EFFECTS OF POLICIES GOVERNING WATER REUSE ON AGRICULTURAL CROPS

Jeffrey Pfeifer[1]
Leeann De Mouche[2]
Dr. Rhonda Skaggs[3]
Dr. Adrian Hanson[4]

ABSTRACT

The state of New Mexico is located in the Chihuahuan Desert, an environment characterized by high aridity and a very limited water supply. New Mexico's water is supplied by both rivers and underground aquifers with the Rio Grande serving as the principle source of surface water throughout the state's central corridor. Recycled wastewater has been recognized as a promising source of "new" water throughout the world and in the arid western United States. However, recycled wastewater has yet to be exploited in New Mexico due to current regulations and technological limitations which make it infeasible to employ recycled water in agricultural uses. In order to meet future water needs, New Mexico needs to revise the distribution of testing responsibilities between producers and consumers of recycled water. Technology currently used to treat recycled water in the state also needs to be upgraded in order to guarantee its safe use on crops.

New Mexico is in the process of increasing the efficiency of recycled water production and use but the state still needs more investment and regulatory changes in order to achieve sustainable and higher levels of wastewater reclamation. The use of recycled water for green space irrigation has increased in southern New Mexico. Clear evidence of this increasing trend is the recent construction of a wastewater reclamation facility on Las Cruces' East Mesa. The majority of the water treated at this facility, water which originates in the Jornada Aquifer, will be used for green space irrigation, and as a result will not end up being returned to the Rio Grande. Las Cruces, New Mexico's second largest city, has a rapidly growing population and diversifying economy, and is regularly included on lists of most desirable places to retire, livable small cities, etc.

The objective of this paper is to describe the current water resource situation in southern New Mexico, compare and contrast New Mexico and California regulations regarding recycled water, and provide recommendations for improved recycled water regulations in New Mexico.

[1] Graduate Assistant, New Mexico State University, MSC 3169, New Mexico State University, P.O. Box 30003 Las Cruces, NM 88003; Jeffp@nmsu.edu
[2] Water Resource Specialist, New Mexico State University, MSC 3AE, New Mexico State University, P.O. Box 30003 Las Cruces, NM 88003; ldemouch@nmsu.edu
[3] Professor, New Mexico State University, MSC 3169, New Mexico State University, P.O. Box 30003 Las Cruces, NM 88003; rskaggs@nmsu.edu
[4] Professor, New Mexico State University, MSC CE, New Mexico State University, P.O. Box 30003 Las Cruces, NM 88003; athanson@nmsu.edu

INTRODUCTION AND BACKGROUND

Sources of Water in Las Cruces, New Mexico

Las Cruces, New Mexico is located in south-central New Mexico in the northern part of the Chihuahuan Desert. New Mexico is split from north to south by the Rio Grande, which traverses several rapidly growing metropolitan areas located along the central spine of the state and is the primary source of water for agricultural irrigation in the region. This river is primarily fed by snowmelt from Colorado's southern Rocky Mountains.

New Mexico is a prior appropriation state which means that water rights are established using the "first in time-first in right" principle (Center, 2001). Agricultural water rights are old, well established, and are facing the challenges which arise from growing demand for water by non-agricultural users as well as increasing demand for water by relatively new crops with high levels of consumptive use. The need for more water for agricultural irrigation in New Mexico forces farmers into difficult situations. Farmers must either buy water rights or wet water from other farmers or agricultural water rights holders or use an alternative "new" source of water. Currently all the water that flows down the Rio Grande is fully appropriated which means there are few sources of "new" water. Buying water rights or wet water can be very expensive, and in some cases the cost may be higher than the value of additional crop yield. Furthermore, many cities and local governments are aggressively purchasing water rights in order to secure a future supply of potable water for municipal and industrial (M&I) users. The added competition from M&I users for water rights means that agricultural water users now have relatively less bargaining power in water market transactions.

