershed is under public ownership (mostly by the USFS), with the remaining 19 percent privately owned. Pacific Western Land Company is the largest private landholder in the river valley near Gila and Cliff. The number of households within the watershed is roughly 230, 38 of which are members of UGWA (as of spring 1998) (http://www.ugwa.org/ugwa.htm).

- The Gila Conservation Coalition (GCC), which was organized in 1984 to protect the free flow of the Gila and San Francisco Rivers and the wilderness characteristics of the Gila and Aldo Leopold Wilderness areas, is a partnership of local environmental and conservation groups and concerned individuals that promotes conservation of the upper Gila River Basin and surrounding lands. The GCC was instrumental in stopping the Hooker and Conner Dam proposals in the 1980s. The group also achieved protection of the East Fork of the Gila River from road building and partial closure of the wild San Francisco River to off-road vehicle use.

- The USFS routinely conducts watershed management activities. The most significant of these in relation to water yield is conducting controlled burns and/or allowing natural fires to burn in wilderness areas. The large-scale burns that have occurred in the Gila National Forest in the last several years have contributed to increased species diversity. In some areas, increases in spring flows were also observed after the burns (Burke, 2004; Boucher, 2002).

- The NRCS and the Soil and Water Conservation Districts (SWCDs) in the Southwest Region have been active in conducting watershed management programs. Some of the ongoing programs include mesquite removal, installation of check dams, streambank restoration, and other projects to improve the overall health of watersheds in the region.

8.4.1 Technical Feasibility

The management activity with the greatest potential to increase surface water yields is to reduce vegetation density. The technical feasibility of watershed restoration efforts is evidenced by the ongoing thinning techniques to reduce vegetation density that are conducted on a regular basis throughout the western United States, and there are no technical issues that would prevent implementation in the Southwest Region. As discussed above, watershed restoration programs are already occurring in the Southwest Region.

8.4.2 Hydrological Impacts

Thinning the vegetation within a watershed impacts the hydrologic water balance by reducing the transpiration, thus increasing the water yield. In addition to increases in yield, vegetation thinning may impact the timing of stream flows by increasing infiltration, thus reducing peak flow volumes and increasing base flow volumes. An important aspect in considering potential yield increases, however, is that the entity conducting the watershed activity does not necessarily have the right to use the water. Any increases in yield would augment stream flows that are legally apportioned based on water rights priority dates.

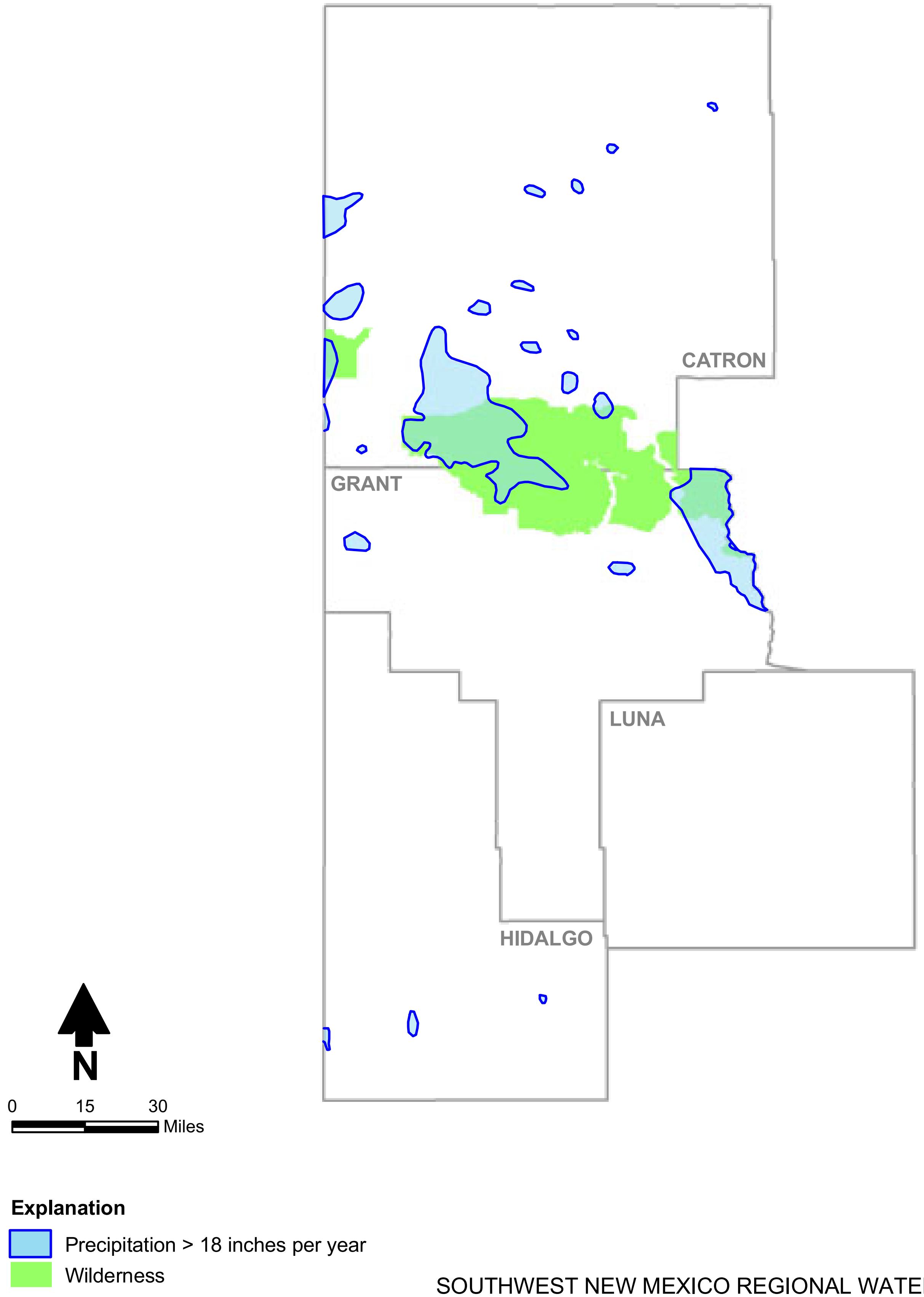
8.4.2.1 Precipitation Effects

In general, water yield increases are proportional to annual precipitation and the proportion of the forest canopy that is removed (Bosch and Hewlett, 1982; Troendle and Kaufmann, 1987, as cited by MacDonald et al., 2002; McCord and Winchester, 2001). Little or no water yield increases can be expected in areas where annual precipitation is less than about 18 to 20 inches (Ffolliott and Thorud, 1975; Bosch and Hewlett, 1982; Stednick, 1996, as cited by MacDonald et al., 2002). In the case of the Southwest Region, only limited higher elevation areas in Grant and Catron Counties have precipitation averaging above 18 inches per year (Figure 8-2).

The large variability in annual precipitation is another important limitation to managing forests for water yield. Data from the Fool Creek study in central Colorado showed that water yield increases in dry years were only about one-quarter of the increases in wet years (Troendle and King, 1985, as cited by MacDonald et al., 2002). This means that water yield increases from forest harvest would be least in the dry years, when they are most needed, and greatest in the wet years, when they are least needed. Since the relative variability of annual precipitation increases as annual precipitation decreases, the increase in water yield with forest management becomes increasingly variable and therefore increasingly uncertain. If vegetation thinning is to be a viable option for increasing water yields, additional storage capacity will be needed to carry over excess water from wet years.

8.4.2.2 Vegetation Effects

Increases in water yield with forest cover reduction have been studied since 1955, when the Hubbard Brook Experimental Forest was established in New England by the USFS,



S:/PROJECTS/WR03.0004/GIS/MXD/PRECIP_GT_18IN.MXD

SOUTHWEST NEW MEXICO REGIONAL WATER PLAN

Precipitation Greater Than 18 Inches and Wilderness Areas

Daniel B. Stephens & Associates, Inc.

07-02-04

JN WR03.0004

Figure 8-2

Northeastern Research Station, as a major center for hydrologic research. One of these studies (Hibbert, 1967) concluded that water yield increases with forest cover reduction, and Bosch and Hewlett (1982) complemented Hibbert's findings by analyzing data from 94 catchment experiments, as reported by Huff et al. (2000). They generalized that reducing conifer cover can be expected to produce about a 1.5-inch change in annual water yield for every 10 percent change in forest cover in excess of the 20 percent minimum threshold of forest cover reduction. Therefore, water yield consistently increases when vegetation cover is removed; however, the magnitude varies with both the annual rainfall of the catchment and the proportion of cover removed (Newson, 1997).

For the purpose of this plan, this alternative considers watershed management activities in six vegetation zones defined by elevation, precipitation, and therefore plant species:

- *Mixed conifer forests.* Mixed conifer forests occur at elevations above 6,900 feet, and receive 25 to 30 inches of rainfall annually, more than half of which is snow. Spruce, fir, Douglas fir, and ponderosa pine are typical species in these mixed conifer forests.

- *Ponderosa pine forests.* Ponderosa pine forests occur between 5,900 and 8,900 feet in elevation. Precipitation ranges from 19 and 25 inches per year, equally divided as summer rain and winter snow.

- *Piñon-juniper woodlands.* Piñon-pine and juniper woodlands are prevalent in the Southwest Region in areas between about 5,000 and 7,000 feet in elevation. Annual precipitation is typically from 10 to about 15 inches in the piñon-juniper woodlands, and tree species in these communities have evolved both drought and cold resistance.

- *Chaparral shrublands.* Chaparral shrublands are found at elevations of 2,900 to 6,500 feet and are dominated by shrub live oak and other shrub species that proliferate following fire or cutting. Annual precipitation varies from 15 to 25 inches.

- *Semidesert shrublands.* These shrublands, which are characterized by creosote bush, mesquite, four-winged saltbush and a variety of cacti, occur at the 150- to 3,000–foot elevation and receive from 6 to 10 inches of precipitation annually.

- *Riparian Ecosystems.* Riparian ecosystems occur along river and stream corridors at all elevations. Cottonwood and willow trees form part of the riparian vegetation in these river and canyon bottoms.

Results of research conducted regarding water yield increases resulting from forest management activities in these zones in other parts of the western U.S. are discussed in Sections 8.4.2.2.1 through 8.4.2.2.6.

8.4.2.2.1 Mixed Conifer Forests. Research conducted in mixed conifer forests at Workman Creek in the Sierra Ancha Experimental Forest in central Arizona indicates that increases in streamflow can be obtained by replacing trees with a grass cover on strategically located parts of a watershed or by reducing forest overstory densities (Gottfried et al., 1999a). In the late 1960s the USFS conducted watershed research in the mixed conifer forests of Willow Creek and Thomas Creek in the White Mountains of eastern Arizona to confirm the results obtained and to further test multiple-use forest management treatments (Hibbert and Gottfried, 1987, Gottfried et al., 1999b). Findings from these collective efforts include:

- Clear-cutting the mixed conifer forests on Workman Creek in stages, starting on the wettest and progressing to the driest sites, increased water yields by almost 2.6 inches (72 percent) for the combined treatments over a 20-year period.

- Single-tree selection followed by the conversion of mixed conifer to ponderosa pine forest stands (by removing other conifer species and thinning to residual ponderosa pine forest to a basal area less than 10 square meters per hectare [m^2/ha] also increased water yields on Workman Creek. This treatment, which affected 83 percent of the treated watershed, resulted in an average annual water yield increase of 4.1 inches (110 percent) over 12 years. However, this severe a thinning treatment is not recommended for present-day management.

- Bringing the densities of the mixed conifer forests on Willow Creek to optimum stocking conditions by removing mature, over-mature, and high risk trees resulted in a 3.7-inch (54 percent) increase in water yields in the short term. However, the resulting heavy logging and subsequent wind damage to residual trees on the treated watershed compromised the original research objectives. Final treatment conditions on this watershed were similar to a large clear-cut rather than the intended stands of young-growth, sawtimber-sized trees.

- The implementation of a prototypical operational resource allocation plan on Thomas Creek, involving patch clear-cutting with other single-tree and group selection methods (where appropriate), increased water yields about 1.9 inches (45 percent). The streamflow increases were generated by snowmelt or large rain storms, a phenomenon that was similarly observed during other research efforts in the mixed conifer forests.

Research in Colorado has shown that water yield increases in the higher-elevation lodgepole and spruce-fir forests are directly proportional to the amount of basal area that is removed (Troendle and King, 1987, as cited by MacDonald et al., 2002). This research also indicated that, because of limitations in the accuracy of streamflow measurements and the regressions between paired basins, at least 20 to 25 percent of the basal area within a watershed must be removed in order to detect a statistically significant change in runoff (Troendle and King, 1987; Troendle et al., 2001, as cited by MacDonald et al., 2002). Smaller reductions in basal area should proportionally increase streamflow, but the magnitude of increases from small changes in forest density cannot be predicted with any confidence.

8.4.2.2.2 Ponderosa Pine Forests. Watershed research on water yield improvement in the low-elevation ponderosa pine forests of the Colorado River Basin was conducted on the Beaver Creek watersheds in north-central Arizona (Baker and Ffolliott, 1999), in the high-elevation ponderosa pine forests on the Castle Creek watersheds in eastern Arizona (Gottfried et al., 1999b), and in the ponderosa pine forests on the Colorado Front Range (Gary, 1975). Results of this research include:

- The potential for increasing water yields in ponderosa pine forests is less than in higher-elevation mixed conifer forests because of the drier conditions in the former. However, short-term (up to 10-year) increases of 1 to 3 inches were observed on the Beaver Creek watersheds as a result of varying intensities of overstory thinning, patterns of overstory removal, and combinations of the two treatments. Increases of 0.2 to 1 inch are likely a more realistic expectation of water yield increases within a multiple use management framework, where water, forage, wood, wildlife, and recreation are all considered in the product mix.

- An average water yield increase of 0.5 inch (30 percent) remained stable for 20 years after an irregular-block timber harvest on a watershed at Castle Creek. The initial increase in water yields was attributed largely to reduced evapotranspiration and increased snow accumulations in the created openings. No increase in water yield occurred after a prescribed burn on a second watershed because the fire did not significantly affect the forest overstory conditions and didn't consume much of the litter and duff on the forest floor (Gottfried and DeBano, 1990).

- Low to intermediate stocking levels in two-thirds of the ponderosa pine stands on the Colorado Front Range preclude significant water yield increases from these areas, regardless of the management emphasis (with the exception of clear-cutting).

8.4.2.2.3 Piñon-Juniper Woodlands. The effects of vegetation management practices on water yields in the piñon-juniper woodlands have been mostly studied on the Beaver Creek watersheds (Baker and Ffolliott, 1999). Conversion of these open overstories to less water-demanding herbaceous covers by cabling, felling, and herbicide treatments resulted in the following responses:

- Cabling or felling of piñon-juniper woodlands had a negligible effect on water yields. Any water yield increase that might be expected from these mechanical methods of conversion is thought to be lost to the several-fold increase in herbaceous plants.

- The aerial application of a herbicide treatment resulted in a small increase in water yields of less than 0.5 inch. In this treatment, the test watershed was sprayed with the herbicide mixture from a helicopter to kill the trees. The dead trees were removed after 8 years of post-herbicide evaluation in a second-stage of the treatment. Streamflow returned to near pre-treatment levels after the dead trees were removed.

- In 1956, research conducted in Arizona on the removal of piñon and juniper estimated a per-acre yield between 0.5 and 1.0 acre-inch, and in the next decade, a considerable number of acres were cleared using mechanical methods. Almost 20 years later, continued research and field results found that chaparral-infested lands that were treated, which had been dismissed by the first study, exhibited significantly more potential for water yield, while the piñon-juniper acres that were treated provided disappointing results (Hays, 1998).

- A summary of research into the effects of piñon-juniper management on hydrology was provided by Roundy and Vernon (1999). The results of the studies they surveyed were variable depending on watershed conditions, soil types, removal practices (i.e., whether vegetation is left on-site after cutting), and the scale of the projects, and they cannot necessarily be generalized to cover broader conditions. However, several of the investigations indicated that little usable water would result from piñon-juniper management. Conversely, studies in Oregon and Utah reported some benefits to spring flow and/or increased infiltration.

- One study in the Edwards Aquifer area and upstream "contributing zone" in south-central Texas investigates the potential management strategy for increasing streamflow and groundwater recharge in the area (Afinowicz et al., 2004). Much of the region is covered by a dense canopy of juniper and oak, and there is a high level of interest in using brush control as a mechanism to increase recharge. To learn more about the extent to which brush control affects runoff and infiltration, researchers used rainfall simulation equipment to apply approximately 8 inches of rainfall (6,980 gallons), to the site during a period of 51 minutes, yet no surface runoff was observed during or after the rainfall simulation. Preferential flow was observed within a trench, predominantly from soil areas and places with heavy limestone or root fractures, leading to a theory that the water moves below the surface and potentially recharges the aquifer. This ongoing study will allow quantification of a water budget for the area in real time, as well as determination of how much water brush species use and whether brush control is necessary. Field studies of a paired plot that resembles the first research area in slope and soil type, but does not have any brush growth, are also being conducted (Afinowicz et al., 2004) to compare surface and groundwater flow with and without brush. Preliminary results indicate a larger amount of surface runoff without brush present.

Investigations of other watersheds resulted in the following conclusions:

- In reviewing piñon-juniper management, Gottfried and Severson (1994) indicated that many control programs failed to produce the increased water yields and better wildlife habitat that had originally been expected.

- Research conducted by Wood and Javed (2001) compared runoff from untreated piñon-juniper stands to runoff from stands where the piñon-juniper were clear-cut and the land was either cleared, burned, or covered with slash. The test plots were monitored from the time of treatment in 1989 until 1999. The findings of this study suggest that treatment of slash following thinning can be used to effect short-term changes in runoff, but that long-term changes are more difficult to achieve. The reestablishment of understory growth may be beneficial for certain land use practices (cattle grazing, fire suppression), but does not appear to achieve greater water yields.

Management practices that are used to treat piñon-juniper woodlands, including chaining and prescribed burns, are technically feasible, though the impacts of the treatments on yields may be marginal. Natural widespread loss of piñon trees is currently occurring across New Mexico, due to extended drought and impacts of the bark beetle. Though some improvements in the ecological health of the area and the timing of runoff events can be expected, the opportunities for management actions to affect measurable increases in stream flow water yields in the piñon-juniper zone are generally much more limited than in the forested areas.

8.4.2.2.4 Chaparral Shrublands. A research program on the Three Bar Wildlife Area near the Theodore Roosevelt Reservoir in central Arizona represented the first major experimental watershed program in the chaparral shrublands of the Colorado River Basin (DeBano et al., 1999a). This early program, which was initiated in 1956, was followed by research on the Whitespar, Mingus, and Battle Flat watersheds in north-central Arizona to further assess the potential for water yield improvement through chaparral conversion practices (DeBano et al., 1999b). Findings from these research efforts include:

- Increasing streamflow by converting chaparral shrubland to other vegetation is possible on favorable sites where annual precipitation averages 19.5 inches or more. The key to increasing water yields on these sites is the replacement of deep-rooted chaparral shrubs with shallow-rooted grasses and forbs, which use less water, by applications of herbicides, prescribed burning, and combinations of these conversion methods. The expected average increase is 3.9 inches in water yields on areas receiving 22 inches of average precipitation.

- Chaparral shrubs surviving the initial conversion treatments have to be re-treated to control re-sprouting. Post-treatment shrub cover should be maintained at about 10 percent to sustain the water yield increases. However, the threat to wildlife, concerns about the environmental effects of herbicides, and increased recognition of the other multiple use values in the chaparral shrublands have restricted large-scale applications of the conversion treatments studied.

8.4.2.2.5 Semidesert Shrublands. Low-lying semidesert shrublands are the least important water-yielding areas because of their comparatively low precipitation inputs and high evaporation rates (Baker and Ffolliott, 2000). Average runoff depths of up to 0.4 inch have been observed for these semidesert shrublands, but these amounts are highly variable from year to year and therefore cannot be relied upon.

8.4.2.2.6 Riparian Ecosystems. The potential for increasing water yields through vegetation management practices within the riparian ecosystems can be greater than for any of the other vegetation types. Research in the 1950s through the early 1970s showed that significantly large increases in water yield occur when deep-rooted riparian vegetation is eradicated along permanently flowing streams (Horton and Campbell, 1974; Hibbert, 1979; Johnson et al., 1985; Baker and Ffolliott, 1999). By the middle 1970s, however, pressure by environmental groups and the general public to preserve and (where appropriate) manage riparian corridors for wildlife habitats, recreation, and aesthetic values largely halted the implementation of this practice. As a consequence, riparian ecosystems have been, and continue to be, largely excluded from considerations relative to water yield improvement opportunities. Maintaining the integrity of these fragile ecosystems is currently valued more highly.

Perhaps the most serious threat to riparian vegetation along New Mexico's water courses is the invasion of salt cedar, or tamarisk. This plant, native to the Middle East, was introduced into Texas in the late 1800s and has since spread along all of the major waterways and tributaries of the Rio Grande and Pecos River. Its rapid growth and reproduction, combined with its ability to replace native vegetation and tap precious underground water, has classified it as a noxious weed. Though salt cedar is generally not widespread in the Southwest Region, and eradication programs are therefore not expected to contribute to measurable yield increases, it would be valuable to address salt cedar encroachment issues before salt cedar becomes widely established in the area.

8.4.2.3 Scale Effects

As the thinned area increases, total runoff volume will also increase. However, Huff et al. (2000) suggest that the change in yield relative to expected annual runoff is on the order of 1 percent for large watersheds, generally too small to measure. In their modeling study, a 40,000-square kilometer (km^2) watershed in the Sierra Madre Mountains of California was assessed for 1-km^2 areas eligible for thinning and found that 60 percent of the watershed was ineligible for consideration. The authors' thinning criteria excluded set-aside, protected, and non-forested land. A minimum remaining vegetation criterion of 135 square feet of basal area was imposed for each 1–km^2 treatment area, which further reduced the thinning operations to 15 percent of the entire study area. For each thinned 1-km^2 area, the modeled annual water yield for average climate conditions ranged from 0 to 6.5 inches. Because only 15 percent of the total 40,000–km^2 was thinned, aggregating the individual 1-km^2 thinned areas produces the watershed scale thinning simulation. The area weighted watershed increase in water yield from their idealized scenario was 0.2 $\pm$ 0.1 inch, ranging from 0 to 1.3 inches; at larger hydrologic unit code (HUC) scales, the water yield ranges from 0 to 0.16 inch. Although the change in water yield per unit area decreases as the size of the area increases, the actual volume of produced water increases.

8.4.2.4 Flow Timing Effects

For any scenario, the timing of the increase in runoff may be out of phase with the timing of peak demand, so storage capacity will be required to obtain the full benefits of any projected increase in streamflow. The timing and quality of streamflow can change substantially after removing piñon-juniper, even though annual water yields remain unchanged. If the removal of the woody vegetation results in a much denser grass and forb cover, runoff processes during high-intensity rainstorms can shift from overland flow with high surface erosion rates to subsurface flow with no surface erosion rates. The increased infiltration reduces storm flow volumes and increases base flow volumes. Thus while total annual runoff may be unchanged, the timing of the runoff could be drastically changed. Such changes will be highly site-specific and will depend on a variety of factors, such as soil depth, soil texture, slope, bedrock type, changes in percentage of ground cover, and precipitation amounts and intensities. Sid Goodlow, a rancher in the Capitan area, demonstrated this change by rehabilitating his land, which had become overgrown with piñon and juniper. After removing the piñon and juniper and establishing grass, the once dry arroyos became perennial streams.

8.4.2.5 Ownership of Produced Water

The amount of water that can be gained from watershed restoration throughout the region is affected by New Mexico laws and regulations, which specify that any "additional" runoff created by watershed management becomes part of the public water supply and is subject to the prior appropriation system. This effectively means that any appropriator could obtain the increased water generated, regardless of their role (or lack thereof) in the land management activities leading to the increased supply. No mechanism exists whereby the person or entity that increases the amount of runoff can lay a priority claim to the water produced. Furthermore, any permit obtained to use that water would be a new, very junior water right. The more likely scenario is that no new appropriations would be allowed, but that holders of existing water rights would be more like to receive their full supply each year.

In the Gila-San Francisco Basin, there are some provisions in agreements with Arizona (Section 8.6) to potentially allow for changes in diversions if increases due to watershed yields are proven.

8.4.2.6 Summary

In summary, the average long-term increase in water yield depends on the annual precipitation, the species being treated, the proportion of the canopy that is removed, the regrowth rate, and the length of time between treatments. These variables significantly affect the amount of water yield increase that may be expected.

In order to approximate the expected yield increase in the Southwest Region, a simplified calculation was conducted. Areas with precipitation of 18 inches per year or greater (Figure 8-2), which cover approximately 172,000 acres of the region, were used to estimate the potential yield increases in the Southwest Region. The estimated potential yield increases are based on two primary assumptions:

- Based on previous studies summarized herein, it was assumed that yield increases from thinning would be on the order of 0.2 to 0.5 inch over the land treated.

- Because it is probably not realistic to assume that the entire area could be thinned, it was assumed that 30 to 70 percent of the non-wilderness area with precipitation above 18 inches would be thinned.

Table 8-12 illustrates the potential water supply increases in the region. As shown in this table, for the assumed 30 to 70 percent of the high-precipitation area that would be thinned, yield would increase by approximately 1,000 to 7,000 ac-ft/yr. However, as discussed above, this amount would vary from year to year, with lesser yield increases occurring in the dry years.

Table 8-12. Potential Water Supply Increases in the Southwest New Mexico Water Planning Region

Percentage of Total Area Thinned [a]	Area Thinned [b] (acres)	Water Yield Increase (acre-feet)	
		Low-End [c]	High-End [d]
10	24,698	412	1,029
20	49,395	823	2,058
30	74,093	1,235	3,087
40	98,791	1,647	4,116
50	123,489	2,058	5,145
60	148,186	2,470	6,174
70	172,884	2,881	7,203
80	197,582	3,293	8,233
90	222,279	3,705	9,262
100	246,977	4,116	10,291

[a] Within each incremental fraction, at least 25 percent of the basal area (i.e., 25 percent of the vegetation) must be removed to achieve indicated yield.
[b] Total nonwilderness area where precipitation is above 18 inches per year = 246,977 acres.
[c] Calculations assume that thinning results in 0.2 inch of additional water yield over area thinned.
[d] Calculations assume that thinning results in 0.5 inch of additional water yield over area thinned.

8.4.3 Financial Feasibility

Costs for conducting thinning projects are variable depending on the ease of access, thickness of vegetation, amount of thinning to be done, treatment of slash (i.e., whether it is, in order of increasing cost, scattered, piled, burned, or removed), and techniques used (in order of increasing cost, hand pruning, chainsawing, bulldozing). Current costs for mechanical thinning programs in the Gila National Forest (Boucher, 2004) range from about $800 to $1,000 per acre including planning. In wilderness areas, where no mechanical cutting is used, the cost for using wildland fire as a method of restoring forests is about $6 per acre (Boucher, 2004).

The primary ongoing cost of forest thinning projects is the need to address regrowth through periodic thinning or prescribed burns. In general, a ponderosa forest must be thinned at least every 30 to 40 years to prevent fires and to maintain increased water yield. Costs for repeat thinning would be similar to the initial costs (excluding inflation).

Costs for conducting watershed projects that affect water quality are highly variable. A general approach is to identify needed projects in the planning stage and implement those projects as funding becomes available.

Funding for watershed activities can be derived from a variety of sources:

- U.S. EPA Section 319 nonpoint source grants can potentially be used to form watershed groups, to identify nonpoint source issues, and to implement projects that use best management practices. The focus of these grants is to improve water quality conditions.

- During the past several years, the New Mexico Water Trust Fund issued a request for funding applications in four categories, one of which was watershed management. Depending on legislative appropriations, this is likely to be a continuing source of funding.

- The Collaborative Forest Restoration Program (CFRP) provides grants for forest restoration projects that reduce the threat of wildfire, improve watershed conditions, improve the use of small trees thinned from restored lands, and provide jobs and training to local communities. State, local and tribal governments, educational institutions, landowners, conservation organizations, and other interested public and private entities can apply for CFRP grants. Restoration projects must be on federal, tribal, state, county, or municipal forest lands in New Mexico, or any combination thereof. The program does not provide grants for the treatment of private land, but CFRP grants can be used for processing facilities on private land that use small trees from thinning projects on public lands.

Other potential funding sources include NRCS grants (e.g., Conservation Technical Assistance, Small Watershed Program, Environmental Quality Incentives Program, Conservation Reserve Program, Emergency Watershed Protection).

8.4.4 Environmental Impacts

An extensive program of forest harvest or thinning could increase erosion rates and adversely affect water quality (due to increased turbidity and sediment loads). The increase in erosion from harvested areas and the accompanying adverse impacts on water quality can usually be minimized through careful design of treatments that use best management practices (MacDonald et al., 2002). The careful design and construction of the road and skid trail system is critical to minimizing overland flow and reducing erosion, and the use of buffer strips along ephemeral and perennial streams is needed to minimize sediment delivery into the stream network. Maintaining riparian vegetation is the best means to minimize increases in water temperatures.

The primary environmental advantage of reducing forest density is the reduced risk of high-severity fires. High-severity fires in coniferous forests can increase runoff and erosion rates by one or more orders of magnitude relative to unburned conditions, and these increases can have severe downstream effects such as flooding, reservoir sedimentation, and adverse effects on aquatic habitat. The effects of prescribed fires on runoff and erosion are generally minimal, as the fire severity is mostly low to moderate, resulting in much less soil water repellency or highly discontinuous patches that are water repellent (MacDonald et al., 2002). Areas burned at moderate or low severity also have much lower percentages of bare ground, which according to recent research, correlate very strongly with lower erosion rates. As long as the percentage of bare ground is less than about 20 to 30 percent, post-fire erosion rates should be very low and therefore pose little or no threat to water quality and downstream water resources (Benavides-Solorio and MacDonald, 2000; MacDonald et al., 2002).

An important concern in the case of prescribed fire and broadcast burning is the effect on air quality. Fires in forested areas produce a large number of particulates that are a hazard to human health. Smoke also has an adverse effect on visibility and visual aesthetics. Another environmental impact that has been identified as a potential concern (http://www.ugwa.org, accessed October 2004) is potential logging of old growth forests under the fuel reduction program.

In general, watershed management should have a positive impact on water quality. Watershed groups and public lands managers can work to identify and remediate sources of water quality degradation and to address water quality issues associated with grazing, erosion, septic tanks, or other concerns.

Conversely, thinning activities can have a negative impact on water quality if they are not conducted properly. The primary water quality concern from thinning is increased erosion and sedimentation. This type of impact can be minimized, however, by using best management practices for road installation (if needed) and logging activities.

