Brackish and Saline Groundwater in New Mexico--?

John Shomaker, Shomaker and Associates, Inc.

John Shomaker is President and a Principal Hydrogeologist of John Shomaker & Associates, Inc., in Albuquerque. He has over 48 years of professional experience in geological and hydrogeological studies in New Mexico and surrounding states. John holds BS and MS degrees in geology from the University of New Mexico (1963, 1965), an MA in the liberal arts from St. John's College in Santa Fe (1984), and MSc and PhD degrees in hydrogeology from the University of Birmingham, England (1985, 1995). He worked as a hydrologist for the U.S. Geological Survey (1965-1969), and as a geologist for the (then) New Mexico Bureau of Mines and Mineral Resources (1969-1973), before starting the consulting firm in 1973. Shomaker & Associates specializes in ground-water data collection and sampling, ground-water flow modeling, drilling technology and field supervision of drilling projects, water-supply planning, water-rights issues and expert testimony (including in interstate litigation before a U.S. Supreme Court Special Master), and environmental studies.

You will have noticed that I have changed the title of my modest presentation a little since the program was printed—and added a question mark. The question mark is to indicate that I am not going to give you the expected inventory of brackish and saline resources, but instead I am going to explore the question of whether we should begin to depend on them.

It seems a little ironic, but it is true. Now that our good-quality renewable groundwater is showing signs of over-use, we are hearing that our salvation for the long-term may actually be our non-renewable groundwater. I am going to try to describe some of the differences between these two sources, and how it is likely to work out as we develop the non-renewable, poor-quality water stored in deep, non-river-connected aquifers around the state.

As context, we should, of course, remember that pumping renewable groundwater is the same as pumping from a river—the "renewable groundwater" as shown in this familiar slide on Albuquerque demand and supply (Figure 1) from the Albuquerque Bernalillo County Water Utility Authority. That equivalence may take a while to manifest itself, but it will turn out to be true. We have learned that lesson in the Albuquerque-Belen Basin; we are on the verge of seeing it develop on a large scale in the Lower Rio Grande, and it is being demonstrated elsewhere around New Mexico. The reason we have shifted sharply to surface-water supplies in Albuquerque is precisely that we must limit ourselves to the surface water we can legally divert, whether we divert it directly from the river, or indirectly, from wells, and it may not be wise to over-divert from wells only to incur a debt to the river that will be troublesome to repay. Most of our experience in New Mexico has been with the renewable kind of groundwater.

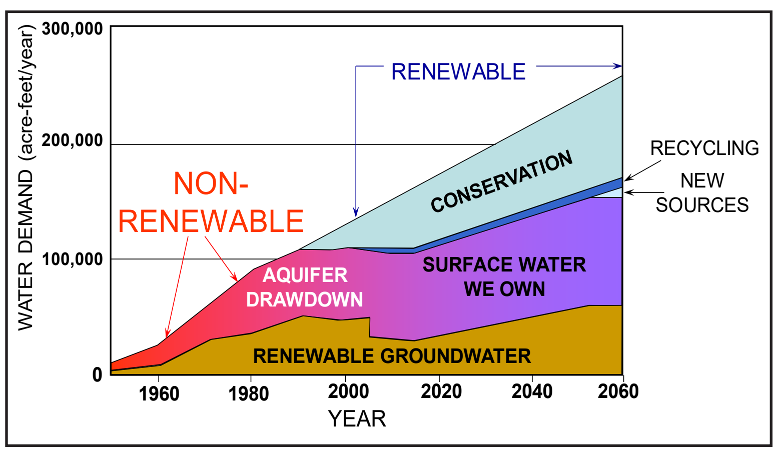

Figure 1. Albuquerque's projected water demand and available supplies (modified from ABCWUA presentation).

Non-renewable, or very slowly renewable, brackish or saline groundwater is almost everywhere. Figure 2 shows where in New Mexico it potentially is and isn't—the only areas where there may not be any deep groundwater at all are the areas of extremely low-permeability igneous and metamorphic rocks from the land surface all the way down, shown in bright red and pale pink. Deep aquifers, very poorly connected to shallow groundwater and to surface water, underlie most of the state, and underlie the highly productive shallow aquifers in most places.

