

WATER CONSERVATION TECHNIQUES IN IRRIGATION: TRENDS & TECHNOLOGY

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ABSTRACT

We are studying water conservation and livestock forage production in a greenhouse designed by Chihuahua hydroponic experts. Using wireless sensors, nutrition analysis and modeling and simulation, we hope to better understand and optimize the system. The work is in the spirit of the BiNational Sustainability Laboratory and located at the Santa Teresa Cattle Crossing on the US/Mexico border. Our ultimate goal is to provide viable technology for water conservation in agriculture for this and other arid lands of the world. Partners sharing this goal are desired.

SUMMARY

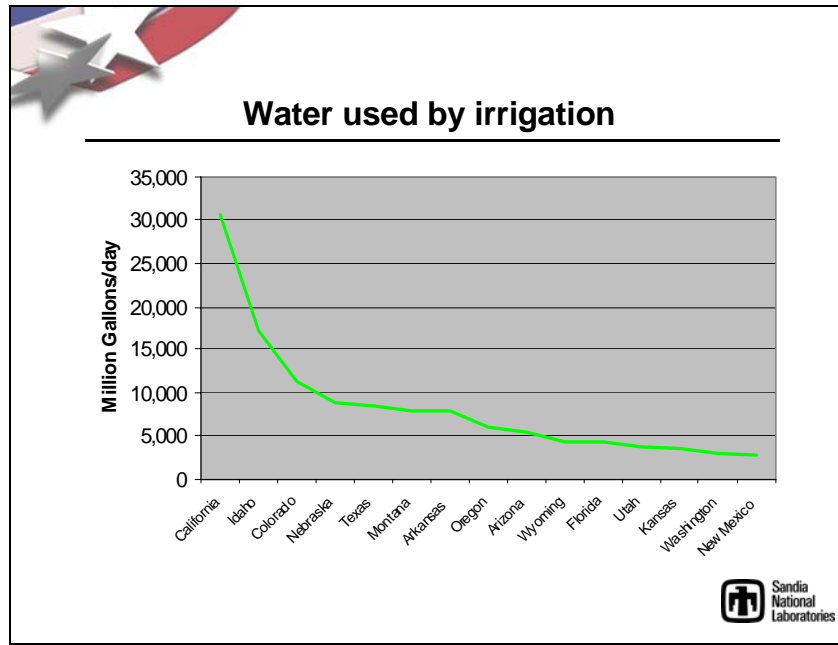
- Water use in the United States during the years 1950-2000 has recently been compiled by the USGS. Aside from water used by thermoelectric power, irrigated agriculture uses 65% of the freshwater withdrawals. Analysis of these data shows that New Mexico is in the top 15 states in water used, is 8th in water used per acre and second only to Arizona in groundwater to surface water ratio. On the positive side, New Mexico is third in fraction of drip and sprinkler versus flood irrigation applications amongst the western states. The trend towards more controlled watering techniques must continue. The purpose of this paper is to critique the watering methods that exist for water use in New Mexico and propose methods for water conservation and supply extension.
- Underground water storage is a great opportunity to reduce the amount of water that is evaporating while in storage. There are many technical issues associated with this technique, such as recovery, storable volume and environmental impacts, but the potential water savings is enormous. Every year, the amount of water that evaporates from Elephant Butte is equal to that amount the city of Albuquerque uses.
- The challenge facing many farmers is determining when and how much to water crops. Given an endless supply of water, the answer would be always and enough. However, the timing for efficient watering is going to depend on the crop and the current weather. Scientists have determined the water use efficiency of different crop/soils systems in different regions of the country by using lysimeters to weigh the 'garden.' This method allows quantification of the crop/soil/water system and enables a better understanding of crop water use. This, in turn, allows the grower the opportunity to accurately evaluate the water necessary to optimize crop growth using minimal water. The use of low energy precision application (LEPA) is a means to deliver just the right amount of water at the right time to as close to the root zone as possible.
- The final technology we studied was cloud seeding. The objective here is simple—provide a condensation nuclei for supercooled water in a cloud to freeze and begin to build up and fall. The technology is used for both hail suppression and rain enhancement. The nuclei can be a number of different particles and may be released from the sky by plane or from the ground. One interesting rule of thumb is that a 10% drop in precipitation results in about a 30% drop in runoff. There are many assumptions in this, but it seems reasonable that a 10% increase in precipitation may result in a 30% increase in runoff, thus making cloud seeded water \$1-10/acre foot (AF). By contrast, desalinization will never provide water at less than \$1,000/AF, water in Santa Fe can cost \$4,500/AF and bottled water goes for over \$1million/AF.