The National Forest Management Act (NFMA) directs the USFS to manage national forest lands according to forest plans prepared every 10 to 15 years. This planning process must, according to NFMA and NEPA, provide for public involvement and allow for incorporation of economic, environmental, or other concerns into the process. Implementation of these forest plans, however, is dependent on funding.

Management actions taken in the national forests to increase water supply emanating from the forests generally must comply with a number of federal laws, including:

- National Forest Management Act, 16 U.S.C. §1600, et seq. (NFMA)
- National Environmental Policy Act, 42 U.S.C. §4321 et seq. (NEPA)
- Clean Water Act, 33 U.S.C. §1251 et seq. (CWA)
- Endangered Species Act, 16 U.S.C. §1531 et seq. (ESA)
- National Historic Preservation Act, 16 U.S.C. §470 et seq. (NHPA), where applicable
- American Indian Religious Freedom Act, 42 U.S.C. §1996 (AIRFA), where applicable

8.4.5 Political Feasibility and Social/Cultural Impacts

Efforts to harvest or thin public forest lands often elicit opposition initially, although efforts to inform and educate the public can create support for those actions that might substantially reduce the risk of high-severity wildfires while having minimal effect on water quality. Strong public support for watershed management was expressed at public meetings held throughout the Southwest Region. There are some public concerns regarding thinning in old-growth forests and potential road building activities. Also, prescribed burning programs often encounter considerable public resistance due to the adverse effect of smoke from the fire on visibility and visual esthetics, as well as concerns about the ability to control prescribed fires. An extended period of prescribed fire could also raise issues such as the potential effect on tourism. Initially there was considerable opposition to fires in the Gila National Forest, but public support for the program has grown (Burke, 2004).

Designing restoration and management plans in collaborative consultation with affected local communities helps to enlist local support and involvement and to integrate valuable knowledge about local resources. Direct socioeconomic and cultural benefits would flow from contracting with local communities and small-scale local enterprises for forest thinning and fire management, riparian system enhancement, erosion control, and/or other stewardship work.

8.5 Enhanced Recharge

In areas where the hydrology is such that surface water quickly flows out of an area following precipitation events, the use of enhanced recharge to store surplus surface water underground (thereby minimizing evaporative losses or reducing storm flows out of New Mexico back to a natural condition) can be an important component of water resources management. Artificial or enhanced recharge is defined as the planned, human activity of augmenting the amount of groundwater available through works designed to increase the natural replenishment or percolation of surface waters into the groundwater aquifers, resulting in a corresponding increase in the amount of groundwater available for extraction. Common sources of recharge water are treated wastewater, storm runoff, and surface water bodies. This discussion provides an overview of the various types of artificial or enhanced recharge alternatives. A detailed analysis of one of these alternatives, the aquifer storage and recovery of New Mexico's Gila River entitlement, is provided in Section 8.6

The main purpose of the enhanced recharge technology is to store surface water in the aquifer for later use, sometimes improving water quality (decreasing the salinity level) by recharging the aquifer with better-quality water. Water managers use artificial recharge for a number of purposes: the maximization of storage (including seasonal, long-term, and drought or emergency water supplies), physical management of the aquifer, water quality management, management of water distribution systems, and ecological benefits. The use may determine what method a group may choose for enhanced recharge.

Artificial recharge can occur through direct and indirect processes, and a variety of in-stream and near-stream technologies have been used to artificially recharge groundwater aquifers. Several direct methods of artificial recharge are commonly used, including spreading basins and ditches for near-surface recharge applications and pits and shafts for penetrating below near-surface restrictive layers. A third method, direct well injection into the unsaturated zone, is often used to penetrate below deeper restrictive layers. Indirect methods include enhanced streambed infiltration by promoting a downward hydraulic gradient under streambeds and conjunctive wells.

8.5.1 Technical Feasibility

Enhanced recharge to an aquifer may be achieved by either surface spreading, injecting into wells, or altering the natural conditions of stream channels to increase infiltration. The technical feasibility of some of the key direct and indirect methods is discussed below.

Direct methods can be divided into surface recharge techniques and subsurface recharge techniques. In surface recharge, water moves from the land surface to the aquifer by means of infiltration through the soil. The surface is usually excavated and water is added to spreading basins, ditches, pits, or shafts and allowed to infiltrate. Generally, surface methods are dependent on the amount of time that the water is in contact with the soil. Direct surface methods involve low construction costs and are easy to operate and maintain compared to other methods.

- *Spreading basins.* Spreading basins, in which water is distributed over the surface of basins excavated in the existing terrain, are most effective in highly permeable soils. Maintenance of a layer of water over the soil is necessary, and recharge is most effective when there are no impeding layers between the land surface and the aquifer. The common problem with recharging using a spreading basin is that suspended sediment in the recharge water or microbial growth can clog the surface material. Spreading basins can be designed to be gravity-fed from surface streams and to recharge near-stream shallow groundwater. Previous studies conducted on playas indicate that removing surficial fine-grained sediments could increase recharge by 10 times.

- *Check structures.* Building check structures and water traps at suitable intervals in an irrigation canal or within a stream channel slows the flow velocity and increases the contact time with the permeable sediments. This method can increase the recharge capacity several times over recharge under natural flow conditions.

- *Enhanced meandering.* Recharge through the streambed to a stream-connected aquifer can be enhanced by slowing stream velocities and lengthening the stream channel through enhanced meandering.

- *Recharge pits and shafts.* Conditions that permit surface spreading methods for artificial recharge are relatively rare. Often, lenses of low permeability lie between the land surface and water table. In such situations artificial recharge systems such as pits and shafts could be more effective in penetrating the less permeable strata in order to access the aquifer. The rate of recharge has been found to increase as the slopes of the pit sides increased. Recharge pits and shafts may be circular, rectangular, or square and may be backfilled with porous material (O'Hare et al., 1986).

- *Ditch.* A ditch is a long narrow trench with its bottom width less than its depth. The system can be easily designed to fit the topographic and geologic conditions at a site.

- *Recharge wells.* Recharge wells are used to directly recharge water into deep water-bearing zones. One of the more popular techniques is aquifer storage and recovery (ASR), the storage of water in a well during times when water is available and recovery of the water from the same well during times when it is needed. According to a 2001 American Water Works Association (AWWA) survey, more than 50 ASR facilities exist in the U.S. All ASR wells are regulated as Class V underground injection control (UIC) wells. Because water enters without natural filtration, the quality of the recharge water for ASR must be carefully considered. Recharge wells can be used to dispose of treated industrial wastewater, to divert streamflow, or most commonly, to inject potable water.

Indirect methods include installing groundwater pumping facilities near connected surface water bodies to lower groundwater levels and induce infiltration elsewhere in the drainage basin. Indirect methods include modifying aquifers to enhance groundwater reserves.

- *Enhanced streambed infiltration.* Enhanced streambed infiltration involves creating a system of wells near a surface water body. Two lines of wells are set parallel to the bank of a river, one on the riverbank and the second a short distance from the river.

- *Conjunctive wells.* Conjunctive wells are screened in both a shallow confined aquifer and a deeper artesian aquifer. Water is pumped from the deeper aquifer and, if its potentiometric surface is lowered below the shallow water table, water from the shallow aquifer drains directly into the deeper aquifer.

Advantages of enhanced recharge include:

- The amount of water stored in and available for distribution from aquifers is increased.

- Contaminants can be removed by natural cleaning processes.

- Groundwater recharge stores water during the wet season for use in the dry season, when demand is highest.

- Aquifer water can be improved by recharging with high quality injected water.

- Recharge can significantly increase the sustainable yield of an aquifer.

- Recharge methods are environmentally attractive, particularly in arid regions.

- Most aquifer recharge systems are easy to operate.

- In many river basins, control of surface water runoff to provide aquifer recharge reduces sedimentation problems.

Some disadvantages associated with enhanced recharge include:

- The hydrogeology of an aquifer should be investigated and understood before any recharge project is implemented. In karstic terrain, dye tracer studies can assist in acquiring this knowledge.

- During the construction of water traps, disturbances of soil and vegetation cover may cause environmental damage to the project area.

- Unless significant volumes can be injected into an aquifer, groundwater recharge may not be economically feasible.

- Recharge can degrade the aquifer unless quality control of the water is adequate. In particular, because surface water runoff is usually not pre-treated before injection, runoff used as a source of recharge may contaminate existing groundwater, especially if the surface water runoff is from agricultural fields and roads surfaces.

- In the absence of financial incentives, laws, or other regulations to encourage landowners to maintain drainage wells adequately, the wells may fall into disrepair and ultimately become sources of groundwater contamination.

Except for recharge using injection wells directly into an aquifer, artificially recharged water must first move through the unsaturated zone. For the most part, the unsaturated zone provides the underground storage space for recharge, although the amount of storage is dependent on the water retention characteristics and the natural recharge occurring at the site. The greater the natural recharge at a site, the greater the percentage of porous materials that are already occupied by antecedent water moving through the unsaturated zone, resulting in a smaller amount of available space for the artificially recharged water.

The hydrologic properties of an unsaturated zone help determine the suitability of a particular location for artificial recharge. Optimally, areas used for artificial recharge should have high-permeability soils, the capacity for horizontal movement of water in the unsaturated zone and in the receiving aquifer, a lack of impeding layers, and a thick unsaturated zone. Under optimal conditions, water should reach the top of the saturated zone and spread laterally rather than building up a column of water toward the surface, which would greatly reduce recharge (Freeze and Cherry, 1979). The suitability of a site is often determined by field and laboratory measurements of soil properties, field experiments, and numerical modeling.

Water quality considerations are important when groundwater recharge is enhanced. For example, artificial recharge may be used to store treated sewage effluent and stormwater runoff for later use. However, in order to accomplish the uses without adverse environmental consequences, the optimum combination of treatment methodologies before recharge and after recovery from the aquifer must be identified. It will also be necessary to consider the sustainability of soil-aquifer treatment and the health effects of water reuse when using treated wastewater as the recharge source or when stormwater runoff is derived from urban areas.

8.5.1.1 Implementation Considerations

Whether a proposed project is appropriate for a particular site is dependent on several conditions:

- Quantity of source water available
- Quality of source water available
- Resulting water quality
- Clogging potential
- Underground storage space available
- Depth to underground storage space
- Local hydrologic conditions
- Urban development in the floodplain
- Transmission characteristics
- Topography/applicable methods (injection or infiltration)
- Legal/institutional constraints
- Costs
- Public perception
- Maintenance

In New Mexico, prior to implementing a direct injection project where the water would later be recovered, a permit must be obtained in accordance with the Aquifer Storage and Recovery Act, which requires pilot testing as part of the program. For modification to streambeds, such as enhanced meandering or check dams, an Army Corps of Engineers Section 404 permit must be obtained. Any projects on federal lands or funded with federal dollars must meet NEPA requirements.

The current uses of the floodplain must be considered when targeting areas for enhancing recharge. For instance, a stream may have incised its channel, resulting in dewatering of the shallow aquifer. However, to restore this stream to its natural function, allowing flood flows to spill over its banks, may not be desirable in areas that are now urbanized.

Artificial recharge techniques have been implemented throughout the world and are currently being investigated. Representative studies are described in Sections 8.5.1.1.1 through 8.5.1.1.4.

8.5.1.1.1 Groundwater Recharge/Seasonal Habitat Study, Eastern San Joaquin County, California. The Sacramento District of the U.S. Army Corps of Engineers, in partnership with several local agencies including the Stockton East Water District, is conducting a feasibility study to evaluate groundwater recharge in eastern San Joaquin County, California (Montgomery Watson Harza, 2001). The study area encompasses three water districts that overlie an area of severe groundwater overdraft.

Recharge testing for this study began in December 1999 at four sites in eastern San Joaquin County. At least two test facilities were constructed at each site to provide comparative information about percolation recharge effectiveness. Recharge techniques being tested included field flooding, shallow spreading basins, and pits to depths of 15 feet.

Recharge effectiveness is being measured in two ways. First, the volume of applied water is being monitored and adjusted for climatic conditions to determine how quickly water percolates into the ground. Groundwater levels are then monitored to determine when the recharged water reaches the groundwater table. Information collected during these tests will be used to estimate long-term recharge effectiveness.

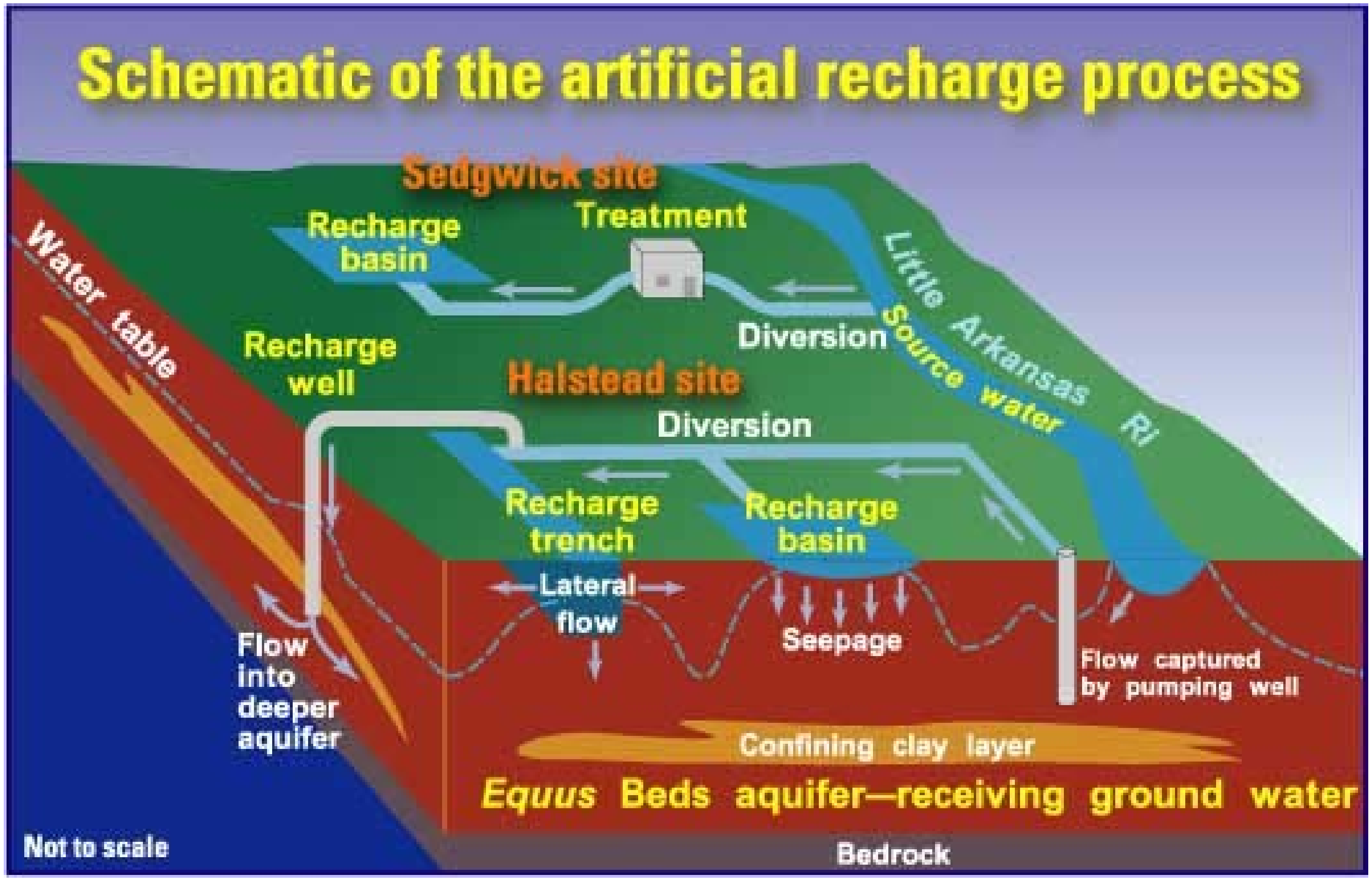
Initial recharge rates at the test sites have been very encouraging. After approximately one month of operation, sustained rates of 1 to 4 feet per day were recorded. These responses are consistent with initial rates at other successful recharge facilities in the Central Valley. As seen in other groundwater recharge projects throughout California, however, long-term rates are expected to be lower. Factors that can affect long-term recharge rates include accumulation of fine sediment on the bottoms of spreading basins, algae growth, and the saturation of soils near the recharge facility.

Initial results of this study found that flooded fields provide the most cost-effective combination of groundwater recharge performance and opportunities for seasonal habitat restoration (Montgomery Watson Harza, 2001).

8.5.1.1.2 Artificial Recharge of Groundwater Through Surface Drainage Systems, India. Irrigators in the Indo-Gangetic Plain in India are considering using check structures to reverse current water level declines in the aquifer due to intensive agriculture that has resulted in over-development of groundwater resources. One proposed method of preventing further water level declines is to use a network of surface drains constructed to control previous waterlogging to recharge groundwater with surplus canal water during the low irrigation requirement period. In the proposed method, water is released under natural flow conditions, and the flow is interrupted by providing check structures across the drains at suitable intervals in such a manner that outflow becomes zero at the outfall of the drain. A group or researchers at Punjab Agricultural University (Khepar et al., 2000) developed a model to determine the optimum discharge to be released at the head of each drain. The results obtained reveal that the strategy developed could be adopted for recharging the declining water table through surface drainage systems.

8.5.1.1.3 Effects of Artificial Recharge on Water Quality, South-Central Kansas. The city of Wichita, Kansas has conducted a pilot study to enhance infiltration of high streamflows to the Wichita well field. Artificial recharge of the Equus Beds aquifer (Figure 8-3) is being investigated as one alternative to meet future water-supply demands (Ziegler et al., 2001). An additional potential benefit of artificial recharge includes preventing degradation of the aquifer's water quality by chloride plumes from the Arkansas River to the southwest and the Burrton oil field to the northwest (Ziegler et al., 1999). The demonstration project showed localized water level rises near the two recharge sites studied (Figure 8-4) (USGS, 2004b). The plan for full production would add millions of gallons of water per day that would be available for city use during times of need.

8.5.1.1.4 Use of Recharge Pits to Reduce Declining Water Levels, Illinois. The town of Peoria, Illinois investigated the use of recharge pits in the 1940s to reduce declining water levels in well fields. The Illinois State Water Survey determined that the overpumpage of groundwater was between 8 and 10 million gallons per day (mgd), demonstrating the need to adopt conservation measures and some method of artificial recharge. Several methods were investigated, one of which was recharge pits.



Source: USGS, 2004a

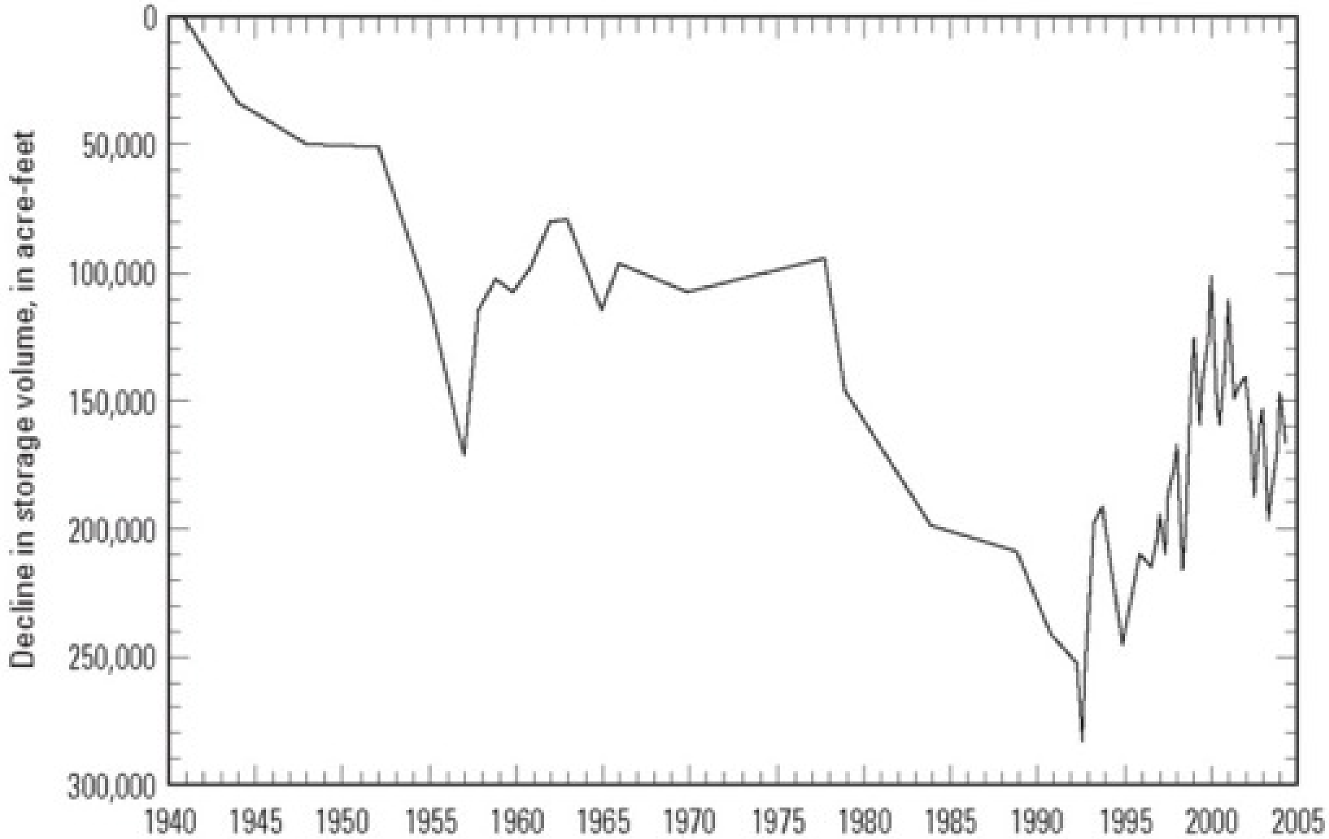
SOUTHWEST NEW MEXICO REGIONAL WATER PLAN

Equus Beds Artificial Recharge Project

Daniel B. Stephens & Associates, Inc.

5/25/05

Figure 8-3



Source: USGS, 2004b

SOUTHWEST NEW MEXICO REGIONAL WATER PLAN

Changes in Storage Volume
Equus Beds Artificial Recharge Project

Daniel B. Stephens & Associates, Inc.
5/25/05

Figure 8-4

Preliminary tests in August and September 1941 on an abandoned gravel pit had indicated that these pits, if refilled by river water, would increase groundwater levels. Water levels within Water Survey monitoring wells reacted almost immediately to this recharge method. To further test this method, funds were appropriated in 1949 for the Water Survey to construct and operate a research pit with a capacity of 0.3 mgd. Pit 1 began operation on October 4, 1951 and was operated for seven more seasons through 1959. Pit 2 (2.0 mgd capacity) was built in 1956, and artificial recharge within the pit was initiated in October 1957. Both pits yielded recharge rates that were higher than expected.

8.5.1.2 Operation and Maintenance

Infiltration basins and ditches require minimal maintenance, consisting mostly of avoiding excessive sedimentation in the basins and ditches and preventing erosion of ditch banks. A bulldozer is often used in the infiltration basins to remove accumulated sediments and to rehabilitate the system.

Check structures and water traps require maintenance during the first few years of operation, until the natural vegetation grows again in the area. Intense rainfalls may damage or destroy the traps, in which case they will have to be rebuilt. They may also be washed out during flood events, in which case periodic maintenance may be required.

Maintenance of pits and shafts is similar to that required in infiltration basins. Runoff from areas with unpaved streets can carry large loads of sediment, which may clog porous media and will need to be removed during dry periods.

Operational and maintenance cost for recharge wells can be high due to pumping costs and water quality controls. Pumping costs include electricity and line maintenance costs. Water quality controls may be more expensive for recharge wells because of the potential need to treat water that will mix with different source water (as opposed to check dams or enhanced meandering, which increase surface recharge to a system that is already geochemically connected to the source water).

8.5.2 Hydrologic Impacts

The effectiveness of the various enhanced recharge technologies in the Southwest Region is dependent on the availability of surface water for enhanced recharge. As discussed in Section 8.6, the use of New Mexico's share of the CAP water potentially provides a new supply of surface water that could be used for artificial recharge. Other possibilities include the enhancement of recharge by slowing down storm flows in ephemeral channels through the use of check structures and slowing down flows in perennial streams with enhanced meandering. Both of the predominant perennial streams in the Southwest Region, the Gila and San Francisco Rivers, are gaining in much of the region. Therefore, a reconnaissance of the areas where the stream may be losing or where flood flows could be allowed to spill out of the banks and recharge shallow alluvial aquifers should be considered.

Potential areas for enhanced recharge in the Southwest Region include the following:

- The San Francisco River Association and the San Francisco SWCD are currently investigating potential reaches on Whitewater Creek, a tributary to the San Francisco River, where levees could be removed without flooding homes. Figure 8-5a shows one of the many levees on Whitewater Creek that has disconnected the floodplain from the creek. Removing the levee would not risk residential homes downstream in Glenwood during floods but rather help them by allowing for over-banking of flood waters and attenuation of peak flows.

- The Quivera Coalition is working on a project to enhance the riparian habitat on Largo Creek, near Quemado. This project is funded by an EPA Section 319 grant and involves the installation of check dams in the ephemeral reaches of the creek.

- Apache Creek and the Tularosa River are perennial streams that have been disturbed through gravel operations in the stream channels. Restoration of these streams back to their natural state could enhance recharge to the local aquifers.

- Pat Morrison of the Quemado Ranger District has worked to reduce erosion and rehabilitate wetlands in the northeastern part of the Gila National Forest over the last few decades. Figure 8-5b shows a view of the Arroyo Grande Wetlands Project, which is a

a. Levee on Whitewater Creek between the first low-water crossing and the Catwalk Campground low-water crossing

b. View of the lower end of the Arroyo Grande Wetlands Project in the USFG Gila National Forest

Source: Menzie, 2004

tributary to Centerfire Creek and the San Francisco River, and illustrates (in contrast to Figure 8-5a) a healthy riparian area. Although the intent of the rehabilitation project was not to increase recharge from flood flows, establishing a healthy riparian habitat will allow flood flows to spill over the banks and recharge the groundwater.

- Another project in the Centerfire Creek watershed includes the Spur Ranch Project near Luna. This project is addressing incision of Centerfire Creek through a fairly wide alluvial floodplain with construction of a sediment retention structure that will raise the base level of the channel and help restore a better connection between the creek and the historical floodplain (Menzie, 2004).

- Streamflows in the Mimbres River will ultimately recharge the aquifer in this closed basin; however, upstream of Faywood, opportunities exist in several reaches to slow down flood flows and enhance recharge. The use of check dams in San Vicente Arroyo downstream of the town of Silver City's wastewater treatment discharge could provide many benefits, including enhanced recharge. The restoration of this stream channel through the use of check dams to slow down storm flows could also improve recharge to the local aquifer in the vicinity of the City's well fields and reduce erosion. San Vicente Arroyo is also incised through the town; however, enhancement of the stream channel in this reach might result in the flooding of downtown Silver City. Other tributaries to the Mimbres River and arroyos in the Southwest Region could benefit from enhanced meandering and check structures to reduce the downcutting of stream in losing reaches, improve recharge rates, and reduce erosion.

8.5.3 Financial Feasibility

The cost of implementing an artificial recharge method varies considerable depending on the magnitude of the project and the specific hydrologic conditions. Table 8-13 illustrates the range of costs for the various methods of enhanced recharge. Cost can range from very minimal (for instance, to enhance stream meandering through the introduction of beavers, where conditions will allow) to fairly significant (for areas requiring the removal of large stands of exotic vegetation).

Table 8-13. Costs of Artificial Recharge Methods

Measure	Costs		
	Capital Cost [a] ($1,000)	Annual O&M Costs ($1,000)	Annual Cost ($ per acre-foot)
Flooded fields (80-acre site)	517 [b] - 531 [c]	32 [b] - 40 [c]	28 [c] -50 [b]
Spreading basins (80-acre site)	1,966	33	117
Excavated recharge pits (40-acre site)	909	23	413
Unlined flat ditch	15,819	84	244
Recharge shaft	1,651	220	275
Injection wells (4 wells)	4,510	646	173
Enhance recharge through streams	2,657	32	119
Flood detention basins	500 [d]	38	48

Source: Montgomery Watson Harza, 2001 O&M = Operation and maintenance

[a] Including land acquisition, construction, equipment, contingency, etc.

[b] Assumes infiltration rate of 0.25 ft/day

[c] Assumes infiltration rate of 0.5 ft/day

[d] Cost does not include conveyance modifications that may be necessary to support recharge.

8.5.4 Environmental Impacts

The environmental implications of enhanced surface recharge projects depend largely on the quality of the proposed influent water. Regulatory agencies are understandably much less concerned about clean water recharge projects, such as stormwater recharge, than about projects involving reuse or recharge of wastewater effluent. In-stream restoration projects, such as check dams or enhanced meandering, will generally have positive environmental benefits. However, care must be taken during construction to ensure that habitat disturbance or sedimentation does not create adverse conditions. Table 8-14 lists some of the potential ecosystem benefits of enhanced recharge methods that are most likely to have environmental impacts.

8.5.5 Political Feasibility and Social/Cultural Impacts

At meetings held throughout the Southwest Region, support was expressed for enhanced recharge, as well as for other watershed restoration activities. Many citizens in the area are concerned that the natural ecosystem be protected; therefore, it is important that projects are carefully planned and take into account water quality, aesthetics, and habitat requirements.

Table 8-14. Environmental Benefits of Artificial Recharge Methods

Measure	Potential Ecosystem Benefits
Spreading basins	• Large areas of ponded water with gradually sloped sides • Desirable habitat for waterfowl
Excavated recharge pits	• Smaller areas of ponded water with steeply sloped sides • Fair habitat for waterfowl
Unlined flat ditch	• Similar to excavated pits • Opportunity for continuous corridor
Enhance recharge through streams	• Broadened floodplain areas along streams would provide additional riparian habitat
Flood detention basins	• During shallow flooding (water depths from 0 to 12 inches) most desirable waterfowl habitat • Similar to excavated pits during flood events

Source: Montgomery Watson Harza, 2001

8.6 Divert New Mexico's Gila River Entitlement for Aquifer Storage and Recovery

This alternative considers the possibility of using diversions from the Gila River to supply an ASR project that would inject or artificially recharge water into the drawn-down areas of Silver City well fields in the Mimbres and Gila Basins. The project would be designed to, over time, replenish the aquifer around these municipal well fields, thereby extending its life. This alternative discussion also considers the option of creating a regional water system that would supplement the water supply for Silver City, Bayard, Ft. Bayard, Hurley, Hanover, Tyrone, Santa Clara, and other communities in the Silver City area now served by local groundwater. There are many potential variations in diversion, surface water storage, and aquifer storage locations and mechanisms. Some of these variations could range from main stem storage on the Gila River to no surface storage at all, storage at higher elevations to minimize evaporation, other diversion locations and pipeline routes, diversion of some portion of the entitlement through groundwater withdrawals as discussed in 8.6.1.9 or leaving the instream flow as discussed in 8.7. The final plan for use of New Mexico's Gila River entitlement is to be decided by the Southwest Water Planning Group and its member entities, in conjunction with the ISC; this alternative is only one possibility to be considered.