We are really looking, not so much for water itself, as for permeability in the rocks that contain it so that the water will flow to a well, and enough thickness of permeable rocks to contain a lot of water in storage per unit of land area. Those characteristics vary dramatically from place to place, but they are fairly well known, largely through oil and gas drilling.

We do not have as much experience with development of the deep, non-renewable groundwater on a large scale, although there are a few illustrative examples like the City of Gallup's supply (Figure 3). And we do have a lot of experience with individual wells in these deep bedrock aquifers.

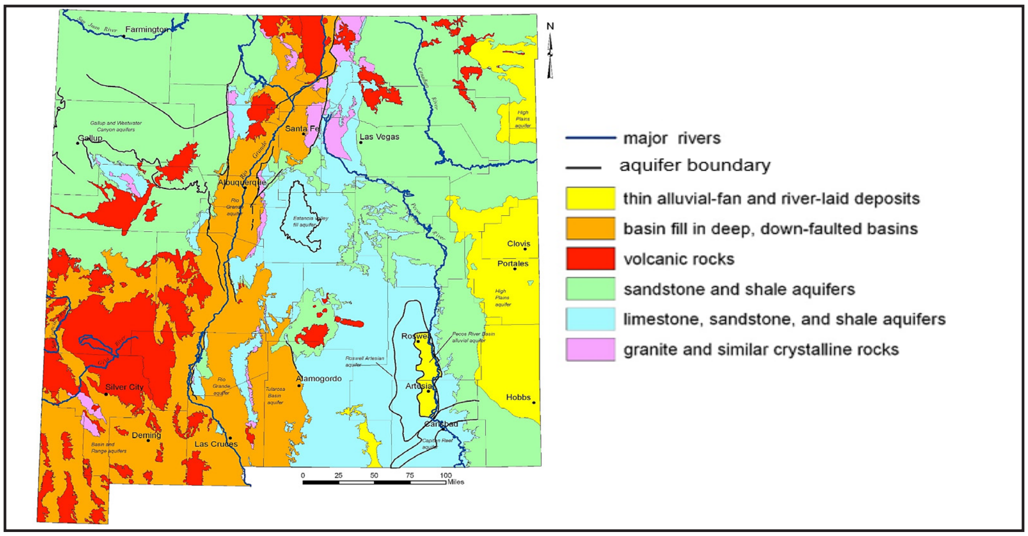

Figure 2. New Mexico's aquifers.

We have some experience…

Well	Depth, ft	Year	Aquifer
City of Gallup, Munoz 1A	3,200	1968	Jmw
Apache 1 Foshay re-completion	5,933	1974	Kg, Jmw, Je
El Paso Natural Gas, Burnham 1	5,200	1974	Jmw
Santa Fe Mining, Star Lake 1	5,656	1975	Jmw, Je
Santa Fe Mining, Gallo Wash 1	5,690	1975	Jmw, Je
Santa Fe Mining, South Hospah 1	2,808	1975	Jmw
Santa Fe Mining, Gallo Wash 2	5,744	1978	Jmw, Je
Santa Fe Mining, Gallo Wash 3	5,747	1978	Jmw, Je
NTUA, Standing Rock 1	2,657	1980	Jmw
City of Gallup, Lewis 1N	3,306	1983	Jmw
City of Gallup, Allen 1	3,494	1986	Jmw
…and so on.			

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Figure 3. Wells in deep bedrock aquifers.

Our company has been involved in a lot of them in the San Juan Basin over the past 40-some years, as indicated by the red dots and yellow dots on Figure 4. The red dots are the ones that are more than 2,500 ft deep.

There are several major issues with the deep, non-renewable groundwater, as compared with the river-related groundwater to which we are accustomed.

- You get comparatively little of it for your money, partly because of the aquifer characteristics, and partly, or even largely, because there is no river there to provide part of the production from your well.
- Because it is non-renewable, water levels continue to go down and the cost of producing water increases over time. Eventually a particular well becomes uneconomic, so you have to keep moving to new places.
- You may become dependent on a supply that will eventually have to be replaced, and the question "with what?" will loom large.
- Much of the deep, non-renewable groundwater is brackish or saline, and you will need to produce significantly more than your actual demand because a significant fraction will be lost as brine concentrate during desalination, and you will have to deal with the costs and environmental issues of disposal.
- Mining water out from under someone else's lands is not an issue under New Mexico law, as long as his existing water right is not impaired, but I wonder if that will continue to be true if landowners begin to recognize that a future resource is being depleted.

