EARTH ECONOMICS

The Value of Aquifers in Sonoma County

In Sonoma County, the water to support households, businesses, and agriculture comes from the Russian River and groundwater. The agricultural economy and rural households particularly rely on groundwater supplies, drawn from underground aquifers in places such as the Santa Rosa Plain and Sonoma Valley.

An aquifer is a below-ground geologic structure of material (rock, gravel, sand, silt) with pore space containing water. Aquifers are among the most critical economic assets in the Sonoma County economy, supporting the economic, environmental and social health of the regional through a clean water storage and supply, food production, and flood risk reduction among other services. While they provide tremendous value on a daily basis, the "work" these aquifers do often goes unnoticed.

Replenishment of these aquifers, and continued availability groundwater, depends on infiltration and percolation of water in natural areas such as grasslands, pastures, oak woodlands, or other impervious (i.e., unpaved) areas.

Benefits of the Santa Rosa Plain Aquifer System

Several of Sonoma County's most economically important aquifers lie beneath the Santa Rosa Plain, home to half of the County's population, and the Cities of Santa Rosa, Sebastopol, Rohnert Park, Cotati, and the Town of Windsor. The Santa Rosa Plan includes a groundwater system made up of several aquifers at various depths: The Glen Ellen Formation, Wilson Grove Formation, Petaluma Formation, and Sonoma Volcanics. The aquifer system receives water inflows from rainfall, irrigation, and surface water, while outflows include pumping, uptake by plants, and discharges to the Laguna de Santa Rosa, Mark West Creek, and other streams. With roughly 40 inches of rainfall per year, about 560,000 acre feet (182 billion gallons) of water falls in the area each year.

Sonoma County residents, agriculture and businesses depend on a number of benefits provided by the Santa Rosa Plain Aquifer system, including:

1. **Water Capture & Supply.** While much of the water supplied to urban areas such as Santa Rosa is imported from the Russian River, the Santa Rosa Plain Aquifer is used as a supplemental source for these areas. In addition, numerous mutual water companies, special districts, rural households, and agricultural operations depend entirely on water pumped from the aquifer.[1] In total, approximately 42,000 acre feet (14 billion gallons) of water were pumped from the aquifer annually between 2004 and 2010.[2] Based on water rates used by the Sonoma County Water Agency for Prime Contractors ($672.03 per acre foot[3]), the market value of this water is at least

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$28 million annually. Aquifers also support improved water quality by filtering out pollutants such as nitrogen, viruses, and effluent.[4]

2. **Water Storage.** The Santa Rosa Plain aquifer system stores water moving across and below the landscape. This water is available for extraction and provides water supply reliability throughout the year. A 1994 survey conducted with consumers across multiple water utilities in Northern California indicated that people are willing to pay between $20 and $27 over and above their water bills (in 2015 dollars) to ensure water supply reliability (i.e. to avoid water shortages).[5]

3. **Avoided Subsidence.** Healthy aquifer systems also support structural integrity through the avoidance of land subsidence. Subsidence of the land can damage vital infrastructure, such as wells, sewers, roads, and bridges. A 1984 study conducted in the Santa Clara Valley estimated that each foot of land subsidence resulted in at least $19 million (2015 dollars) in damages to infrastructure such as well casings, sewers, bridges, as well as the cost of raising the height of levees due to greater flood risk.[6] While the Santa Rosa Plain Aquifer is considered to be at a low-medium risk of subsidence compared with other groundwater basins, according to the California Department of Water Resources,[7] continued proactive management of the aquifers will ensure that subsidence costs are not incurred in the future.

In addition to the services discussed above, aquifers provide a suite of other important benefits. For example, by holding and slowly discharging cool water into streams and rivers, aquifers enhance habitat for fish and support healthy riparian ecosystems.[8] Habitat loss can result in significant economic consequences, such as costs associated with restoring endangered species, or loss in fisheries revenue. Groundwater recharge areas in the Santa Rosa Plain also mitigate flood risk by capturing rainwater that would otherwise contribute to flooding.[9,10]