The water for this project would be made available by the recently passed Arizona Water Settlements Act and the CUFA (discussed in Sections 4.2.1.3 and 4.2.1.4, respectively, and summarized below). As this is the only new surface water diversion available to the region, it is an important aspect of regional water planning.

The Colorado River Basin Project Act of 1968 (Section 4.2.1.4) authorized the Secretary of the Interior to contract with water users in New Mexico for up to 18,000 acre-feet per year of Gila River water in exchange for an equivalent amount of CAP water to be delivered to downstream users in Arizona. The Act also authorized construction of the Hooker Dam or a suitable alternative on the upper Gila River in New Mexico.

The Arizona Water Settlements Act of 2004 (Section 4.2.1.3), which amends the original act and was signed into law in December 2004, now allows New Mexico an average of 14,000 ac-ft/yr of diversions (10,000 ac-ft/yr from the Gila and 4,000 ac-ft/yr from the San Francisco Rivers), not to exceed an average of 140,000 ac-ft/yr over 10 years (P.L. 108-451). The Act places numerous restrictions on the location, timing, and amount of diversions under different scenarios in order to protect baseline streamflows and deliveries to downstream irrigators in Arizona. It also allocated significant funding for development of a diversion project in New Mexico and/or for feasibility studies or mitigation measures.

All of the specifics regarding diversion limitations and the rights of all parties in New Mexico and Arizona are set out in the CUFA (Section 4.2.1.4). This document assigns responsibility for construction of facilities and diversions in New Mexico to the Secretary of the Interior and allows for the creation of the New Mexico Unit, authorizing the Secretary to delegate construction and operation to a “N.M. entity.” The CUFA also sets up a “technical committee” that will oversee project development and operation to assure that diversion conditions and limits in the agreement are met (CUFA Section 12.4). The agreement was built around the concept of authorized diversion points to be selected on the Gila and San Francisco Rivers, but allows alternate points of diversion, including diversion by groundwater pumping, with the finding of the technical committee that the essential conditions of the agreement can be met.

How the Arizona Water Settlement Act is implemented in the Southwest Region has not been decided, and significant additional planning will be necessary before any specific project design and development begins. In the interest of finding out the preferences of the Region concerning how the allotment of CAP exchange water will be used, the ISC worked with local governments to set up the Southwest Water Planning Group (SWPG) (AWSA Section 212(i)). It is anticipated that this group could transition into a joint powers authority suitable for contracting for and operating the New Mexico Unit. This group is closely related to the regional planning group in that the same four counties that make up the Southwest Region are represented and many of the same individuals, representing local governments and agricultural and watershed interests, are active with both the SWPG and the Southwest Region water planning effort.

The remainder of this section evaluates the feasibility of implementing an ASR project using Gila River water diversions under the CUFA. The evaluation is conceptual in nature and identifies issues related to the technical, hydrologic, and financial feasibility of potential diversion, recharge, and regional delivery scenarios. This analysis is not an engineering feasibility study. Additionally, this alternative analysis is preliminary and considers only the possible approaches outlined by the Steering Committee, which defined this alternative as “Divert Gila water through a pipeline, infiltration gallery, or small side stream reservoir to an ASR project to store the water in underground basins.” Thus this alternative does not analyze diversion from the San Francisco River. Small-scale enhanced recharge projects that could be applicable to the San Francisco River are discussed in Section 8.5.

8.6.1 Technical Feasibility

The New Mexico CAP unit that was authorized under the Colorado River Basin Project Act was never built, based in part on BOR findings that constructing a large diversion dam and reservoir on the Gila River (the proposed site of Hooker and, later in the planning process, Conner Dams) could cause significant environmental impacts (Section 8.6.1.1). Alternative approaches involving diversion and storage in smaller side canyon facilities appear more practical with less environmental impact. During the same period that the BOR was conducting its study of non-mainstem alternatives, the potential to use the water to offset depletion of groundwater in Silver City well fields in the Mimbres and Gila basins, to allow their extended use as a regional municipal and industrial supply, was identified (Hernandez et al., 1984). Subsequent work on the BOR *Upper Gila Water Supply Study* (U.S. BOR, 1987) incorporated this concept. The cost of these projects is still high, and the overall cost and necessary local share probably eliminates use of the diverted water for agriculture. Accordingly, the focus of the technical feasibility analysis presented herein is development of a diversion facility and other infrastructure for recharge of municipal well fields.

8.6.1.1 Source Water Legal Issues and Volumes

The CUFA requires that certain amounts of flow be delivered to downstream users in Arizona and specifies alternate means of calculating amounts that must be bypassed, from the New Mexico point of view, to downstream users. The ways in which these amounts are calculated are "at the option of the Secretary" (U.S. Secretary of the Interior), who may select among the options spelled out in the agreement. In actuality, the method of calculation will probably be selected by the Technical Committee set up under CUFA to interpret all the technical issues relative to flow measurement and control of downstream impacts. The concept behind the "bypass" requirements is to allow diversion only when enough water will remain available for users in Arizona who divert above San Carlos Reservoir. The diverted flow, which would have gone past these "Upper Valley users," is replaced in advance by New Mexico CAP water called for by users below San Carlos Reservoir.

One of the options for determining bypass requirements is a table of the "Upper Valley Daily Demands" (i.e., the demand of the Upper Valley users above San Carlos Reservoir [CUFA Exhibit 2.47, Section A(24)]) by month of the year. Use of this table is complicated by the fact that "additional Arizona rights" that may in the future be adjudicated by court decree, and therefore defined, will constitute "additional daily demand." To establish the "Daily Diversion Basis," 50 percent of this additional demand, up to a maximum of 40 cfs, is added to the amounts in the table or to the Upper Valley Daily Demands established by the other option in the CUFA (CUFA Exhibit 2.47, Section (B)(1.4)). A "New Mexico Diversion Day" is allowable only when the flows at specified gages exceed the total. Once this "Daily Diversion Basis" (bypass requirement) is met, the available flow is multiplied by 0.75 in May through September, or by 0.8 for the remaining months of the year, to determine the amount that can be diverted (CUFA Exhibit 2.47, Section (B)(1.5)).

In addition to the above bypass requirements, the main conditions that regulate diversions and consumptive use of Gila River and San Francisco River water are:

- The maximum allowable cumulative consumptive use in diversions from the Gila and San Francisco Rivers is 140,000 acre-feet in any 10 consecutive years (CUFA Section 4.3).

- No more than 64,000 acre-feet can be consumptively used in an individual year (CUFA Section 4.9) and no more than 4,000 acre-feet of the total use can be consumptively used on the San Francisco River in any year (CUFA Section 4.4)

- San Carlos Reservoir must normally have 30,000 acre-feet of stored water in that year (CUFA Exhibit 2.48, Section 4.5). The San Carlos storage requirement may be reduced if imposing that requirement would result in the number of allowable diversion days being less than would have occurred in the period from 1968 to 1996 (CUFA Exhibit 2.48, Section 4.7).

- The New Mexico CAP water bank must have credits in an amount equal to or greater than the amount to be consumptively used (CUFA Exhibit 2.48, Section 4.6). These credits are established by advance delivery of CAP water to Arizona users below San Carlos Reservoir. The maximum number of credits in the New Mexico CAP water bank cannot exceed 70,000 acre-feet. Deductions from the account occur if the Arizona users call for water that cannot be delivered through no fault of their own. For example, when Arizona users put in a call for CAP water at the beginning of a year, the New Mexico CAP water bank is credited for that amount of water. If not all the water is used at the end of the year, the unused portion is deducted from the New Mexico CAP account. Deductions from the account also occur when New Mexico diverts and consumptively uses Gila or San Francisco River water.

The CUFA also establishes a New Mexico CAP Mitigation Water Bank to address "additional Arizona Rights" that may result from court adjudications (CUFA Section 8.2). "The Secretary of Interior as CAP owner may deliver NM CAP water to the Upper Gila River Arizona water users after the New Mexico Unit is authorized and in advance of any reduction in their Gila diversions to build up this Mitigation Water Bank" (CUFA Section 8).

Additional conditions on diversions to address the actions of individual water rights holders, such as Phelps Dodge, and to maintain certain specified streamflows are included in CUFA Exhibit 2.47 (Sections (B)(1.9)(1.10)(1.11)).

The maximum allowable diversion under the CUFA is 350 cfs. Assuming that San Francisco consumptive uses will occur at a constant rate, the 4,000 ac-ft/yr amounts to about 5.5 cfs, leaving a maximum allowable diversion rate from the Gila River of 345 cfs. There may be times when no deduction for consumptive use on the San Francisco is occurring, and because San Francisco diversions have little influence on the peak Gila diversion rate, DBS&A assumed that any system for diversion from the Gila River as a source for ASR would have a maximum diversion rate of 350 cfs, taking maximum advantage of the period when diversions may be available. Additional constraints and analyses of potential diversions are discussed in Section 8.6.2.

An estimate of the yield available on the Gila in typical years is included as Table 8-15. This estimate is by no means a definitive prediction of diversions that would be feasible in practice, but it does illustrate that a practical level of diversion may be available under all the limitations. As indicated by summing the column of monthly median streamflow values in Table 8-15, 10,000 ac-ft/yr may be physically available in average years. However, as indicated by summing the column of monthly minimum streamflow values in Table 8-15, there may be years during which no water is available. Further, given that an ASR project can probably be developed with less than 10,000 ac-ft/yr, as discussed in Section 8.6.1.5, the yield may make a project feasible, provided practical and reasonably economical diversion, conveyance, and storage methods can be developed.

Table 8-15. Potential Diversions Based on the CUFA and Historical Streamflows in the Gila and San Francisco Rivers

Month	Number of Observations	Streamflow (ac-ft/yr)						
		Maximum	Minimum	Median	Mean	Standard Deviation	25% Quartile [a]	75% Quartile [b]
January	72	21,521	0	3,155	6,547	7,307	472	11,483
February	72	20,133	0	4,852	7,058	7,339	8	13,141
March	72	21,521	0	5,735	8,576	8,967	0	18,648
April	72	20,827	0	0	5,796	8,105	0	13,508
May	73	20,821	0	0	1,990	4,622	0	814
June	73	6,446	0	0	153	793	0	0
July	73	3,308	0	0	226	602	0	81
August	73	16,948	0	53	1,876	3,389	0	2,041
September	73	14,694	0	0	1,240	2,484	0	1,291
October	71	14,130	0	0	1,325	3,022	0	864
November	71	18,362	0	0	2,040	3,932	0	2,017
December	71	18,620	0	2,417	5,271	5,704	325	9,964

[a] The value at which 25 percent of the flows are less than or equal to and 75 percent are greater
[b] The value at which 75 percent of the flows are less than or equal to and 25 percent are greater

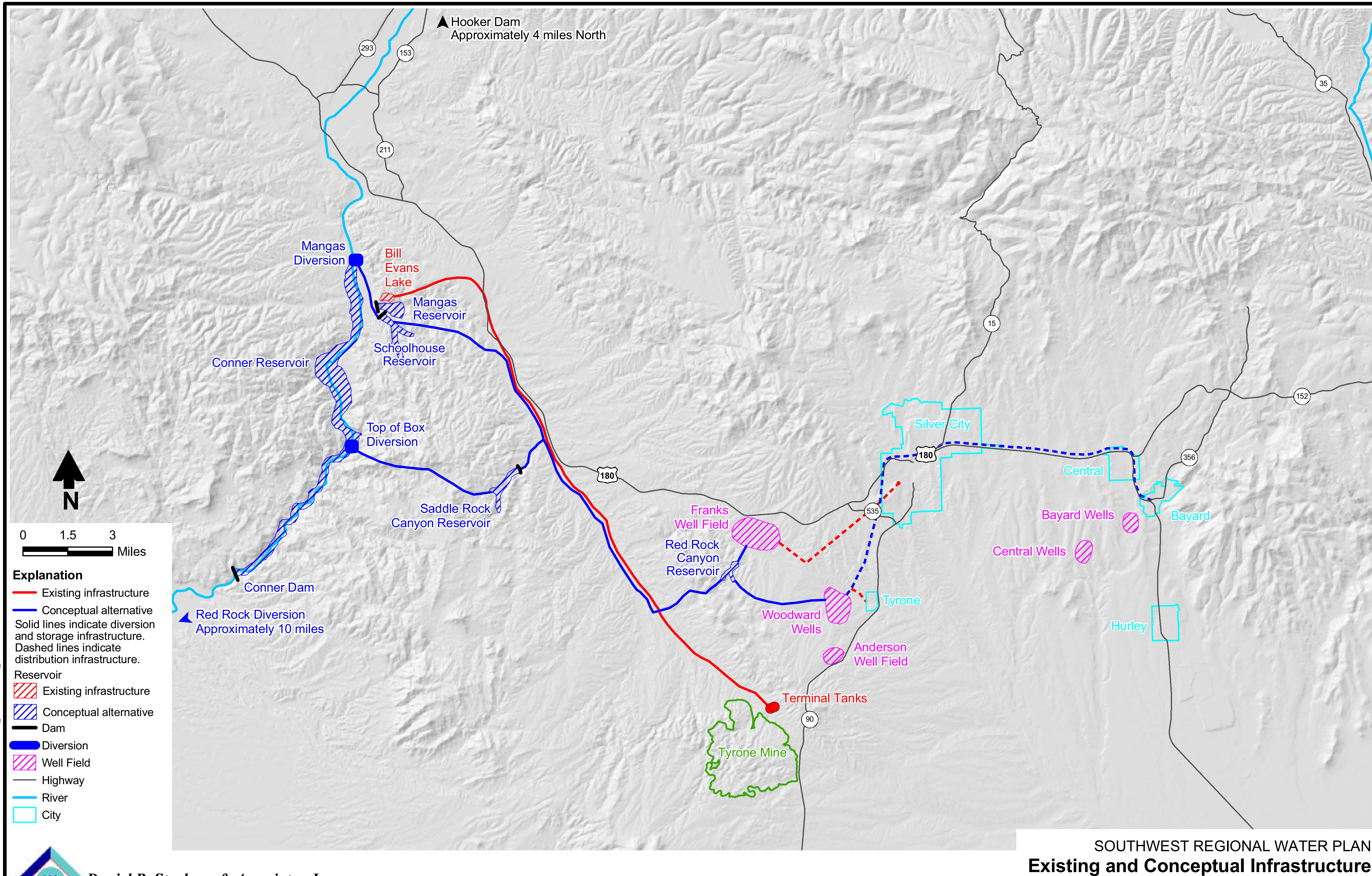
ac-ft/yr = Acre-feet per year

8.6.1.2 Potential Surface Diversion Locations

The only existing large-scale physical diversion for nonagricultural use on the Gila or San Francisco Rivers is operated by Phelps Dodge Tyrone, Inc. (PDTI). This structure diverts from the Gila River above the entry point of Mangas Creek and leads water into a side channel from which it is pumped to Lake Bill Evans and from there to the Tyrone Mine (see red line on Figure 8-6). The path followed by the PDTI pipeline is one of the likely routes for bringing water to the Silver City area for recharge of the aquifers (the pros and cons of using PDTI facilities to divert and convey water for an ASR project are discussed in Section 8.6.1.4). Another potential route would divert from just above the Gila “middle box,” an area about 5 miles downstream (south) (labeled “Top of Box Diversion” on Figure 8-6). A third potential diversion location in the Red Rock Valley would probably not be practical to feed a Silver city area ASR project due to the long transport distance. The ISC did an initial investigation of the hydraulic feasibility of a diversion further upstream, just below the Gila Wilderness boundary, that would allow gravity flow to storage in the Mangas Creek area (Roepke, 2004).

In 1987, the BOR published a report that summarized an initial comparison of nine potential dam sites along the Gila and San Francisco Rivers in New Mexico, two off-stream storage sites in New Mexico, and withdrawal by groundwater pumping along the Gila River in New Mexico (U.S. BOR, 1987). Two mainstem sites (Conner on the Gila and Quail Springs on the San Francisco), the two off-stream sites (Mangas Creek and Schoolhouse Canyon, a side canyon to Mangas Creek) (Figure 8-6), and the groundwater pumping alternative were selected for further study. Subsequent environmental investigation determined that two species listed as threatened under the Endangered Species Act and the native fish population in general would have been negatively impacted by the any of the main stem reservoir sites (USFWS, 1986a, 1986b).

The judgment of the BOR at the time of their feasibility study was that endangered species fish flow requirements increase upstream on the Gila, indicating that Mangas Creek or higher diversion points would be more sensitive. The CUFA negotiations and modeling by ISC and others have considered flow requirements for endangered species and downstream irrigation diversions in establishing the bypass (minimum flow) requirements and other conditions that must be met before New Mexico diversions are allowed.



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12-22-04
JN WR04.0032

SOUTHWEST REGIONAL WATER PLAN
Existing and Conceptual Infrastructure

Figure 8-6

The amount of intermediate storage needed as equalization prior to pumping upstream to ASR varies with the planned amounts of annual recharge to the aquifers, the sizing and capacity of the system that feeds from equalization storage to the ASR location, and the sizing, capacity, and available operating periods for the diversion and gravity flow or pumped conveyance facilities that feed the equalization storage. Based on the estimated yield discussed in Section 8.6.2, it may be most practical to design diversion and initial conveyance facilities up to the intermediate storage location for a capacity of 350 cfs, or 693 acre-feet per day. Assuming that the maximum annual delivery to ASR is 8,000 acre-feet, operating the diversion at maximum capacity would provide the necessary water in about 12 days of operation. The system should be designed to also operate at less than full capacity for times when lesser amounts of diversion are available under the rules, but for purposes of sizing equalization storage, DBS&A assumed that a reservoir would have to be designed to fill in a short time period and be drawn down at a more or less constant rate and fed to the ASR system.

In order to take advantage of the ability under the rules to divert up to 64,000 acre-feet (92 or 93 days at 350 cfs) in a wet year, larger storage quantities would be advisable. With the aquifer as the ultimate storage location for an ASR system, the system will be very reliable over wide ranges of divertible flow and available interim equalization storage. However, significant equalization storage will increase the net yield, improve the water quality, and reduce the cost of the conveyance system from intermediate storage to the recharge location. The cost-effectiveness of equalization storage also increases with the size (cost per acre-foot of storage declines).

8.6.1.3 Potential Surface Diversion Methods

In addition to potential locations, the BOR diversion and use feasibility studies examined several potential diversion methods, including overflow dam and side channel methods similar to the current PDTI diversion, as well as diversion through infiltration gallery systems and groundwater pumping (U.S. BOR, 1985, 1986; Smith, 2004). One of the options studied, which was favored by the USFWS because of its reduced impact on the threatened fish species, was modification of the existing diversion to increase its capacity and improve its ability to avoid harming the fish by entrainment (USFWS, 1986a, 1986b).

The necessary capacity of the pipeline and pumping facilities to and from intermediate storage depends partially on the volume of storage available. It also depends on issues such as reliability and willingness to accept some loss of net yield for economy in construction.

Diverting up to 350 cfs during high flows creates practical problems for design of the diversion method. As discussed in Section 8.6.1.6, the existing PDTI diversion system has a pumping capacity on the order of 30 cfs and, to avoid problems with sediment, has typically not been operated during flood conditions where the diversion system was damaged or when excessively turbid conditions existed. Any direct surface diversion design should ideally include provisions for the management of sediment loads. A diversion below the elevation of intermediate storage will also require firm pumping capacity for 350 cfs and a pipeline 6 to 8 feet in diameter to avoid excessive head loss up to the intermediate storage location. This is probably the motivation for initial investigation by ISC of upstream diversions that would feed by a gravity pipeline to the intermediate storage. Such an approach would avoid high first-stage pumping costs but would require a long (on the order of 10 to 15 miles), large-diameter pipeline or a canal, possibly with some tunneling and probably with presedimentation basins of some sort at the inlet. A gravity system will also have routing and right of way issues.

In their 1980s preliminary planning, the BOR looked at diversion by infiltration galleries (bank filtration) (Smith, 2004). Apparently this was conceptual work, and infiltration capacity was not measured in the field. However, the BOR staff involved seem to believe that bank filtration might be feasible. The BOR did not have the bypass parameters and diversion rates currently contemplated when they did their studies, and they may have been considering lower diversion rates. A bank filtration system would avoid the need for presedimentation, but might be subject to diminished capacity that requires reconditioning or replacement of the filtration devices. A field of horizontal collector wells, perhaps extending under the riverbed, might provide enough capacity. Further investigation of the alluvial hydrogeology would be necessary to evaluate the ability of bank or horizontal collector filtration to support diversions at high rates.

8.6.1.4 Side Canyon Intermediate Storage

All of the BOR alternatives included varying amounts of surface water storage in side channel reservoirs at either the Mangas Creek, Schoolhouse Canyon, or Saddle Rock Canyon sites (Figure 8-6). Either the Mangas Creek or Schoolhouse Canyon sites would be possible storage locations for a diversion from the Mangas Creek area, while the Saddle Rock Canyon site was envisioned as a storage location for a top of the box diversion. Of these three sites, the Mangas Creek site offers the largest potential storage volume, with a given dam height, but would dam a perennial stream and may therefore be more likely to impact the environment. Original BOR storage volume targets for the Mangas Creek site were in the 80,000- to 100,000-acre-foot range (later work reduced the storage range from 20,000 to 76,000 acre-feet), with the smaller storage volumes intended for lower yield alternatives. The USFWS (1986b) was concerned about the potential for eutrophication and propagation of exotic species (non-native fish) and favored a dry canyon storage option such as Schoolhouse Reservoir.

As mentioned in Section 8.6.1.2, there is no fixed storage requirement, but the volume of available storage increases the yield and reduces the cost of the project. Although further study of the trade-offs is needed, significant storage will be necessary, and a volume in the neighborhood of 50,000 acre-feet might be reasonable.

8.6.1.5 Transfer from Intermediate Storage to Silver City Well Fields

Diversion and intermediate storage would provide a water source to be pumped up to Silver City for storage in the aquifers that supply well fields in the Silver City area. The route that would be used depends on the diversion and intermediate storage locations. The two potential routes studied by the BOR, from the Mangas Canyon area and a “top of the box” location (U.S. BOR, 1987), and the 1984 groundwater recharge study route (Hernandez et al., 1984) from the then proposed Conner Reservoir to a small intermediate reservoir in Red Rock Canyon are shown on Figure 8-6.

As discussed in Section 8.6.1.2, the logical design basis for the conveyance from a Gila Diversion to intermediate storage may be the maximum diversion rate of 350 cfs. The BOR feasibility work conducted in the 1980s assumed that, for the alternatives they investigated, the feed to an ASR system in the Silver City well fields could have a net annual yield of 3,000, 6,000, or 9,000 acre-feet to aquifer recharge (U.S. BOR, 1987). The groundwater recharge study (Hernandez et al., 1984) was based on a projected annual demand of 8,000 acre-feet and assumed the construction of a mainstem reservoir, backed up by Conner Dam, from which water would be pumped to intermediate storage at Red Rock Canyon and then on up to the well fields. In both cases, future demand was based on estimates of long-term population growth and future per capita demand.

The groundwater recharge study (Hernandez et al., 1984) looked at two alternatives for sizing the pumping and pipeline to the well fields. One system was sized to pump at a rate of 15 cfs, while the other was sized for 66 cfs. Using the 8,000-acr-ft/yr yield proposed in that study, continuous, year round pumping results in a required rate of 11 cfs. Their purpose in considering this range of pumping capacities was to examine the extra capital cost necessary to be able to pump at higher rates for shorter periods. One consideration was the ability to take advantage of off-peak power rates by pumping at night. Another was the ability to pump larger-than-normal quantities in years when the Gila River had higher-than-normal flow.

The study did not appear to consider variation in the size of the intermediate storage reservoir required for the 15- and 66-cfs pumping rate up to the well fields. Being able to empty intermediate storage more quickly would appear to allow some reduction in size of the reservoir. The specified pipeline diameter for the 15- and 66-cfs pumping rates were 24 inches and 48 inches, respectively. Without an intermediate reservoir of significant size, the transfer rate up to the well fields must approach the 350 cfs maximum diversion rate, which would require a 6- to 8-foot-diameter pipeline or more (and much more expensive) pumping and other facilities.

Some intermediate storage is also necessary to assure that the turbidity and suspended solids content of the raw water is such that it can be artificially recharged and/or injected into existing Silver City wells for ASR. Without residence time in a reservoir of significant size, an expensive water treatment plant would be necessary. The sediment load might also still require presedimentation basins prior to the water treatment plant, probably at the diversion location.

8.6.1.6 Use of Phelps Dodge Tyrone, Inc. Diversion Facilities

The existing PDTI diversion in the Mangas Canyon area includes a diversion dam that feeds a side channel taking water to pumping facilities. These diversion pumping facilities lift water up to Bill Evans Reservoir, on the north side of Mangas Canyon. The water is normally not pumped from the diversion during high flood stages if the diversion has been compromised by flood conditions or excessive suspended solids are present. The pumping plant contains four 4,500-gpm pumps, which provide a pumping capacity of 10 cfs per pump or 40 cfs with all the pumps operating. The pumping to Bill Evans occurs through a 1-mile–long, 30-inch-diameter pipeline. The water is pumped from about 4,400 feet above mean sea level at the diversion to 4,660 feet at the point where it enters Bill Evans Lake. When full, the lake has a maximum elevation of 4,676 feet; therefore, the total static head on the system is about 275 feet. The lake holds approximately 2,100 acre-feet and has a surface area of 62 acres.

Up to six 1,620-gpm (400 horsepower [hp] each) pumps send the water from Bill Evans Lake through 13 miles of 27-inch-diameter pipeline to the Upper Mangas Pumping Plant, which in turn sends the water through another 9 miles of 27-inch pipeline to two 4 million-gallon terminal storage tanks at the Tyrone Mine. The bottom elevation of the terminal tanks is 5,870 feet, and the water surface when full is approximately 5,900 feet; therefore, the elevation gain from Bill Evans Lake is as much as 1,240 feet and the total gain from the Gila is about 1,500 feet.

PDTI has expressed some interest in assisting with regional municipal and industrial use of water diverted from the Gila River, either by leasing an unspecified amount of their diversion rights at some future time and/or by allowing use of excess capacity in their diversion and pumping facilities (Shelley, 2004b). Excess capacity in the PDTI system might be used to carry water diverted under the CUFA agreement.

The Tyrone Mine is authorized to consumptively use an average annual limit of 6,582 acre-feet. The maximum in any one year is 7,614 acre-feet, and use above the average annual allotment must be compensated by reductions in other years. The maximum capacity of the system is considered to occur with five out of the six available pumps operating at each of the post Bill Evans pump stations. This translates to a flow of from between 7,900 and 8,700 gpm (about 19 cfs) to between 12,800 and 14,000 ac-ft/yr (Shelley, 2004a; LHJ, 1968). This analysis of excess system capacity beyond Bill Evans Lake has led PDTI to the conclusion that 6,200 to 7,400 ac-ft/yr of excess capacity is available (Shelley, 2004a). The question is whether this capacity could be used to transport water to the Silver City area as a source for aquifer recharge. With one pump out of service in the system from the diversion to Bill Evans Lake, the capacity would be about 13,500 gpm or 30 cfs.

Although the excess capacity beyond Bill Evans is in the range necessary to supply an ASR system, use of existing PDTI facilities would be limited by the capacity of diversion pumps and pipeline and by the limited Bill Evans storage capacity. PDTI has diverted at a range of flow conditions allowable under the CUFA, but typically does not operate the diversion pumps at high flood stage to avoid damage to the diversion operation and excessive sediment load in the flow. Under the CUFA, water is most likely to be diverted under higher flow conditions, and ideally, the diversion capacity should approach the 350-cfs maximum rate. Considerable redesign and enlargement of the diversion system, pumping facilities, and pipeline would thus be necessary to use the PDTI facilities to achieve the ideal diversion capacity allowable under the CUFA. A system for presedimentation of diverted flow and possible additional storage (beyond Bill Evans Lake) might also be necessary.

The BOR study did consider modification of the existing PDTI diversion dam and channel to feed new pumping and a new first-stage line up to (at that time) Mangas Creek Reservoir (U.S. BOR, 1985, 1986). The USFWS favored this approach to avoid additional diversions, provided that the redesign included multilevel intake structures, upstream fish barriers, and the design and/or operation of the "Direct Pumping diversion facilities to avoid entrainment and impingement of fishery resources" (USFWS, 1986a). USFWS also preferred the Schoolhouse Canyon storage location to avoid the problems of damming a perennial stream (USFWS, 1986b).

Another means of using PDTI diversion and conveyance facilities would be actually leasing some of their Tyrone Mine water rights, as a substitute for diversion under the CUFA, as the source for aquifer recharge. Discussions with PDTI staff indicated that leasing water rights at some point in the future is possible, but additional evaluation of Tyrone Mine future requirements is necessary to identify the quantity and timing.

Some combination of CUFA diversions and facilities and/or PDTI diversions and facilities could be made available as a source for artificial aquifer recharge to feed a regional system. The possibility of incorporating PDTI facilities and water rights should be maintained as part of the mix of alternatives to be further investigated. The conveyance would have to be tapped off at the location shown on Figure 8-6 to supply the existing Silver City well fields, and some additional pumping from the 5,900 maximum elevation of the Tyrone system to the 6,100-to 6,300-foot elevation of the Franks and Woodward well field storage reservoirs would be necessary. Approximately 40,000 feet of new transmission line would also be required.

8.6.1.7 Aquifer Storage and Recovery Facilities

The primary aquifer in this central Grant County area is the Gila Conglomerate. This aquifer is made up of alternating layers of mostly consolidated to poorly consolidated clay, silt, sand, and gravel. In many areas the aquifer exhibits semi-artesian conditions. The hydrologic system in the area involves two major OSE-declared hydrologic basins: the Gila-San Francisco and the Mimbres (Figure 5-12). The groundwater divide between the two basins closely parallels the Continental Divide, and except in areas where the gradient is reversed by groundwater pumping, water moves generally northwest toward the Gila River or southeast toward the Mimbres Valley. This groundwater divide lies between Silver City's Franks Ranch well field to the north and the Woodward-Anderson well fields to the south.