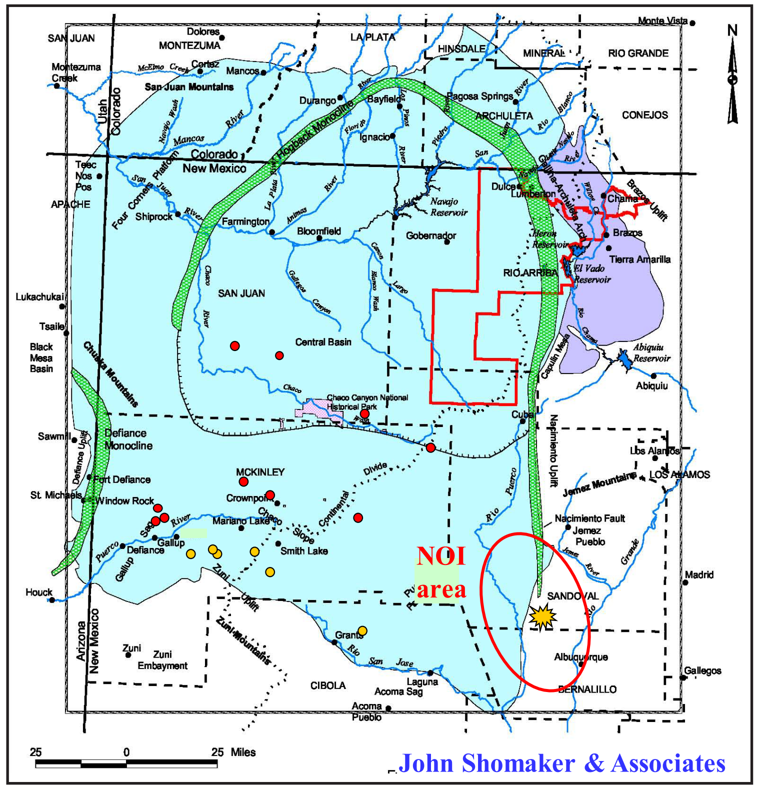

Figure 4. The San Juan Basin.

As to what you get for your money, Figure 5 shows a comparison between a typical Albuquerque production well, the Ridgecrest No. 5, and a typical well producing from a deep, bedrock aquifer. (This comparison was suggested by Bruce Thomson).

Now, if we want more water, a well like the Ridgecrest No. 5 can produce it. The drawdown is so small that we can simply pump more water from the same well. But if we want more water from the wells in the "deep well" field, we need to add wells. And those wells must be far apart as we shall see shortly. We will have to have lots of pipeline right-of-way and pipeline, and a vast electrical distribution system.

Just as an example, Figure 6 shows calculated drawdown contours for a hypothetical case involving 40 years of pumping from 60 wells in the Albuquerque area, producing roughly one-half of the present-day supply, net after desalination. Drawdown is more than 1,000 ft in something like 700 square miles in western Bernalillo County and southwestern Sandoval County, and even though the supply is mostly "mined," there is enough leakage through the confining beds that streamflow depletion in the Rio Grande system would have reached around 6,700 ac-ft/yr.

