Economic Costs of Borrego Valley Aquifer Overdraft

For: California Department of Water Resources and Borrego Water Coalition

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This memorandum develops estimates of the economic value of reducing withdrawals from the Borrego Valley Basin by one acre-foot (AF). This economic benefit can be attributed to any AF of reduced overdraft or increased recharge. The economic value includes avoided costs associated with a lower groundwater table including: energy, well efficiency and well drilling costs, water quality, habitat loss, and subsidence. Then, the economic value of water saved for future use is included. Loss of mesquite habitat and other avoided costs such as subsidence are not considered quantitatively in this analysis. That does not mean there are no probable economic impacts from habitat loss or subsidence. Rather, it is beyond the scope of this study to forecast what such costs might be.

Summary

This memo provides an economic benefit associated with the elimination of overdraft in the Borrego Valley on a per acre-foot (AF) basis. Economic concepts are introduced. Then, discounting is used to estimate the present value of future costs that could be eliminated if overdraft ends. Overdraft costs that could be eliminated are

- Increased energy costs from pumping lower groundwater tables.

  The benefit of eliminating this cost is estimated to be worth $40 to $143 per AF of overdraft eliminated, depending on the discount rate and rate of groundwater decline.

- Loss of wells when groundwater tables fall below well intakes

  The benefit of eliminating this cost is estimated to be worth about $10 per AF. About half of the benefit is associated with new BWD pumps and distribution required by 2040.

- Water quality and water quality treatment costs

  The benefit of eliminating this cost is estimated to be worth about $11 per AF of overdraft eliminated. Most benefit involves the avoided cost of advanced treatment required by 2050.

- Subsidence and environmental costs

  The benefit of eliminating this cost could not be quantified.

- The opportunity for use of the water to support development later

This benefit cannot be counted if the aquifer must remain in a steady-state condition indefinitely. If water saved for 50 years can be used to provide water for development, the benefit of future development could be over $1000 per AF in present value terms, depending on discount rate and assumptions regarding the amount of benefit from new regional spending.

Total estimated benefit is $61 to $164 per AF if the saved water can never be used, and $500 to $1500 if the saved water could be used to support residential development in 50 years. All of these estimates are uncertain. Additional forecasting and cost estimating might improve the quality of the estimates.

Introduction

The costs of Basin overdraft, or the benefits of stopping overdraft, are important issues for Borrego Valley residents and water users and the local economy. Currently, the rate of water withdrawal is three to four times the rate of natural recharge, and the groundwater table is declining at an average rate of about 2.7 feet per year for the Basin as a whole. Since the volume of groundwater in storage decreases with depth, it is expected that basin-wide rates of water level decline will increase (USGS 2014). The groundwater decline increases unit-pumping costs, and the decline may be associated with water quality degradation, land subsidence, and loss of natural habitat. As water levels drop below the intake perforations in a well, the well must be abandoned and a new well may be required to meet demands. Wells may also go out of service due to declining water quality.

The Borrego Valley groundwater system consists of three aquifers: the upper, middle, and lower aquifers. The three aquifers, which were identified on the basis of the hydrologic properties, age, and depth of the unconsolidated deposits, consist of gravel, sand, silt, and clay alluvial deposits and clay and silty clay lacustrine deposits (USGS, 2014). Later this century, if overdraft continues, the more permeable parts of the system will be dewatered. The lower parts of the aquifers may be less desirable for water supply because of worse water quality, and because permeability and storage properties likely resulting in a decrease in potential well capacity. The specific yield of the aquifer system decreases rapidly with depth (USGS 2014). If existing wells cannot produce at their current capacity, then additional new wells may have to be drilled to meet demands.

If overdraft is not corrected, these costs are expected, but it is also expensive to reduce overdraft. Costs and benefits of aquifer overdraft can be compared to help decide if actions to reduce overdraft are warranted on an economic basis. This memo provides a summary of quantifiable overdraft costs that can be used to help justify corrective actions.

