Hydrogeology consulting

To: Los Osos Sustainability Group
From: Stephanie Shakofsky
Re: Review of Basin Yield Metric & Chloride Metric (CONFIDENTIAL)

I. Basin Yield Metric

RECOMMENDATION: The BMC should strongly consider resetting the maximum sustainable yield back to 2,450 AFY as outlined in the Basin Plan, the Stipulated Judgement, as calculated by the 2012 Model run. The basis for this recommendation is the continuing degradation of the basin, which includes but is not limited to, certain production wells exceeding 250 mg/l of chloride.

RECOMMENDATION: The BMC should strongly consider resetting the agricultural water usage back to 800 AFY as originally set in the Basin Plan (2015) which was based on historical surveys of agricultural use and aerial photography. The basis for this recommendation is that the 2017 calculated agricultural water use (applying an evapotranspiration and rainfall model that lowered the agricultural water usage by 130 AFY) is an idealized and unrealistic water usage calculation given typical agricultural practices in San Luis Obispo County and an unrealistic irrigation efficiency factor of 92%.

Discussion

As defined in the Basin Plan, the basin yield metric is calculated each year by:

$$\text{Annual GW Production} \div \text{Maximum Sustainable Yield}$$

Where Annual GW production is the total water removed by purveyors, community users (parks), agriculture, and domestic wells. And, where Maximum Sustainable Yield was calculated using the basin Model (Modflow + SEAWAT) and initially set at 2,450 AFY.

Specifically, Section 6.3.2 of the Basin Plan states "The Sustainable Yield$_x$ is determined for a given set of infrastructure in place by using the Model to determine the maximum amount of groundwater extractions that may occur with a stable seawater intrusion front, and no active well producing water with chloride concentrations above 250 mg/l."

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This initial Maximum Sustainable Yield of 2,450 AFY was to be set for 5 years, as agreed upon in the Stipulated Judgement (2015). However, because certain infrastructure was completed by 2016, the Maximum Sustainable Yield was increased by 310 AFY in 2016 to 2,760 AFY which is where remains today for calculating the 2020 metric.

The recommendation to return to the 2,450 AFY Maximum Sustainable Yield is based on the fact that chloride readings for at least one well (LA10) has exceeded the 250 mg/l of Chloride goal set by the Model. It also appears that well LA11 will likely exceed the 250 mg/l of Chloride goal in the very near future. Moreover, water quality data is clearly showing a continuing degradation and increasing salintiy of the basin which does not meet the criteria of maintaining a stable seawater intrusion front. This is discussed in more detail in the Chloride metric discussion.

An additional concern is that the DRAFT 2020 Annual Monitoring Report recommends an update and an increase to the Maximum Sustainable Yield now that the location of the second Program C expansion well is finalized. However, current water quality data do not support a increase in the Maximum Sustainable Yield as this memo discusses.

The Maximum Sustainable Yield in the basin is constrained primarily by the need to prevent Lower Aquifer seawater intrusion. The goal is to keep the Basin Yield Metric at or below 80% which is intended to represent a conservation of water usage and maintain a stable intrusion front, as well as compensate for a variety of uncertainty factors in the model. While this goal is articulated well in the Basin Plan, it is important to keep expectations for simulated model forecasts in line with chloride concentration and other water quality and real time data.

Coastal aquifers are complex environments characterized by transient water levels, variable salinity and water density distributions, and heterogeneous hydraulic properties. Climate variations, groundwater pumping, and fluctuating sea levels create dynamic hydrologic conditions, which are interrelated with the distribution of dissolved salts through water density-salinity relationships. Moreover, these processes are often important at different spatial and time scales.

Saltwater intrusion is severely affecting the water quality in the Los Osos basin, which presently is the sole source of potable water in the basin. Intrusion requires years to decades to reverse and remediate. Therefore, any prudent water management plan must include margins of safety that consider the uncertainty in estimated basin yield, monitoring, and an adaptive management strategy that includes contingency actions that can be implemented should the proposed plan not work.