The purpose of this talk is to summarize some water usage facts in the western US and to introduce three different efficient water use technologies and finally to propose a water conservation center for New Mexico.

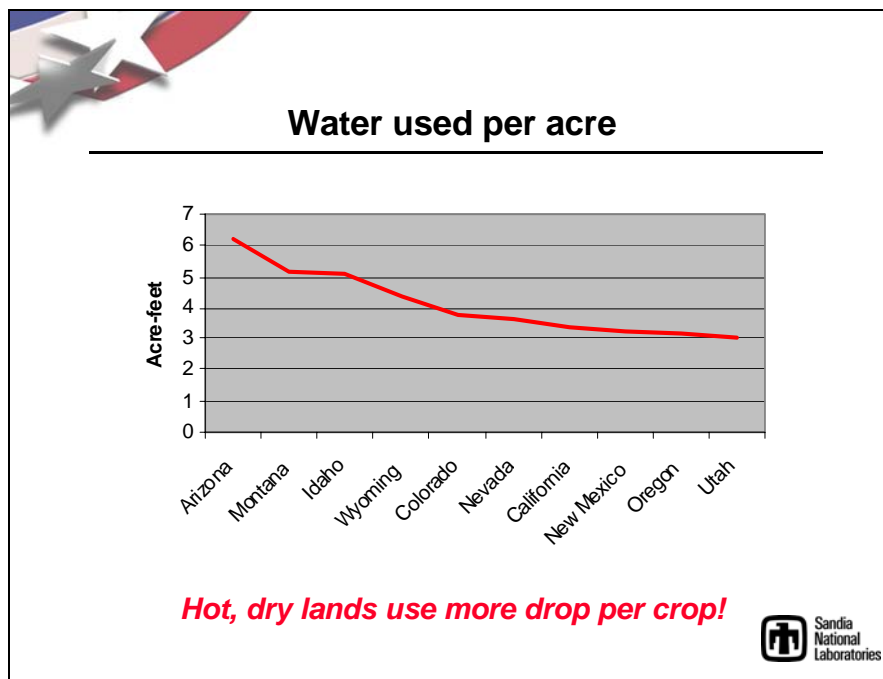
¹Sandia is a multiprogram laboratory operated by Sandia Corporation, a Lockheed Martin Company, for the US Department of Energy under contract DE-AC04-94AL85000.