Background

There is a long history of economic theory in relation to aquifer depletion (NRC, 1997; Strand, 2020; Job, 2009). It is generally recognized that groundwater can have common property characteristics, and pumping can have externalities (costs that are not incurred by the pumper), that together can lead to extraction at higher-than economically optimal extraction rates. Common property means that the resource is used in common by many users. In California, outside of a court-determined adjudication of water rights, no user can presently limit the amount of extraction by another user.

External effects of groundwater pumping include declining groundwater levels, but may also include subsidence, water quality, or environmental costs. If the groundwater supply is finite (may not be replenished) as is the case for a basin in continual overdraft, then groundwater use now subtracts from the finite supply available for all future uses. Opportunity cost is the benefit of future use lost because the water is consumed now.

Each user does not experience the costs they impose on others, so each user has no incentive to reduce their use in consideration of the external costs. These inefficiencies provide economic rationale for regulatory measures to encourage sound management of groundwater basins in California.

Groundwater depletion can be thought of as a property rights problem. In western economics, goods can be allocated efficiently by markets if, among other things, the property right is exclusive. This means that others can be excluded from using it. In California,

> overlying land owners may extract percolating ground water and put it to beneficial use without approval from the State Board or a court. California does not presently have a permit process for regulation of ground water use. In several basins, however, groundwater use is subject to regulation in accordance with court decrees adjudicating the ground water rights within the basins.
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> The California Supreme Court decided in the 1903 case Katz v. Walkinshaw that the “reasonable use” provision that governs other types of water rights also applies to ground water. Prior to this time, the English system of unregulated ground water pumping had dominated but proved to be inappropriate to California’s semiarid climate. The Supreme Court case established the concept of overlying rights, in which the rights of others with land overlying the aquifer must be taken into account (SWRCB, 2014)

The concept of overlying rights is associated with the concept of correlative rights, meaning that each landowner is entitled to a share of the available supply defined as the “safe yield” or average annual natural recharge rate. Despite this concept, except in areas of the State where groundwater rights are adjudicated, groundwater pumping has generally been unregulated in California.

It is useful to imagine an aquifer owned by just one person, and assume that all effects of groundwater extraction are experienced by that person. Then, this owner would consider all externalities in their decision regarding how much to pump. That is because there is no one else to pay the costs of that person’s extraction. The rate of extraction should be economically optimal, at least from their own perspective. This example shows that aquifer overdraft is not necessarily an economic problem. If all overlying landowners can act in common, as though they are one property owner, then they may decide to extract groundwater at an economically optimal (e.g. sustainable) rate.

Analysis Framework and Assumptions

Planning Horizon

This economic analysis estimates increased costs caused by continued overdraft of the aquifer going forward. These costs are estimated for each year of a one hundred year planning horizon, 2014 to 2113. Then, these costs can be discounted and summed to one equivalent cost in 2014 using net present value (NPV). Then, this NPV cost can be annualized, that is, expressed as one annual cost, which has the same NPV over one hundred years as the original one-hundred year time series of depletion costs. The analysis first expresses all costs in current, real (inflation-free) dollars, and then they are discounted and annualized using the same discount rate.

For planning purposes, this analysis assumes an economically useful life for the remaining water in the Basin is 100-years. This assumed 100 years economic life of the Basin is the assumed planning horizon.

The analysis uses the same water use assumptions as used in the detailed actions analysis which are all from BWD (2013). Total 2013 planned use is 19,833 AFY, natural recharge, from USGS (2014) is 7,000 AF per year, so overdraft is 12,833 AFY. Total costs are divided by this overdraft estimate to obtain the cost per AF of overdraft.

Discount Rate

The social discount rate (SDR) is defined as the rate at which people are willing to forgo current consumption for future consumption. The SDR is positive because people invest and lend money, giving up current consumption, receive dividends and interest, and end up with more money to spend later. Real interest rates, being the observed interest rate less the rate of inflation, are often used as a measure of the SDR.

