California WaterBlog

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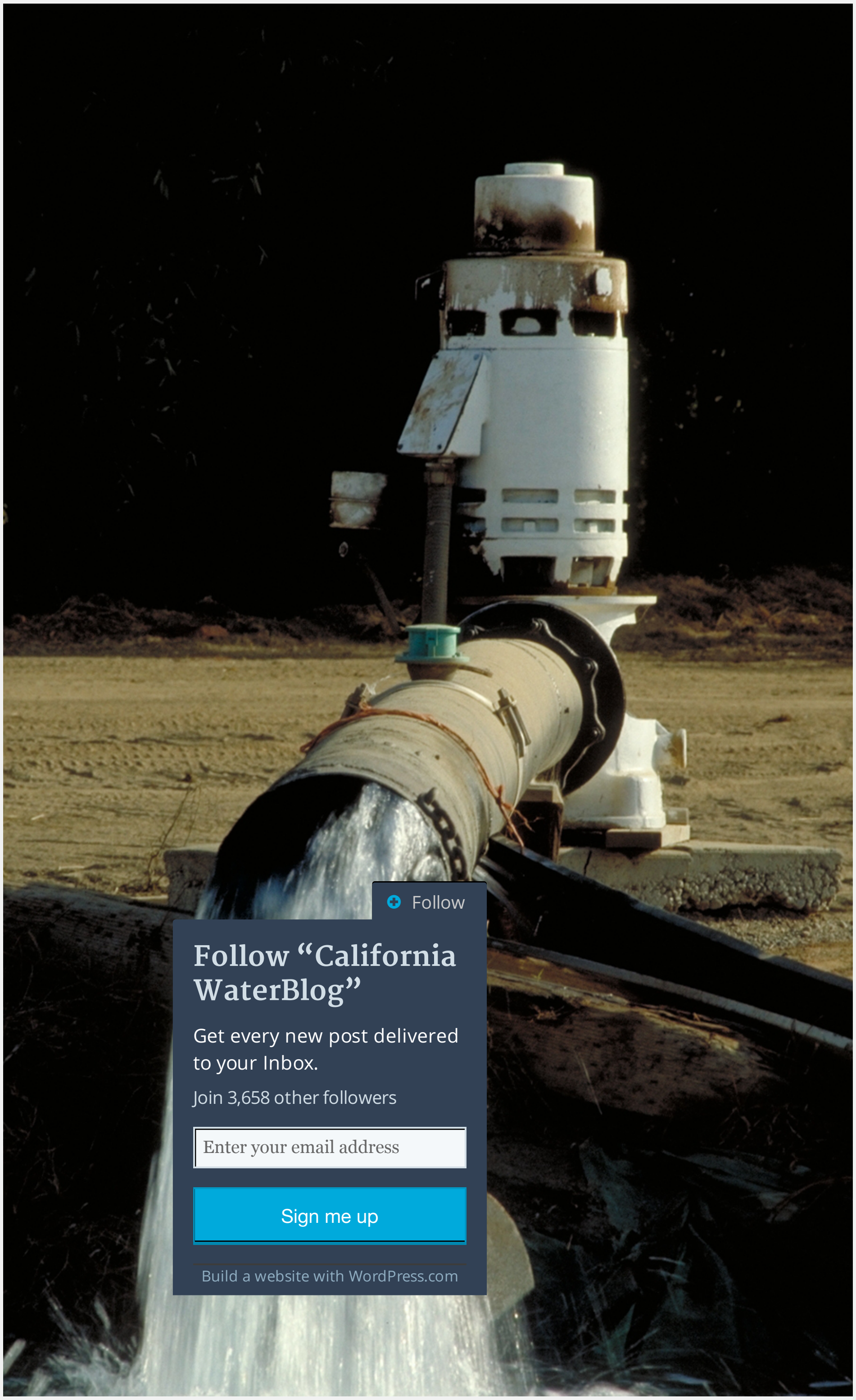
California's groundwater problems and prospects

Posted on January 30, 2013 by UC Davis Center for Watershed Sciences



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Under the rocks and stones, there is water underground – Talking Heads

By Jay R. Lund and Thomas Harter

Groundwater is one of California’s most ubiquitous, widely used resources that is unseen and misunderstood. Aquifers gather and store water and contaminants from large areas over decades to eons to support many human and ecosystem functions. We must manage groundwater wisely.