Groundwater is New Mexico's other important source of drinking water, and one which will be critical to the future of agriculture as well as overall economic and population growth throughout the state. Ground water comes from several underground aquifers, and like surface water is regulated through the New Mexico Office of the State Engineer (OSE). The state engineer has declared 33 underground water basins throughout New Mexico (Center, 2001). The Jornada Aquifer is located along the east side of Las Cruces and is believed to currently hold over 100 million acre-feet of water in the underground storage basin. The Jornada Aquifer (the Mesilla Bolson is the primary drinking water aquifer for Las Cruces) is recharged at a rate of 5,350 acre-feet per year; this is a source of concern because higher volumes of water are annually removed from the aquifer (Creel, 2007). The OSE monitors the extraction of water through limitations on wells. Persons seeking to use groundwater must be granted approval by the state in order to drill and extract the water for use (Center, 2001). The well permitting process requires that a report be sent to the OSE explaining the beneficial use of the water. Upon completion of the beneficial use inspection the OSE will issue a license to appropriate water to that person (Center, 2001).

One of the main concerns about the Jornada Aquifer is that the groundwater that is non-consumptively used is then cleaned and discharged into the Rio Grande. This arrangement adds water to the Rio Grande that otherwise would never end up in the river.

Unlike other aquifers in New Mexico and Texas the Jornada Aquifer is not recharged from the nearby Rio Grande (Creel, 2007). While the current situation contributes to surface water flows in the Rio Grande, the non-consumed groundwater is effectively lost from the Jornada Aquifer forever. The wastewater which remains after M&I pumping of Jornada Aquifer groundwater is currently not reused; however, the City of Las Cruces could use available technology to treat the wastewater and make it acceptable for food crop irrigation, green space irrigation, or other beneficial uses.

New Mexico has not fully utilized water reuse technology in the past; however, the state recently began allowing recycled water to be used for aquifer storage and recovery. State statues (§19.25.8, Natural Resources and Wildlife Administration and Use of Water—General Provisions Underground Storage and Recovery paraphrase) cover the administration and use of water for the purpose of underground storage and recovery (USR). The 1999 Act passed by the New Mexico Legislature allows governmental entities to store surplus supplies of water underground and to withdraw the recoverable amount at a later date for use by the governmental entity. The Legislature found that by passing this act groundwater recharge, storage, and recovery have the potential to: 1) offer savings in the cost of capital investment, operation and maintenance, and flood control and may improve water and environmental quality; 2) reduce the rate at which groundwater levels will decline and stress the aquifer; 3) promote conservation of water; 4) serve the public welfare of the state; and 5) lead to a more effective use of the state's water resources. With this said the effort, efficiency, and process to actually acquire the permit for underground storage and recovery would probably take a sufficient amount of funds and years of time. (State of New Mexico, 2001)

Presently the City of Las Cruces is in the last phase of construction on a Class 1A reclamation plant. This plant will allow the city to clean up to one million gallons of wastewater per day. Presently the non-potable water will be used to irrigate a golf course, high school football field, and several parks. The city has looked into the possibility of USR, but has found that certain barriers exist and limit their capability of USR. Barriers are political in nature but most deal with the fact that there is a need for accountability of stored water and there is a strong need for hydrological modeling. Both of these barriers are expensive and time consuming, although they are not insurmountable.

In recent drought years the Village of Cloudcroft, New Mexico has found itself in critical need of additional M&I water. The Village of Cloudcroft stated that during years of drought it was necessary to truck in approximately 20,000 gallons per day during their peak summer tourism season. (Livingston Associates, 2008) In 2007, Cloudcroft received a $600,000 grant from the State of New Mexico Governors Water Innovation Fund to help fund the village's new $2 million water reuse system. The state of the art system employs a second generation membrane bioreactor (MBR) and gravity fed reverse osmosis system to treat wastewater flows that after treatment exceeds drinking water quality standards. The treated effluent is discharged into a man-made reservoir rather than pumped into a large body of water such as an aquifer. The reservoir serves as a raw water source for the town's drinking water treatment system (Livingston Associates,

2008). This process of developing the treatment system has been very long and tedious, but designing and permitting the system is one of the first steps in the process of developing reclaimed water supplies statewide. Overall New Mexico remains very restrictive with respect to the guidelines and regulations affecting recycled water. In order to use recycled water the producer and the user are heavily regulated, required to produce numerous documents, and continuously test water quality. In many cases it is not economically beneficial or feasible to use recycled water because of the rigid regulatory environment, numerous restrictions, and barriers.