The selection of a discount rate is not a trivial matter; books have been devoted to that subject. There are three major methods that guide the calculation of an SDR: (1) social rate of time preference (SRTP), (2) social opportunity cost of capital (SOC), and (3) shadow price of capital (SPC).The appropriate discount rate may depend on perceived risk. Risky investments demand a risk premium. The best rate may depend on whose benefits or costs are being discounted. In general, discount rates associated with private investors are among the highest; investors expect risk-free real return rates of 5 percent or more. Some have argued that discount rates involving benefits and costs across generations should be very low; perhaps 0 to 2 percent.

A range of 2 to 4 percent is used for this analysis. Results are calculated and displayed at 2, 3 and 4 percent.

Rate of Groundwater Decline

CSDDPLU (2010) states

> Between 1945 and 1980, water levels declined by as much as 100 feet, due to more water being extracted than was being replenished (USGS, 1982).

This works out to be more than 2.8 feet per year.

CSDDPLU (2010) reviews data from eight monitoring wells and finds

> From 1998 to 2006, water level declines have averaged 2.4 feet per year, which is roughly twice the rate of decline measured in the 1980s. This is likely primarily due to the increased extraction rates that are occurring compared to extraction in the 1980s.

The 2014 rate of decline is assumed to be 2.7 feet per year. Under current pumping rates, the rate of decline is expected to increase as the volume of water remaining in storage and the permeability and specific yield of the aquifer declines with depth (CSDDPLU, 2010). To illustrate this more rapid decline, it is assumed that the rate of decline will increase by 1 percent or 2 percent per year. This range is believed to be representative of current trends in the basin. Under the 1 percent assumption, the rate of decline reaches 4 feet per year by 2053, and 6 feet by 2094. A sensitivity analysis is provided with the rate of decline increasing by 2 percent per year. Under the 2 percent assumption, the rate of decline reaches 4 feet per year by 2033, 6 feet by 2054, and 10 feet by 2018.

Electricity Costs and Rates

Most electricity used for pumping is purchased from San Diego Gas and Electric. Most groundwater users pay business rates. Some pumpers pay time of use (TOU) rates, pumping water at night when rates are lowest and storing water in holding tanks for distribution during the day when water demands are highest.

Assumptions were obtained by reviewing SDGE rate sheets for commodity rates during summer (SDGE, 2014). The on-peak, semi-peak and off-peak rate during summer is currently about $0.11, $0.09 and $0.07 per kwh, respectively. It is assumed that pumpers pay an average of $0.08 per kWh under current conditions, and the real price of electricity increases 2 percent per year. This is consistent with long-term trends, and groundwater depletion, by limiting the instant rate of groundwater withdrawal, might force more pumping into the higher-cost time of use brackets.

Water Quality

Overdraft may cause the concentration of a variety of undesirable water quality constituents to increase in the future. Salinity, measured as increasing tds, is declining in the region. This decline is estimated to be 1.67 mg/l per year. It is not clear that this decline is caused by overdraft, or if other factors may be contributing. However, it is assumed that the increasing tds would cease with overdraft.

Table 1.
Production Well Water Quality, 2007 to 2013, in mg/l tds

Year **WELL #**	**2013** **tds**	**2007** **tds**	
ID1-8	500	430	
ID1-10	280	250	
ID1-12	270	260	
ID1-16	280	320	
WILCOX	230	210	
ID4-4	330	320	
ID4-10	500	490	
ID4-11	340	390	
ID4-18	620	590	
Average	372.22	362.22	
Decline per year			1.67

The Lower Colorado River Basin Water Quality Model, a salinity economics model used for Southern California studies, which includes residential, commercial, industrial and other salinity costs, results in a benefit of $0.15 per milligram per liter (mg/l) of tds per household per year. That estimate is applied here to 2,611 housing units as reported by the 2010 Census of Population and Housing (USDC, 2010).

Number of wells and well replacement

Aquifer depletion will increase well costs as the water level falls below levels that wells are designed to draw water from. An explicit estimate of BWD well costs are included in some scenarios. Brecht (2014) estimated that the BWD south pumps will be replaced with north pumps at a cost of $2 million in 2039, (2014 dollars), and the distribution system will need to be modified at a cost of $3 million in 2040. No new O&M is included for the new wells and distribution system because the O&M for the old system will no longer be required.