OUTLINE

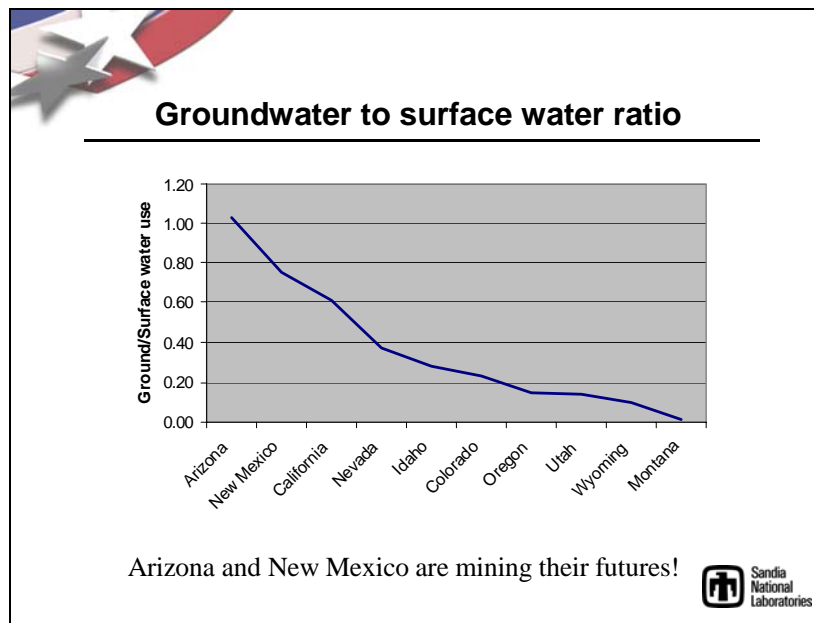
- Water use in the west
- Underground water storage
- Low energy precision application
- Cloud seeding
- Water conservation center



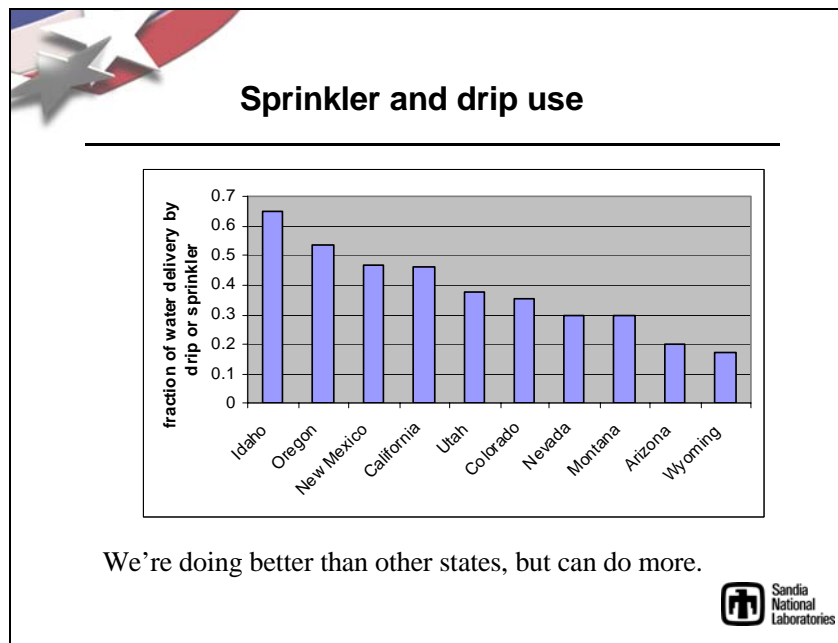
In a recent USGS report on water use by states, the ranking of water used in irrigation looks like this with California at the top and New Mexico in 15th place, about 3 billion gallons/day. This is equivalent to almost 4 million acre feet per year, so the data may just be during the growing season.




Of the 15 largest water users, the amount of water used per acre is clearly dominated by the western states where humidity is low and the evaporation losses are greater.



An interesting further cut of the data shows that Arizona and New Mexico have the greatest groundwater to surface water ratios in their irrigation practices.



Finally, a ranking of these western states as to the fraction of water delivered which is drip or sprinkler (vs. flood) irrigation shows that New Mexico is doing better than most states but there is much room for improvement.



Underground Water Storage


Purpose: Eliminate evaporation from reservoir storage:

Example: Amount of water evaporated from Elephant Butte
~ amount of water used by Alb. each year.