WATER REGULATIONS AND POLICY: NEW MEXICO VS. CALIFORNIA

New Mexico Recycled Water Regulations

Water users throughout New Mexico have not taken full advantage of technology and research that has been conducted within the wastewater reclamation industry. New Mexico has seen the neighboring states of Texas and Arizona embrace readily available and proven water technology designed to help arid regions cope with limited water supplies. Clearly, if New Mexico is to meet the water challenges which will result from population growth and economic expansion, the state cannot afford to fall behind. The need for modernized, reality-based water policy is evidenced by the state's current recycled wastewater classification scheme. New Mexico has four recycled wastewater classes which range from Class 1A to Class 3. The following table describes the four classes and what each class of water can be used for.

Table 1. Uses of Recycled Water by Class Allowed in New Mexico (Utilities, 2007)

Class of Recycled Waste Water	Approved Uses
Class 1A	**Includes usage on all classes listed below:** No setback limit to dwelling unit or occupied establishment
	Backfill around potable water pipes
	Irrigation of food crops
Class 1B	**Includes usage on all classes except 1A:** Impoundments (recreational or ornamental)
	Irrigation of parks, schools yards, golf courses
	Irrigation of urban landscaping
	Snow Making
	Street Cleaning
	Backfill around non-potable piping
	Toilet Flushing
Class 2	**Includes usage on class 2 & 3:** Concrete mixing
	Dust control
	Irrigation of fodder, fiber, and seed crops for milk-producing animals
	Irrigation of roadway median landscapes
	Irrigation of sod farms
	Livestock watering
	Soil compaction
Class 3	**Includes usage only for class 3:** Irrigation of fodder, fiber, and seed crops for non-milk-producing animals
	Irrigation of forest trees (silviculture)

Class of recycled wastewater 1A is the highest standard of treated water in New Mexico. It is approved for the irrigation of food crops; however, the edible portion of the crops cannot come into direct contact with the recycled water. Based on this stipulation cabbage, onions, chile peppers, lettuce, and other vegetables produced in southern New Mexico cannot be irrigated using recycled water. This stipulation does allow other crops produced in the region, such as pecans and corn silage, to use recycled water, although other regulations make it very difficult to do so economically. Wastewater in New Mexico is monitored very strictly at both the reclamation plant and at the point of use. Recycled wastewater has strict quality tolerances that must be met in order to meet Class 1A standards. These Class 1A tolerances are presented in Table 2 below.

Beyond testing by the recycled water producer at the treatment plant, the water must also be tested at the point of use. For example, if a farmer uses recycled water to irrigate their field or orchard, the water must be tested at the point of use. This testing requirement is an extra burden for agricultural irrigators and is a disincentive to the use of recycled water in crop production.

Table 2. New Mexico Water Quality Requirements for Class 1A Recycled Wastewater (Utilities, 2007).

Class of Recycled Wastewater	**Wastewater Quality Parameter**	**Wastewater Quality Requirements**		**Wastewater Monitoring Requirements**	
		30- Day Average	**Maximum**	**Sample type**	**Measurement Frequency**
Class 1A	Biochemical Oxygen Demand (BOD)	10 mg/l	15 mg/l	Minimum of 6-hour composite	3 test/week at major WWTP[1] 1 test per 2 weeks at minor WWTP
	Turbidity	3 Nephelometric Turbidity Units (NTU)	5 Nephelometric Turbidity Units (NTU)	Continuous	Continuous
	Fecal Coliform	5 per 100ml	23 per 100ml	Grab sample at peak flow	3 test/week at major WWTP 1 test/week at minor WWTP
	Ultraviolet UV Transmissivity	Monitor only	Monitor only	Grab Sample or reading at peak flow	Record values at peak hourly flow when fecal coliform samples are collected

[1] Major waste water treatment plants (WWTP) are plants that clean one million gallons or more per day and minor WWTP are ones that produce less than one million gallons per day.