As discussed above, a study conducted for the Town of Silver City and the ISC investigated the feasibility of using a Gila diversion as a source for storage in this and other aquifers in the area (Hernandez et al., 1984). Other well fields and locations were investigated, but recharge into drawn-down areas of the Franks Ranch and Woodward-Anderson well fields was considered the most practical alternative. The study found highly favorable conditions for artificial recharge, including washes with highly permeable sandy alluvial fill crossing areas near well field draw-down locations.

The work compared using artificial recharge into these natural systems both with use of constructed recharge pits and basins and with conventional ASR by injecting into existing wells. The various methods all seemed feasible provided the water had less than 5 parts per million of suspended solids. Water from Bill Evans Lake was used as a reference, and it normally meets that water quality requirement, partially due to operating the Gila diversion only during periods of lower flow.

The study envisioned that Conner Reservoir would be the means of capturing high flows on the Gila and included a small equalization storage reservoir (5,000 to 6,000 acre-feet) at Red Rock Canyon. From the 5,450-ft msl elevation of Red Rock Canyon reservoir, the water would be pumped to the Silver City Franks and Woodward well fields and recharged into the aquifer by the most economical method, probably by spreading in washes or discharge into excavated recharge trenches. Various methods of injecting water into an aquifer, including infiltration galleries and recharge wells, are discussed in Section 8.5.

8.6.1.8 Regional Water System

The layout of the regional water treatment system may be less of a concern than the many other issues generated by this alternative. The Silver City/ISC study (Hernandez et al., 1984) included a plan for the communities to be served and a backbone layout of the system (Figure 8-6). The Silver City wells would feed into the existing Silver City system, probably with new piping and booster pumping to handle the additional regional demand. An enlarged transmission line could take water to existing Silver City tanks. Some new storage tanks would be necessary. Water would be routed through Silver City and out Highway 180 to new demands from the central Grant County participants in the regional system. The backbone layout of the system is provided in Figure 8-6, but details of which communities should be connected and the exact design and sizing of system elements will require additional engineering analysis.

Operation of the Gila diversion, intermediate storage, transmission, aquifer recharge, and regional water systems could be done or contracted by a Joint Powers Authority (JPA) evolving from the SWPG or by combinations of the BOR, Town of Silver City, the JPA, and others.

A central Grant County regional water system would not provide water for the entire Southwest Region, as the remoteness of the central Grant County area and the Silver City well fields from some demand centers, such as Deming, Lordsburg, Reserve, and others, will probably make them impracticably costly to serve. Regional solutions will require use of some of the other alternatives analyzed in this *Southwest New Mexico Regional Water Plan.*

8.6.1.9 Groundwater Pumping as a Diversion Method

One area of the region that could immediately benefit from additional water availability is the Gila-San Francisco declared groundwater basin. Groundwater pumping and use is very restricted in this area due to the requirements of the *Arizona v. California* decree (Section 4.2.1.2). For example, individuals with a domestic groundwater right are prohibited from using groundwater for outdoor watering, essentially preventing homeowners from having a garden or outdoor landscaping. Finding a way to allow users in this area to pump additional groundwater that would be offset by importation of Gila CAP exchange water into the region would alleviate these severe restrictions.

The feasibility of this alternative depends on whether additional groundwater pumping would be allowed by the OSE and whether additional pumping could be conducted in such a way as to meet the diversion limitations set out in the CUFA.

The authorizing legislation (Colorado Basin Project Act) and the amending legislation (Arizona Water Settlement Act) allow for the exchange mechanism to take place through groundwater pumping (AWSA Section 212(d)). The CUFA allows diversions by groundwater pumping with the approval of the Technical Committee (CUFA 12.4.1.4). From a water rights perspective, the

OSE would have to determine how to administer this “new” water from the Gila and likely would need to develop new guidelines for processing applications to use CAP water through a groundwater pumping exchange mechanism. Water rights under the AWSA have a priority date of 1968 (CUFA, Section 4.15). The issue for the OSE would be whether such diversions would result in impairment to water rights holders located near the wells where the additional pumping would take place. Another issue is how to account for diversion amounts.

A groundwater modeling effort, sanctioned by the Technical Committee, would be required to estimate impacts of increased groundwater diversions. Because depletions of river flow are not allowed during low-flow periods and groundwater withdrawal near the rivers might result in higher flow depletion in dry periods, some mechanism for analyzing groundwater-surface water interactions and making the low flows whole would probably be required. This might be accomplished by pumping to the river or by diversion to side canyon storage and low-flow releases back to the rivers. It is therefore conceivable that an actual physical diversion and storage alternative could serve as a source for both aquifer storage in Silver City well fields and mitigation of the low flow depletion effects of diversion by groundwater pumping.

Aside from the legal issues, water users in the region desiring some relief against outdoor use restrictions are likely spread diffusely within the river basins, and some may be fairly remote from direct groundwater-surface water interaction. Again, the key issue in implementing groundwater withdrawals in outlying areas is whether they will impact surface water, specifically the ability to meet the bypass flow requirements of the CUFA.

8.6.2 Hydrologic Impacts

The amount of water that can potentially be added to the regional supply as a result of this alternative is affected by both legal and physical constraints. As described in Section 8.1.1, the recently passed legislation allows for up to an additional 14,000-ac-ft/yr (on the average) withdrawal. However, this amount is constrained by the need to provide bypass flows to downstream irrigators and to adhere to other restrictions specified in the CUFA.

In order to estimate how much water may actually result from this alternative, an analysis of potential diversions based on the historical flow record was performed. USGS streamflow records for the Gila River near Gila, New Mexico and the San Francisco River at Clifton, Arizona gages were selected to be consistent with earlier surface water analyses conducted by the ISC.

Based on the historical record from these gages, the amount of water that could be diverted on a daily basis was calculated based on the following assumptions that were derived from the CUFA and/or discussions with ISC (Roepke, 2004):

- Diversions could only occur when bypass flows and slope factors negotiated with Arizona were met as shown on Table 8-16. The bypass parameters pertain to the combined flow from the Gila and San Francisco Rivers.

- The combined diversion rate from the two rivers cannot exceed 350 cfs (CUFA Section 4.11)

- No diversions from the Gila River are allowed when streamflows are below 80 cfs or from the San Francisco River when San Francisco streamflows are below 30 cfs. These minimum values were set to be consistent with earlier ISC modeling efforts. Additional work to establish appropriate biological minimums will be required as implementation of this alternative progresses.

- No diversions are allowed when the storage in San Carlos Reservoir is below 30,000 acre-feet.

Table 8-16. Bypass and Slope Factor Requirements

Month	Bypass Requirement (cfs) [a]	Slope Factor [a]
January	82.5	0.80
February	137.5	0.80
March	292.5	0.80
April	432.5	0.80
May	437.5	0.75
June	442.5	0.75
July	442.5	0.75
August	442.5	0.75
September	442.5	0.75
October	267.5	0.80
November	152.5	0.80
December	75.5	0.80

[a] Monthly bypass requirement and slope factor values determined through negotiation with the State of Arizona

The calculated monthly and annual allowable diversions based on these requirements are presented in Table 8-15 and Figure 8-7, respectively. These estimates show that the majority of the allowable withdrawals would be in the winter months and, for most years, the total allowable withdrawal would be greater than the 14,000-acre-feet average withdrawal, though in the drier years this withdrawal would not be met. The CUFA does allow for up to 64,000 acre-feet in a single year, provided that the 10-year average does not exceed 14,000 acre-feet.

Using the historical record does not provide an exact prediction of future withdrawals, which are highly uncertain, but it does show potential withdrawals under a range of climatic conditions.

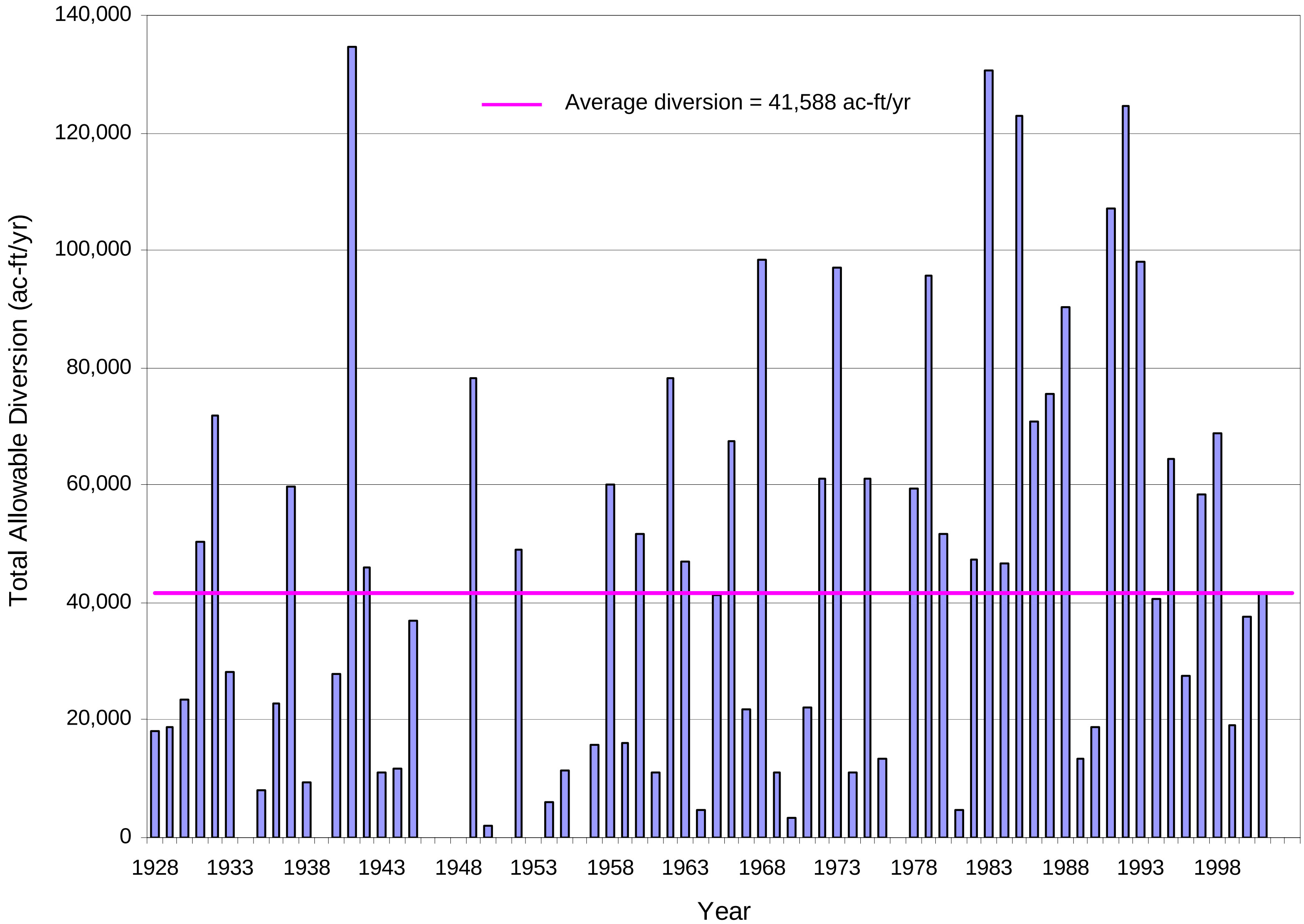
8.6.3 Financial Feasibility

Funding of an ASR project using Gila flows could be provided by the Lower Colorado Basin Development Fund, which under Section 107 of the AWSA can disburse $66 million to $128 million to pay for construction of the New Mexico Unit of the CAP or, if no New Mexico CAP unit is built, up to $66 million for water projects and related activities in the Southwest Region. The funding would be available beginning in 2012. Section 212 of the Act states that "withdrawals from the New Mexico Unit Fund shall be for the purpose of paying costs of the New Mexico Unit or other water utilization alternatives to meet water supply demands in the Southwest Water Planning Region of New Mexico" (P.L. 108-451, Section 212(i)). Allowable expenditures include costs associated with planning, environmental compliance activities, and environmental mitigation and restoration."

8.6.3.1 Infrastructure Costs for Surface Diversion Structures, Aquifer Storage and Recovery Facilities, and a Regional Water System

Previous investigations have estimated the cost of diverting and storing water from the Gila River for use in the central Grant County area (Hernandez et al, 1984; U.S. BOR, 1985, 1986, 1987). Several different scenarios were considered in these documents, and the alternatives changed as mainstem reservoirs were dropped from consideration and project concepts evolved. This evolution continues as is evident in previous discussion of the alternatives, and the recent CUFA further alters the parameters under which any diversion must occur.

The numerous factors that will affect the cost of a diversion and storage project include but are not limited to:



Note: Where withdrawals shown here are greater than 14,000 acre-feet on average, they will be further limited by legal restrictions limiting withdrawals to 64,000 acre-feet in a single year and 140,000 acre-feet over 10 years.

SOUTHWEST NEW MEXICO REGIONAL WATER PLAN

Annual Gila River Diversions

Daniel B. Stephens & Associates, Inc.

5/25/05

- Diversion location
- Diversion type and construction (pumping, gravity, direct surface or infiltration, fish protection and other features)
- Diversion rate and volume, as influenced by maximum diversion and bypass restrictions
- Equalization storage facility location
- Equalization storage facility size and design
- Conveyance system capacity, as influenced by target aquifer storage amounts and operational down time
- Conveyance system route
- Design and annual storage goals for recharge system
- Utilization of existing facilities

The BOR Upper Gila Water Supply investigations (1985, 1986, 1987) considered diversion facilities from the Gila River, intermediate storage facilities on Mangas Creek, and conveyance systems to the Continental Divide above Tyrone and the Silver City well field area. The Silver City/ISC study (Hernandez et al., 1984) was based on the assumption that stored water would be pumped from the then proposed Connor Reservoir (Figure 8-6) and therefore did not consider diversion and lower-elevation equalization storage facilities. However, that study did provide cost estimates for transmission to the ASR location, an artificial recharge facility, and a regional distribution system.

Because the specific design and location of any potential project is unknown at this point, DBS&A's attempt at estimating the cost of a hypothetical project is preliminary and requires a number of assumptions that are subject to change. Further work in selecting and planning elements of any diversion alternative, including field measurements and environmental assessments, is essential to accurate cost estimating but beyond the scope of work for this Regional Water Plan. Nevertheless, in order to provide the planning region with some idea of the current cost of this type of project, DBS&A assumed a scenario for a possible project design, based on the findings of previous investigations and our understanding of current diversion limitations.

This scenario consists of diverting Gila River high flows, as defined by CUFA diversion parameters, to an intermediate storage facility as close to the Gila River as possible, and from there, transferring it to a recharge facility near the Silver City well fields at a continuous rate during the remainder of the year. The following assumptions were made as part of this scenario:

- Water will be diverted by a new surface diversion structure.
- The diversion type will be direct pumping of surface water.
- The diversion rate will be 350 cfs maximum capacity.
- The average supply to be diverted will be 8,000 ac-ft/yr (higher in years when more water is available; lower in years when water is not available).
- The storage facility will be located in Mangas or Schoolhouse Canyons.
- The capacity of the conveyance system above the storage facility will be 15 cfs.
- The storage facility will have a volume of up to 50,000 acre-feet.
- Recharge facilities will be surface trench infiltration and/or arroyo spreading, with a maximum capacity of 8,000 ac-ft/yr.
- No existing facilities will be used.

The infrastructure associated with this example project cost estimate consists of five primary components:

- Diversion facilities and transport to storage
- Intermediate storage facility
- Conveyance system above storage
- Aquifer storage and recovery facility
- Regional water distribution system

Total annual costs for each of these components of this example project, including operation, maintenance, repair, and repayment of capital expenses, and other miscellaneous expenses, are summarized in Table 8-17. Annual repayment costs were determined using an interest rate of 3.34 percent based on a project life of 50 years (a compromise between long-life reservoir facilities and short-life water line and other facilities). The total annualized costs of the project and price per acre-foot are also indicated on Table 8-17. These cost estimates are based on original costs derived in the early to mid-1980s, adjusted to 2003 equivalent costs using the Consumer Price Index (CPI): estimates made by Hernandez et al. (1984), which used 1981 dollars, were corrected to 2003 dollars using a CPI multiplier of 2.024, and estimates made by the BOR (1987) using 1986 dollars were corrected to 2003 dollars using a CPI multiplier of 1.62. The validity of this cost estimating approach is discussed further at the end of this section.

Table 8-17. Example Capital, Annualized Repayment, and Operation and Maintenance Costs for a Gila ASR Project

Component	Cost ($)	
	Original Estimate	2003 Equivalent
Capital costs		
Diversion facilities	34,000,000 [a]	55,080,000 [b]
Intermediate storage facility	30,000,000 [a]	48,600,000 [b]
Conveyance system to well field	11,693,750 [c]	23,668,150 [d]
Environmental mitigation	4,250,000 [a]	6,885,000 [b]
Subtotal for diversion/storage	79,943,750 [e]	134,233,150 [e]
Recharge and distribution capitol costs		
Recharge facility	4,385,000 [c]	8,875,240 [d]
Regional distribution system	10,591,000 [c]	21,437,196 [d]
Subtotal for regional system	14,976,000 [e]	30,312,436 [e]
Total capital costs	**94,919,750 [e]**	**164,545,586 [e]**
Annual costs		
Capital recovery (repayment)	3,907,632 [f]	6,773,940 [b,f]
Operation and maintenance	1,109,300 [a,c]	1,797,066 [b]
Energy	2,351,000 [a,c]	3,808,620 [b]
Total annual cost	**7,367,932 [e]**	**12,379,626 [b]**
Cost per acre-foot	920 [g]	1,547 [g]

[a] From U.S. BOR, 1985, 1986, 1987
[b] Calculated using a CPI multiplier of 1.62
[c] From Hernandez et al, 1984
[d] Calculated using a CPI multiplier of 2.024
[e] Sum of individual components
[f] Assumes 3.34% interest on 50-year project repayment term
[g] Total annual cost divided by 8,000 acre-feet per year

The estimates in Table 8-17 include:

- *Diversion facilities:* The BOR estimate includes a concrete diversion structure approximately 2.5 miles upstream from the intermediate storage facility, two pumping plants, and 2.5 miles of pipeline from the diversion to the storage facility. Because of the pumping and conveyance costs associated with moving 350 cfs, it would be highly desirable from an economic standpoint to locate the intermediate storage facility as close to the diversion point as possible.

- *Storage infrastructure:* The BOR estimate includes an earthfill embankment dam, a 46,000-ac-ft-capacity reservoir, and all associated inlet works, outlet works, and other physical components.

- *Post-storage conveyance infrastructure:* The Hernandez et al. (1984) estimate includes 20- to 24-inch-diameter piping and several pumping stations capable of transmitting 11 cfs of water from the diversion location to a reservoir in Red Rock Canyon near the Silver City well field and 15 cfs to the ASR area, as well as all associated land acquisition, road construction, and other project costs. This information was used to compile cost information for constant rate pumping from storage to the ASR site.

- *Aquifer storage and recovery infrastructure:* The Hernandez et al. estimate (1984) includes excavation of recharge trenches capable of recharging 9,000 ac-ft/yr, fencing and maintenance facilities, water lines, pumping stations, chlorination stations, refurbished pump stations at the Silver City well fields, and engineering costs.

- *Regional water distribution system:* The Hernandez et al. estimate (1984) includes transmission lines, tanks, booster pumps, and telemetry systems capable of conveying water from the existing well fields to the Silver City, Central, Bayard, Arenas Valley, and San Vicente areas.

New Mexico may also be required to pay operation and maintenance costs for the CAP exchange water used to build up the New Mexico Water Bank (CUFA Section 5.4.2). However, for an 8,000-acre-foot yield, that cost should be only a few hundred thousand dollars per year. Because some environmental mitigation will be necessary for any projects, BOR estimates for that cost were also updated; such costs are even more subject to change than facilities costs.

The greatest challenge in estimating the cost of this alternative is the lack of clear project definition. More formal cost estimating procedures would be based on either (1) current cost of land, materials, power, construction and other project elements or (2) adjustments of equivalent previously costed elements (with better definition of the project) using construction cost, power cost, and other appropriate indices. This level of effort is beyond the scope of this regional water plan and, given the fluid state of the potential project elements in any diversion and aquifer storage project, is probably unwarranted at this time. Using a CPI adjustment approach simplifies the cost update and overcomes the lack of easily obtainable information for adjustment with the other cost indices. Accordingly, the costs in Table 8-17 are very preliminary and could be vastly different from a thorough cost estimate using up-to-date prices and well defined facilities.

More careful conceptual design of the various elements may introduce new ideas and approaches that drastically reduce the cost. DBS&A's cost basis was totally new diversion and storage facilities, but some work has been done to consider modifying and sharing the existing PDTI diversion structure. Also, a lower yield project would reduce the total project cost, but increase the cost per acre-foot. However, low enough yield might allow pumping all the way up to the ASR location without any intermediate storage and might also make the use of existing PDTI excess capacity a viable alternative. Although the total facilities cost in Table 8-17 is higher than the available funding allotted from the Lower Colorado Basin Development Fund ($128 million), the diversion and storage total is close ($134 million), and more thorough investigation of alternatives may well develop a financially feasible project.

8.6.3.2 Costs for Additional Groundwater Pumping

Costs for added groundwater pumping would involve costs for additional technical studies and modeling required to evaluate groundwater pumping impacts on surface flows and to establish appropriate diversion limits. Assuming that physical diversion and transport or storage would not be required, these costs could range from a few hundred thousand to several million dollars. Well installation costs are discussed in Section 8.9. The financial feasibility depends to a large degree on the practical diversion yield of this kind of approach.

8.6.4 Environmental Impacts

In 1986, the spikedace and the loach minnow were listed as threatened species under the ESA (51 FR 2379, and 51 FR 39468). Because the Gila and San Francisco Rivers make up part of the habitat of these species, any diversion activities that might affect them are subject to extensive review. In fact, much litigation has ensued regarding the critical habitat designation for these species and activities taking place in the critical habitat areas.

In addition to these endangered species, there is widespread concern about overall protections for the natural environment of these stream systems, as evidenced by the concern and interest of several national environmental groups regarding potential development on the Gila. Any actions to divert and store water from the Gila or San Francisco River will require careful consideration of the timing of diversions in relation to minimum flows needed for endangered species and habitat protections. Diversion structures and storage facilities will also need to be carefully designed to minimize environmental impacts. Before disbursement of any funding, the

CUFA requires compliance with NEPA (42 U.S.C. 4321 et seq.) and the ESA (16 U.S.C. 1531 et seq.), including issuance of a "Record of Decision approving the project based on an environmental analysis required pursuant to applicable Federal law" (AWSA Section 212 (f), (j)). The required "environmental analysis" is generally an environmental impact statement (EIS); that process can also be used to ensure that environmental mitigation is in place.

8.6.5 Political Feasibility and Social/Cultural Impacts

This alternative raises the competing and equally important issues of the need to develop water supplies for the future and the need to maintain the rivers and sustain their riparian and aquatic habitats. Whereas some entities and individuals believe that New Mexico should be able to benefit to the maximum extent possible from the Gila CAP agreement and divert water when and where it is needed, other groups and entities believe that preserving the river as it is is paramount and that additional conservation could provide water for the future rather than diverting water from a free-flowing river.

In order to ensure that all interests are taken into consideration, a continued regional approach to identifying potential diversion projects and scenarios is critical. Involvement of all interested parties will ensure that a future project is designed to help meet future water demand while protecting the rivers.

8.7 Protect Riparian and Aquatic Habitat by Preserving Instream Flows

The Gila and San Francisco rivers sustain a thriving riparian ecosystem that depends in part on the free-flowing nature of the rivers. Recreation in the area, which benefits from healthy riparian systems, provides important economic benefits to the rural community. The passage of the Arizona Water Settlement Act of 2004 (AWSA) and the execution of the CUFA (Section 4.2.1.4) both of which will allow additional diversions on these rivers, raise concerns about maintaining the streamflows and protecting the riparian ecosystem. Accordingly, this alternative considers the feasibility of transferring water rights to instream flow uses to help protect riparian and aquatic habitats. This discussion does not identify where instream flows need to be protected or describe minimum streamflows necessary to sustain certain ecosystem functions. In-depth biological studies would be necessary to make these determinations and could likely be undertaken as part of the studies to consider how best to implement the AWSA in the Southwest Region.

As the region evaluates how it can benefit from the CAP/Gila River exchange mechanism allowed by the AWSA while ensuring protection of the Gila and San Francisco Rivers, a regional process for integrating decision making will be necessary. Through this process the region can decide whether to transfer water rights for the purpose of protecting riparian and aquatic habitat and, if so, determine the number of water rights that should be purchased for such purposes, the ownership of the transferred water rights, and the studies necessary to ascertain instream flow requirements and water right availability. Regional input in terms of allocating funding for these purposes is essential.

8.7.1 Technical Feasibility

This section discusses legal considerations related to water rights transfers, approaches to finding water rights available for transfer, and issues related to implementation. It also briefly discusses instream flow programs from other states and the water rights purchase program on the Pecos River in New Mexico. Finally, two other approaches for protecting streamflows while implementing the AWSA are presented.

8.7.1.1 Transferring Water Rights to Instream Flow under New Mexico Law

In 1998, the New Mexico Attorney General issued an opinion finding that instream use, defined as “the act of leaving water in a streambed for recreation, fish or wildlife, or ecological purposes,” can be considered a “beneficial use” under New Mexico law. The opinion points out that no constitutional provision or statutory section requires a diversion of water for a beneficial use and reasons therefore that instream use can be so classified. The OSE, of course, would have to determine the necessary measuring and metering requirements for an instream use permit.

This opinion has not been tested in court nor has the OSE processed transfers of privately owned water rights to instream flow uses. Attorney General opinions are not binding law (*Local 2238 v. Stratto*n, 108 N.M. 163 (1989)), but courts will nevertheless consider arguments presented in Attorney General opinions (*Board of County Commissioners v. Ogden,* 117 N.M. 181). However, in 1998, prior to the issuance of the Attorney General opinion, the

OSE legal staff drafted a memorandum finding that instream uses could be considered under New Mexico law. Additionally, the ISC routinely transfers water rights through its purchase and lease program on the Pecos River to augment streamflows.

OSE administrative criteria may limit certain transfers in the Gila-San Francisco area, which could limit the number of water rights available for transfer. Specifically, consumptive water rights cannot be transferred between the eight sub-basins (Section 4.5.1.1) of the Gila-San Francisco administrative basin. However, instream uses are generally not considered “consumptive” because the water is left in the river and only a small amount of water is lost to seepage and evaporation. Given that additional diversions and depletions, including remote diversions approved by the CUFA Technical Committee, will be allowed under the AWSA, the OSE may modify its administrative criteria to allow more flexibility in how water is transferred within the Gila-San Francisco Basin.

8.7.1.2 Identifying Water Rights Available for Transfer to Instream Flow Use

Obtaining water rights for transfer to instream flow can be a challenge. One issue is whether sufficient water rights would be available on the market. Even if funding were readily available, water rights owners may not be willing to lease or transfer their water rights. This issue is driven by both economic and cultural concerns: the purchase price must be sufficiently high to convince water rights holders to sell, but individuals who object to such transfers in principle are unlikely to sell under any conditions.

Another factor in selecting key water rights for transfer is location. Water rights that are currently diverted directly from the river or wells located very close to the river would guarantee the most direct impact on streamflows once the right is transferred and the diversions curtailed. Conversely, transferring a groundwater right located at some distance from the river would not immediately benefit the river, as the pumping effects will continue to affect the river even after pumping ceases.

In an inactive market, one approach would be to identify water rights of interest and contact the sellers. The first step would be to fully inventory the water rights on record in the areas of interest and compile the basic water right information available from the OSE databases and paper files. Pertinent information would include owner of record, priority date, consumptive and diversion right amounts, and purpose of use. Based on this analysis, the region would be better able to identify water rights of interest that should be further researched and could possibly be available for purchase or lease for instream flow. The responsible entity would then have to contact sellers to determine whether they were interested in selling or leasing their water rights.

The Deming office of the OSE is developing a tool for the Virden Valley (called the Virden Valley Enterprise-Geographical Information System) that would assist the water right identification process in the future. According to the OSE, this tool, once it is fully developed, will allow users to access the complete history of a water right electronically. Such a tool simplifies the process of identifying water rights that would be best suited for transfer to instream flow. For example, it would be possible to search for water rights that are currently diverted near sensitive reaches.

8.7.1.3 State Managed Instream Flow Programs

Many western states have well established instream flow legislation (which typically defines instream flow as a beneficial use) and programs:

- The State of Washington passed legislation in 1999 to set up a pilot program enabling the state to purchase "water rights under the trust water rights program for the purpose of improving stream and river flows in fish critical basins."

- The State of Oregon also recognizes instream flow rights and has several different programs in place. An interesting example is a program organized by the Deschutes Resources Conservancy, a non-profit organization dedicated to improving streamflow and water quality in the Deschutes basin in north-central Oregon. In the summer of 2002, the Conservancy leased more than 7,500 acre-feet of water from irrigators to enhance streamflows.

Similar types of programs, either state-run or organized by non-profit entities, exist throughout the west and have been effective in protecting and restoring streamflows in various basins.

In New Mexico, the ISC oversees a water rights purchase program on the Pecos River whereby it purchases or leases water rights to increase Pecos river flows to the state line using funds allocated by the Legislature. Although its purpose is to increase streamflows for Pecos River Compact compliance, the program operates much like other instream flow programs in western states. The ISC also has a land and water rights acquisition program authorized by the legislature in 2002 (HB 417). This legislation allows the ISC to purchase land with appurtenant water rights for the purpose of increasing streamflows on the Pecos in order to comply with the Pecos River Compact. These programs could serve as examples for establishing an instream flow protection water rights purchase program on the Gila and San Francisco Rivers.

8.7.1.4 Implementing an Instream Flow Purchase Program

The entity charged with overseeing the New Mexico Unit of the CAP could purchase water rights for instream purposes. Alternately, the ISC or perhaps a regional entity could set up a program similar to the one on the Pecos River. A purchase program that includes lands in addition to water rights could be ideal in certain areas of the Gila and San Francisco river basins because not only would water be available for instream flow, but ownership of the land would afford more control over projects located in specific areas of the watershed for supporting specific habitats.