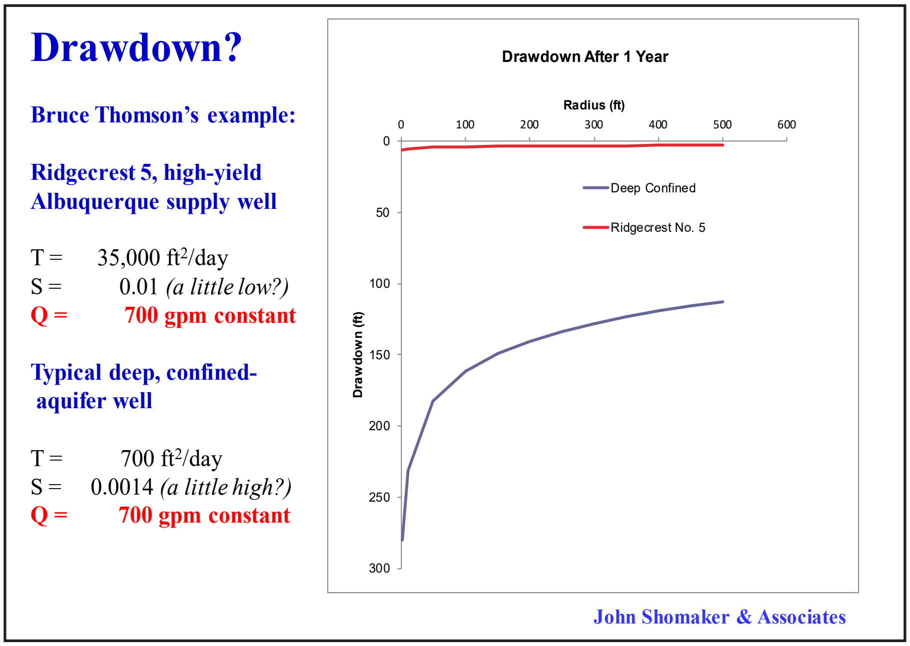

Figure 5. Comparison between a typical Albuquerque production well, the Ridgecrest No. 5, and a typical well producing from a deep, bedrock aquifer.

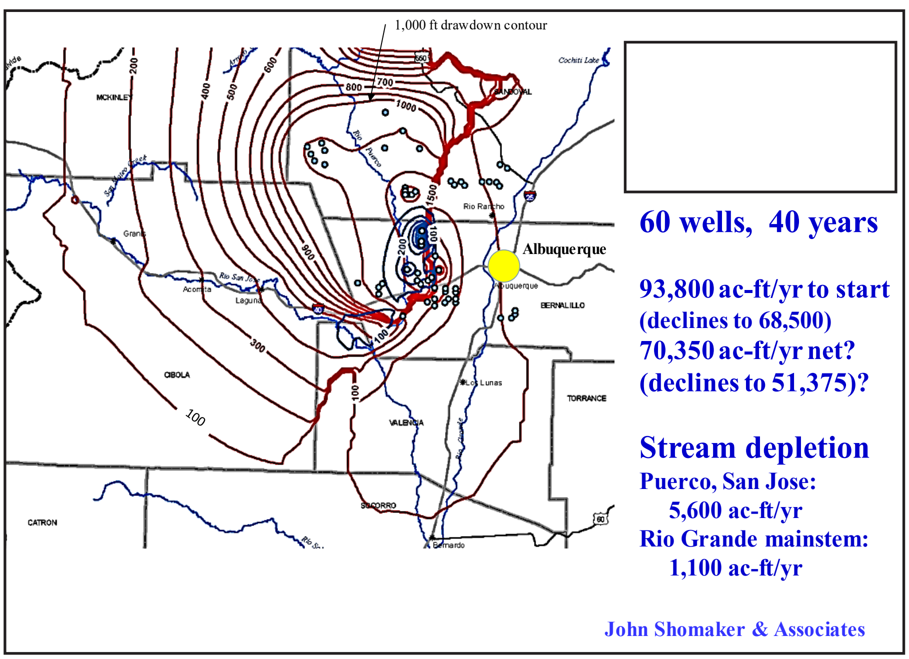

Figure 6. High development case (Melis, 2013).