The BMC created metrics that allow the parties, regulatory agencies, and the public to evaluate the status of seawater intrusion in the Basin through objective, numerical criteria that can be tracked over time. However, metrics were not designed for early detection, and decision-making must rely on current, available high-quality data.

Therefore, because the water quality data clearly shows that the BMC is not meeting the goals set forth in the Basin Plan (specifically Section 6.3.2), it recommended that the BMC consider setting the Maximum Sustainable Yield back to 2,450 AFY.

It is also recommended that, at a minimum, the BMC consider resetting the Agricultural Groundwater Production back to 800 AFY. The Basin currently encompasses approximately 1,090 acres of land that is zoned for agricultural uses. In 2015, estimated acreage of irrigated agricultural land was 375 acres. Over the past five years that number has been lowered to 283 acres based on the County's aerial photography updates. Although inaccuracies may exist in the estimation of irrigated lands from aerial photography, the most significant calculation errors and inaccurate assumptions exist in the parameters used to estimate agricultural use based on soil moisture content, crop rooting depth, local rainfall and evaporation, and the efficiency of any given farmer's irrigation system.

In brief, the most significant potential errors in the method used by the BMC for calculating water usage for irrigated crops are as follows:

1. The BMC used an unreasonably high irrigation efficiency number of 92%. Although, an extremely efficient and properly maintained drip irrigation system might approach a 92% efficiency, typically sprinkler irrigation systems tend to have low efficiencies ranging between 50% to 70%, while drip irrigation sysems have less losses with efficiencies ranging between 70% and 90%.

In estimating water usage for unmetered irrigation systems the U.S. Department of Energy suggests the following efficiency coefficients (source: US Dept of Energy, *Guide for Estimating Unmetered Landscaping*, 2010):

- Low Efficiency: 50%: sprinkler type systems that are aging with poor maintenance and lack of proper scheduling
- Medium Efficiency: 65%: sprinkler type systems that have regular maintenance and proper scheduling
- High Efficiency: 85%: micro irrigation systems that have regular maintenance and proper scheduling.

2. The calculation assumes that every farmer uses an evapotranspiration model in their irrigation decision process. This is an extremely idealized view of farming practices. While some farmers may use an ET model to assist in their irrigation schedule, most farmers irrigate on a typical schedule which most likely uses more water than typical ET model estimations.

3. The calculation does not consider other onsite farm water usage including, but not limited to: plant wash down, production processing facilities, frost protection sprinkler systems, and pesticide and herbicide delivery systems. These processes can use significant amounts of water.

While it is understood that agricultural wells are privately owned and often not metered so that exact water usage is not available and educated guestimates must be calculated, it is also imperative that calculated estimates take a prudent and conservative approach to estimating water use.

For example, to compensate for the uncertainties of the parameters used in the agricultural ET model and use a conservative low efficiency coefficient of 50% (instead of the 92% currently being used), then agricultural water production for 2020 is 1,198 AFY (as opposed to the BMC calculated 650 AFY).

It is interesting to note, that by applying an efficiency coefficient of 50%, the approximated agricultural water use is closer to the historical estimates published by others for the Basin:

Dept of Water Resources (1973)	**1,100 AFY**
Brown & Caldwell (1983)	**1,070 AFY**
this paper (2020) @ 50% irrigation efficiency	**1,198 AFY**
CHA (2020) @ 92% irrigation efficiency	**650 AFY**

The Basin Plan (pages 110-114) describes the range of uncertainties for the model calculations noting that the two most significant factors contributing to uncertainty are (1) the physical characteristics of and hydrogeologic relationships with the Basin, and (2) the assumptions regarding the estimated levels of pumping by private domestic and agricultural water users.

The Basin Plan (page 113) goes on to state that, "depending on the severity of any inaccuracies regarding the underlying assumptions or unexpected conditions, the impact on future Basin management could range from minimal to significant."