California Recycled Water Regulations

Every U.S. state has different regulations regarding acceptable levels of wastewater treatment, permitted treatment processes, and allowable uses for recycled water. The state of California is a leader in exploitation of recycled water in a variety of applications.

The California Department of Public Health Title 22 Regulations determine the uses for recycled water. Recycled water treated to the tertiary level can be used to irrigate food crops, including edible root crops, parks and playgrounds, schoolyards, residential landscaping and public golf courses (State of California, 2009). California regulations allow treated wastewater to be used in agricultural irrigation, public green space irrigation, and aquifer recharge or storage. Table 3 describes California's regulatory system for recycled water.

Table 3. California Permitted Recycled Water Uses (California, 2009).

Class of Reclaimed Waste Water	**Approved Uses**
Disinfected tertiary recycled water	Irrigation of crops in which edible portion comes into contact with the water
Un-disinfected secondary recycled water	Orchards in which the water has no contact with the edible portion
	Vineyards where water has no contact with edible portion
	Non-food bearing trees
	Fodder and fiber crops and pasture animals not producing milk for human consumption
	Seed crops not eaten by humans
	Food crops that must undergo commercial pathogen – destroying processes
	Ornamental nursery stock with no human contact 14 days after last irrigation with reclaimed water

California's policy of allowing the use of disinfected tertiary recycled water in irrigation of crops where the edible portion is in contact with the water means that state can take full advantage of recycled wastewater. California leads the nation in the production of high quality fruits, vegetables, and specialty crops. The future of these crops in the state depends on the availability of a safe and consistent supply of irrigation water. California agriculture has benefitted from technology development and research done on wastewater reclamation, and as a result now firmly includes recycled water within its short and long-run water resource planning. Due to continued water shortages and expected increases in demand for water in California, the use of recycled water will continue to play an important role in California agriculture. Other California industries also currently use recycled water, with varying degrees of dependence on the recycled supplies. The energy industry, public utilities, and prevention of sea water intrusion rely heavily on recycled water in California. The table below describes the requirements for disinfected "2.2 recycled water." Water recycled at the 2.2 parts of total coliform bacteria/milliliter standard and which has been oxidized and disinfected can be used to irrigate edible food crops if the crops do not have contact with recycled water.

Table 4. Quality Requirements for Recycled Waste water in California (California, 2009).

Class of Recycled water	**Wastewater Quality Parameter**	**Wastewater Quality Requirements**		**Measuring Frequency**
		30- day average	**Maximum**	
Disinfected secondary 2.2 recycled water	Total coliform organisms	2.2 per 100ml	23 per 100ml	Once daily
	Turbidity	2 NTU	5 NTU	Continuous
	Treatment process must contain coagulation			

Disinfected secondary "23 recycled water" is treated water that never surpasses a total of 23 per 100ml of coliform organisms and does not meet the requirement of the 2.2 per 100ml for a 30 day average. This level of treatment allows water to be used for public areas and seed and fodder production but not for edible food production (California, 2009).

California requires the producer/supplier of the recycled water to test and assure that the treated water meets regulatory standards. These regulations give the recycled water producer the primary responsibility for water quality, rather than the treated water consumer. California also allows manufacturers to demonstrate using a standard protocol that the standard can be met consistently. Use of a certified technology then reduces the testing burden for the water producer. As a result, barriers to the use of the recycled water are reduced.