Groundwater is important to California in many ways. Roughly 30 percent of water deliveries in California come directly from groundwater, with much more in drought years, particularly long droughts (CDWR 2005, Megdal et al. 2009). Smaller urban and rural areas depend entirely on groundwater, as do many sizable cities, including Fresno. In all, 85 percent of Californians depend on groundwater for at least part of their drinking water. (SWRCB, 2012). The state’s groundwater storage capacity is more than 10 times that of all its surface reservoirs. Groundwater removes some, but not all, forms of drinking water contaminants. Groundwater also accumulates contaminants with time, particularly salts and nitrate. Groundwater pumping energy is about 2% of California’s electricity use (5,800 GwH/yr of total 280,000 GwH/yr). And many native species depend on streamflows and wetlands fed by springs and supported by high groundwater tables. California’s multifaceted dependence on groundwater leads to diverse controversies and myths.

Where does groundwater come from? Groundwater comes from surface water, natural landscape recharge and irrigation return water. When pumping exceeds recharge, it depletes aquifer storage. Recharge from streams occurs when the groundwater table is lower than the stream. Natural landscape and irrigation water recharge occurs when unused water percolates to below the root zone of plants and crops. Percolation is vital to crops and ecosystems. Without some percolation, the root zone accumulates salinity that kills plant life. In some areas, recharge basins, injection wells and irrigation management are used to intentionally recharge and bank groundwater during wet years or winters when ample water is available, for long-term storage and use in dry years or summer. In much of California, groundwater pumping has significantly lowered groundwater levels, which often increases recharge from streams. Increased losses from streams to groundwater can reduce downstream flows and affect ecosystems, if not regulated by upstream dams. Ultimately, almost all groundwater used for irrigation and drinking water would have become streamflow were it not pumped. (The largest exception is chronically overdrafted aquifers, less than 10% of California’s groundwater use.) .

Irrigation “inefficiency” is a major source of groundwater recharge. In the Central Valley and other agricultural regions of California, irrigation inefficiency is a major source of aquifer recharge (Ruud et al. 2004). In many areas, drought-year groundwater supplies depend substantially on irrigation inefficiency in wetter years, when surface water is available and used by farmers. Ironically, local inefficiency often improves regional water use efficiency and sustainability. However, excessive groundwater pumping causes long-term continual decline in groundwater levels (“overdraft”) and irrigation inefficiency increases salt and nitrate loads to groundwater. There are few perfect solutions in water.

Groundwater problems in California vary greatly and are locally quite important.

- **Overdraft** in California today occurs in parts of the Central Valley, especially the Tulare Lake Basin, but also in some coastal and southern California basins with limited surface water supplies and intensive agriculture.

During wet periods with more surface water deliveries, some overdraft reverses temporarily. Still, statewide overdraft is estimated diversely to average between 500,000 acre-feet a year to more than 1.5 million acre-feet a year, which amounts to 10-20 percent of all water use in the Tulare Lake Basin (Faunt et al 2009). Other Central Valley areas with groundwater overdraft are along the eastern margin of the San Joaquin Valley, including east of the Delta. Overdraft in much of the Sacramento Valley has been limited due to increased infiltration from streams induced by lower groundwater tables (Harou and Lund 2008; Faunt, et al. 2009). Overdraft in most of Southern California has largely ended by regulation from local groundwater adjudications and water imports (Blomquist 1998). In Southern California, the Tulare Lake Basin and elsewhere, drawdown of aquifers has created empty groundwater storage capacity used to store water from wet years for droughts (Vaux 1986; Jenkins 1998; Hanak et al. 2012). The Tulare Lake Basin's long dependence on the Delta and overdraft for about 60 percent of its water supplies is a major regional and statewide challenge. The Tulare Lake Basin uses more water than any other region of California – about 8 million acre-feet a year. Delta imports and San Joaquin River diversion supply about 3 million acre-feet; local streams, 3.2 million acre-feet; local groundwater inflows from precipitation, 1.1 million acre-feet; and 0.7-1.5 million acre-feet from groundwater overdraft (Hanak et al. 2011; CDWR 2009). The high value of Tulare Lake Basin agriculture, its dependence on water imports and overdraft, and the accumulation of salts and nitrate in this closed basin raise substantial long-term economic and social challenges for this region and the state (Chou 2012).

