moving water in new directions
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Groundwater Challenges

There are some old lessons that continue to repeat themselves throughout the history of irrigation. For example, it has become a common understanding that accumulated salinity from irrigation spelled the doom of some ancient civilizations in the Middle East. Despite this ancient knowledge, today we still have numerous irrigated basins in which there is no outlet for high-salinity drainage flows.

Likewise, groundwater is something that traditionally has not been well understood, and is often treated as an ever-present back-up plan for irrigation. The "water rights" laws in the western US and elsewhere almost exclusively formalized rules about and concentrated on surface water flows, while simultaneously ignoring the problem of groundwater depletion. One could say that many of today's groundwater modeling projects contain strong elements of "voodoo" science – especially when looking at how the boundary conditions are estimated.

Making changes to surface water supply routes often brings public attention to water shortage problems. The development and O&M of flexible, dependable surface water supplies (dams, canals, irrigation districts) is extremely expensive, sometimes at thousands of dollars per acre. Surface water management also calls for environment impact studies (in-stream flows and quality). In contrast, wells are often relatively inexpensive to construct, energy costs have historically been relatively low, and by putting a well on each field it isn't necessary to build an extensive water distribution system because the aquifer is the distribution system.

Large areas of the world have seen almost explosive irrigation development as a result of groundwater pumping. In India, for example, many of the public irrigation systems have reputations for being close to dysfunctional, if traditional measures of the quality of delivery service are used. However, farmers can still control their own destinies by installing small "tubewells", which also don't show any quick, obvious evidence of environmental damage.

Here in the US, conjunctive use (use of both surface and groundwater supplies) has allowed irrigators to obtain relatively inexpensive water (in many but not all cases) and has also enabled them to weather the ups and downs of surface water availability. This is of huge importance, especially in California where there has been a strong shift towards permanent crops (e.g., almonds, pistachios, vines, citrus, and walnuts). Elasticity disappears with permanent crops; before this, farmers could grow wheat during a dry year rather than grow a more water-intensive crop such as alfalfa.

Suddenly, however, groundwater challenges are becoming noticeable to the wider public. It's not as if this is magical or new – a realistic look at basin-wide water balances has shown a crisis coming in the San Joaquin Valley from a long way off. I've been preaching this for years. History is repeating itself; in the 1930's in the San Joaquin Valley, groundwater levels started to drop at alarming rates due to irrigation. Ground subsidence was evident in many areas – with the area of Three Rocks being the classic example in textbooks.

As a result of public concern in the middle of the 20th century, several major water projects were developed. The Friant system was constructed by the USBR to replenish groundwater on parts of the east side of the San Joaquin Valley. Irrigation districts with independent supplies on the east side increased the sizes of their dams/reservoirs. The California Aqueduct was finished in the early 1970's to bring water to agriculture on the west side of the San Joaquin Valley. Groundwater levels returned to earlier higher levels.

Subsidence stopped. People were happy. Farmers kept expanding irrigated acreage, and converting to crops with higher evapotranspiration (ET). Improved irrigation efficiencies increased the ET per acre (due to healthier crops, better uniformity, and less stress). So as people began to forget the lessons of the past, the groundwater trends slowly began to reverse. Groundwater cones of depression started to show up in some areas such as the Tulare Lake Basin. For perhaps 20 years we have had said that "there is an annual groundwater overdraft of about 2 million acre-feet in the San Joaquin River". Ho-hum. No big deal. Pumping costs got a bit higher for some people, but popular opinion was that we could just use more efficient (i.e., higher ET) irrigation and somehow overcome this.

Of course, this is not unique to the United States. The expansion of irrigation throughout the world has been helped by groundwater development. Look at Saudi Arabia as an obvious example. I've also seen serious overdraft issues in numerous countries such as Mexico, Chile, China, and India.

Here in California a number of things have happened almost simultaneously to raise public (or at least, irrigation district-level) awareness of the problem. Yes, there has been some mumbling about problems with water quality, about the need to deepen wells, and increased power costs. But those details just didn't catch the attention of most people.

First, about two years ago, during the highly debatable process of restoring "natural" flows in the San Joaquin River, it was noticed that groundwater subsidence is occurring at a key point at the rate of about a half a foot/year. Planners found that it is tough to construct large fish screens at canal inlets where there was almost no head available before subsidence started.