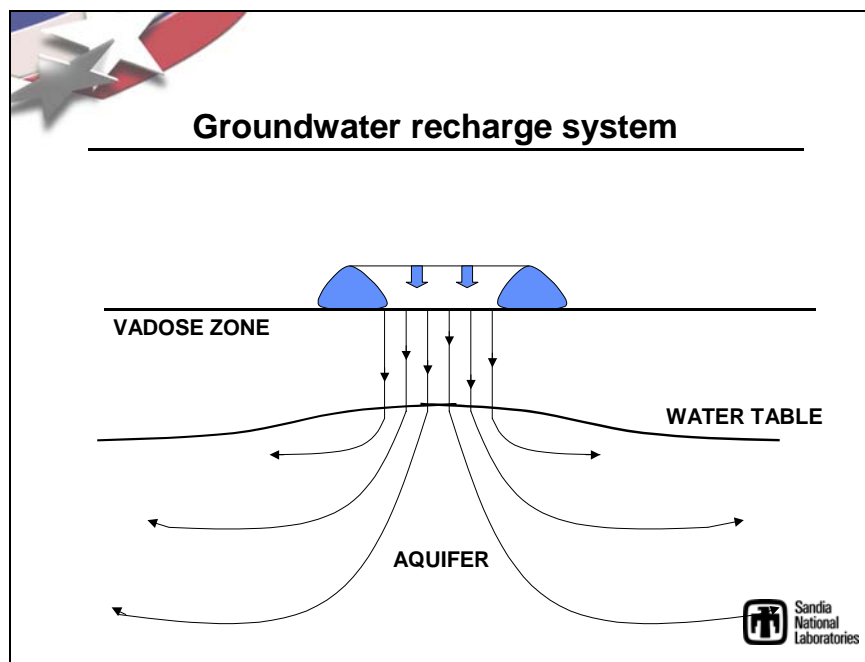
Solution: Percolate surface water into aquifer for later pumping

History: Used in Germany in 1875

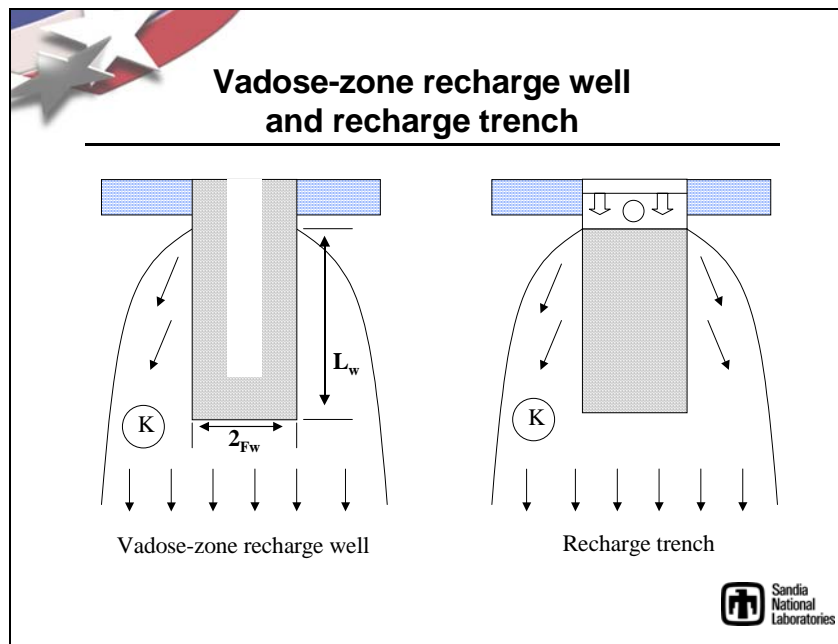
Planned forum in July in Abq., with legal & technical factors



The primary issue with water in arid lands is evaporation, which is a result of the hot dry air. The storage of water in open reservoirs then creates a significant gradient for evaporation. The shape of most reservoirs creates a very large surface area for evaporative losses. One solution to this loss would be to store water in aquifers and remove the water at a later date. The evaporative losses would be minimized.



The basic conceptual model of the underground storage of water is shown here, where the water is put into a surface impoundment and allowed to percolate into the vadose zone to the aquifer.




The two different types of recharge are shown here.