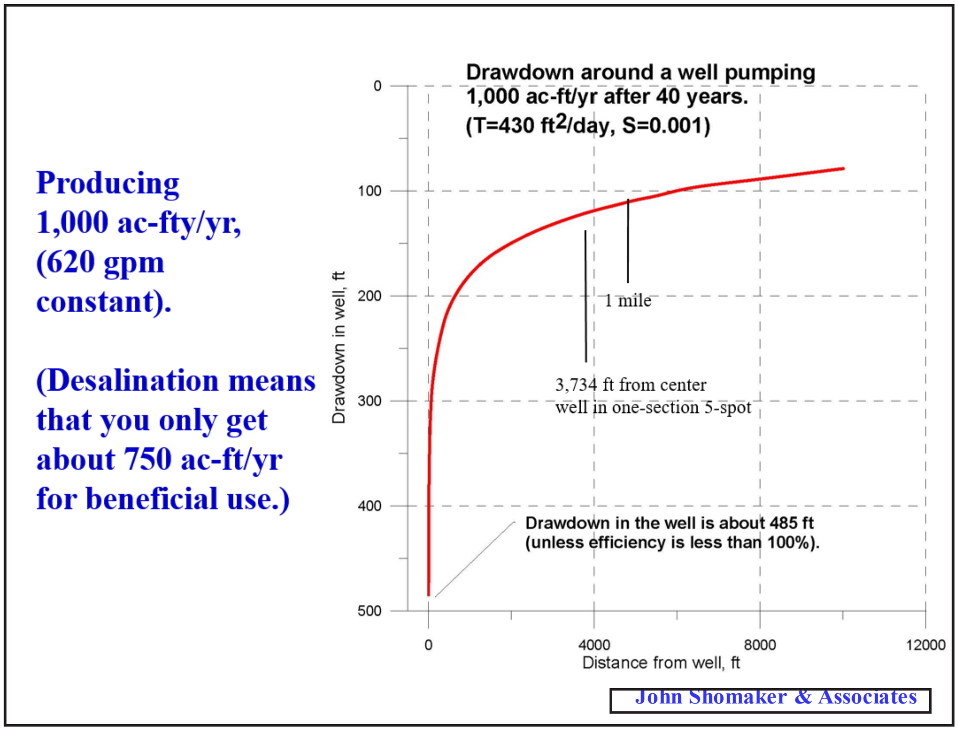

Figure 7. Well spacing.

The spacing between these deep-aquifer wells has to be large, because the drawdowns are so large, and so widespread (Figure 7). And that leads to the question...

Why is drawdown so great?

Permeability is typically low, because the aquifers in many cases are fine-grained, well-cemented sandstone bedrock, not at all like the weakly cemented valley-fill sediments with coarser sand and gravel lenses that we are used to. The storage coefficient (the volume of water released from a unit area of the aquifer per unit change in head [i.e., drawdown]), is very small; aquifers typically are confined with low-permeability clays above and below.

The diagram on Figure 8 shows the difference between the storage condition for an unconfined, valley-fill aquifer from which the water drains by gravity, and for a confined aquifer that contains water under pressure. Withdrawing water from a confined aquifer, as the deep supplies generally are, is the same as releasing water from a pressure tank. Little or none of the volume of the aquifer is actually dewatered, and the water is all yielded by expansion of the compressed water and aquifer matrix. The storage coefficient is typically several orders of magnitude less.

Valley-fill wells are a lot cheaper than deep-aquifer wells (Figure 9). A new supply well in the Rio Grande Valley cost about a quarter of a million dollars, and produces good quality water. You could compare it with a fairly typical San Juan Basin deep-aquifer well (Figure 10). The C&P Star Lake No. 1, a deep-aquifer well, has about the same capacity in terms of pumping rate, but the water is hot and has high total dissolved solids content, and would cost nearly $3 million today.

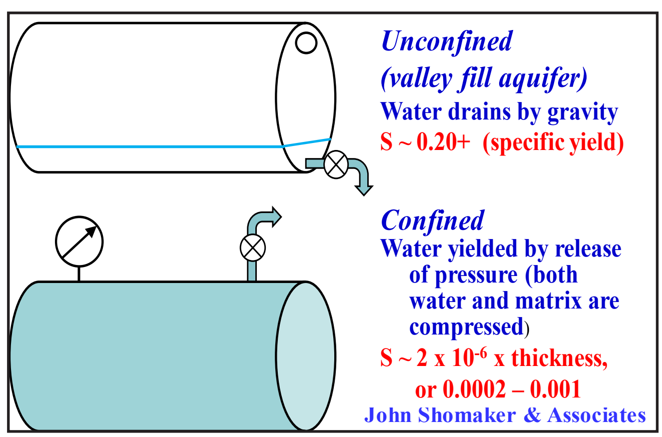

Figure 8. Two basic conditions for storage coefficient: consider two sand-filled tanks.