Second, it became more evident that there is also subsidence close to the California Aqueduct. That catches attention, because the California Aqueduct conveys a major percentage of the water supply for the Los Angeles basin, and failure of the Aqueduct is not a very attractive option. I have been saying for years that nothing would happen until subsidence threatened the California Aqueduct. Recall that past subsidence problems were halted in many areas because the groundwater levels were restored. However, now those levels are back to the historical lows, and of course the subsidence process is just picking up where it left off.

Third, California has been in a drought for several years. Water allocations for many districts are in the 20% range. Everyone has turned on the well pumps.

Fourth, people along the east side of the San Joaquin Valley have started to notice that all those new almond trees planted outside the irrigation district boundaries actually have an impact on groundwater levels. Simultaneously, a large group of people in Sacramento and elsewhere are declaring that the flows in the San Joaquin River should be substantially increased to restore fisheries or water quality or recreation, or many other uses. Unfortunately, that water is the only water that could possibly restore depleted groundwater. This is referred to as a problem with "competing interests".

The bottom line is that we just have too many irrigated acres in California. Questions about environmental allocations aside, we are consuming more water than we have available. Supposedly, climate change is not going to help the situation. It makes for some very interesting questions about who will give up what. Obviously, many of the decisions will be related to value judgments (e.g., fish vs. crops, agriculture vs. urban). For irrigation professionals, there is great opportunity for removing as much of the "art" as possible in what we do, so that we have a clear idea of how to best use what water we have.

References

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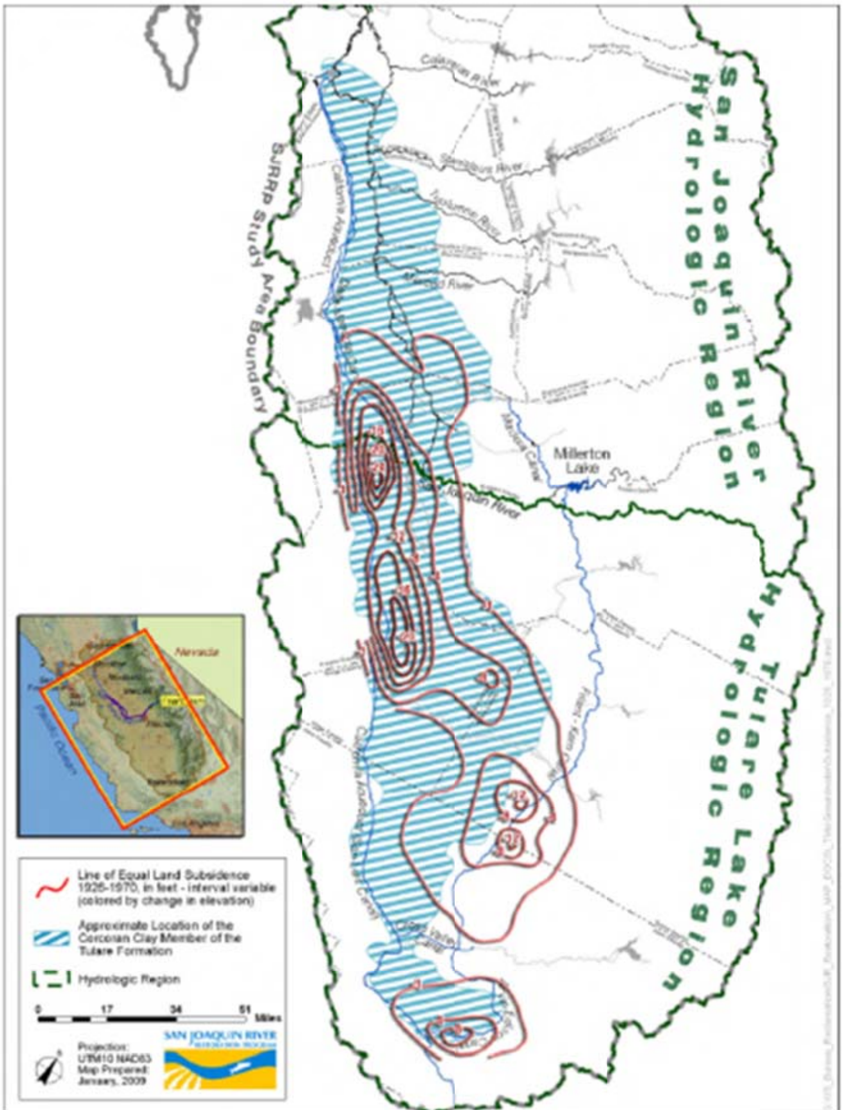