Analysis for small business partner

- Transmissivity of 8600 feet²/day (avg. for region)
- 10 acre square recharge area
- 5 cm/day infiltration rate (low – still 600 acre-feet/yr)
- Steady state (Bouwer, *Hydrogeology J.*, 10:121-142, 2002 Eqn. 11)

- Mound height is 16 feet
- Technically viable for later use





A recent analysis for a small business partner is presented here, where the vadoze zone characteristics were put into a steady-state equation for estimating the mound height. This and other aspects of the project suggest that the water storage would be feasible.




Low Energy Precision Application

This system has small sprayers hanging down from a large water-carrying pipe above. At the bottom of each pipe, very close to the ground, is a nozzle that gently sprays water onto the crops




The next water conservation method is to deliver the water as close to the root zone as possible to avoid wasted watering. The nozzles in LEPA spray water very close to the ground from a large center pivot pipe or other traditional method.




LEPA Details

- water placed in every other furrow
- operates at low pressures (6-10 psi at the nozzle)
- faster resulting in more frequent irrigations
- plant watered more frequently will yield more than a plant receiving fewer irrigations
- typical center pivot irrigation machine irrigates approximately 128 acres




The basics for LEPA are listed here. The low pressure saves energy.




Why LEPA?

- LEPA is 95-99 percent efficient
- conventional systems are 60-65 percent efficient (Without wind)
- conventional systems wet 100 percent of the soil surface and all the leaf surface
- approximately 1,600 center pivots in Roosevelt and Curry counties over 200,000 acres
- Converting to LEPA on these pivots would conserve
- To convert a typical center pivot to LEPA hardware costs about \$15,000
- typical payback period based on energy savings alone of three to four years




Some results about LEPA are that the payback period of the systems is 3-4 years.