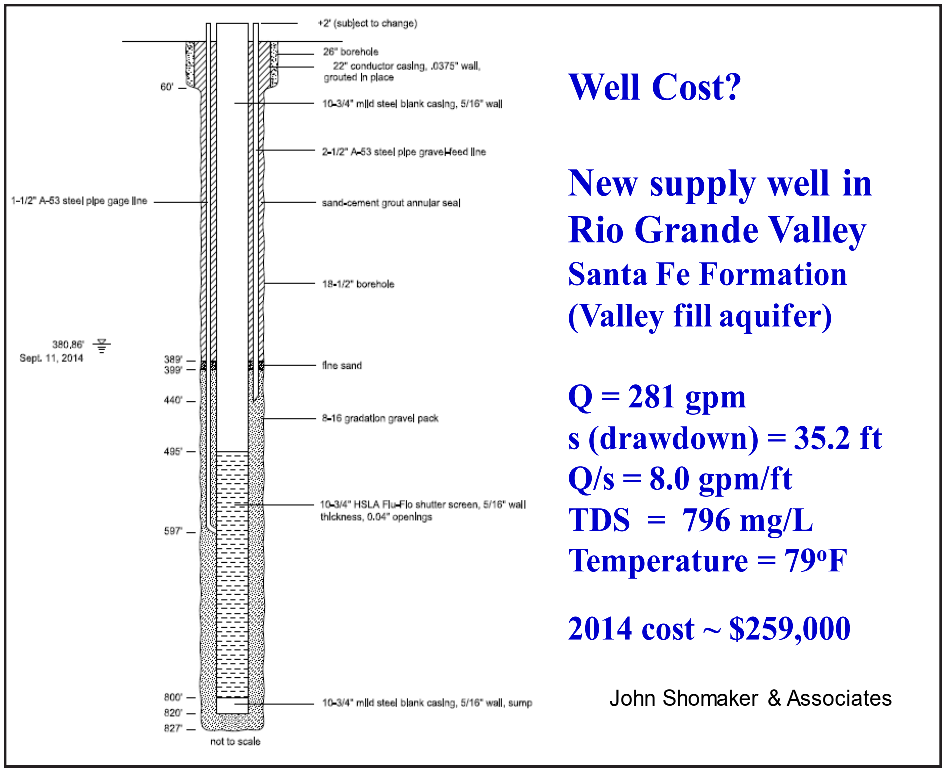

Figure 9. Well cost?

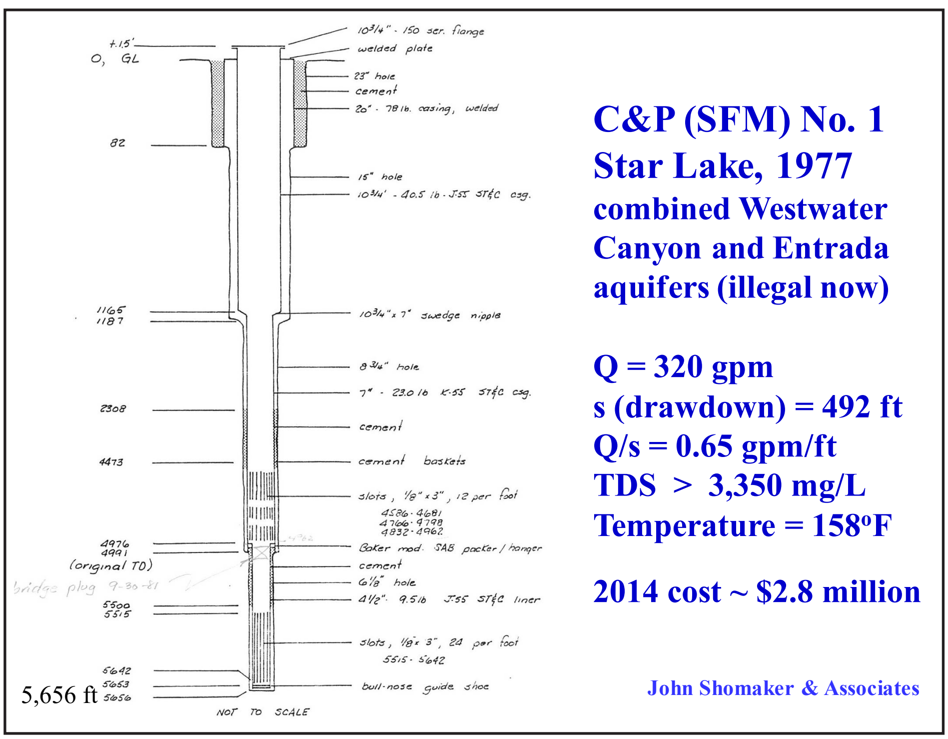

Figure 10. C&P Star Lake No. 1.