The assignment of recycled water quality responsibility to water producers has resulted in California's status as a leading state in the use of recycled water. In 2006-07, California used 14,118 acre-feet of water in agricultural irrigation. Recycled water used in Los Angeles County alone totaled 94,750 acre-feet in the same year; figure 1 below illustrates the distribution of recycled water use in Los Angeles County in 2006-07. Almost 50% of the recycled water used in Los Angeles County was used in USR, thus contributing to the long-run sustainability of water supplies in the region (MIT, 2010). By comparison, as of 2008, there was minimal recycled water used in USR anywhere in the state of New Mexico. The City of Albuquerque Public Works Department stated that a pilot project was conducted in Albuquerque (2007-2008), but this project has been discontinued (Yuhas, 2009).

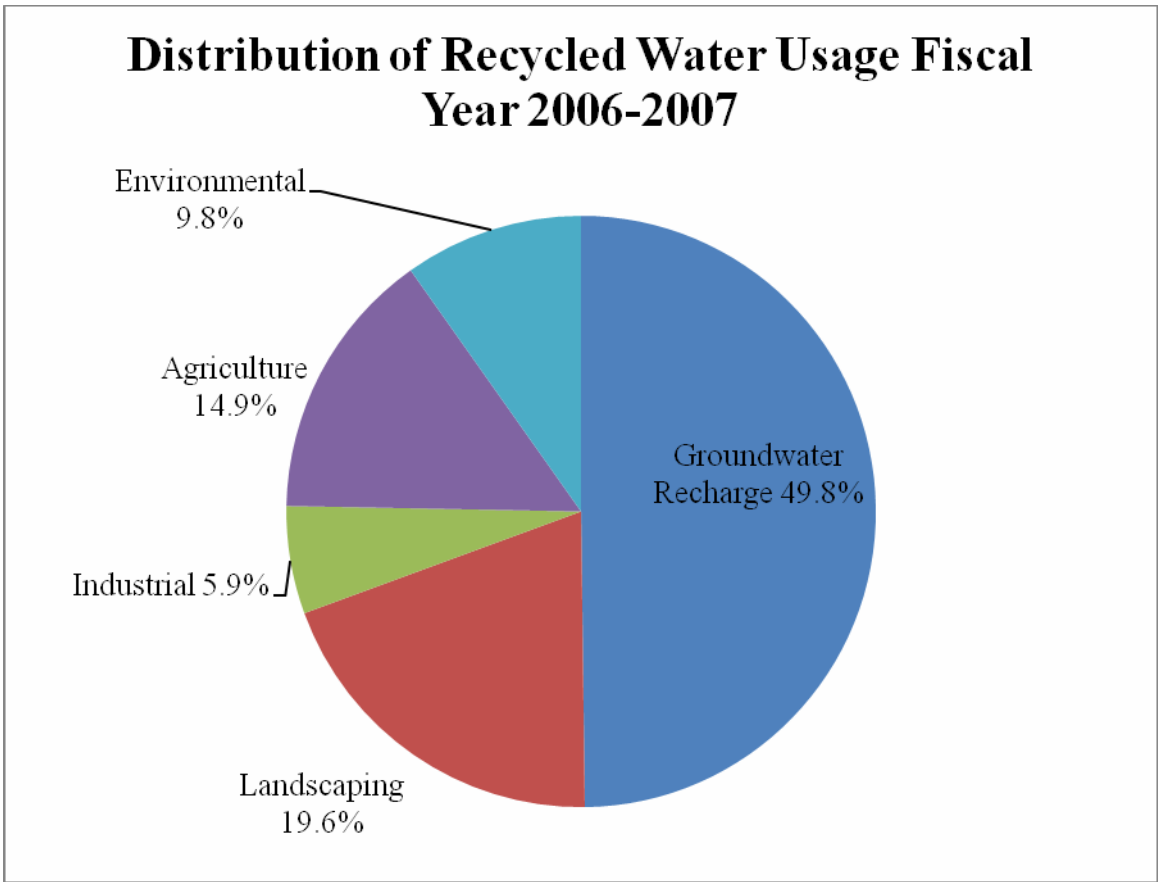

Figure 1. Recycled Water Use in Los Angeles County, California, 2006-07 (MIT, 2010).