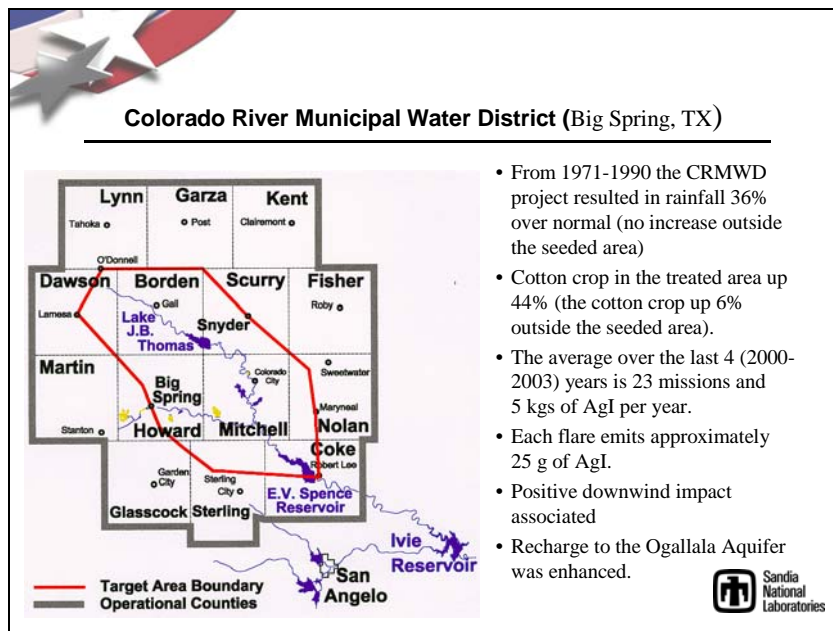


Cloud Seeding - Background

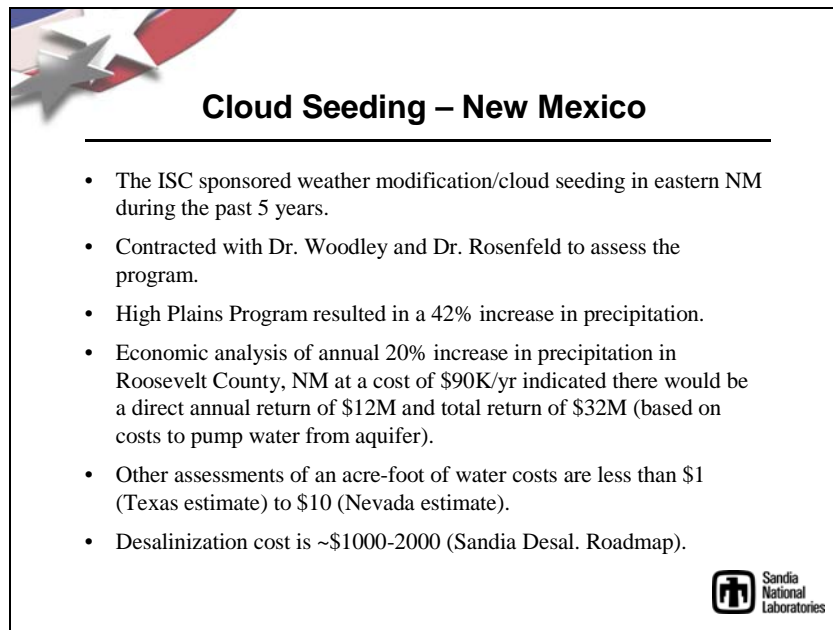
- Conducted since 1950s
- 10-12 states have cloud seeding programs.
- Mexico, Canada and some 40 other countries have cloud seeding programs.
- Silver iodide is introduced into clouds that meet three criteria:
 - abundance of super cooled moisture,
 - no ice crystals, and
 - good updrafts
- Utah, snow enhancement program resulted in a 13% increase in runoff at a cost of \$1.02/ac ft.
- Kansas, hail suppression program since 1975 resulting in 27% less hail and a return of \$37 for every \$1 invested.
- North Dakota, program resulted in a 10% increase in rainfall and 43.5% decrease in hail with a 15:1 benefit (45:1 with insurance).




The final technology discussed is that of cloud seeding, where basically supercooled water is seeded to create snow or rain. The reason for doing this is to enhance precipitation, but it is also done to reduce hail that damages crops. There is a long history of cloud seeding and still a number of programs going on in this country and throughout the world.



A large program in Texas shows results of 36% increase in rainfall and 44% increase in cotton production. The flights each deliver around 25 grams of silver iodide with each flare and a total of 5 kilograms per year over 23 missions. The environmental impact is thus fairly light.




In New Mexico, cloud seeding has been employed for several years. An estimate of the value of this effort shows that water from cloud seeding costs about 1-10\$/acre foot, while that for desalination is over 1000\$/acre foot.




World-class water conservation center

- experimental farm operated by New Mexico State University (NMSU) Cooperative Extension Service
- strategic partnerships, committed political champions, sufficient resources, and a genuine relevancy to a majority of New Mexicans
- centrally located within the state and it needs to be highly visible, aesthetically pleasing, and easily accessible
- low risk and relatively low cost investment that would significantly reduce water use in New Mexico
- private and government partners



Finally, I would like to propose a means to accomplish all of the activities that were presented in this presentation as well as many of those in this symposium. A water conservation center operated by the NMSU extension service and strategically located would allow many new technologies to be developed and emerging technologies to be demonstrated. The WCC would have private, government and university partners and could leverage the huge investments that the government is making at Sandia and other installations throughout the state.



Conclusions

- New Mexico is mining its water to participate in agricultural industry.
- New water, efficient storage and use are important in water planning.
- Cloud Seeding, Aquifer water storage and LEPA should be pursued as part of the solution in Arid lands.
- A compendium of successful water use technologies such as these should be produced
- Ranking of top research goals should be established
- A world-class water conservation center can be built with the participation of LANL, UNM and Sandia
- NM Research Institutions can have a major impact in water conservation technology