In addition, to cope with drinking water standards, advanced wellhead treatment may be required at a cost of $10 million. This wellhead treatment, assumed to be required in 2049, presumes that brine can be disposed of economically under Federal and State permitting laws at that time. Additionally, the incremental operating and maintenance (O&M) costs and amortized repair and replacement (R&R) costs for the wellhead treatment is assumed to be $500,000 annually, starting in 2049.

BWD (2001) found that

> Today, the agricultural area (predominantly north of Henderson Canyon Road) operates approximately 50 wells. Golf courses operate approximately eight wells for irrigation. Domestic water supplies for the Borrego Springs Park Community Service District and the Borrego Water District are pumped from 14 wells. Individual domestic wells total in the neighborhood of 50.

It is assumed that there are a total of 108 affected wells, which does not include the BWD wells. It is assumed that, without groundwater level declines, the average life of these wells is 50 years. With groundwater decline, the average life is decreased to 30 years. The average cost for drilling new irrigation/golf wells and small domestic wells is assumed to be $75,000 and $15,000, respectively.

Subsidence

Brecht (2013) suggested that $12 million in subsidence costs might be expected in the future due to the low probability of a large amount of subsidence/compaction with continued water level declines (USGS, 2014). No subsidence costs are included in the analysis. There will be some subsidence costs, but they are believed to be not large and they cannot be estimated at this time.

Environmental costs

Mesquite bosque is an unusual habitat sustained by relatively shallow groundwater levels. CSDDPLU (2010) states

> With the exception of the southernmost mapped habitat where recent groundwater levels have been relatively static, groundwater levels been declining at a rate of approximately 1 to nearly 3 feet per year. It is likely that as groundwater levels continue to drop, portions of the mesquite bosque will not be able to adequately adapt and habitat will be permanently lost. Potential

secondary affects could also negatively impact local residents, plants, and wildlife from dust storms resulting from topsoil that is left exposed when plants die off.

Most of the mesquite bosque habitat may be already lost. A quantitative analysis of the cost of loss of habitat is outside the scope of this analysis.

Value of water left in aquifer

The default analysis presumes that pumping could be reduced so that it equals the amount of recharge on average. In this condition, discharge (groundwater pumpage) would not exceed recharge. As compared to continued overdraft, the water left in the aquifer to eliminate overdraft would never be pumped and the aquifer would remain in balance.

However, an important benefit of not consuming a finite resource now is that it remains available for use later. This potential is especially important if the type of use of the water could be expected to change in the future.

A sensitivity analysis is provided where it is assumed that the water saved by eliminating overdraft would be available for residential development in the future. This saved water is the accumulated volume of water that is not pumped because overdraft is eliminated for 50 years. The future residential development has four benefits; 1) the net income enabled in the home construction industry, 2) the net income enabled by water sales, 3) the net incomes created by the local spending of the new residents, and 4) the willingness-to-pay of the new residents, above what they actually pay, for their new homes. This last benefit is not estimated for this report; the new homes would enable housing for some new residents who are not residents now.

The quantitative analysis associated with this sensitivity analysis is provided to be representative only. At this time, the potential future demand for development in the Borrego Valley cannot be forecast.

Annual overdraft ranges from about 19,000 to less than 5,000 acre-feet (USGS, 2014). The average annual overdraft has been estimated to be 15,000 AF per year (USGS, 2014). Using irrigated land water use assumptions developed for BWD water crediting (BWD 2013) the amount of overdraft is estimated to be significantly less, about 12,833 AF. If this overdraft is eliminated for 50 years, then 641,670 AF more remain in the aquifer. At 0.59 AF per household, this water could support 10,875 homes for 100 years. It is assumed that these homes would be built in 2063, priced at $250,000 on average (in 2013 dollars), and profit margin is 5 percent. The potential profit earned in 2063 is then $136 million.