- **Nitrate contamination** is one of the most widespread groundwater problems worldwide and in California, affecting drinking water supplies in many agricultural or historically agricultural areas. While even large cities such as Fresno are affected, nitrate contamination is most expensive for small rural water supplies that lack economies of scale. Nitrate contamination affects many groundwater-dependent systems in California, including more than 200,000 people in small and household wells in the Tulare and Salinas basins (Harter et al. 2012). Most nitrate contamination is from agricultural fertilizers, although other sources, notably septic tanks and dairies, can be important locally. Most agricultural areas can expect nitrate contamination of drinking water supplies. Source control of nitrate discharge is only a partial long-term solution because of the large extent of contamination and its decades of travel in groundwater. Providing drinking water solutions and compensation for affected communities now and into the foreseeable future is an unavoidable and urgently needed response (Harter et al 2012). Nitrate problems for drinking water are often compounded by naturally occurring arsenic, chromium, uranium, and other groundwater contaminants (SWRCB 2012).

- **Salinity accumulation** is another long-term groundwater quality challenge. Salt accumulation is particularly problematic on the Westside of the Tulare Lake and San Joaquin basins, which lack much ability to export salt from imported water or local soils – affecting about 500,000 acres of farmland (SJVDP 1990). In many other parts of California, such as the cities of Davis and Woodland, the accumulation of salts in groundwater is threatening the viability of urban groundwater water use, because of wastewater regulations regarding the consequently higher salinity in urban wastewater discharges. Statewide, major sources of salt are local soils and aquifers, irrigation water, animal farming, and municipal and industrial wastes – including salts from water softeners. Salts in irrigation water and wastewater applied to crops or urban landscapes are concentrated by evapotranspiration from plants, leaving salts behind. Salinity accumulation has a history of ending agriculture in arid regions (Hillel 2000).

- **Land subsidence** resulting from groundwater use has been considerable in some areas, particularly in the Tulare Lake and San Joaquin basins. In the mid-20th century, land subsidence in the San Joaquin Valley and Tulare Lake basins has ranged from a few feet to over 30 feet (Poland et al 1975; Faunt et al. 2009). Due to decreasing groundwater levels, land subsidence is recurring and remains a threat in these regions (Corbett et al. 2011). While physically remarkable, there has been insufficient analysis of the occurrence and implications of subsidence and little accounting of the long-term economic costs. However, regional subsidence can incur potentially large costs from flooding and insufficient slopes on canal and drainage systems.

- **Decreased streamflows** have occurred on many California streams, as groundwater levels were lowered from pre-development levels. Lowered groundwater levels drain water from rivers, stressing ecosystems during low-flow times (Harou and Lund 2008; Faunt et al. 2009). Ironically, streams with an upstream dam now often have higher summer streamflows than they would have with natural runoff, despite surrounding groundwater levels being lowered. Reservoir operations delivering summer streamflow significantly contribute to groundwater recharge. But in unmanaged rivers, pumping drains water from riparian ecosystems (Fleckenstein et al. 2004; Harter and Hines 2008; Howard and Merrifield 2010) and more generally undermines surface supplies for junior surface water right holders (who sometimes respond by increasing their own groundwater pumping).

Should the State do anything?

- **The sky is not falling, in most places.** California has widespread groundwater problems, and probably always will. California is a dry place, after all. Many groundwater problems are severe, growing and local. Some groundwater problems could benefit from state action, but California's groundwater problems must be solved mostly at local and regional levels, perhaps with some state legal, financial, and technical help. The state can provide better institutional and information frameworks to help locals solve local and regional groundwater problems.