Whose water is it, anyway? The question of ownership of the actual water in the ground may come into prominence in a way that it has not before. Instead of thinking in terms of the impairment of existing water rights in the context of the prior-appropriation system, we may find that some landowners will object to the mining out from under their lands of a resource that may be useful to them in the future. I am thinking here particularly of the Tribes and Pueblos, whose water rights are not administered by the State Engineer. The large-scale development of non-renewable deep-aquifer water as contemplated by the Notices of Intention filed with the State Engineer in the Albuquerque area would lead to very large drawdowns beneath the tribal and pueblo lands west of town.

And we still haven't talked about…

- Desalination: Capital and O&M cost; long-term energy commitment
- Disposal of brine concentrate-20%?: evaporation ponds?, still more wells for injection?
- Huge infrastructure (pipelines, powerlines) for widely spaced wells
- Non-renewability and the dependency problem (what will you do next?)

A real-life example of a municipal system relying on almost non-renewable deep groundwater is afforded by the City of Gallup (Figure 11).

I'll end on this thought: some deep well projects work out exactly as planned, but... (Figure 12)

Ya-Ta-Hey well field (JSAI records; Lee Wilson & Assoc., 2013)

- **10 wells, starting in 1968.**
- **Depths 2,100 to 3,511 ft.**
- **Capacity of best wells >1,000 gpm, now down to 600 gpm.**
- **Combined capacity now 5,000 gpm: average 500 gpm per well.**
- **Specific capacity: typical well about 0.75 gpm per foot.**
- **First wells flowed; typical static level now about 800 ft.**
- **Water levels declined 25 ft per year, until demand was reduced through conservation (now 1.29 GPCD).**

The dependency problem. After 46 years…

- **"Long-term implications of declining well yields are severe."**
- **Struggling to acquire more deep-aquifer rights under G-22.**
- **Navajo-Gallup pipeline will rescue Gallup--in 2024(?)-- but may not meet projected demand by mid-century.**

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Figure 11. Gallup's real-life experience with deep groundwater.

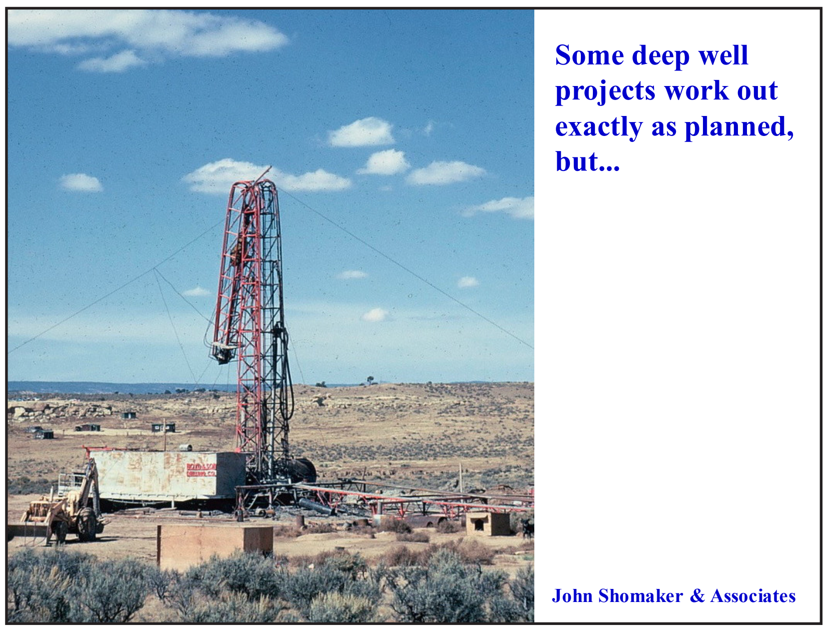

Figure 12. Boyd & Sons Rig 1, City of Gallup Munoz No. 1 Well, March 1968.