Source: Williamson et al. 1989

Figure 1. Land subsidence in the Central Valley (from SJRRP 2011)

Figure 2. Illustration of maximum subsidence at a site 10 miles southwest of Mendota, showing 29.6 feet of subsidence between 1925 and 1977 (from Galloway et al 2000)

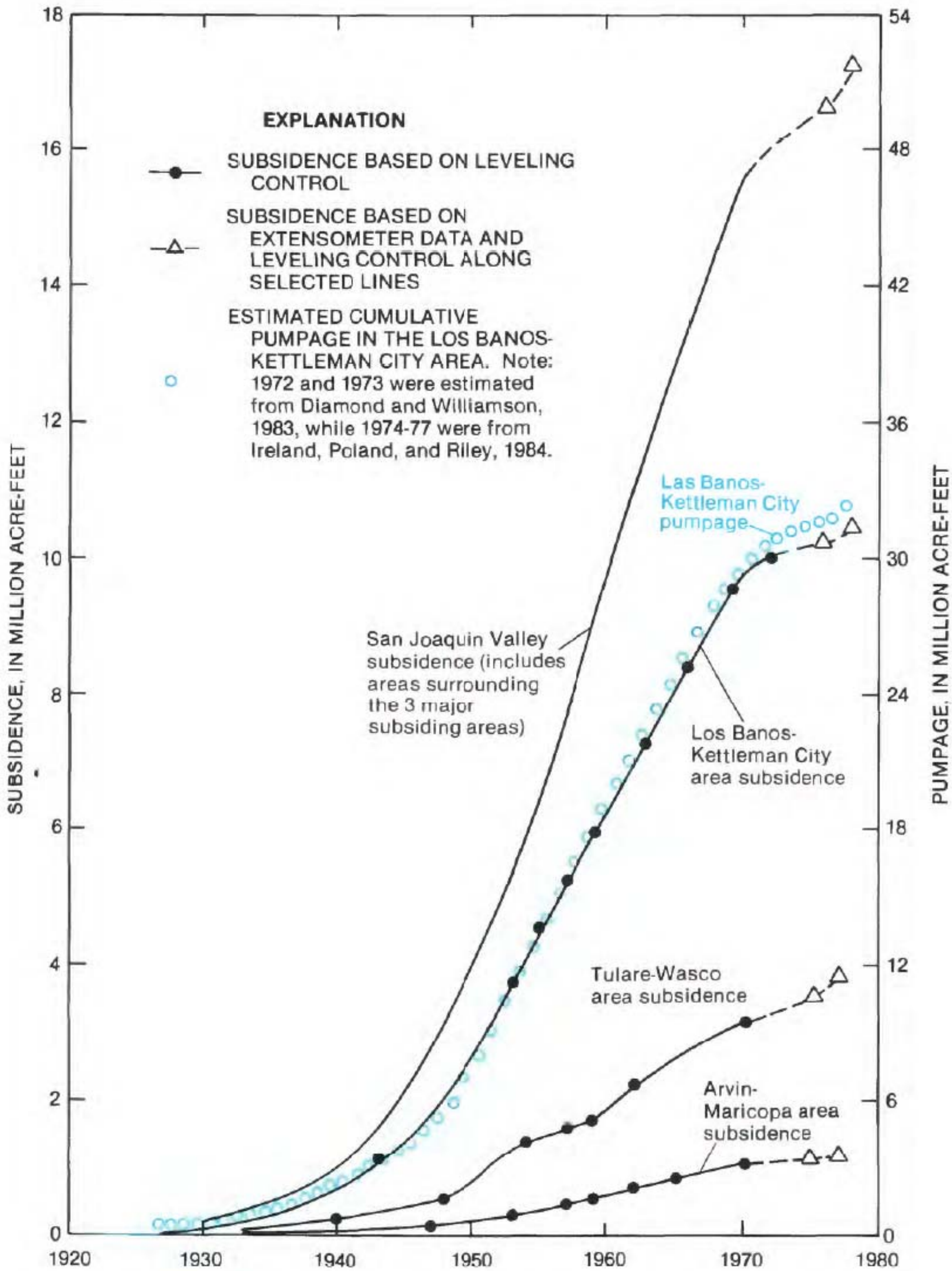

Figure 3. By 1977, the volume of subsidence was more than 17 million acre-feet in the San Joaquin Valley. In the Los Banos – Kettleman City area, one-third of the volume of groundwater withdrawn came from water that had been stored in the fine-grained sediments (from Williamson et al 1989)