8.7.1.5 Other Possible Approaches

Due to the way the CAP will operate in New Mexico, preserving some of the CAP water allocated to New Mexico for instream flows could be difficult to implement in the absence of a storage facility. As discussed in Sections 4.2.1.4 and 8.6, the CAP operates as an exchange: the State of New Mexico will be able to divert and consumptively use more water from the Gila River than it is currently allowed to do, and in turn, downstream users can obtain CAP water in exchange for forgoing a portion of their normal diversions from the Gila River. In essence, the Gila water in New Mexico is exchanged for CAP water in Arizona.

If New Mexico doesn't divert the water, then no exchange will take place. However, after construction of a diversion facility, New Mexico could divert and store water for future release for instream flow purposes. Another possible approach would be to pay New Mexico not to divert water. If New Mexico derived a greater economic return for leaving water in the river because an organization paid New Mexico not to divert the CAP exchange water (and the CAP rules still allowed a downstream entity to divert exchange water), then forgoing diversion in order to leave water in the river might be possible.

The New Mexico CAP water bank could be the mechanism through which this could be implemented. The CUFA allows up to 70,000 acre-feet of credits to be placed in the New Mexico CAP water bank. Downstream users can divert the CAP water that New Mexico hasn't begun diverting from the Gila River. In essence, instream flows would be preserved because New Mexico wouldn't be diverting the water, yet downstream users would benefit by being able to divert CAP water.

Also, since the CUFA allows downstream users to divert CAP exchange water before New Mexico is able to divert Gila River water, which amounts to borrowing on future diversions that New Mexico would make, New Mexico would have future diversion rights in the New Mexico CAP water bank account and could allocate some of those future diversion rights to instream flow. New Mexico would receive payment for the water, but could leave the water in the stream.

Another way to protect the rivers would be to operate the diversion facility in New Mexico to provide maximum protection of ecosystem function. For example, in order to protect aquatic species that need high flows at certain times in order to reproduce, diversions could be timed to provide the needed flows. It may be possible to omit diversions during certain periods that would be allowable "New Mexico diversion days" under the CUFA or divert less than the 350 cfs maximum that would normally be allowable if other limitations of the CUFA are met. Also, water in storage could be allocated to instream uses and released during drought years or low flows. However the water is managed, it should be possible to allocate some portion of stored water for future release for instream flow purposes and/or forgo diversions at specific times in order to leave more water in the river and protect the riparian and aquatic environment.

It is important to note that the CUFA already requires baseline streamflows before any diversions can take place. Additional studies would be required to determine if these flow requirements set up in the CUFA are sufficient to protect riparian and aquatic habitat.

8.7.2 Hydrologic Impacts

Transferring water rights to instream flow will help sustain streamflows, but a significant number of water rights would have to be transferred to achieve a tangible benefit. Maintaining 1 cfs of streamflow over a full year requires approximately 730 acre-feet of water (1 cfs $\approx$ 2 acre-feet per day x 365 days = 730 ac-ft/yr). To meet the goal of the land and water rights acquisition program on the Pecos (to protect a baseline of 50 cfs in a specific reach), for example, the ISC would have to accumulate 36,000 acre-feet of water rights (730 ac-ft/yr x 50 cfs = 36,000 ac-ft/yr), even before taking into consideration losses from seepage or evaporation.

Thus in developing a strategy for identifying and purchasing water rights for instream flow, it might be best to begin by identifying reaches vulnerable to lower flows and setting a priority of purchasing water rights in those areas. Near springs or areas with generally low flows, even 1 cfs of increased flow could be beneficial to the aquatic environment.

From a practical perspective, it will be essential to measure flows in order to determine whether the instream water rights are remaining in the river. The AWSA provides funding for adding more gages along the Gila and San Francisco rivers. These additional gages will allow better understanding of flows in certain reaches and will allow for the measurements needed to ensure that instream flows remain in the river.

8.7.3 Financial Feasibility

Funding for maintaining instream flows could come principally from the monies set aside in the AWSA, Section 107 of which states that "withdrawals from the New Mexico Unit Fund shall be for the purpose of paying costs of the New Mexico Unit or other water utilization alternative to meet water supply demands of the Southwest Water Planning Region of New Mexico, as determined by the New Mexico Interstate Stream Commission in consultation with the Southwest New Mexico Water Study Group or its successor, including costs associated with planning and environmental compliance activities and environmental mitigation and restoration."

This language appears fairly broad and could potentially allow funds to be allocated for purchasing existing surface water rights for instream flow. Since diversions for the purpose of meeting water supply demands may have an impact on riparian and ecosystem functioning, purchasing water rights to transfer to the river to offset those diversions could be considered an environmental mitigation measure.

State funds for a water rights purchase program could also be pursued, including a legislative appropriation for a water rights purchase program or an application to the water trust board.

8.7.4 Environmental Impacts

Protection of instream flows is one of the key elements needed to preserve riparian and aquatic habitats in the arid southwest. This alternative would benefit the Gila and San Francisco rivers if sufficient water could be transferred or dedicated to instream flow so that minimal flows are maintained during drought years and so that diversions along the river do not severely impact smaller reaches. Because the Gila and San Francisco rivers are free flowing, it should be possible to design future diversion projects and diversion strategies so that aquatic and riparian habitats are maintained. Dedicating water to instream flow will contribute to the maintenance of a healthy riparian ecosystem.

8.7.5 Political Feasibility and Social/Cultural Impacts

This alternative raises the competing and equally important issues of the need to develop water supplies for the future and the need to maintain the river and sustain its riparian and aquatic habitat. The heart of the issue is diversion versus leaving water in the river. Some entities and individuals believe that New Mexico should be able to benefit to the maximum extent possible from the Gila CAP agreement and divert water when and where it is needed. Other groups and entities believe that preserving the river as it is is paramount and that additional conservation could provide water for the future rather than diverting water from a free-flowing river.

In order to ensure that all interests are taken into consideration, a continued regional approach to identifying potential diversion projects and scenarios is critical. Involvement of all interested parties will ensure that any diversion projects are designed to help meet future water demand while protecting the rivers.

8.8 Water Banking

Water banking, as presented in this alternative, refers to a streamlined method of reallocating or transferring the use of water through a centralized management entity. Rather than attempting to find buyers or lessees for a particular water right, water rights holders “deposit” their water rights in a “bank,” which then leases the water rights to third parties. The water rights holder is protected from forfeiture of the water right and benefits from revenues obtained for use of the water by a third party. Buyers or lessees of water rights can apply directly to the water banking organization and request a certain amount of water without having to research what water rights are available on the open market.

Other forms of water banking not considered in this alternative include:

- An information clearinghouse that allows buyers and sellers of water rights to identify and find one another. This arrangement can be initiated by a governmental entity (such as in the State of Idaho) or by private brokers who list water rights on an internet database that can be consulted by the general public.

- A facility such as a reservoir where water can be stored or banked for future use. For example, the Arizona Water Banking Authority operates the water bank associated with the CAP.

- The New Mexico CAP water bank, which accounts for diversions of water under the AWSA.

- Groundwater storage, which could serve the same function as an aboveground reservoir. New Mexico law allows the use of groundwater aquifers to store water for future use through the Groundwater Storage and Recovery Act (NMSA 72-5A-1 through 17). Legislative changes would be necessary to use such storage as a water bank since the current law does not allow water stored in aquifers to be transferred or leased to other entities. Only the existing permit holder has the right to use the water in the future (Belin et al., 2002).

8.8.1 Technical Feasibility

The concept of moving water among users to optimize use or address shortages is not new. Water users within irrigation and conservancy districts informally transfer water and regularly enter into agreements regarding transfers and the fallowing of fields. As long as the purpose and use remain the same and the transfer is within district boundaries, OSE approval is not necessary. However, a regional water bank would involve moving water from existing uses to new uses and would occur throughout a stream system or basin. The technical feasibility associated with a regional water bank consists of:

- Overcoming legal impediments to water banking
- Establishing and managing a water bank, including:
  - Setting up the water bank agency or entity
  - Drafting water bank rules

- Administering the water bank
- Training staff

8.8.1.1 *Legal Impediments to Water Banking*

Water banking is new to New Mexico, and for the moment, no comprehensive water banking legislation exists that would allow for a regionally operated water bank. Attempts to pass statewide water banking legislation have failed in the past. Significant opposition to water banking comes from representatives of certain acequias throughout New Mexico (New Mexico Acequia Association, 2000).

Nevertheless, a limited local water banking initiative was successfully passed in 2002 (NMSA 72-1-2.3) for an area (the Pecos River) that excluded any acequias. Under this statute, the only entities with the authority to create water banks are irrigation districts, conservancy districts, artesian conservancy districts, community ditches, and water users' associations in the lower Pecos River Basin below Sumner Lake for purposes of compliance with the Pecos River Compact (NMSA 72-1-2.3A). The legislation allows the water bank to create (with ISC support) expedited transfer procedures that would be submitted to the OSE for approval. Once approved, these procedures would allow for the water bank to "temporarily transfer deposited water to new purposes and places of use and points of diversion without formal proceedings before the State Engineer" (NSMA 72-1-2.3A(4)). The success of this initiative may encourage lawmakers to consider broader water banking legislation in the state.

8.8.1.1.1 Water Rights Transfer Process. The existing water rights transfer process serves the important purpose of protecting water rights holders from impairment due to changes in location or use of the water. However, it acts as an impediment to successful water banking and marketing. Under New Mexico water law, water rights sales or leases are subject to notice, publication, and protest and must be approved by the OSE. While transfers taking place within the boundaries of an irrigation or conservancy district are not subject to OSE approval (NMSA 73 13-4 and 73-14-47), transfers outside such boundaries are involved transactions that can take a year or more to complete and are therefore not conducive to addressing short-term water needs unless arranged ahead of time. Temporary transfers of up to 3 acre-feet are allowed under the New Mexico law; however, this limited amount is insufficient for public water supplies or irrigated agriculture needs. No existing statute allows for expedited transfers of larger amounts of water rights.

Section 72-5-28(G) of the Water Code provides that periods of non-use of water rights that are placed in an OSE-approved water conservation program shall not be computed as part of the four-year statutory forfeiture period. This provision allows qualifying entities—including an individual, acequia or community ditch association, conservancy district, irrigation district, soil and conservation district, or the ISC—to conserve water yet avoid the "use it or lose it" dilemma. The ISC has used this provision to lease water rights in order to increase surface water flows on the Pecos River.

8.8.1.1.2 Limitations of Water Transfers in Declared Groundwater Basins. In some of the declared basins in the Southwest Region, the OSE administrative criteria would make water banking more complex. The Gila-San Francisco, the Mimbres, and the Playas basins all have limitations on transfers within the basin:

- Administration of water in the Gila and San Francisco basins and sub-basins is governed by the Globe Equity Decree and the *Arizona v. California* (373 U.S. 546) decision. Domestic water use is very restricted in this area, and the availability of banked water for short-term small leases would thus be of great benefit. While water right owners who temporarily cease using their water rights may not wish to sell their rights, they might be willing to lease some rights for outdoor use on a temporary basis. This way, individuals would have access to water for outdoor purposes without upsetting the water balance in the region. Administration in the region takes place in a similar block fashion where water rights cannot be moved between blocks or across grid lines. However, because of the need for small amounts of water for outdoor use, it may be possible to have a functioning water bank within each administrative block. Nevertheless, the OSE would scrutinize each transaction to ensure that no impairment would occur as a result of the temporary change.

- The Mimbres Valley Basin has some restrictions on water transfers; however, these restrictions vary depending on the local hydrology, and the OSE will even consider new appropriations in very specific circumstances (Section 4.5.2). Although these restrictions would not prevent water banking, the complex hydrologic review required would slow down the process. In addition, restrictions on transfers between administrative blocks would limit the geographic extent of a water bank.

- For administration purposes, the Playas Valley Basin is divided into 3-mile wide strips, and transfers across those strips are not allowed. Again, these restrictions would limit the geographic extent of a water bank. All transfers would also be reviewed for potential impairment and other OSE criteria such as conservation and public welfare.

8.8.1.1.3 Efforts by the OSE to Facilitate Water Banking. In recently approved, albeit controversial, surface water administration regulations, the OSE sets out an “expedited marketing and leasing” process (NMAC 19.25.13). The process is available after the OSE establishes water master districts and appoints a water master in any drainage area of the state pursuant to existing authority. The OSE must then adopt “appropriate hydrologic models for the (water master) district” through a public rule-making process (NMAC 19.25.13.7(O); NMAC 19.25.13.32). The approved model or models are also referred to as a “generalized hydrologic model” and “take into account existing surface and groundwater diversions and the combined effect of groundwater and surface water uses on the basin groundwater and surface water system” (NMAC 19.25.13.32).

If an applicant agrees to the use of the approved hydrologic model, then the OSE may expedite its review of the application. Relying on the model, the OSE will determine whether the proposed transfer will impair existing water rights or be contrary to public welfare and conservation. With adoption of a generalized model, less time is required by OSE staff to review the accuracy of the models currently proposed by individual applicants and their experts. As a result, application processing time should be reduced. Water rights holders may still protest the application and claim impairment. However, since the model will have been approved through a public rule-making process and will have been closely scrutinized by experts, it will be difficult for a protestant to demonstrate that the model is inaccurate. The expedited marketing and leasing rules do not apply to acequias or community ditches.

8.8.1.1.4 Strategic Water Reserve

In April 2005, the Strategic Water Reserve (SWR) bill became law. Once established, the SWR will function like a state water bank. This legislation allows the ISC to purchase, lease, or accept donations of surface water or water rights or storage rights to make up the reserve. Underground water and water rights may be acquired similarly for the purpose of implementing a cessation of pumping or for limited stream augmentation. The primary purpose of the reserve is to assist the state with interstate compact compliance and assist water management projects to benefit endangered species.

The ISC has the task of developing river reach or ground water basin priorities for the acquisition of the water, water rights, or storage. For each priority reach or ground water basin, the ISC must coordinate with Indian tribes and pueblos, boards of county commissioners, special districts, SWCDs, water authorities, and water planning regions to determine additional priorities within the basin.

The legislature placed some limitations on the water reserve:

- Acequia or community ditch water rights are not eligible for the SWR

- Conservancy and irrigation districts rights may only be acquired through the District board rather than individual water rights holders.

- Water rights must only be used in their basin of origin and cannot be acquired by condemnation. This requirement appears to allow for regional or basin-specific water banks since water cannot move outside the basin.

- Only water rights with sufficient seniority and consistent, historical beneficial use can be purchased.

- Strategic river reserve water rights will not be subject to forfeiture for non-use.

The ISC may lease water at market value, and the proceeds of the leases are appropriated to the ISC to carry out the purposes of the SWR. The ISC may sell water rights that are no longer necessary for the SWR, but water rights may not be sold to the United States, and the first offer of sale shall be for its original purpose of use. Proceeds from the sale of water are appropriated to the State Engineer to adjudicate water rights.

The law requires the ISC to work with regional entities in setting out priorities for the SWR. The Southwest Region, through its municipalities, SWCDs, county boards, and the regional water planning steering committee, will have the opportunity to participate in implementing the SWR in the Southwest Region.

8.8.1.2 Establishing and Managing a Water Bank

If all legal impediments to water banking were overcome, establishing and managing the water bank would be fairly straightforward and would present no insurmountable technical difficulties.

This first step would involve establishing the legal structure of the organization, hiring and training staff, and locating facilities. A water bank would operate under rules and regulations that comply with New Mexico water law. If the model used in the Pecos were to be followed, the OSE would draft a set of rules under which a regional water bank could be chartered and operated.

Administration of day-to-day transactions would be overseen by the director of the water bank. These activities could easily be implemented once water banking is allowed under New Mexico law.

Other tasks to be undertaken by the water bank would include developing an inventory of water rights available for transfer or lease, setting price and transaction fees, defining eligibility requirements, administering leases and contracts (including obtaining metering data), and resolving disputes. Other functions required for successful water banking, such as verification of water right validity and quantity in areas where no adjudication has taken place, would be carried out by the OSE under the current legal framework.

Administration of a water bank where water rights have been fully adjudicated would proceed more quickly than in basins where rights have yet to be adjudicated. Depending on the water banking rules in place, it is likely that only adjudicated or licensed water rights may be allowed to be deposited in the water bank. In cases where a water right has not been adjudicated, the OSE would first review the water right to determine if it is a valid and transferable water right.

8.8.2 Hydrological Impacts

Water transfers and water banking should not alter the water supply or the hydrologic balance in the Southwest Region. A water transfer would move an existing adjudicated water right from its current place of use to a different location. In some cases, the change in place of use of a surface water right may alter the timing or amount of flows in certain river reaches; however, unless the water right was very large, the change in the amount of overall flow of the stream would likely be minimal.

In small-volume systems such as springs, small streams, or ditches, transferring a water right out of the system could alter the flows more significantly or reduce the effectiveness of a conveyance by reducing the volume of the flow. However, for impacts such as these to occur, a significant percentage of the water would have to be moved to a different location. Additionally, if such a change in the water flow had the potential to impair the rights of other water users on that system, the transfer might not be allowed or could be conditioned in a way that protects existing uses.

Additionally, transfers involving groundwater may not impair the water rights of surrounding well owners. The OSE may deny a transfer if the additional groundwater pumping in the move-to location (where the water right is transferred and pumped) will result in impairment.

8.8.3 Financial Feasibility

The price of a water rights transfer is determined by market forces. Prices vary depending on the location and seniority of the water right being transferred, with some rights going for as much as $4,000 an acre-foot in 1995 and probably more today (*Water Strategist*, 1995). In addition to the cost of the water right, transfers include transaction costs such as application and attorney's fees. Finally, if the question of impairment arises, a complex hydrologic evaluation, which could cost anywhere from $50,000 to $200,000, may be necessary.

Water banking would facilitate water rights transactions and perhaps reduce the cost of finding an available water right. However, the water bank would have initial setup costs and annual budget requirements as well as transaction fees, and these would be borne in part by the buyers and sellers of water rights. Consequently, the prices per acre-foot for water rights may increase. However, the risk of litigation and its attendant costs would be greatly reduced.

Setting up the water bank, hiring employees, and purchasing necessary computer and other equipment constitute the initial startup costs for a water bank. Ongoing, recurring costs include salaries and personnel training and operation and maintenance of existing equipment and facilities.

Assuming that a regional water bank would be housed in local government offices, equipment could come from existing inventory. Two full-time employees would likely be necessary. Employees would be required to review existing water rights in the adjudicated areas to update current records of ownership and would require training to perform the duties of the new positions.

Based on these assumptions, the first year's costs for starting a water banking program would be $150,000 to $200,000, depending on the geographic extent of the bank. If surface and/or groundwater modeling is required in order to evaluate potential impairment, the costs could be triple that estimate. Recurring costs would be approximately $125,000 annually.

Potential sources of funding or financing for these costs are:

- Legislative appropriations to the agency housing the water bank
- Income from transaction fees
- General obligation bonds
- Federal or state funding sources (e.g., New Mexico Water Trust Fund)

8.8.4 Environmental Impacts

The environmental impacts resulting from water rights transfers or leases, or from establishing a water bank, depend on the locations that the water is moved from and to. For example, if a water use is moved from a downstream location to an upstream place of use, the streamflow below the new (upstream) point of diversion will be diminished. Depending on the percentage of overall streamflow that the diversion represents as well as the variations in climatic conditions, these types of transfers can have negligible to significant impacts.

Water transfers implemented for environmental purposes, such as ensuring minimum streamflows, can have positive impacts in stream systems.

8.8.5 Political Feasibility and Social/Cultural Impacts

Public policy concerns are central to the debate around water banking. The main concern of rural agricultural water rights holders is that water banking will remove water from traditional agriculture communities to fast-growing urban areas, thereby causing significant impacts to the economy and quality of life in those acequia communities. The other key concern is that movement of water through a water banking process will not allow for sufficient evaluation of impairment on a case-by-case basis. To address these concerns, legislation passed in 2003 now gives acequias the authority to pass regulations that allow them to prevent a water transfer that could harm community interests (NMSA 73-3-4.1). Prior to implementing this legislation, acequias must pass the appropriate bylaws.

Nevertheless, water banking offers opportunities to better manage water shortages by allowing water rights holders to quickly lease their water to other users, avoiding forfeiture and generating income. Many western states have created water banks, and studies show that implementing certain water banking policies and requirements can offset some of the potential negative effects of the water transfers (Interbasin Transfer Working Group, 2002). Proponents of water banking cite the potential economic gain from banking water and the fact that it would provide a means to secure water for economic development.

8.9 Groundwater Development

Localized groundwater depletion has occurred and continues to occur throughout the region, especially in and around municipal well fields (Silver City, Deming, Lordsburg, Columbus) and near large agricultural areas (Animas, Mimbres, Playas Basins). In areas where extensive groundwater extraction has occurred, well fields may eventually be required in new locations in order to maintain historical production rates. In other areas, such as the northern portion of Catron County, extensive groundwater extraction has never occurred because aquifers are naturally deep and have low yields. In both cases, additional sources of groundwater could help the region meet future demand.

Development of new groundwater resources would most likely occur some distance from the location where it would be used, necessitating the construction of new conveyance and distribution systems. Because of the significant costs associated with developing and delivering new groundwater sources, the primary beneficiaries of this alternative will likely be municipal users. Areas within the region where near-future shortages are the most serious and where additional groundwater resource development is most likely to be economically feasible are:

- Silver City area
- Deming area
- Lordsburg area
- Columbus area

Depending upon location, there may be some industrial and agricultural incentives for developing additional groundwater resources as well, especially if done in conjunction with municipal efforts.

8.9.1 Technical Feasibility

Although specialized technical expertise will be required, there are no unusual or particularly challenging technical impediments to developing groundwater resources in the areas listed above. Technical expertise will be required in the following areas:

- Legal assistance will be required to secure water rights (very minimal in undeclared basins).

- A hydrologic assessment and analysis will have to be conducted in declared basins to determine the potential for impacts to nearby water resources and other water users.

- A professional hydrogeologist and/or engineer will be required to locate and design new wells.

- An experienced driller will be required to install any new wells.

- A professional engineer will be required to design and oversee construction of pumping and conveyance infrastructure.

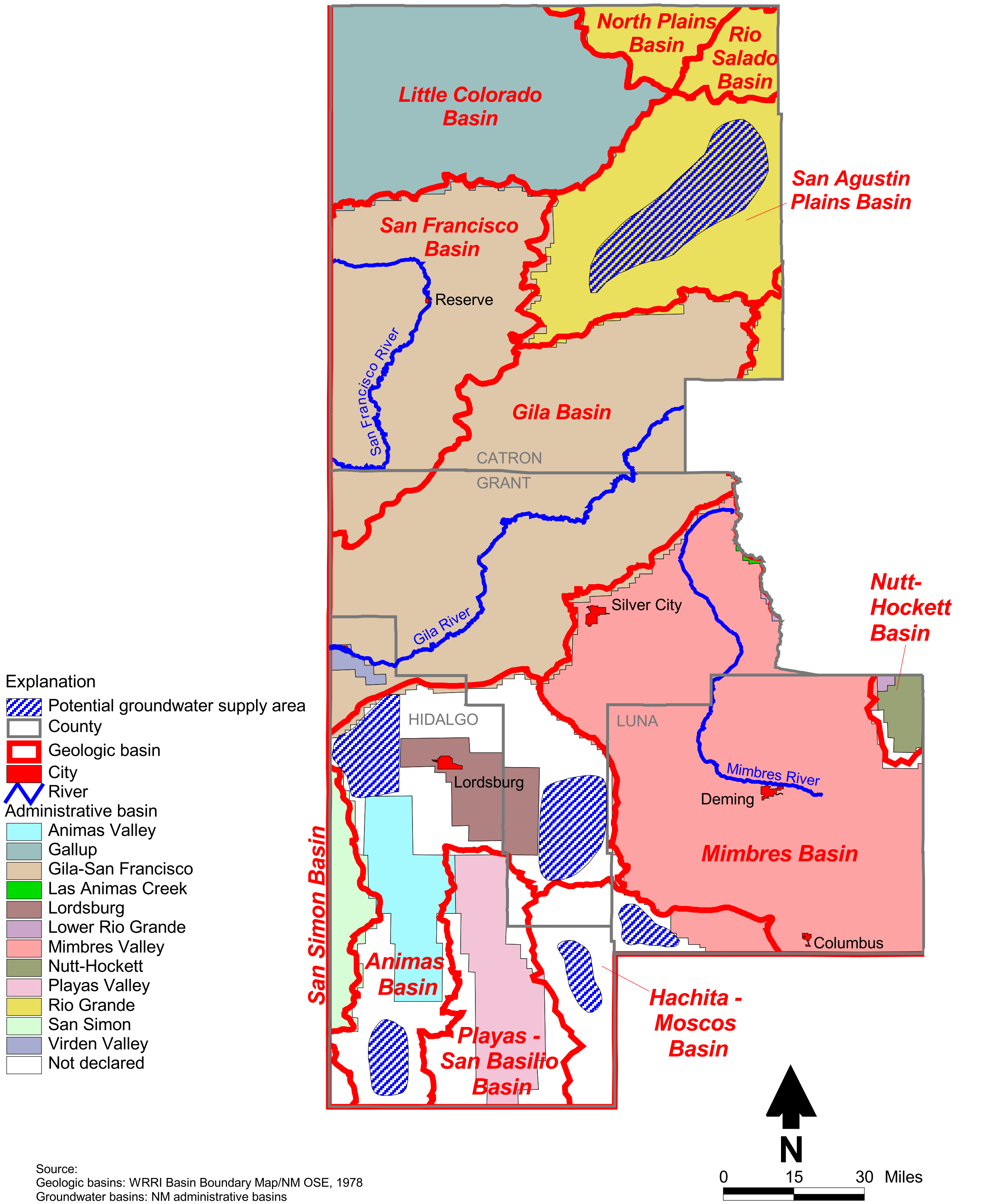
- Skilled technicians will be required for operation of the well field and conveyance system.

In the Southwest Region, potential areas for additional groundwater development were identified based on (1) the presence of significant groundwater supplies, (2) currently low use in the area and (3) the absence of significant legal issues. Based on these criteria, 6 potential areas for groundwater development were identified (Figure 8-8). With the exception of the San Agustin Basin, the potential areas are all within the undeclared basins, and no water right is therefore needed prior to development. In the San Agustin Basin, a water right could only be attained (without an offset) if there is no impairment to the Rio Grande. However, due to the significant distance from the Rio Grande, further investigation of the potential for development in the basin may be warranted. The groundwater resources and potential for new groundwater development in each county are discussed in Sections 8.9.1.1 through 8.9.1.4.

8.9.1.1 Catron County

Although groundwater is found beneath nearly all of Catron County, much of it exists in localized volcanic or deep (more than 500 feet bgs) sedimentary units. The volume of water in the volcanic formations is estimated to be about 20,000,000 acre-feet in Catron County. The amount in localized areas is not thought to be extensive enough for large-scale production wells, and the transmissivity of the deeper sedimentary units is generally too low for large-scale extraction. In order to extract large quantities of water from these units, numerous smaller wells (1 to 10 gpm) would need to be installed and the yields from each combined into a regional collector system.

The Gila Conglomerate is estimated to hold more than 98,000,000 acre-feet in storage in the entire County. Half of that volume is in stream-connected aquifers of the Gila and San Francisco Basins and would require offsets of surface water rights to divert the groundwater. However, in the San Agustin Basin, the Gila Conglomerate and the alluvium could potentially provide large quantities of water. Within the San Agustin Basin lie two structural features, the San Agustin Graben and the Gallinas Embayment, which are comprised of the Gila Group and overlying basin fill materials characteristic of the southwestern closed basins to the south. The thickness of the Quaternary/Tertiary alluvial/lacustral fill is as much as 4,000 feet in these features. Groundwater is usually between 150 and 300 feet bgs, and the average saturated thickness is 277 to 477 feet (Myers et al., 1994). The production of individual wells would be sufficient for large-scale extraction: short-term aquifer tests indicate transmissivities ranging from 2,300 to 48,400 ft^2/d and specific capacities ranging from 5.7 to 90 gpm/ft (Myers et al., 1994). Based on a conservative estimated area of 200 square miles within the San Agustin Basin, a saturated thickness of 300 feet, and a storage coefficient of 0.1, it is estimated that at least 3,840,000 acre-feet of groundwater exists within 500 feet of ground surface.



SOUTHWEST NEW MEXICO REGIONAL WATER PLAN

Potential Groundwater Development Areas

Daniel B. Stephens & Associates, Inc.

7-19-04 12:02PM JN WR03.0004

Figure 8-8

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8.9.1.2 Grant County

The area of greatest potential for additional groundwater production in Grant County is within the undeclared portions of the Animas geologic basin, in the southern panhandle portion of the county. Of the approximately 650 square miles of undeclared basin in Grant County (Figure 5-12, Table 5-10), approximately 350 are underlain by volcanic rocks, which are unlikely to provide substantial groundwater; however, the remaining 300 square miles of undeclared basin are underlain by highly permeable basin fill and Gila Group unconsolidated materials (Hawley et al., 2000), and approximately half of this area is likely to have a saturated thickness greater than 330 feet (Hawley et al., 2000). Groundwater is typically encountered near the middle of this part of the basin, at 200 feet bgs (Trauger, 1972). Based on an area of 150 square miles, a 300-foot saturated thickness, and a storage coefficient of 0.1, a rough approximation of available groundwater within 500 feet of ground surface is 2,850,000 acre-feet. Although the basin is not well explored below 500 feet bgs, some locations are suspected to contain saturated unconsolidated materials up to depths of 2,000 feet, although yields would likely be somewhat lower due to compaction and finer sediment particle size (Hawley et al., 2000). Nevertheless, the potential for finding significant volumes of water with good yields and few legal constraints makes pursuit of groundwater development in this area attractive.

While development of additional well fields in the Mimbres Basin within Grant County may be possible near the Luna County line, any increased diversions will impact existing water right users and such impacts would have to be offset. In an investigation of the potential for the aquifer to meet existing demands of current well fields, Johnson et al. (2002) concluded that the predicted drawdown in Silver City's well fields will reduce the capacity of the well field to the extent that it is unable to meet demands by 2040. Demands by Deming, to the south (in Luna County) but in the same aquifer system, are predicted to exceed the supply to the Deming well field by 2015. Accordingly, although water rights could be transferred from an existing use to a less developed area within the Mimbres Basin, increased drawdowns will likely be protested by existing water users.

The potential to develop groundwater in the Gila Basin within Grant County may also be technically feasible; however, the water right implications due to impacts on the Gila River must be addressed. Section 8.6 discusses the potential of developing a well field in the Gila Basin that is recharged with Gila River water.

8.9.1.3 Hidalgo County

Hidalgo County contains the largest area of undeclared basins in the region. The areas with the greatest potential to yield additional groundwater in Hidalgo County are the undeclared portion of the geologic Animas Basin to the west of the declared Lordsburg Basin and the Hachita-Moscos geologic basin in the southeastern corner of the county. A relatively large area in the southwestern portion of the county is also undeclared, but is less promising as an extensive groundwater supply because the unconsolidated sediments are relatively thin (approximately 300 feet total thickness).