It would now appear that non-purveyor pumping rates may be significantly underestimated, particularly given the downward guestimate calculated for agricultural production based on evaporation and soil moisture modeling and the impacts on the Basin management are likely significant.

Therefore, the BMC should consider, <u>at a minimum</u>, resetting the agricultural use back to 800 AFY, until such time that actually water usage can be obtained from the agricultural community.

By using the originally agreed upon Maximum Sustainable Yield of 2,450 AFY and the original calculated agricultural water use of 800 AFY, then as the table below shows, **the BMC has never met the 80% goal for the Basin Yield Metric.**

Year	Reported Water Use/SY	Reported Basin Yield Metric (Goal = 80%)	Recalculated Water Use/SY	Recalcuated Basin Yield Metric (Goal = 80%)
2015	$\frac{2{,}170}{2{,}450}$	89%	$\frac{2{,}170}{2{,}450}$	89%
2016	$\frac{2{,}160}{2{,}760}$	78%	$\frac{2{,}160}{2{,}450}$	88%
2017	$\frac{2{,}070}{2{,}760}$	75%	$\frac{2{,}200}{2{,}450}$	90%
2018	$\frac{2{,}030}{2{,}760}$	74%	$\frac{2{,}160}{2{,}450}$	88%
2019	$\frac{1{,}900}{2{,}760}$	69%	$\frac{2{,}070}{2{,}450}$	85%
2020	$\frac{2{,}010}{2{,}760}$	73%	$\frac{2{,}160}{2{,}450}$	88%

II. Chloride Metric

Recommendation: Chloride readings should be combined with existing Conductance and Total Dissolved Solids readings to create a clearer understanding of the overall salinity and degradation of the basin.

Discussion

The BMC has defined the Chloride Metric as the weighted average concentration of chlorides in four key wells (LA8, LA10, LA11, and LA12), where the concentration of well LA10 is given twice the weight of the other three wells in order to increase the sensitivity of the metric to various management actions.

Chloride is the major anion of seawater, and it moves through aquifers at nearly the same rate as the intruding water. Thus, it is recognized that increasing chloride concentrations are typically the first indication of the approach of a seawater contamination front. In an area where no other source of saline contamination exists, high chloride concentrations in groundwater can be considered definite proof of seawater contamination and an appropriate measurement.

However, other water quality measurements can also provide indications of increasing salinity and should also be used in describing conditions in the Basin. Specifically, electrical conductivity (measured as Conductance umhos/cm) is a strong indicator of salinity, and total dissolved solids (TDS) is also a common salinity parameter, particularly for groundwater quality measurements (source: *Chloride, Salinity and Dissolved Solids*, USGS Science Center, 2020).

The BMC acknowledges that the Chloride Metric is a simplification of basin conditions that will vary significantly from year to year due to localized chloride fluctuations.

However, the BMC has not considered the continuing increase in Conductance and TDS over time in the four key wells. <u>The current and historic water quality data show a slow and steady increase in salinity in all four key wells</u>. Again, a cautious level of concern should be adopted by the BMC with a reasoned approach to decision-making that is based on the quantitative water quality data available to date in order to avoid a threat that is serious and plausible.

Conclusions:

1. The Los Osos Groundwater Basin continues to degrade with seawater intrusion advancing.

2. The BMC is not meeting its Basin Yield Metric goal of 80% based on its initially agreed upon production and sustainable yield calculations outlined in the Basin Plan and the Stipulated Judgement. Therefore, the BMC should consider resetting the Maximum Sustainable Yield to 2,450 AFY and resetting the Agricultural Water Usage to 800 AFY.

3. The BMC is not meeting its Chloride Metric. Chloride levels are rising in key wells and overall salinity is increasing as evidenced by the increases in conductance and total dissolved solids.

4. It is clear that established metrics are not being met and, under current conditions, may never be met. Therefore, it would be prudent policy to minimize any new additional water usage in the basin until the BMC has adequately shown that agreed upon metrics and goals are being met.