INCREASING RECYCLED WATER USE IN A WATER-SHORT REGION

Technology and Improved Regulations

New Mexico has not taken full advantage of technology development and research that has been conducted to ensure the safety of recycled water. The majority of water currently used for irrigation in the southern half of the state comes from the Rio Grande with the remainder coming from groundwater. The region's surface water is fully appropriated, and future M&I water supplies in the region will likely be developed from reallocating surface water away from agricultural users. Expansion of irrigated agriculture in the region is thus constrained by water availability now and in the future. Groundwater supplies in the region are also limited and subject to competition from M&I users. Not all aquifers in the region are replenished by surface water flows, and mined groundwater is a significant source of water for many of the region's users. Thus, recycled wastewater represents a rare opportunity to expand existing water supplies in a water-short region.

As of 2010 New Mexico's regulations do not allow recycled water to be used in the production of food crops where the edible portion of the crop is in direct contact with the

water. Wastewater reclamation plants in New Mexico need to consider adopting new technology that will enable them to treat water to disinfected tertiary levels. This technology would allow communities or utilities to treat their wastewater to the level required for comprehensive agricultural use and provide an additional source of revenue for the wastewater producers.

The use of recycled water on pecan orchards in southern New Mexico should be urgently considered. A recent study conducted in Florida examined the effect of using irrigated recycled water on citrus orchards. The study focused on whether fruit yield, quality, and foliage health and density decreased or increased. Results from the study indicated that citrus yields were affected along with leaf concentration by the recycled water. The tonnage of fruit harvested increased but the actual number of fruit picked decreased. Overall, yields (by weight) increased due to the increase in fruit size while fruit quality was also higher. The study also found that soil quality was not compromised as a result of irrigation with recycled water. Researchers concluded that when wastewater is treated effectively and fertilizer is adjusted accordingly, plants are not harmed and fruit yields are not compromised (Morgan, 2008). There is however an anecdotal account of small wastewater treatment plant effluent being used to irrigate pecans with no loss in yields or quality. However there are no studies being performed in this orchard, nor is there easily available verification of anecdotal accounts.

New Mexico's recycled water regulations should be modified to reflect the reality of current and future water shortages. Revising water testing responsibilities to align with California regulations would increase the willingness of New Mexico agricultural irrigators to use recycled wastewater. With consistent, robust demand for the recycled water, producers would have increased incentives to invest in proven treatment technologies.

Benefits of Using Recycled Water

Recycled water use has many benefits. The primary benefit of recycled water use in New Mexico would be increased sustainability. The use of recycled water would allow residents of the state to reduce the rate of use and preserve fresh water in the underground aquifers, thus allowing that water to be banked for the future. The underground aquifers in the state are an important and reliable source of water, and thus need to be conserved for as long as possible. The use of recycled water would reduce aquifer drawdown and increase the length of time the aquifers could be economically pumped. Recycled water could also contribute to aquifer recharge in some areas.

Wastewater reclamation would also contribute to improved water quality throughout the region, as wastewater which is now returned to the Rio Grande is minimally treated and ultimately applied to crops after it enters the river and joins the surface water flow. The quality of recycled water treated to higher standards would be of higher quality than the region's current surface water supply which includes irrigation return flows, minimally treated wastewater from numerous municipalities, as well as rainfall runoff and other underground flows hydrologically connected to the river. Surface water quality

throughout the Lower Rio Grande Valley would be improved by keeping contaminates such as heavy metals, endocrine disrupters, and other biologically active agents out of the river system as a result of the higher-level treatment processes.