The undeclared portion of the geologic Animas Basin to the west of Lordsburg contains more than 1,000 feet of saturated unconsolidated materials (basin fill and Gila Group). Large scale agricultural areas are present east of this area, near Lordsburg, and to the south, near Cotton City; however, surface playas and associated alkali flats have precluded development of further agricultural use here. Groundwater is typically encountered within 150 feet of ground surface. This area contains the thickest sequence of unconsolidated materials in the Animas Basin and has a productive saturated thickness of 600 feet (Hawley et al., 2000). Deeper portions of the aquifer likely contain substantial water, but the transmissivity is considerably lower due to compaction and finer sediment particle size (Hawley et al., 2000). Based on an estimated area of 100 square miles, a saturated thickness of 300 feet, and a storage coefficient of 0.1, the amount of groundwater stored in this part of the basin is estimated to be about 1,920,000 acre-feet.

8.9.1.4 Luna County

Aside from a small section in the southwestern corner, Luna County falls completely within administratively declared groundwater basins (Mimbres and Nutt-Hockett). The undeclared portion of the county covers an area of approximately 75 square miles within the Hachita-Moscos geologic basin. Limited subsurface investigations have been conducted in the area, but based on the hydrogeology in other nearby basins, it is likely that groundwater exists within 200 feet of ground surface and that the saturated zone is at least a 300 feet thick. Using these assumptions and a storage coefficient of 0.1, a rough approximation of the amount of groundwater stored within 500 feet of ground surface is 1,400,000 acre-feet. Furthermore, analysis of the groundwater budget for the Hachita-Moscos basin indicates that about 2,300 acre-feet are estimated to be lost to evapotranspiration, and approximately half of that amount is within Luna County. Therefore, development of groundwater up to this amount would intercept water currently lost to evapotranspiration.

8.9.2 Hydrological Impacts

Groundwater depletion is a major concern throughout the region, and large-scale groundwater extraction would likely not be sustainable over a long period of time. Water level declines in the vicinity of wells and well fields indicate that groundwater is being mined at those locations. Reductions in spring flows may also be an undesirable impact of groundwater pumping. Localized declines in aquifer water levels can result in aquifer compaction and loss of storage capacity in the aquifer, which in turn result in a permanent decline in yield. Drought conditions reduce recharge to aquifers and can either increase the effects of mining on the aquifer, leading to an accelerated decline in water levels, or change an aquifer that was previously in equilibrium (i.e., recharge equals or exceeds pumping) to an aquifer that is being mined (i.e., pumping exceeds recharge).

Groundwater reserves that interact with surface water systems may also have a limited new production potential. Wells or well fields that would reduce surface water flows may not be permitted unless the impact is offset by the retirement of a surface water right.

To avoid further groundwater depletions, the region may choose to limit total groundwater development only to a level that can be replaced through natural recharge. Estimates of the amount of natural recharge that occurs in the areas identified for potential development (as shown in Figure 8-8) are shown in Table 8-18. Because these areas are hydrologically connected to the rest of the basin in which they occur, any withdrawals would be in addition to those that occur in other portions of the basins. Table 8-18 also shows the amount of estimated evapotranspiration and groundwater pumping in the basins.

As shown in Table 8-18, increased pumping in the San Agustin and Hachita-Moscos Basins could occur at levels less than the estimated losses to ET without impairment to the aquifer. However, the areas identified in the Animas Basin should be considered as replacement for existing pumping in declining well fields.

Table 8-18. Natural Recharge Estimates for Areas Identified for Potential Groundwater Supply

Groundwater Basin	Location	Estimated Recharge (ac-ft/yr)	Estimated Losses to ET (ac-ft/yr)	Estimated Groundwater Pumping (ac-ft/yr)	Estimated Groundwater Depletions (ac-ft/yr)
San Agustin	San Agustin Basin	3,700	18,000 [a]	500	300
Animas	Northwestern Hidalgo County	1,200	0	29,300	16,900
	Southern Animas Basin	600			
	Southern Grant County	1,400			
Hachita-Moscos	Southwestern Luna County	300	2,300 [a]	100	100
	Eastern Hidalgo County	400			

ac-ft/yr = Acre-feet per year
ET = Evapotranspiration

[a] Estimated ET losses may represent amount of water currently being discharged based on inflows from the entire basin, not just the area shown on Figure 8-8.

Development of deep groundwater resources in areas where shallow groundwater extraction also occurs may impact the shallower groundwater tables. Hydrologic investigations will be required to determine the connectivity of deep groundwater with shallower zones. Closely spaced wells may cause well interference that increases water level declines. Wells should be spaced far enough apart so that the effects of interference are minimal. However, if the wells are too far apart, conveyance and pumping system costs may be prohibitive for municipal well fields. Efforts to reduce well interference have been implemented in other basins, including restricting pumping based on allowable rates of drawdown in the aquifer and regulating spacing of domestic wells through minimum lot sizes and requirements on water availability beneath the lots.

8.9.3 Financial Feasibility

The primary difficulty with implementing this alternative will be economic. Any new water developed will be expensive due to the cost of (1) the hydrogeologic studies needed to identify water supplies and gain OSE approval for extracting them, (2) drilling and well installation, and (3) conveyance structures for pumping the water from the extraction area to the area where it will be used.

Hydrologic investigations are necessary to identify the exact location of favorable groundwater resources and sites for wells or well fields. To obtain the site-specific data required to evaluate the feasibility of a groundwater appropriation, applicants may need to examine existing well logs, interview well owners, and drill test wells and collect water quality samples in selected locations.

If an application to appropriate groundwater is protested, the applicants will be required to prove that the appropriation would not impair existing rights. Depending on local conditions, a study may be limited to a simple analytical model or may entail a complex numerical model. Costs for such models typically range from about $50,000 to $300,000.

The potential sites in the Animas Basin are 15 to 45 miles from Lordsburg and 30 miles from Deming. The closest site in the Hachita-Moscos Basin is at least 30 miles from Deming. Costs for each of the required infrastructure components, based on a distance of 30 miles between the well field and the demand, are discussed below:

- *Well field.* For a 1 million gallon per day (mgd) project (approximately 3 ac-ft/day or 1,000 ac-ft/yr), approximately five wells would be required (assuming they each pumped 200 gpm for 16 hours per day). Each supply well would cost approximately $150,000 (assuming at 500-foot depth). Additional anticipated costs are shown in Table 8-19.

- *Conveyance system.* To convey 1,000,000 gallons per day, 8-inch pipe would be required. Booster stations would also be required, at a highly variable cost that would depend on elevation changes and the number of stations required. A rough estimate of the conveyance costs associated with a 30-mile pipeline is indicated in Table 8-19.

Increasing infrastructure is fairly straightforward, and financing is available for municipalities and community water associations through, for example, the Community Development Block Grants and the New Mexico Finance Authority (domestic well owners must seek their own financing to pay for a new well). Another option is to pass the costs on to the consumer. Assuming that 2,000 acre-feet of water were extracted annually and sold for $1,140 per acre-foot (based on the bulk rate for the City of Deming), it would take approximately 5 years for water sale revenues to pay for construction and annual O&M costs. Most of the rate revenue goes to operations and maintenance (including operations staff), however, and if a 30- to 45-mile conveyance system were needed, significant water rate increases would be required to cover the high capital costs.

Table 8-19. Estimated Cost To Design, Construct, and Operate a Typical Well Field and Pipeline

Item	Unit	Unit Cost ($)	Quantity	Total Cost ($)
Well field design and permitting	lump sum	40,000	1	40,000
Land purchase	acre	5,000	40	200,000
Supply well	each	150,000	5	750,000
Well field O&M	annual	100,000	1	100,000
Pipeline design and permitting	lump sum	100,000	1	100,000
Easement purchase/lease	mile	2,000	30	60,000
Pipeline	mile	225,000	30	6,750,000
Booster station	each	400,000	2	800,00
Pipeline O&M	annual	100,000	1	75,000
			Total Capital Costs	8,700,000
			Total Annual O&M Costs	175,000

O&M = Operation and maintenance

The magnitude of water well costs varies with the quantity of water that the owner expects to pump from the well:

- Municipalities in the planning area may need relatively deep wells capable of producing 400 to 500 gpm. A large municipal well requires the services of an experienced hydrologist or engineer capable of designing, overseeing construction of, and testing the new well. The hydrologist assists the municipality in selecting an experienced driller, provides contract administration, and oversees the construction activities. The costs presented in Table 8-19 include drilling and consulting services for municipal supply wells.

- A community well should yield between 50 and 150 gpm and will not need to be as deep as a municipal well. A community would benefit from the services of an experienced hydrologist or engineer for well design and construction oversight. A local driller may also provide insight for well design based on their experience in the area.

- Domestic wells are generally designed and installed by a local well driller. Most domestic wells are intended to produce less than 50 gpm. Costs for domestic wells are dependent largely on the depth of the well.

8.9.4 Environmental Impacts

Environmental impacts that could occur as the result of initiating this alternative would be associated primarily with the construction of pumping and conveyance facilities. These construction projects would require an environmental assessment, but barring the presence of any endangered species or significant cultural resources, are not likely to pose any significant environmental detriments. The potential for subsidence due to mining groundwater at a rapid rate should be considered, particularly where pumping is near population centers.

8.9.5 Political Feasibility and Social/Cultural Impacts

Because developing additional supplies does not involve removing water from existing uses and transferring it to new uses, no major political impediments should exist. Nevertheless, proposed individual wells or well fields could affect existing users and result in either a protest or, in the case of the undeclared areas, political opposition. In pursuing groundwater supply development, existing users should be identified and consulted.

Water rights issues, which do consider public welfare, as they pertain to the potential for development in each county of the region, are as follows:

- *Catron County:* Although the San Agustin Basin lies within the declared Middle Rio Grande Basin, no specific administrative criteria govern water use in the basin. Water rights applications are evaluated to determine whether the granting of the application will impair existing water rights or be detrimental to the public welfare, but because of the relatively low population density and large quantities of water, it is likely that a water right could be obtained for public benefit in this area.

- *Grant, Hidalgo, and Luna Counties:* The locations within these counties identified as having potential for additional groundwater are contained within undeclared portions of the region. Within undeclared basins, there are typically few impediments to groundwater extraction. However, the purchase of water rights and/or land would likely be required.

8.10 Water Quality Protection

Protecting water resources from potential water quality degradation can help to ensure viable water supplies to meet the future needs of the region. Accordingly, this alternative would identify and implement programs that can assist in protecting water resources within areas of the Southwest Region that are vulnerable to contamination. As discussed in Section 5.3, many potential sources, such as underground storage tanks, landfills, mines, and facilities with discharge permits, can be specifically identified (point sources). These sources are already monitored and characterized by NMED. Other potential threats to water quality are spread over large areas (nonpoint sources) and include agriculture, livestock, erosion, road construction, and septic tanks. The impacts from these nonpoint sources are less well characterized and monitored.

Both point and nonpoint sources can contribute significantly to water quality degradation. Whereas point source contamination is typically from more identifiable and specifically regulated sources than contamination from nonpoint sources and therefore attracts more attention and funding, nonpoint source contamination is oftentimes more chronic and difficult to address. A successful water quality protection program will identify all potential sources, both point and nonpoint, and promote shifts in practices and land use that decrease the threats to local and regional water supplies.

8.10.1 Key Issues

All the major identified point sources of contamination located within the region fall under the jurisdiction of NMED regulatory programs. Therefore, additional efforts to identify and monitor contaminant point sources within the region would be largely redundant. It may, however, be desirable and beneficial for the region to review the NMED's monitoring and permitting or remediation for listed sites to ensure that concerns from the region are being adequately addressed. One potential mechanism for doing so would be to set up a water quality council that operates under the direction of a regional agency such as a council of governments or the proposed regional Joint Powers Authority. Inclusion of watershed management groups for the river basins, such as the newly forming effort on the Mimbres Basin, should also be considered.

The agency could review existing NMED programs, including:

- Monitoring of underground storage tank (UST) sites, overseen by the NMED Petroleum Storage Tank Bureau

- Monitoring of active and closed landfills, overseen by the NMED Solid Waste Bureau

- Monitoring of hazardous waste generators and hazardous waste treatment, storage, and disposal facilities, overseen by the NMED Hazardous Waste Bureau

- Monitoring of mining sites and groundwater discharge plans, overseen by the NMED Groundwater Quality Bureau

- Monitoring of Superfund sites, overseen by the U.S. EPA in conjunction with the NMED Groundwater Quality Bureau

- Monitoring of NPDES permits, overseen by the U.S. EPA in conjunction with the NMED Surface Water Quality Bureau

The New Mexico Source Water Assessment and Protection Program (SWAPP) is another existing program that could be considered. SWAPP can be used to address monitoring and control of potential sources of contamination near public water supplies. This is a federally funded program overseen by the U.S. EPA that assists communities in protecting their drinking water supplies. Specifically, the New Mexico SWAPP will assist local communities in:

- Determining the source water protection area for the water system

- Taking inventory of actual and potential contaminant sources within the source water protection area

- Determining the susceptibility of the source area and water system to contamination

- Reporting the SWAPP findings to the water utility, its customers, and the community

- Working with the community and other stakeholders to implement source water protection measures that safeguard and sustain the water supply into the future.

This existing program can be used to address this issue with minimal additional cost to the local community. To participate in this program, communities can contact the New Mexico SWAPP (http://www.nmenv.state.nm.us/dwb/swapp.html). The development of source water or well-head protection plans for the Southwest Region may require hiring or contracting technical personnel to work with the New Mexico SWAPP.

Because nonpoint source contamination such as septic tanks, agricultural runoff, or livestock are often not fully addressed by any of the NMED programs, the region would likely benefit the most from focusing on these sources.

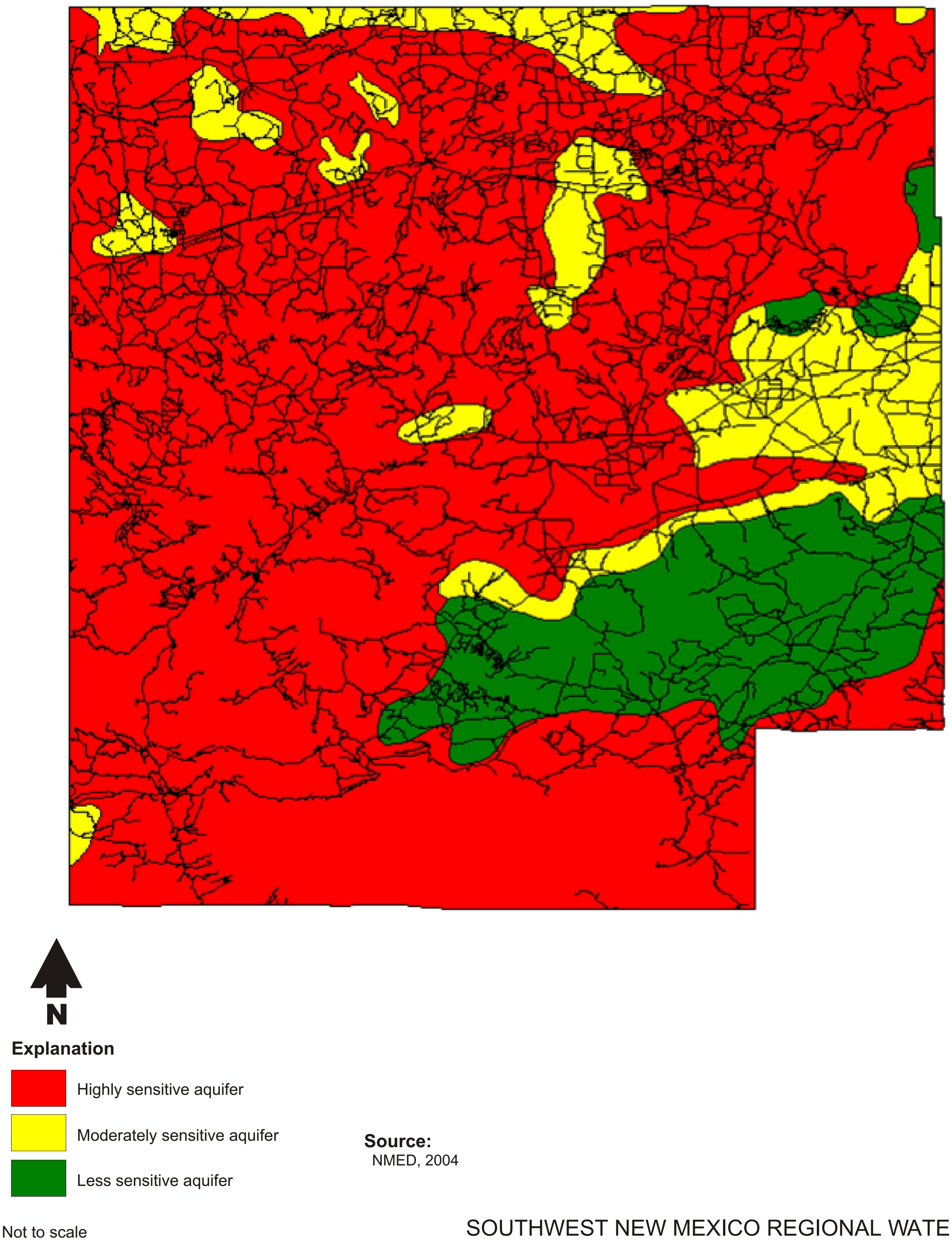
The main contaminant sources relevant to vulnerable areas of the planning region that are not completely included under existing regulatory jurisdiction are on-site domestic wastewater treatment systems (i.e., septic tanks). In the Southwest Region, septic systems are most likely to cause significant impacts to water quality where higher population centers coincide with shallow groundwater or surface water bodies. NMED has mapped the entire state to determine areas where groundwater is most vulnerable to contamination; Figures 8-9 through 8-12 present the NMED's mapping of aquifer sensitivity for each county in the Southwest Region.

The New Mexico Environment Department is currently considering proposed amendments to the State Liquid Waste Disposal Regulations (20.7.3 NMAC), which regulate domestic leachfield or septic systems. The proposed changes would require modifications to existing systems as well as the design, set-back, and maintenance of new systems. In areas that NMED has determined to be "areas of concern", new systems on less than ¾ acre would require installation of what NMED is calling "advanced treatment" systems, which are septic systems capable of treating biological oxygen demand (BOD) to less than 30 mg/L and total nitrogen to an average of 20 mg/L or less, prior to discharge.

The "areas of concern" are the same as the areas on Figures 8-9 through 8-12 and are underlain by highly sensitive aquifers. An area of concern has one or more of the following characteristics:

- Overlies an aquifer within 100 feet of ground surface

- Lies within 1 mile of a known groundwater contamination plume that contains anthropogenic anoxic conditions or nitrate contamination



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SOUTHWEST NEW MEXICO REGIONAL WATER PLAN

Aquifer Vulnerability to Contamination
Catron County

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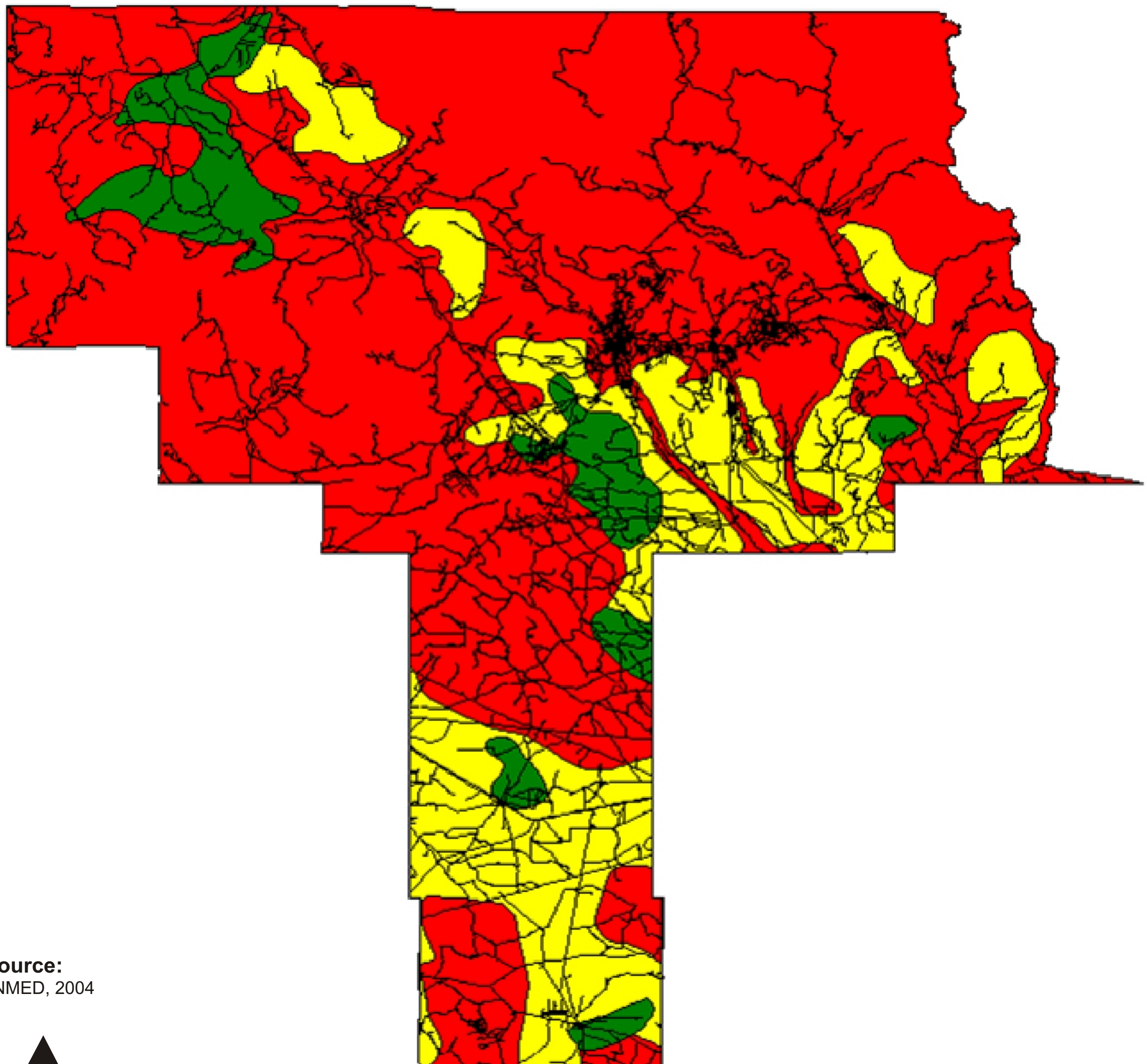
1-5-05
JN WR03.0004

Figure 8-9



Source:
NMED, 2004

N

Explanation

- Highly sensitive aquifer
- Moderately sensitive aquifer
- Less sensitive aquifer

Not to scale

SOUTHWEST NEW MEXICO REGIONAL WATER PLAN
Aquifer Vulnerability to Contamination
Grant County

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Figure 8-10

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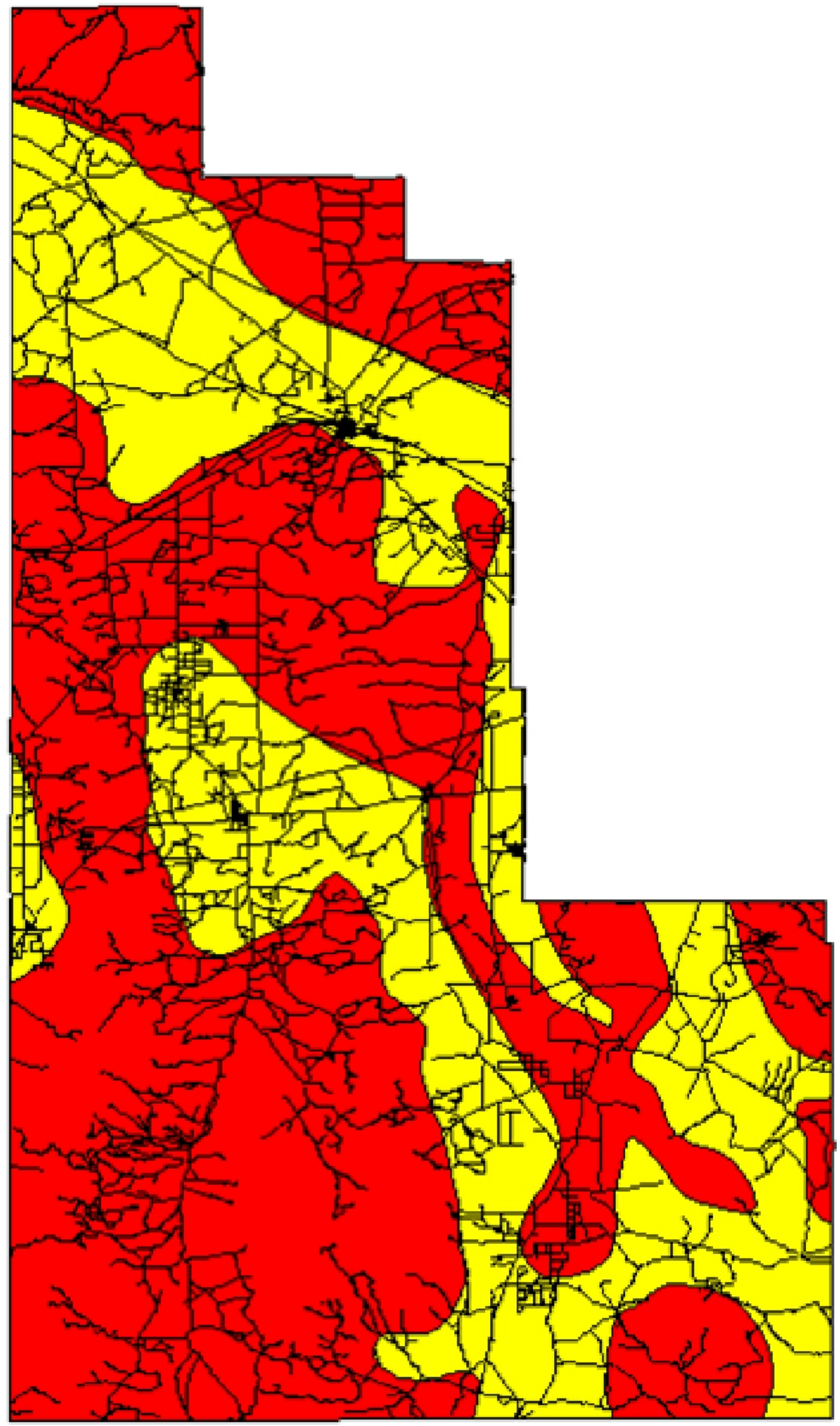

Source:
NMED, 2004

N

Explanation

- Highly sensitive aquifer
- Moderately sensitive aquifer
- Less sensitive aquifer

Not to scale

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SOUTHWEST NEW MEXICO REGIONAL WATER PLAN

Aquifer Vulnerability to Contamination
Hidalgo County

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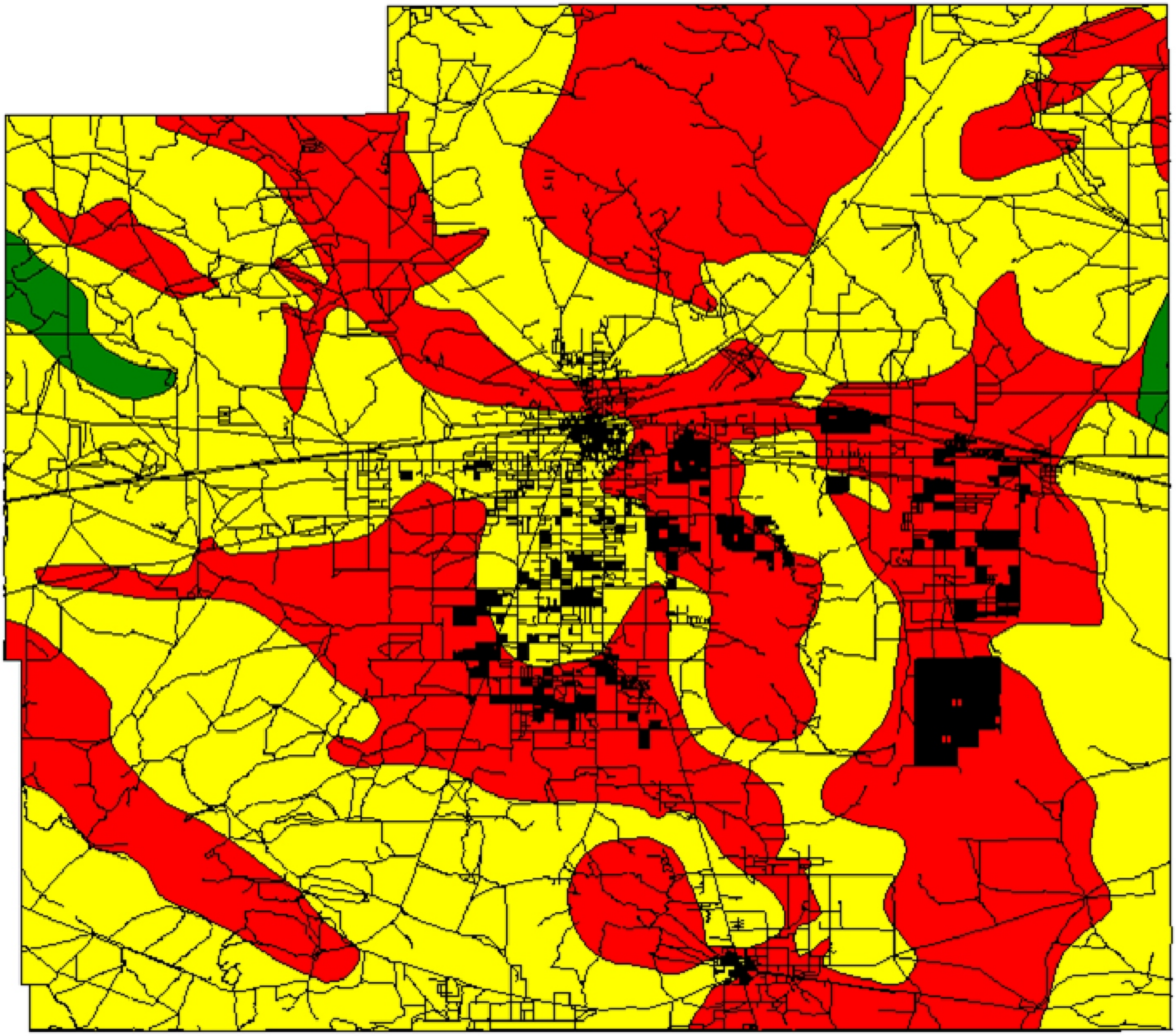
Figure 8-11



N

Explanation

- Highly sensitive aquifer
- Moderately sensitive aquifer
- Less sensitive aquifer

Not to scale

Source:
NMED, 2004

SOUTHWEST NEW MEXICO REGIONAL WATER PLAN
Aquifer Vulnerability to Contamination
Luna County

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1-5-05
JN WR03.0004

Figure 8-12

VDR10-VDR-PROJECTS\00-WATER_RES\WR03_004_14W.CDR

- Lies above an aquifer that is overlain by fractured rock
- Lies above an alluvial aquifer that discharges to a gaining stream located within 200 feet of the proposed septic system

The proposed new regulations can be accessed on the NMED web site at http://www.nmenv.state.nm.us/fod/LiquidWaste/LWDR.latest.draft.pdf.