- **Many local groundwater problems are being handled well locally.** California has had a remarkable record of effective local groundwater management (Nelson 2011, 2012; ACWA 2011; Blomquist 1992). Historical overdraft in some areas of California has been eliminated or limited by build-out of surface water projects, and more recently by effective local conjunctive use in much of the Central Valley or groundwater adjudication in Southern California. In other areas, problems of groundwater depletion remain. Groundwater quality management has been much more difficult, with accumulations of salt and nitrate having so far defied local solutions. Groundwater quality and groundwater overdraft management are closely linked, as are groundwater and surface water. Creative regional solutions that consider these broader scales and interconnections are needed. Support for successful development of stakeholder supported local-regional management is also critical.

Some state reforms would be useful.

1. **Official information is important.** State agencies should declare areas at risk of nitrate and salinity contamination. Many domestic well users will not know of contamination without such official declarations. And local governments and interests are likely to lack capacity or incentive to address long-term groundwater contamination issues without the attention of state agencies.
2. **Effective compensation is needed more than source control.** Source control for large-scale groundwater problems, such as nitrate and salt contamination, often take decades to be effective, but people drink from and use these aquifers every day. Declarations of at-risk areas should trigger compensation mechanisms for affected water users, while long-term source control policies are developed and implemented.

Long-term source control poses a dilemma for the state, as even the best source control may not provide clean recharge and large-scale groundwater degradation often requires decades of response time. Because degradation in some aquifers is long-term and perhaps permanent for nitrate and salinity, providing mechanisms for information and compensation are key state roles.

3. **Better data and science.** Much data is available on groundwater in California, but too much of it is poorly organized, not in electronic format or hidden by secrecy rules. Consequently, little synthetic work is done to develop insights from these data. A serious technical program is needed, at arm's length from stakeholders, to develop the perspective and insights needed for informed public policy and management discussions and actions. State efforts to account for and model groundwater have been missing and hindered by data problems, but advanced substantially for the Central Valley with the recent California Department of Water Resources C2VSIM model and the U.S. Geological Survey model, CVHM. While both substantially improve answers to major groundwater questions, they still have great potential for further improvement.
4. **Security of groundwater rights and integrated regional water management.** Except in adjudicated groundwater basins, where courts have divided and allocated groundwater rights and established watermasters and enforcement mechanisms, most groundwater use in California is largely unregulated. Environmental limits on some surface water supplies for agriculture and urban users have stressed groundwater to levels not seen since the 1950s and '60s. In addition, large-scale groundwater quality management, driven by the state's nutrient and salt management policy, is becoming intimately intertwined with water quantity management. The state needs to find a way to more expeditiously establish groundwater use rights in ways compatible with separately regulated water quality and with physically connected, but legally separated surface water rights. Groundwater recharge management, integrated with groundwater quality management, in both urban areas and agricultural areas must become part of state and local groundwater protection strategies.
5. **The major overdraft areas of California create substantial economic value.** In the Tulare Lake Basin and numerous smaller basins, groundwater is mined, as one would deplete gold, oil and other mineral deposits. Are there areas of California where depletion of water should be viewed and accepted economically? In many areas, new solutions should be sought to increase groundwater banking and conjunctive use that allow water users to work within a long-term water budget, particularly in agricultural regions. This approach would provide a sustainable future for groundwater reservoirs (Scanlon et al., 2012; Hanak et al. 2012).

California will always have groundwater problems, and its dependence on groundwater is likely to increase with changes in demands, climate and environmental regulations. Success will be in how effectively groundwater is managed, especially in managing groundwater together with other water supplies and demands. Effective management will require state and regional frameworks of information, organization and authorities that help local water managers work effectively and transparently. Effective management of overdraft, salinization and contamination also will require a long-term perspective and serious technical efforts – through the end of the 21st century and beyond. This requires an important, if limited, role for the state.

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