Securing a Sustainable Water Future

Without the use of recycled water, the state of New Mexico is limiting its water resource sustainability. Future population and economic growth, as well as agricultural irrigation, all depend on adequate water supplies. California's track record in wastewater reclamation provides a model for New Mexico and other arid, water-short regions to emulate. Policy and regulatory changes are essential if New Mexico is to take full advantage of existing wastewater supplies. It is critical that state regulations require the majority of water quality testing be conducted at the treatment facility by the recycled water producer rather than at the point of use by the recycled water user. Relieving the burden of testing from agricultural irrigators would increase the likelihood that these users will actively seek out and use recycled water in crop production. Treating recycled water to a higher quality would ensure robust demand for the water by providing a safety assurance to agricultural irrigators and make the water acceptable for application to higher value food crops. Recycled water treated to a higher quality is a more valuable input for agricultural producers, and thus would be worth more to food crop irrigators than to forage or other lower valued crop producers.

California has demonstrated that wastewater reclamation and the application of recycled water to food crops is safe and economically feasible. Consumers throughout the United States currently consume fruit, vegetables, and specialty crops produced in California, and by their actions, are demonstrating that using recycled water to irrigate food crops is acceptable.

CONCLUSION

New Mexico is located in an arid desert environment where water is scarce. New Mexico has two sources of water: rivers and underground aquifers. The Rio Grande traverses the middle of the state and provides irrigation water to thousands of agricultural irrigators. Rapidly growing cities and towns located in the state's Lower Rio Grande Valley will soon withdraw surface water for M&I uses. Surface water is fully appropriated, groundwater is already extensively used throughout the region, and there are virtually no untapped water supplies available. However, recycled wastewater use is an option which would supplement existing water supplies, support future population growth, and contribute to a sustainable water future in the region. Unfortunately, New Mexico currently enforces strict regulations that inhibit both development of recycled water supplies and demand for the recycled water by agricultural users.

Policy and regulations related to the use of recycled water in crop production in New Mexico must be changed; California regulations provide a template for the changes. Regulatory changes are necessary in order to expand the use of recycled water on crops. Without regulatory change, there is little incentive for investments in water reclamation

technology that treats waste water to the levels required for higher valued uses (e.g., food crop irrigation). The use of recycled water in New Mexico would relieve the pressure on underground aquifers, increase downstream water quality, provide a reliable source of water to agricultural irrigators, and enhance water resource sustainability in the region.

REFERENCES

Center, National Science and technology. (2001). *Water Rights Fact Sheet.* Retrieved from http://www.blm.gov/nstc/WaterLaws/newmexico.html

City of Las Cruces, Utilities Department (2007). *NMED Ground Water Quality Bureau Guidance:Above ground Use ofReclaimed Domestic Wastewater*. Las Cruces. http://www.las-cruces.org.

Creel, B. J. (2007). G*roundwater Resources of the Las Cruces/Dona Ana County Region*. Presented at the Water Symposium, Las Cruces NM. http://www.las-cruces.org/utilities/docs/MesillaJornada.pdf

Livingston Associates, P.C. 2008. Village of Cloudcroft, NM. Pure PURewater Project, Presentation to Water Smart Innovations, 2008. Conference. 10/10/2008.

Massachusetts Institute of Technology (MIT). Current Water Reclamation and Reuse Los Angeles, California Retrieved 3/14/2010, http://web.mit.edu/12.000/www/m2012/finalwebsite/index.shtml

Morgan, K. T. (2008). Effects of Reclaimed Municipal Waste Water on Horticultural Characteristics, Fruit Quality, and Soil and Leaf Mineral Concentration fo Citru. H*ortScience, 43*(2), 459-464.

State of California. (2009). *Title 22 and 17 California Code of Regulations*. http://www.cdph.ca.gov/certlic/drinkingwater/Documents/Lawbook/RWregulations-01 2009.pdf

State of New Mexico, Underground Storage and Recovery § Chapter 25, 19.25.8.9 Stat. (2001).

Yuhas, Katherine (2009). Personal interview, City of Albuquerque, Water Conservation Bureau. City of Albuquerque, New Mexico. March 30, 2009.