In addition to NMED regulatory requirements, administrative and public participation efforts may be required to develop and implement enhanced on-site wastewater treatment ordinances in the Southwest Region. Using other existing ordinances as models will minimize these efforts. Bernalillo County recently enacted a strengthened wastewater ordinance (Bernalillo County Municipal Code, 2001) to address private septic systems, and this ordinance could be used as an initial model for Catron, Grant, Luna, and Hidalgo Counties. The Bernalillo County ordinance is performance-based in that treatment requirements are determined by on-site physical conditions and an assessment of the potential risk that effluent from the site's system will contaminate groundwater.

Another key issue regarding adoption of an enhanced septic tank ordinance is the cost to homeowners. Costs for upgrading existing septic systems can be on the order of $5,000 to $20,000, depending on site conditions and system configuration, and costs to maintain improved on-site wastewater systems range from $10 to $25 per month (UNM, 2001). Additional financial support for homeowners may be necessary. In addition to homeowner financial assistance, enforcement will be needed to ensure that septic upgrades are completed and that required maintenance occurs.

8.10.2 Implementation

The first step in implementing this alternative would be to identify potential areas of groundwater vulnerability. In addition to areas close to known contamination concerns, areas with certain geologic, geographic, and ecologic characteristics are more susceptible to contamination than others. Mapping of these sensitive areas is shown on Figures 8-9 through 8-12.

Perhaps the most significant implementation consideration is cost; representative costs include:

- Costs for developing wastewater ordinances are minimal. Existing government employees in Catron, Grant, Hidalgo, and Luna Counties can work with the New Mexico SWAPP to develop source water/wellhead protection plans and to develop and implement enhanced on-site wastewater treatment ordinances. Using other ordinances as models will minimize these efforts.

- Costs for upgrading existing septic systems can be on the order of $5,000 to $20,000, depending on site conditions and system configuration (UNM, 2001). Individual homeowners are responsible for paying for system upgrades; however, low-income families may not be able to afford the cost of system upgrades. To effectively reduce potential septic contamination, additional financial support for homeowners may be necessary.

- Costs to operate and maintain improved on-site wastewater systems range from $10 to $25 per month (UNM, 2001). If additional water quality monitoring programs are established and monitor wells are installed, periodic sampling and water quality analyses will also be needed and costs for these analyses may range from approximately $200 to $1,000 per sample, depending on the required analyses.

8.11 Groundwater Management Plan

The development of local groundwater management plans would enable better management of basin-scale groundwater resources. Agricultural districts and rural communities where numerous wells are operated by numerous entities could be organized according to hydrologic units and voluntarily managed to increase current yields, promote current conservation, prepare for future demands, or a combination of the three.

Although nearly every location within the region could benefit to some degree from local groundwater management programs, locations within the region that could benefit the most include the:

- Animas Valley
- Lordsburg area
- Columbus area

- Deming area
- Central Grant County
- Reserve area
- Northern Mimbres Basin communities (Mimbres, San Lorenzo, Sherman, San Juan)

Some of the options that can be pursued once a local groundwater management plan has been developed are

- Appropriate and reserve additional groundwater
- Implement growth management and land use planning
- Optimize well field management

Key issues related to these options are described in Section 8.11.1.

8.11.1 Key issues

8.11.1.1 Appropriate and Reserve Additional Groundwater

Developing water supplies for future use is a means of protecting the region and supporting existing and future uses. New Mexico law allows for certain types of water providers and local governmental entities to appropriate water for future use as part of the long-term planning process. This option consists of submitting applications to obtain permits to use (appropriate) groundwater that is unappropriated and available in the region. Appropriating available groundwater resources would increase the supply available to the region and protect regional water supplies from appropriation by neighboring regions or states.

In most cases, water users in New Mexico who acquire permits from the OSE to appropriate groundwater or surface water must put it to beneficial use within four years or be subject to forfeiture of the right after receiving notice from the OSE (Appendix D). However, a qualifying applicant (public entity) can reserve water rights for up to 40 years without putting them to beneficial use if it has completed a 40-year water plan that demonstrates a future need for water (NMSA 72-1-9).

Certain eligible entities may wish to pursue individual applications, especially if they are located near groundwater supplies with the potential to be appropriated and developed. However, a cooperative approach among various eligible entities would allow the costs for developing the wells or well field and conveyance structures to be shared among multiple users. Such an approach would also expand the capacity to secure funding through various types of funding mechanisms. For example, the Jemez y Sangre water planning region is developing a cooperative approach for appropriation and has submitted a notice of intent to appropriate flood waters for future use in the region. Participating entities in the Jemez y Sangre region include cities, counties, and private water suppliers. Participants will conduct a negotiation process to determine how any additional water supplies obtained through this avenue are allocated among individual entities.

New Mexico statutes define the process for appropriating waters of the state in declared basins. In declared basins, the OSE must determine that water is actually available for appropriation and that the proposed application will not impair existing water rights and will not be contrary to public welfare or conservation. However, a small portion of the Southwest Region is undeclared and does not fall under the jurisdiction of the OSE.

Until the OSE declares the basin and exercises jurisdiction of those areas, the priority system of allocating water and protecting existing rights is not in place, and no application is needed to drill a well and begin pumping water. This can be an advantage for entities wishing to develop rights in undeclared basins, because they are not required to follow the sometimes lengthy and costly application process. However, the disadvantage of developing rights in an undeclared basin is that existing water rights would not be protected against subsequent development.

8.11.1.2 Implement Growth Management and Land Use Planning

Land use decisions are often made independently of water considerations. As an area grows, however, new approaches may be needed to ensure the reliability, safety, and quality of water supplies and service. For instance, as domestic wells increase in number, problems may develop such as excessive well interference and localized drawdown that drops the water table below the level of older, shallower wells. To avoid this problem, community or mutual domestic water associations for smaller water systems that serve 3,300 households or fewer can be formed. Due to the rural nature of much of the planning region, small community water systems could be important tools for managing water resources. An added benefit of this approach is that water use can be more easily quantified, enabling better long-range planning decisions.

Ideally, local groundwater plans will address the following:

- Requirements for demonstration of secured water supplies as a criterion for approval of new subdivisions. Any regulations with such a requirement must be in accordance with the New Mexico subdivision act.

- Requirements that address water quality (i.e., wellhead protection, drainage, and septic tank regulation).

Specific land use policies that can help to protect and preserve water supplies include the following:

- Provisions for ensuring that adequate water supplies are available can be considered as part of the approval process for new developments. Decisions regarding the timing and location of new subdivisions can consider the physical availability of water and water rights.

- To enable efficient infrastructure and water service investments, development can be restricted to the existing service area or land contiguous to the service area.

- Future land use and growth projections can be used as criteria for water infrastructure expansion and improvements so that piping and pumps are installed at appropriate locations and sized adequately.

- Regulations regarding the installation of new domestic wells can be implemented to ensure that development does not occur in a manner that impacts senior water right holders.

- Drainage design standards can help protect the watershed. For instance, nonpoint source pollution can be prevented by such strategies as controlling erosion or filtering runoff through swales and detention basins.

Developing a comprehensive land use plan can be a complex task, especially in balancing the variety of opinions and input. Coherent incorporation of water issues into land use planning requires a determination of projected water supply. For instance, new subdivisions should typically be permitted only if a 70- or 100-year water supply is available.

The primary technical issue regarding integrating land use and water policies is determining the amount of supply available to support development. This determination may be technically complex. In areas such as the Animas Valley, where there is extensive groundwater use, the combined pumping of existing and proposed new wells should be considered, and such an evaluation can most easily be made through use of a groundwater model. Developing groundwater models is technically feasible, but can be complex.

8.11.1.3 Optimize Well Field Efficiency

This option entails optimizing existing well field facilities to ensure that issues such as poor well construction, well interference, or encrustation of well screens do not inhibit the optimal performance of the well field. Modeling and pumping tests can be used to determine the optimum number, sizes, spacing, depths, pumping rates, pumping times, and locations of supply wells.

Well field design involves the determination of effective well spacing to create cost-effective pumping and conveyance systems. Such design considerations apply to municipal, irrigation, and domestic wells, although efficient design is generally more critical for municipal and irrigation wells due to their larger pumping rates. Determination of the appropriate well spacing is primarily dependent upon the transmissivity and storage coefficient of the aquifer and the locations, pumping rates, and depths of the wells. Design of supply wells should follow the procedures and standards presented by the U.S. EPA and the American Water Works Association.

The OSE has promulgated aquifer management criteria for various portions of the region (e.g., the Mimbres and Lordsburg Basins). These basins are administered on a grid system in which pumping is restricted based on allowable rates of drawdown in the aquifer, a condition that imposes minimum spacings between production wells, dependent upon pumping rates and aquifer characteristics.

8.11.2 Implementation

The following actions would be required to develop and implement a voluntary local groundwater management plan:

- Convene a meeting of water users/stakeholders for a given area to determine who would be interested in participating in developing a local plan. Some planning activities are ongoing and may best be implemented through irrigation districts.

- Evaluate the correlation between historical data and current conditions to ensure understanding of water level trends.

- Conduct technical studies and develop groundwater models to evaluate potential well interference, to develop optimal well field designs, and to simulate future drawdowns.

- With public input, prepare local groundwater management plans that address appropriation of reserves for the future and well field efficiency.

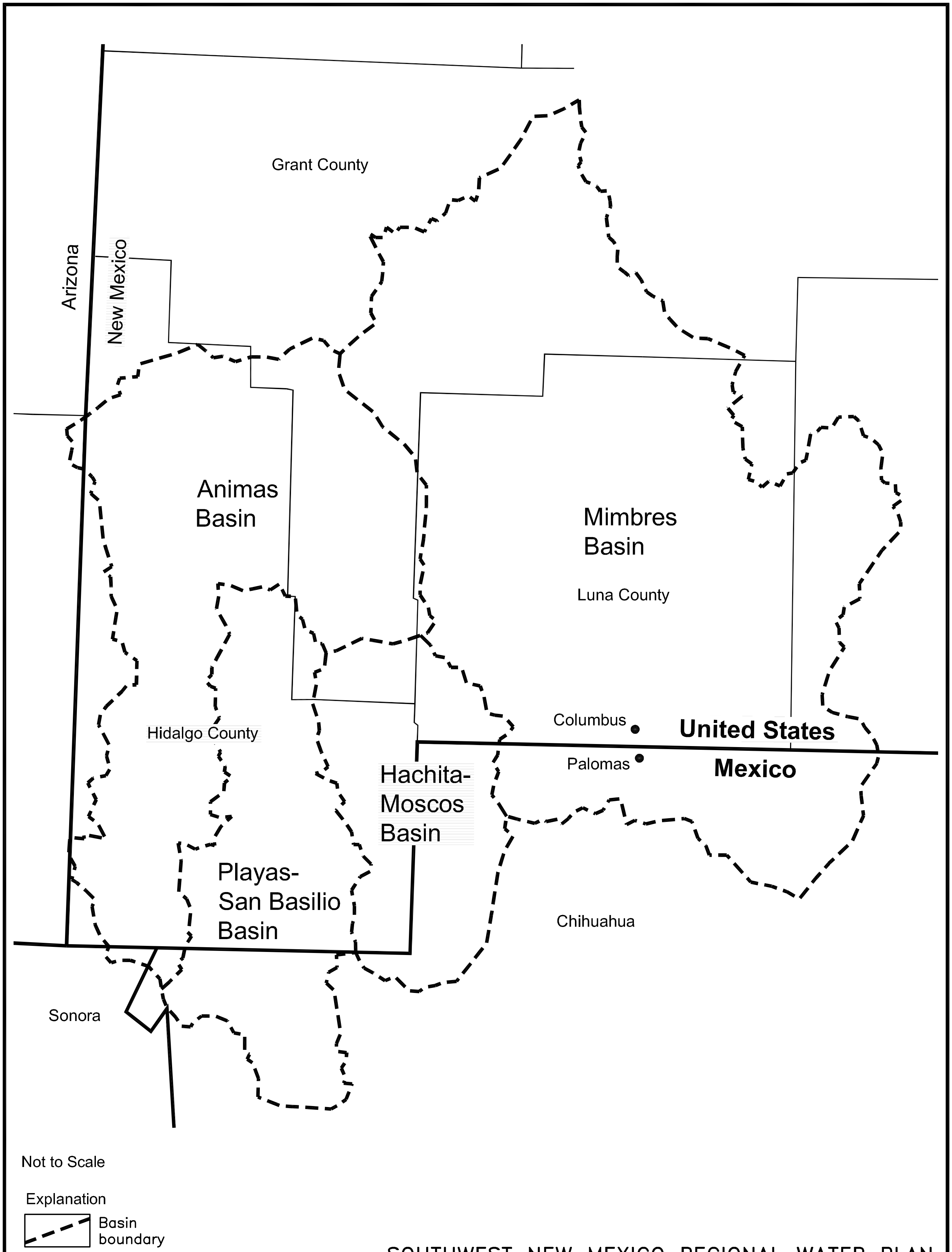
8.12 Border Groundwater Management

The Southwest Region shares four groundwater basins along the U.S.-Mexico border with Mexico; these aquifers are the Animas, Playas-San Basilio, Hachita-Moscos, and Mimbres Basins (Figure 8-13. Management and regulation of this shared resource can pose a problem for water managers in the Southwest Region due to lack of information regarding availability and use of the resource in Mexico, as well as a lack of coordination and planning between U.S. and Mexican local governments. This section briefly discusses two aspects of the border issue: key hydrologic issues in the four border aquifers and initiatives to address binational water management.

8.12.1 Key Issues

8.12.1.1 Hydrology and Water Use

This section provides a brief overview of the hydrologic issues in the border basins and identifies whether shared use of the resource is creating problems in terms of water supply or



SOUTHWEST NEW MEXICO REGIONAL WATER PLAN

Shared Basins

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1-3-05

JN WR04.0032

Figure 8-13

T:\VDR\0-VDR-PROJECTS\00-WATER_RES\WR04_0032\WR04_0032_03K.DWG quality in the Southwest Region. More detailed analysis of the hydrology of these basins is provided in Section 5.3.2.2 through 5.3.2.5.

8.12.1.1.1 Animas Basin. Almost all (2,400 square miles) of the Animas Basin exists within the U.S.), but a small portion of the basin, about 35 square miles, extends into Mexico. The historical and current direction of flow near the border is from the south to the north. The small portion that exists within Mexico is of little consequence to the water supply in the rest of the basin, because very little recharge or extraction occurs within the Mexico portion, relative to that in the U.S. portion.

Activities within Mexico pose no immediate or foreseeable threats to groundwater supply or quality in the Animas Basin. The primary land use in and near the Mexico portion of the basin is livestock grazing, and no municipalities or even small towns are nearby. Although portions of the Animas Basin further to the north in the U.S. have experienced substantial lowering of the water table in response to extraction, mostly for agricultural use, these practices do not appear to impact water supply or quality in Mexico.

8.12.1.1.2 Playas-San Basilio Basin. The Playas-San Basilio Basin system is a continuous structural basin system. The Playas Basin is located in the U.S., and the San Basilio Basin is located in Mexico. The divide between the two very closely follows the international border; however, a small portion of the Playas extends into Mexico, and a small portion of the San Basilio extends into the U.S. The boundary between the Playas and the San Basilio Basins (roughly the international border) is a groundwater divide. The flow direction north of the divide is to the north, and the flow direction south of the divide is to the south. The pre-development rate of groundwater flow across the border was very near zero.

The border crossing of Antelope Wells is within the portion of the San Basilio that extends into the U.S. Immediately south of the border is El Berrendo. The population in this area is sparse, and water usage in these two locations, although not well documented, is not substantial. Within 10 miles of the border only 12 wells are known to exist in Mexico and only 20 in the U.S. There is no commercial agriculture that would impact water flow across the border, due largely to the fact that the groundwater divide lies almost directly on top of the border. No known water quality concerns are associated with the border region in the Playas and San Basilio Basins.

8.12.1.1.3 Hachita-Moscos Basin. The Hachita-Moscos Basin is an interconnected group of three hydrogeologic sub-basins. Approximately one-half of the basin lies within Mexico, and the other half exists within Hidalgo, Grant, and Luna Counties, New Mexico.

In general, the flow direction is from the northwest toward the southeast, and groundwater moves across the border from the U.S. toward Mexico. In some locations near the border, the potentiometric surface approaches the land surface, and seeps and springs are found on both sides of the border. Hawley et al. (2000) estimated that approximately 2,000 ac-ft/yr of groundwater flows across the border from the U.S. into Mexico. Very little development of groundwater has occurred within the Hachita-Moscos Basin, and current conditions are believed to be unchanged from historical conditions.

8.12.1.1.4 Mimbres Basin. The Mimbres Basin contains the largest transboundary aquifer zone in the planning region. Approximately 90 percent of the Mimbres Basin occurs within the U.S., with the remaining 10 percent in Mexico.

In general, groundwater in the Mimbres moves from north to south and has historically flowed from the U.S. into Mexico. The estimated movement of groundwater into Mexico was approximately 6,500 ac-ft/yr prior to development of the basin (pre-1909) (Hawley et al., 2000), but has dropped to an estimated 2,300 ac-ft/yr (Hansen et al., 1994).

Between the northern recharge area and the U.S.-Mexico border, large quantities of groundwater are extracted for agricultural, municipal, mining, domestic, and stock use. Over the past 50 years, groundwater extraction in the Mimbres Basin—primarily in the Deming, Hermanas, Columbus, and Palomas areas—has lowered the water table and, in the Columbus area, has locally altered the direction of flow.

The recharge areas for the Mimbres Basin are in the northern portion of the basin, at the mountain front extending from the Gila Wilderness. Relatively little recharge occurs in the southern portion of the basin, including the portion that exists in Mexico, with the exception of flood flows, which will recharge the aquifer in this closed basin.

The Columbus, New Mexico-Palomas, Chihuahua region has the most significant transboundary aquifer issues in the Southwest Region. Both cities rely solely on Mimbres groundwater for all water uses. Between 1990 and 1997, the combined population of the two cities has grown from approximately 4,300 to 7,765. About 90 percent of this combined growth has occurred in Palomas, which grew from 3,500 to 7,100 during that period, due largely to the introduction of several maquiladora operations.

Groundwater extraction on both sides of the border in this area is difficult to quantify due to a lack of long-term, consistent water-level monitoring; however, water levels in existing wells seem to be declining. Based on available records from approximately 86 wells within the U.S. and 8 wells within Mexico, the water table is declining as fast as 9.7 feet per year in some locations. Based on 45 wells with long-term data (at least 50 years), it is estimated that water levels are decreasing on average by about 2 feet per year near Columbus and 1.5 feet per year near Palomas. Hawley et al. (2000) indicate that the direction of flow across the border has changed from a north to south direction to a south to north direction, south of Columbus.

The majority of water extracted on the U.S. side is from private domestic and irrigation wells. In addition, the Village of Columbus owns three wells. It is anticipated that demand will exceed the capacity of these three wells by 2015 (Johnson et al., 2002). Because of aquifer drawdown, deeper wells will be needed to provide water.

In Palomas, three wells are operated by the municipality. Although the population is almost 10 times higher in Palomas than it is in Columbus, the per capita water use in Palomas is only 23 gpd, as compared to 240 gpd in Columbus. Even so, severe water restrictions are often imposed, which have reportedly caused people to go to Columbus to purchase water for potable domestic uses.

The overall water quality in the Mimbres Basin decreases from the north to the south. In the northern two thirds of the basin groundwater quality is sufficiently good for agriculture and potable uses (<500 mg/L TDS). The southernmost one third of the basin has increased salinity (>1,000 mg/L TDS), which makes the groundwater of questionable quality for some applications. The degradation in water quality is due to natural aquifer characteristics. Available water quality data do not suggest that widespread water quality impacts have occurred as a result of groundwater extraction or increased anthropomorphic activity on either side of the border. The two largest threats to groundwater quality in the area of Columbus-Palomas are agricultural practices (nutrients, chemicals) and septic systems.

8.12.1.2 Key Initiatives in Binational Water Management

As growth and development take place along the U.S.-Mexico border, water resources will be more taxed and the need for international cooperation on shared water resources will become more critical. The border area shares a problem common to much of the groundwater resource in the Southwest Region: although quantities in storage are high, recharge rates are very low. In neighboring Doña Ana County, a very large developer recently purchased 20,000 acres, adding to an approximately 30,000 acres already owned by the company near the Columbus Port of Entry west of Santa Teresa. The company has ambitious plans for extensive binational development of these areas (Velasco, 2004).

This section reviews some initiatives underway or proposed to improve coordination, availability of pertinent data, and international cooperation along the border in the Southwest Region. The Steering Committee may wish to obtain additional information about the numerous border programs in California, Arizona, and the El Paso-Juarez areas to use as a model and framework to undertake binational water management activities in the future.

*8.12.1.2.1 U.S.-Mexico Transboundary Aquifer Assessment Act (*SB *1957).* This proposed legislation could greatly benefit binational water management initiatives by developing the scientific tools needed to understand and manage the resource. The main purpose of the law would be to "systematically assess priority transboundary aquifers and provide the scientific foundation necessary for State and local officials to address pressing water resource challenges in the U.S.-Mexico border region" (SB 1957 Sections 2 (1) and 2(2)).

The two objectives of the Act are to develop an integrated scientific approach to assess transboundary groundwater resources and to expand existing agreements between the USGS, the border states, water resources research institutes, and appropriate authorities to conduct investigations, share data, and "carry out any other activities consistent with the program" (SB 1957 Section 4). The funding allocated for this Act is $50 million over nine years and will be distributed to various organizations to conduct the activities (SB 1957 Section 8).

The House Committee on Resources is currently reviewing the legislation that the Senate passed in September 2004.

8.12.1.2.2 Border 2012. The U.S. EPA and Mexico's Secretariat of Environment and Natural Resources (SEMARNAT) have developed the Border 2012 program to protect the environment and the public's health in the U.S.-Mexico border region.

Border 2012 is implemented through regional work groups that emphasize regional public health and environmental issues (U.S. EPA, 2004a). Each regional work group has one state and one federal co-chair from each country. Regional workgroups can create task forces to address issues raised by local communities, to implement site-specific projects, or to address issue-specific concerns.

The New Mexico Chihuahua Rural Task force addresses environmental issues and has established a Water Subcommittee that is developing a local initiative in the Mimbres Basin. This effort aims to improve dialog among water managers, stakeholders, local government entities, and their Mexican counterparts such as water utility directors or local planning professionals. Developing working relationships among individuals with water management responsibilities will enhance understanding of issues and foster development of common approaches to problems. This initiative has just begun, with the first meetings held in October and December 2004 (U.S. EPA, 2004b). Additional meetings will take place over the next year. Members of the Southwest Regional Water Plan Steering Committee have participated in these meetings.

8.12.2 Implementation

The Southwest Region should continue its participation in the local initiatives discussed in Section 8.12.1.2 and follow the progress of the U.S.-Mexico Transboundary Aquifer Assessment Act. In areas with significant water issues, such as the Columbus-Palomas area, it may be useful to work toward a formal binational groundwater management plan. The existing work groups could start the dialogue toward developing such a plan.

8.13 Rainwater Harvesting

Rainwater harvesting involves capturing rainfall from roofs of personal dwellings or commercial buildings and storing it for later use. The advantages of rainwater harvesting include convenience, low operational cost, good water quality, and low environmental impact.

Cisterns of one sort or another have long been used in arid areas to capture rainwater from roofs or other impervious areas for use during dry periods. Typically storage tanks are constructed below roof drains to capture runoff. The water is most often used to irrigate landscaping, thereby reducing the demand for potable irrigation water. In some parts of the world, rainwater is collected and used for drinking water purposes. However, because of water quality concerns, the focus in the Southwest Region is the collection of rainwater for outdoor use. If potable use is important to individual residents of the region, treatment systems are available for collected rainwater.

The components of a rainwater harvesting system include the catchment surface (roof), storage reservoir, and delivery system (gutters and downpipes) from catchment area to storage reservoir. Rainwater harvesting systems are simple; however, their effectiveness in increasing supply is limited by the amount of rainfall and size of the catchment area, and water quality can be vulnerable (Gould and Nissen-Petersen, 1999).

8.13.1 Key issues

Water quality is a key issue with rainwater harvesting systems. Rainwater has much higher levels of atmospheric pollution in urban areas, and it should not be harvested in agricultural areas where crop dusting and pesticide use is prevalent (Gould and Nissen-Petersen, 1999). Roofs that include lead flashing or that have been painted with lead-based paints should not be used as catchment areas, and water storage tanks need to be watertight and located at least 50 feet away from sources of contamination such as septic tanks (TWDB, 1997). Rainwater catchment systems may also be affected by roof tar, animal wastes, or other contaminants that may be present on either the roof or the catchment system. If rainwater is used solely for outdoor use, water quality concerns do not pose as great a problem. However, water quality should be considered in the design of any collection system.

Catchment facilities for roof harvesting of stormwater are generally installed and maintained by property owners. To effectively use the harvested water, the storage volume must be adequate to balance inflow and irrigation uses. A storage volume in the range of 1,000 to 1,500 gallons per home is typically needed to optimize capture. Larger volumes are required to serve larger commercial or institutional water harvesting arrangements.

The amount of water available for harvesting is a function of catchment surface (roof or pavement) area and weather. Climatic variability, including drought, will impact the amount of water that can be collected from rainwater harvesting systems. Based on an estimated catchment (roof) area of 1,200 square feet and an assumed 80 percent collection efficiency factor (TWDB, 1997), the average amount of rain that can be collected by a rainwater harvesting system in different parts of the Southwest Region is as follows:

- With an average of 14.3 inches of rain per year, as measured by key climate stations in the area (Section 5.1), a rainwater harvesting system in the Gila River Basin could yield 8,237 gallons per year.

- With an average annual rainfall amount of 9.4 inches in Deming, the average annual amount of water that could be collected is much less, about 5,400 gallons per year for a typical house with a catchment area of 1,200 square feet.

- A rainwater harvesting system on a typical house in Silver City, which receives an average of 16.1 inches per year, could yield 9,300 gallons.

Nothing in the State Water Code prevents individuals from harvesting runoff from roofs or property. Surface water does not become public and subject to State Engineer permitting until it enters a natural stream or watercourse (NMSA §72-5-27). Local governments are free to regulate and/or encourage this type of water management. In the Gila and San Francisco River Basins, outdoor watering using domestic well water is prohibited in the absence of a specific water right. Rainwater harvesting may provide a supplemental supply, providing that depletions are not increased significantly (i.e., redirecting the typically 90 percent of precipitation that does not become streamflow should not affect depletions).

8.13.2 Implementation

Roof water systems can typically be installed by homeowners or local contractors. Cisterns require no pump to water nearby landscaping. Underground tanks usually require a pump or sloped terrain plus piping to deliver the irrigation water to landscaping.

If the terrain permits, shallow earthen basins can make very inexpensive alternatives to cisterns. Landowners can plant trees, grass, and ornamental landscaping that otherwise would require irrigation directly in the basins. Infiltration pits with pumice wicks have also been successfully placed under individual roof spouts to promote infiltration and irrigate landscaping near the house (Williams et al., 2002).

The success of a rainwater harvesting system depends heavily on roof condition. Roofs need to be impervious and clean, and roof litter and overhanging branches need to be trimmed to discourage bird perches and promote good water quality. Water collection systems should not be installed on roofs with lead flashing and/or lead-based paint. Gutters need to be clear and have adequate capacity to prevent water from overflowing during large storms. Reservoir inlets need to be covered in order to keep animals out, and water needs to be filtered before entering the reservoir. Although water treatment should be considered for some intended uses, treatment should not be necessary for use in outdoor watering (TWDB, 1997). Rainwater harvesting system maintenance is also an important aspect of the ongoing success of a system.

For roof water harvesting, the cistern tank is typically the most expensive component of the system, costing on the order of $1 per gallon of storage (Williams et al., 2002). If landscaping within a shallow earthen basin is feasible, the storage and distribution costs are essentially eliminated. Roof water harvesting may easily be implemented with new development. However, government subsidies, regulatory requirements, or water rate incentives may be necessary to encourage retrofitting existing development for water harvesting.

A potential mechanism for encouraging rainwater systems in the Southwest Region is the incorporation of rainwater harvesting requirements in local building codes. Both Counties and municipalities in the Southwest Region can consider this option.

8.14 Industrial Conservation

Except for mining operations, industrial self-supplied water use accounts for a relatively small portion of water use for the Southwest Region (Wilson et al., 2003), due both to the relatively small amount of industrial and commercial activity in the region and the fact that commercial and industrial uses are supplied by municipal water systems as well as self-supplied sources. In the U.S., 70 percent of commercial and 18 percent of industrial water demand is provided by public water supply sources (Vickers, 2002). For many public water supply systems, customers in the industrial and commercial water use sector represent 20 to 40 percent of the billed urban water demand, although that percentage is probably somewhat lower in the Southwest Region.

Some of the users of industrial and commercial water that are currently located or might be expected to locate in the Southwest Region are:

- Office buildings
- Hospitals
- Hotels and motels
- Schools
- Manufacturing facilities
  - Food processing
  - Computer and electronic manufacturers
- Car washing facilities
- Metal finishing
- Mining
- Power production

Although most of these industrial and commercial users are not major components of water demand in the region, within a local area they can be large water users per site or account compared with individual residential users. Additionally, power plants and mining operations are major water users in the Southwest Region. Therefore the industrial/commercial sector presents significant conservation opportunities.

8.14.1 Key Issues

Where industrial and commercial users are not already engaged in water conservation, the perceived cost of implementing conservation measures may be a disincentive. Such resistance might be overcome by providing technical support and information to these users and making them aware of potential cost savings.