The Impacts of Over-Pumping Aquifers

Over-pumping occurs when more water is extracted from an aquifer than is naturally replaced through rainfall and other processes. Many aquifers in California have historically been over-pumped, and this has been exacerbated during the current drought. Because there is no substitute for water, groundwater pumping across California has risen as communities have struggled to make up for less rainfall and snowmelt from the mountains. A third of California's monitoring wells dropped by more than 10 feet between 2010 and 2014, and another third have seen levels drop between 2.5 to 10 feet.[11]

It is estimated the Santa Rosa Plain Aquifer lost 120,000 acre feet (39 billion gallons) of water from storage between 1976 and 2010 due to over-pumping,[12] enough water to supply the City of Santa Rosa for approximately 6 years.[13] Data is sparse for the Santa Rosa Plain and other regions of Sonoma County, and overall trends are difficult to estimate, but available data suggests that shallow aquifers in the Santa Rosa Plain have remained stable, while many of the deeper aquifers (which do not recharge as quickly) have shown declining trends.[14] Therefore, while groundwater conditions in

Sonoma County do not appear to be as serious as in other parts of the state, continued prudent management of groundwater can avoid a number of economic costs, including:

1. **Increase in pumping costs.** Groundwater levels drop as aquifers are over-pumped, requiring deeper wells. New wells entail construction costs, and deeper wells also incur higher electricity costs, due to the increased energy required to pull water up from further below the ground. For example, the earlier-referenced study conducted on Santa Clara Valley Aquifer calculated the additional cost of pumping 1 acre foot of water 1 extra foot in depth.[15] Assuming similar pump efficiencies but adjusting for current power rates, the additional cost would be approximately $0.12 per acre foot per foot. While it is difficult to estimate the overall costs associated with lower groundwater levels in Sonoma County to date, it is likely that areas with declining aquifers are already incurring these additional costs.

2. **Land subsidence and loss of storage capacity.** Land subsidence is the sinking of land surface, which can occur as groundwater is extracted from certain types of rocks, such as fine-grained sediments. If too much water is withdrawn, it no longer fills the "pore space" between the rocks, and the rocks collapse in on themselves. Once this pore space has collapsed, it cannot be recovered, and the water storage capacity is lost forever.[16]As discussed earlier, subsidence can also result in damages to infrastructure such as well casings, sewers, bridges, as well as the cost of raising the height of levees due to greater flood risk.

3. **Saltwater intrusion**. Healthy coastal aquifers maintain a healthy freshwater "lens", which maintains outward pressure on the saltwater interface. Groundwater levels have dropped by more than 100 feet in southern Sonoma County due to over-pumping.[17] As a result, the pressure exerted by the freshwater lens is reduced, and saltwater has begun to intrude in some areas of the aquifer, creating areas of brackish water that are no longer suitable for agriculture or require additional treatment.

State and Local Actions to Protect Groundwater Supplies

The alarming decline of the state's groundwater supplies has drawn the attention of the California Legislature. In 2014, lawmakers passed a trio of bills intended to manage groundwater on a large scale for the first time in state history. When he signed the bills, Gov. Jerry Brown said it was time for the state to "learn to manage wisely water, energy, land and our investments." Unlike surface water, groundwater had not been regulated at the state level until the passage of this legislation.

Agencies in Sonoma County have also been proactive about groundwater management. In an effort "to inform and guide local decisions about groundwater management in the Santa Rosa Plain Watershed", in 2014 the Santa Rosa Plain Advisory Panel published the Santa Rosa Plain Watershed Groundwater Management Plan, a living document intended to support collaboration on groundwater management in the Santa Rosa Plain Aquifer. Objectives of the plan include greater public awareness of groundwater, maintenance of groundwater levels and quality, and protection of

recharge areas.[18] A similar groundwater management plan has also been created for the Sonoma Valley.[19] Implementation of both plans is led by the Sonoma County Water Agency.

The Sonoma County Water Agency has also investigated piping surplus surface water during wet seasons into aquifers for availability during dry weather conditions and emergencies, and continues to conduct scientific studies to phase in this watershed management technique. Groundwater recharge can potentially enhance all ecosystem services provided by the aquifer.[20]

Understanding an aquifer's value in economic terms – in addition to its ecological attributes – can inform better decision making by highlighting tradeoffs associated with different management policies. The value of ecosystem services provided by the Santa Rosa Plain Aquifer could be calculated in further studies. For example, studies could estimate the cost associated with using alternative water sources, should water quality decrease significantly.

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