Residential development would increase water sales. BWD 2014 rates are $2.09 per hundred cubic feet (hcf) in the low tier of water use, and $3.14 per hcf in the high tier. If the new homes take half of their water in each tier, then the average revenue per AF sold is $1,139. These revenues would be partly offset by the costs of providing the water supply. The cost of energy in 2063 is estimated to be $64.60 per AF, and the cost of new wells $61.20 per AF, and there would surely be additional costs to serve the new residents. Fundamentally, it is assumed that water net revenues could benefit from economies of scale; the new residences could be brought on-line at lower than average cost. It is assumed that the residential net benefit would be $800 per AF, less than the revenue minus variable costs (1,139.00 –

64.60 – 61.20) and new annual net income from water sales would then be about $5.1 million. This net revenue is received for the years 2064 through 2163. This represents a net income for BWD that could use to reduce rates for all customers taken together.

The new residents would bring new spending to the region, increasing retail sales, income and employment. There are no useful estimates. If each new residence creates $5,000 in regional net income per year, then the annual benefit would be $54 million. This value is included in the sensitivity analysis.

Results

Results are summarized in Table 2 below. The analysis provides results in terms of dollars of benefit per AF of overdraft reduction for a large number of scenarios where the scenarios change assumptions about the physical effects of overdraft and the economic discount rate.

Table 2.
Economic Benefit per AF of Overdraft Reduction, $/AF

	Discount Rate		
Assumptions	**2%**	**3%**	**4%**
2.7 feet decline per year	$73.44	$54.00	$39.75
2.7 feet plus 1% decline per year	$98.94	$70.77	$50.67
2.7 feet plus 2% decline per year	$142.76	$98.84	$68.40
2.7 feet plus 1% decline per year			
With WQ cost $0.15/mg/l, 1.5 more/year	$101.27	$72.69	$52.27
Add new BWD pumps, distribution, 2039-40	$106.61	$78.30	$57.87
Add BWD advanced treatment, 2049	$115.47	$86.81	$65.62
Add non-BWD well life up from 30 to 50 yrs	$120.57	$91.64	$70.10
Add ability to sell saved water			
Build 10,876 new homes in 2064	$292.81	$223.57	$167.15
Include $5,000/home in annual net incomes	$1,690.60	$1,122.34	$730.22

First, results are provided assuming that the only effect of overdraft is to increase lift by 2.7 feet per year for 100 years, and associated pumping costs are increased. The benefit of reducing overdraft by one acre-foot (BROBAF) varies from $40 to $73 per AF depending on the discount rate. If the rate of decline will increase one percent a year because of reduced volume remaining and less specific yield in the remaining aquifer, then BROBAF increases, ranging from $51 to $99. If water levels decline even faster at the 2% increasing rate, then BROBAF ranges from $68 to $143.

The remainder of the scenarios assume that the rate of decline increases at the 1 percent rate each year. The additional residential water quality costs appear to make little difference, about $2 per AF, for the bottom line. The assumption that $5 million in new BWD well construction and distribution costs would be required in 2039 to 2040 also makes a small difference in results. The BROBAF increases to a range of $58 to $107 per AF. With the assumption of an additional $10 million in water treatment costs by 2050, with additional operating costs after that, and with the assumption of additional well costs for all private wells, the BROBAF increases to $70 to $121.

In the sensitivity analysis, if all the water saved over 50 years can be sold later to support residential development, then the BROBAF increases to a range of $167 to $293; $224 at the 3% discount rate. If each new home is assigned $5,000 in annual benefit for the regional economy, the BROBAF increases to $730 to $1,691.

The discount rate makes a huge difference for these estimates because of the assumption that the additional residential construction does not happen for 50 years. It is worth noting that, under the assumptions of this analysis, if overdraft is unchanged from current levels but water is provided for residential use, the apparent benefit per AF is $1,569, not including the potential spending benefit of $5,000 per home. The same benefit of building the same homes but 50 years later is only $224 per AF. The $1,569 benefit is large enough to cover costs of any of the detailed actions discussed in a separate measure. That is, if residential growth is at stake, a large number of land retirement, water-conserving, and water supply measures might be economically justified.

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