Typically, a large water user will begin identifying conservation opportunities by conducting a water audit. This information is useful because it identifies inefficiencies that were previously unknown and provides the necessary data for developing a cost/benefit analysis to justify implementation of various conservation activities. For self-supplied industrial users, the existing driver for conservation is often the savings achieved by the ability to reduce the water rights, construction, and operation costs for the water supply system.

Local governments can address industrial and commercial water conservation through two routes. The first is to consider water use in the types of industry targeted by economic development efforts and to determine the types of industrial and commercial activity that would be admissible. The second is to include in water conservation ordinances achievable conservation measures targeted to the particular types of industrial and commercial water users supplied through the local water system.

8.14.2 Implementation

8.14.2.1 Water Use Considerations in Economic Development Efforts

In a water-short region, it is obviously important to consider the likely water consumption of the types of industry being pursued to foster economic development. Key decision makers in the Southwest Regional Council of Governments and in county and municipal governments must have some knowledge of water consumption patterns and options for various types of industry. Many information sources are available including, for example:

- OSE web site water conservation information (http://www.seo.state.nm.us/water-info/conservation)

- EPA water use efficiency program (http://www.epa.gov/OW-OWM.html/water-efficiency/index.htm)

- American Water Works Association Water Efficiency Clearinghouse webpage (http://www.awwa.org/waterwiser)

- *Waste not, want not: The potential for urban water conservation in California, Appendix C, Industrial and commercial water use: Glossary, data, and methods of analysis* (http://www.pacinst.org/reports/urban_usage/appendix_c.pdf)

- Texas Water Conservation Implementation Task Force *Water Conservation Best Management Practices Guide* (http://www.twdb.state.tx.us/assistance/conservation/TaskForceDocs/WCITFBMPGuide.pdf)

- North Carolina Department of Environment and Natural Resources (http://www.ncwater.org)

8.14.2.2 Municipal or County Ordinance

One key tool to implement the industrial conservation alternative is to develop water conservation goals at the municipal level for all users and develop an ordinance that specifically targets large users. Although water conservation will result in costs savings over the long term, it is worthwhile to set up a formal structure within the municipal conservation ordinance to identify conservation goals and requirements for different categories of industrial and commercial users. Deming and Silver City both already have water conservation ordinances and inverted block rate water pricing structures. These ordinances could be specifically amended to require water conservation practices by particular commercial/industrial users with the potential for significant water use.

A large number of information sources are available on the types of commercial and industrial water conservation practices that can be encouraged by municipal water conservation ordinances, including those listed in Section 8.14.2.1. These sources cover a range of possibilities, from maximum water use allocations based on nationwide surveys of water consumption using standard conservation practices to requiring reuse of process wastewater to local government water audits to requiring industrial self audit reports (e.g., TWDB, 2004; Gleick et al., 2003).

The City of Albuquerque sets out its requirements in the Water Conservation Large Users Ordinance (6-1-4-1). The objective of this regulation is to:

- Assist in reducing overall per capita water use

- Require development and adoption of implementation plans for customers using large amounts of water through a cooperative process with the City

- Assist large users in identifying ways to reduce water use
- Formalize monitoring and metering requirements and goals for water use reductions

8.14.2.3 Office of the State Engineer Guidance

To assist large water users in implementing conservation measures, the OSE has developed a lengthy guidance document entitled *A Water Conservation Guide for Commercial, Institutional, and Industrial Users* (NM OSE, 1999). This handbook identifies water conservation opportunities for specific types of industrial and commercial water uses, including:

- Indoor domestic use
- Outdoor landscaping
- Heating and cooling
- Specific processes and industries

The handbook describes successful cases studies, including food processors, hotels, industries, hospitals, and a university.

8.14.2.4 Water Conservation in Mining and Power Plant Operations

Metal mining production uses large amounts of water, and opportunities for water savings exist in several aspects of the mining operation. For example, reduction of the density of tailings slurry by 1 percent results in a water savings of 500 to 800 ac-ft/yr; decant towers installed around tailings ponds can quickly decant the water and reduce water lost to evaporation (Gelt et al., 1999). This is only one example of the many possibilities (a detailed review of mining and ore processing water conservation techniques is beyond the scope of this brief analysis).

Since most of the regional mining activity is conducted by large business organizations with their own water rights and self-supplied water systems, local governments may have little influence over their water conservation practices. Regional coordination and information transfer, as has occurred during the regional water planning process, may result in voluntary cooperation on conservation and supply issues. If water is apparently being used inefficiently and the industry refuses to cooperate with regional interests, the only viable solution may be legislation (often at the State level) or, if existing requirements are being ignored, legal action.

In addition to general operational water conservation measures, power plants can greatly reduce water use by using air-cooling rather than water-cooling technologies (Arizona WRRC, 2002). The key issue with this choice of this technology is cost: water cooling is less expensive, especially if the plant has already acquired water rights. However, as water right prices tend to increase over time, the air-cooling technology may be more appealing for future plant development. In review at the state level and in regional economic development efforts, the type of cooling technology and other water conservation issues should definitely be considered.

The Luna Energy Facility now under construction 2 miles north of Deming is already permitted for use of conventional water cooling technology. It is a large 570-megawatt facility with enough capacity to serve more than 450,000 houses (PNM, 2004) and is an important economic asset to Deming, Luna County, and the Southwest Region. The plant will consume 3,000 acre-feet of water per year, one third of which will come from treated effluent from the City of Deming Wastewater Treatment Plant. Conservation was obviously considered in the design of this facility (PNM, 2004). Wastewater reclamation and reuse is an important technique in both municipal (Section 8.2) and industrial conservation. The reuse can be of either reclaimed wastewater from municipalities or other industrial facilities or directly recycled industrial process wastewater.

Given the limited commercial and industrial consumptive use in the region, the first step in implementing increased conservation should probably be a survey of the likely cost/benefit of potential actions. This survey could be done at the regional, county, or municipal level, and the results can be used in developing economic development plans and planning for practical conservation requirements.

8.15 Domestic Wells

This section explores the potential for protecting groundwater supplies by either limiting the number of or amount that can be withdrawn from domestic wells. The general concept behind this alternative is that while New Mexico state law currently places no restrictions on domestic well withdrawals, restrictions may be needed to protect senior water rights holders. There are some local restrictions on domestic well use:

- Court-ordered restrictions in the Gila and San Francisco basins that limit domestic wells to indoor uses without a separate water right

- County ordinances that limit withdrawals to 1 ac-ft/yr

Although domestic wells pump small quantities of water compared to municipal and agricultural wells, they can in some instances adversely impact groundwater resources in areas that are already stressed. During the year 2000, domestic wells accounted for 6.5 percent (7,200 ac-ft) of all groundwater depletions in the Southwest Region.

Where domestic wells are clustered together on small plots of land, they may interfere with the production of other wells, especially in areas where aquifers are thin or have low transmissivities. Another related aspect of areas that rely on domestic well water is that they generally also rely on septic systems instead of community sewers. In areas where population density is great enough to warrant it, the completion of community water supply and wastewater treatment is generally conducive to protecting both water supply and water quality.

8.15.1 Key Issues

Domestic wells in New Mexico are regulated under Section 72-12-1 of New Mexico state law and are permitted differently than other water rights in New Mexico in two primary ways:

- A domestic well permit does not confer a water right that can be moved away from the specific well permitted.

- The OSE is required by state law to grant domestic well permits for residential use, no matter what their consequences may be. Under certain circumstances, however, the OSE, as well as counties and municipalities, may further regulate the amount of water use and the construction of domestic wells (Section 8.15.2), and in some areas where groundwater is limited, the OSE has specified lower diversion limits.

OSE rules limit diversions from each permitted well to 3 ac-ft/yr. This limit is a remnant of law designed to meet the needs of households decades ago, where dependence upon private gardens and livestock watering was typical, and many households today use much less that 3 ac-ft/yr. However, since there is no required metering of withdrawals from domestic wells, it is difficult to know how much water is actually being used.

8.15.2 Implementation

A municipality or county currently has the authority to deny or otherwise regulate a new or existing domestic well if all of the following conditions exist:

- The boundary of the property on which the well exists or is desired lies within 300 feet of a water supply distribution line.
- The cost of connecting to a distribution system is less than the cost of drilling the well.
- The land is not zoned agricultural.

Denying or modifying a permit when these conditions are not met requires the passage of state law. Numerous attempts have been made in the past to enact laws that modify the current well permitting regulations, but they meet stiff opposition in both chambers of the Legislature. In 2002, for example, House Bill 271, introduced by Representative Joe Stell (D-Carlsbad) and Senate Bill 478, introduced by Senator Dede Feldman (D-Albuquerque) would have given the State Engineer the authority to deny applications for domestic well permits in these and other limited circumstances. These and other bills have been defeated, but additional legislation is anticipated in the future.

8.16 Summary Recommendations and Implementation Schedule

As discussed in Section 8.1, a comprehensive list of alternatives was developed at the beginning of 2004. The list was prioritized and the priority alternatives analyzed, as discussed herein. The other alternatives on the comprehensive list are also part of the long-term planning strategy for the Southwest Region. Recommended actions for implementation of all the alternatives, along with the responsible party and time frame for implementation, are presented in Table 8-20. Potential funding sources for alternative implementation are included in Table 8-21.

Table 8-20. Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
Page 1 of 4

	Alternative [a]	Implementation Priority [b,c]	Action	Responsible Party [d]
Water Resource Infrastructure Development				
ID1	Divert New Mexico's Gila River Entitlement for aquifer storage and recovery	1	• Continue dialogue to resolve concerns • Conduct environmental studies • Conduct feasibility study to identify optimal location and diversion structure	SWWPG
ID2	Store New Mexico's Gila/San Francisco River Entitlement in reservoirs	3	• Focus on small, non-mainstem reservoirs	SWWPG
ID3	Treat and reuse wastewater	1	• Continue and expand local programs	Local water providers
ID4	Recycle commercial and residential on-site water for nonpotable uses.	1	• Develop commercial reuse plans as new commercial development occurs	Local water providers
ID5	Desalinate water in southern basins	3	• Monitor desalination efforts statewide • Investigate further saline sources	State/federal government and/or private entity
ID6	Develop additional surface water	1	• Reconsider feasibility of other resources in the future • Develop implementation plan for San Francisco CAP entitlement	SWWPG
ID7	Collect rainwater off structure roofs or other impervious surfaces	2	• Consider local ordinances requiring rainwater harvesting on new construction • Provide technical resources to individual homeowners	Local governments Private homeowners
ID8	Enhance surface recharge in and along surface water courses	1	• Participate in watershed groups, WRAS development • Implement projects along Gila, San Francisco, and Mimbres Rivers	SWCDs Federal agencies
ID9	Import a large amount of water into the region	3	• Reconsider feasibility in the future	State/federal agencies SWWPG

[a] Shaded alternatives identified as priority alternatives

[b] 1 = Begin implementing immediately (within 1 to 3 years)
2 = Begin implementing in 4 to 10 years
3 = Begin implementing in 11 to 40 years

[c] Implementation may begin by seeking funding or conducting feasibility studies; projects may not be constructed until later.

[d] Primary responsible parties; others may also be involved. Definitions of abbreviations are provided at the end of this table.

CAP = Central Arizona Project
WRAS = Watershed restoration action strategy

Table 8-20. Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
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Alternative [a]		Implementation Priority [b,c]	Action	Responsible Party [d]
Water Conservation				
WC1	Implement municipal water supply conservation	1	• Complete municipal water conservation policies and ordinances • Provide assistance for mutual domestic conservation initiatives	Municipalities; local water providers (e.g., mutual domestic associations)
WC2	Implement agricultural conservation measures	1	• Support statewide agricultural conservation funding mechanisms • Consider using part of the New Mexico Gila Settlement to fund conversion to drip irrigation.	SWCDs Counties NRCS RC&Ds
WC3	Implement industrial conservation measures	1	• Develop industrial conservation policies prior to industrial development	Local government Industry
Water Quality				
WQ1	Identify, monitor and protect groundwater and surface water vulnerable to contamination	1	• Review existing programs and sites	SWCDs NMED
WQ2	Construct alternative wastewater treatment systems to replace/modify septic systems	2	• Update county septic tank ordinances	State and local government
Water Supply Development				
WS1	Manage watersheds to improve yield and reduce the risk of fire	1	• Conduct pilot projects and monitor yield increases to provide data for design of future projects	SWCDs USFS Collaborative watershed groups
WS2	Implement cloud seeding or other programs to increase precipitation	3	• Monitor progress in other regions	SWCDs NRCS NOAA

[a] Shaded alternatives identified as priority alternatives
[b] 1 = Begin implementing immediately (within 1 to 3 years)
2 = Begin implementing in 4 to 10 years
3 = Begin implementing in 11 to 40 years

[c] Implementation may begin by seeking funding or conducting feasibility studies; projects may not be constructed until later.
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CAP = Central Arizona Project
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Table 8-20. Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
Page 3 of 4

Alternative [a]		Implementation Priority [b,c]	Action	Responsible Party [d]
WS3	Remove non-native vegetation and revegetate with native species to reduce riparian evapotranspiration	1	• Remove local exotics before they become widespread in the region	SWCDs Federal agencies
WS4	Develop additional groundwater	3	• Initiate groundwater assessments and modeling as soon as possible	Local governments SWWPG
Water Resources Management				
WM1	Establish a water bank	1	• Define geographic boundaries and meet with users within the boundary • Develop water bank operating guidelines	SWWPG OSE
WM2	Establish a regional water management authority	1	• Consider Gila project implementation as part of SWWPG	All local governments SWWPG
WM3	Develop a border groundwater management plan	1	• Continue to participate in Border 2012 initiative • Consider specific management objectives in Columbus-Palomas area	State and federal agencies WRRI
WM4	Develop local and/or regional groundwater management plans	1	• Conduct additional local groundwater monitoring and modeling	Local governments SWWPG
WM5	Restrict installation of new domestic wells and/or the amount of pumpage from existing domestic wells in areas outside of the Gila	1	• Monitor statewide legislation • Consider additional actions locally	OSE Local governments
WM6	Petition the OSE to declare undeclared groundwater basins in the region	1	• Express regional support for declaration to OSE • Meet with local users in undeclared areas to hear their concerns	SWWPG Hidalgo County Luna County Grant County

[a] Shaded alternatives identified as priority alternatives
[b] 1 = Begin implementing immediately (within 1 to 3 years)
2 = Begin implementing in 4 to 10 years
3 = Begin implementing in 11 to 40 years

[c] Implementation may begin by seeking funding or conducting feasibility studies; projects may not be constructed until later.
[d] Primary responsible parties; others may also be involved. Definitions of abbreviations are provided at the end of this table.

CAP = Central Arizona Project
WRAS = Watershed restoration action strategy

Table 8-20. Implementation Schedule and Recommended Actions for Alternatives to Meet Future Supply Needs
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Alternative [a]		Implementation Priority [b,c]	Action	Responsible Party [d]
WM7	Set aside some of the captured New Mexico Gila/San Francisco River Entitlement for instream flow and environmental purposes in the Gila	1	• Articulate the importance of this alternative • Participate in SWWPG group to ensure that concerns are included in the project design phase • Participate in environmental studies conducted for the Gila CAP project	SWWPG GCC SWCD
WM8	Ensure that future growth optimizes wise use of water resources and protects local social and cultural values	1	• Review county and municipal ordinances and consider strengthening water supply components	Local governments
WM9	Consider making water use in the Gila and Mimbres Basins more equitable with the rest of the region	3	• Research using CAP water for domestic use in the Gila as part of the CAP implementation	SWWPG

GCC = Gila Conservation Coalition
NMED = New Mexico Environment Department
NRCS = Natural Resources Conservation Service
OSE = New Mexico Office of the State Engineer
RC&D = Resource Conservation and Development
SWCD = Soil and Water Conservation District
SWWPG = Southwest Water Planning Group, convened to implement the Gila-San Francisco CAP water, ultimately through a Joint Powers Authority
USFS = USDA Forest Service
WRRI = New Mexico Water Resources Research Institute

[a] Shaded alternatives identified as priority alternatives
[b] 1 = Begin implementing immediately (within 1 to 3 years)
2 = Begin implementing in 4 to 10 years
3 = Begin implementing in 11 to 40 years
[c] Implementation may begin by seeking funding or conducting feasibility studies; projects may not be constructed until later.
[d] Primary responsible parties; others may also be involved. Definitions of abbreviations are provided at the end of this table.

CAP = Central Arizona Project
WRAS = Watershed restoration action strategy

Table 8-21. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Areas: Water Supply Conservation	Funding Areas: Development and Infrastructure	Funding Areas: Water Supply Protection	Funding Areas: Water Resources Management	Description
General Information					
Catalog of Federal Domestic Assistance http://www.cfda.gov/	■	■	■	■	Good information about funding sources, grant writing, etc.
Federal Grants Search www.grants.gov	■	■	■	■	Searches all federal agency sources for grant information
Federal Drought Programs http://www.iwr.usace.army.mil/iwr/drought/feddrghtprogs.htm	■	■	■	■	Summary of federal funding sources available for drought programs.
Catalog of Federal Funding Sources for Watershed Protection http://cfpub.epa.gov/fedfund/			■		Topical listing of funding sources related to watershed protection.
Links to private funding sources http://www.epa.gov/owow/nps/capacity/funding.htm	■	■	■	■	List of links for private funding sources for various areas.
Funding Programs					
New Mexico Clean Water State Revolving Fund *New Mexico Environment Department*, *Construction Programs Bureau* Santa Fe: 505-827-2806 http://www.nmenv.state.nm.us/cpb/cpbtop.html http://www.nmenv.state.nm.us *New Mexico Water Trust Board* Contact New Mexico Finance Authority (NMFA) U.S. *Environmental Protection Agency (EPA)* http://www.epa.gov/owm/cwfinance/cwsrf/	■	■	■	■	Eligible projects include water supply development, conservation, watershed management, and infrastructure. Water quality protection projects for wastewater treatment, nonpoint source pollution control, and watershed and estuary management.

[a] Web site address as of November 2002; address and information found there is subject to change.

Table 8-21. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Areas: Water Supply Conservation	Development and Infrastructure	Water Supply Protection	Water Resources Management	Description
Community Development Block Grants *Department of Housing and Urban Development* http://www.state.nm.us/clients/dfa/Files/LGD/CDB/index.html				■	Funding source for 40-year plans.
Community Facilities (CF) Direct Loans and Grants *U.S. Department of Agriculture (USDA)* http://www.rurdev.usda.gov/rhs/cf/cp_dir_grant.htm		■			Provides loans for the development of essential community facilities for public use in rural areas and towns with a population of 20,000 or less.
Emergency Community Water Assistance Grants *USDA Rural Utility Services (RUS)* Albuquerque: 505-761-4955 Deming: 505-546-9692 http://www.rurdev.usda.gov/nm/ http://www.usda.gov/rus/water/programs.htm#EMERGENCY http://www.usda.gov/rus/water/		■	■		Assists rural communities that have had a significant decline in quantity or quality of drinking water.
Irrigation Works Construction Loan Fund *New Mexico Interstate Stream Commission* Santa Fe: 505-827-6160 Fax 505-827-6188 http://nmlocalgov.net/plan/pdf/seall.pdf		■			Makes loans to entities such as irrigation districts, community ditch associations, and municipalities for engineering and design, construction, or rehabilitation of irrigation works.
Acequia Restoration and Rehabilitation Program *U.S. Army Corps of Engineers, Albuquerque office* *New Mexico Interstate Stream Commission* Santa Fe: 505-827-6160 Fax 505-827-6188		■			Joint program with U.S. Army Corps of Engineers (COE); provides eligible acequias with COE grants that fund up to 75% of a project's cost with 25% acequia funding. Matching requirements may be met through state grants (17.5%) and loans (7.5%).

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Table 8-21. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Areas: Water Supply Conservation	Funding Areas: Development and Infrastructure	Funding Areas: Water Supply Protection	Funding Areas: Water Resources Management	Description
Ditch Rehabilitation Grant Program *Office of the State Engineer* Santa Fe: 505-827-6191 Fax 505-827-6188		■			Joint program with U.S. Soil Conservation Service; provides grants to community ditches for construction, repair, and improvement of ditches, dams, reservoirs, flumes, and appurtenances.
Planning Assistance to States *U.S. Army Corps of Engineers* Albuquerque*: (505) 342-3109* http://www.spa.usace.army.mil	■	■	■	■	Assists in planning for the development, utilization, and conservation of water and related land resources and ecosystems.
Reclamation States Emergency Drought Relief Act of 1991 - Title II *U.S. Bureau of Reclamation* Albuquerque Area Office: 505-248-5323 http://www.uc.usbr.gov/progact/waterconsv/wtr_wmp.html http://nris.state.mt.us/drought2001/reports/DRTBuRecDrRelief.html	■	■	■	■	Assistance in the construction and planning of projects that mitigate effects of drought.
Conservation Technical Assistance *USDA Natural Resource Conservation Service* Deming: 505-546-9692 Albuquerque Office: 761-4407; 1-800-410-2067 http://www.nrcs.usda.gov/programs/cta/			■	■	Planning and implementation of solutions to natural resource concerns, including drought.

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Table 8-21. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Areas: Water Supply Conservation	Funding Areas: Development and Infrastructure	Funding Areas: Water Supply Protection	Funding Areas: Water Resources Management	Description
Safe Drinking Water Act Revolving Loan Program *New Mexico Environment Department, Construction Programs Bureau* Santa Fe: 505-827-2806 http://www.nmenv.state.nm.us/cpb/cpbtop.html http://www.nmenv.state.nm.us *U.S. EPA* http://www.epa.gov/safewater/dwsrf.html		■	■		Water infrastructure improvements, for small and disadvantaged communities and for pollution prevention to ensure safe drinking water.
Water and Waste Loans and Grants *USDA Rural Development* Albuquerque: 505-761-4955 Deming: 505-546-9692 http://www.rurdev.usda.gov/nm/ http://www.usda.gov/rus/water/programs.htm		■	■		Development or improvement of water or wastewater disposal systems in rural areas.
Snow Survey and Water Supply Forecasting Program *USDA Natural Resources Conservation Service* Deming: 505-546-9692 Albuquerque: 505-761-4407; 1-800-410-2067 http://www.nrcs.usda.gov. http://www.nrcs.usda.gov/programs/snowsurvey/				■	Monitoring of climatic and hydrologic elements necessary to produce water supply forecasts.
Reclamation Water Reclamation and Reuse Program *U.S. Bureau of Reclamation* Albuquerque: 505-248-5323 http://www.cfda.gov (Search using keyword: groundwater or wastewater) http://www.usbr.gov/pmts/writing/guidelines/	■	■			Appraisal and feasibility studies on water reclamation and reuse projects.

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Table 8-21. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Areas: Water Supply Conservation	Development and Infrastructure	Water Supply Protection	Water Resources Management	Description
Small Watershed Program *USDA Natural Resources Conservation Service* Deming: 505-546-9692 Albuquerque: 505-761-4407; 1-800-410-2067 http://www.nrcs.usda.gov/programs/watershed/	■		■	■	Agricultural water management, municipal and industrial water supply, groundwater recharge, and watershed protection projects.
Conservation Partnership Initiative *USDA Natural Resources Conservation Service* Deming: 505-546-9692 Albuquerque: 505-761-4407; 1-800-410-2067 http://www.nrcs.usda.gov/programs/cpi/			■		Funds projects that promote terrestrial and freshwater aquatic wildlife habitat and address invasive species (such as noxious weeds). (See guidance for additional non-watershed related project eligibility)
Environmental Quality Incentives Program (EQIP) *USDA Natural Resources Conservation Service* Deming: 505-546-9692 Albuquerque: 505-761-4407; 1-800-410-2067 http://www.nrcs.usda.gov/programs/eqip/	■		■		Practices to address soil, water, and related natural resource concerns on farm and ranch lands.
Emergency Water Supplies *USDA Rural Development* Santa Fe: 505-476-9600 http://www.dps.nm.org/emergency/index.htm Deming: 505-546-9692	■		■		Provision of emergency water supplies to communities that may run out of adequate drinking water.
Finance Authority Emergency Funding and Water and Wastewater Grant Program *NMFA* Contact: NMFA at (505) 984-1454 toll free, 1-877-ask-nmfa		■			Provision of emergency water supplies.

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Table 8-21. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Areas: Water Supply Conservation	Development and Infrastructure	Water Supply Protection	Water Resources Management	Description
Emergency Conservation Program *USDA Farm Services* *Deming: 505-546-9692* *Albuquerque : 505-761-4407; 1-800-410-2067* http://disaster.fsa.usda.gov/ecp.htm	■				Rehabilitation of farm lands and conservation facilities.
Public Assistance /Emergency Measures Program *New Mexico Emergency Management Center* Regional Office Main Number (940) 898-5399 Santa Fe: 505-476-9600 http://www.dps.nm.org/emergency/index.htm http://www.fema.gov/regions/vi/index.shtm		■		■	Activities to alleviate consequences of the subject of a Presidential Emergency or Major Disaster Declaration (such as drought).
Economic Adjustment Program: Sudden and Severe Economic Dislocation Components *U.S. Department of Commerce EDA* http://www.osec.doc.gov/eda/				■	Prevention of serious economic dislocations or reestablishment of employment opportunities after a sudden and significant dislocation.
Conservation Reserve Program *USDA Natural Resources Conservation Service* http://www.nrcs.usda.gov/programs/crp/ Deming: 505-546-9692	■				Helps farmers and ranchers address water resource concerns on their lands.
Emergency Watershed Protection *USDA Natural Resources Conservation Service* http://www.nrcs.usda.gov/programs/ewp/ Deming: 505-546-9692			■	■	Emergency recovery measures to relieve imminent hazards to life and property as a result of natural disasters.

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Table 8-21. State and Federal Funding Sources
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Program Title / *Agency* / Web Site or Contact [a]	Funding Areas: Water Supply Conservation	Development and Infrastructure	Water Supply Protection	Water Resources Management	Description
Emergency Well Construction and Water Transport *USACE* *U.S. Army Corps of Engineers Albuquerque District Office* Albuquerque: 505-342-3109 http://www.spa.usace.army.mil		■	■		Construction of wells or transport of water drought-distressed areas.
Water Quality Program *USDA CSREES* http://www.csrees.usda.gov/nea/nre/in_focus/ water_if_waterquality.html			■		Provide watershed- based information for assessing and improving sources of water quality impairment in targeted watersheds.
Unsolicited proposals *U.S. Geological Survey* http://www.usgs.gov/contracts/grants/unsolbk.html	■			■	Research proposals in many earth science areas, including hydrology and conservation.
State-EPA NPS Partnership *U.S. Environmental Protection Agency* http://www.epa.gov/owow/nps/partnership.html			■		Focus on nonpoint source topic-specific needs including: watershed planning and implementation.
Land and Water Conservation Fund Grants to States *National Park Service* http://www.nps.gov/ncrc/programs/lwcf/			■		Matching grants to states and local governments for the acquisition and development of public outdoor recreation areas and facilities.
Water Reclamation and Reuse Program *U.S. Bureau of Reclamation* http://www.usbr.gov/pmts/writing/guidelines/		■			Projects for reclamation and reuse of municipal and other wastewaters and naturally impaired waters.

[a] Web site address as of November 2002; address and information found there is subject to change.

The larger the projected gap between demand and the existing supply, the greater the need for implementing alternatives. While all communities will benefit from alternatives that protect and restore water supplies, communities in the Mimbres Basin, located in Luna and Grant Counties, are projected to face the largest gap between existing supply and future demand. In these two counties the projected gap in 2040 is about 6,300 and 5,000 ac-ft, respectively, under the high projection, as opposed to less than 1,000 ac-ft, even under the 20 percent safety factor projection, in Catron and Hidalgo Counties (Table 8-22).

Table 8-22. Projected Gap Between Supply and Demand in 2040

County	Projection	Water Use in 2000 [a] (ac-ft)	Projected Water Use [a] (ac-ft)				Gap in 2040 (ac-ft)
			2010	2020	2030	2040	
Catron	Low	471	471	471	471	471	0
	High	471	527	558	565	571	100
	20% Safety	1,119	1,280	1,317	1,326	1,333	214
Luna	Low	5,237	6,032	6,723	7,324	7,842	2,605
	High	5,237	6,857	8,506	10,068	11,501	6,263
	20% Safety	5,237	8,228	10,207	12,082	13,801	8,564
Grant	Low	5,088	4,804	5,130	5,442	5,687	599
	High	5,088	4,811	8,138	9,038	10,035	4,947
	20% Safety	5,379	6,064	10,056	11,136	12,333	6,955
Hidalgo	Low	1,595	1,559	1,511	1,446	1,376	–219
	High	1,595	1,793	1,884	1,894	1,897	302
	20% Safety	1,595	2,151	2,261	2,273	2,276	681
Total	Low	12,391	12,866	13,835	14,683	15,375	2,984
	High	12,391	13,988	19,086	21,565	24,004	11,613
	20% Safety	13,329	17,724	23,841	26,816	29,743	16,414

[a] Withdrawals for municipal, domestic, commercial and industrial uses   ac-ft = Acre-feet

Each decision-making body will conduct their own detailed assessment of options for meeting their projected water supply needs. The implemented solutions will likely be comprised of a combination of the alternatives discussed in this water plan. For Luna and Grant Counties, where the gap is greatest, several of the alternatives could address the gap:

- As discussed in Section 8.2, the gap in 2040 in Luna and Grant Counties can be reduced by about 3,500 and 1,400 ac-ft, respectively, through implementation of municipal conservation.

- Water rights could potentially be transferred from the 114,000 and 30,000 acre-ft diverted for irrigation in these counties and from the more than 21,000 ac-ft/yr currently used for mining in Grant County. However, this option only moves water from one use to another and thus does not create any new water or reduce demand as needed to lessen the demand gap.

- Increased groundwater production on the order of 1,000 to 2,000 ac-ft/yr may be possible in southeastern Luna County; however, existing pumping in other parts of the basin is currently at unsustainable levels and new groundwater development would thus be considered replacement of existing pumping rather than a new supply to address the demand gap.

- The total increase in water that could occur if 100 percent of the 250,000 acres of land that receive more than 18 inches of precipitation in the four-county region are thinned is estimated to range from 4,000 to 10,000 ac-ft/yr. This amount of water would be available for habitat and existing water rights through increased streamflow or groundwater recharge, but would not be considered as a new source of supply to meet projected demand gaps, because no water rights would be associated with this water and the amount would vary from year to year.

- The Gila River Entitlement of 10,000 ac-ft/yr from the Gila River, if used in an aquifer storage and recovery project, could help meet the demand gaps projected in Luna and Grant Counties.

In the absence of a regional joint powers authority stemming from the Southwest Water Planning Group or other future regional water authority, implementation will be a local government responsibility. However, continued regional coordination of water resource planning will be essential to effective solutions to regional water issues.