Developing a Water Supply Optimization Strategy

for the Santa Ynez River Water Conservation District, Improvement District No. 1

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Project Significance

Water managers in California will face many potential supply challenges in the coming years. Future threats to water supplies in the state are becoming a concern due to a higher likelihood of intense drought periods and increased strain on available water resources due to growing population. Additionally, global climate change may cause the seasonality of precipitation to shift, meaning that less water is stored in the Northern California snowpack for use later in the year. One particular change that can be expected to impact water supplies in the immediate future is impending new regulation of hexavalent chromium (Cr(VI)).

Chromium is a transition metal element derived from both natural and anthropogenic sources that is present in municipal drinking water at different concentrations throughout California. In 2011, the State of California Office of Environmental Health Hazard Assessment set a new public health goal (PHG) for concentrations of hexavalent chromium in drinking water of 0.02 parts per billion (ppb).

Key Regulatory Terms:

A **Public Health Goal (PHG)** represents the concentration of a substance that will pose "no significant health risks" if consumed at that level for the entirety of a human life. Though a PHG is determined by regulatory bodies, there are no laws requiring drinking water to meet this standard.

A **Maximum Contaminant Level (MCL)** is an enforceable regulatory standard based off of the PHG. Unlike a PHG, an MCL takes the economic cost of treating water into account, often resulting in a higher value. The goal of an MCL is to be as close to the PHG as possible without putting undue financial strain on water delivery agencies.

Chromium, which has two preferred oxidation states, – hexavalent and trivalent – is already federally regulated in drinking water as total chromium. Increased attention from the scientific community and the media on the health risks specifically associated with Cr(VI) has led to the formation of the new PHG. In response to this PHG, the California Department of Public Health is expected to announce a draft Maximum Contaminant Level (MCL) for Cr(VI) in July 2013. The proposed standard will potentially have financial and strategic impacts on water purveyors throughout the state – particularly small districts.

One such district is the Santa Ynez River Water Conservation District, Improvement District No. 1, (ID1 or "the District") located in Santa Barbara County, California, which has recently tested positive for trace levels of naturally occurring hexavalent chromium in one of its water sources.

Objectives

Based on this information, we developed the following project objectives:

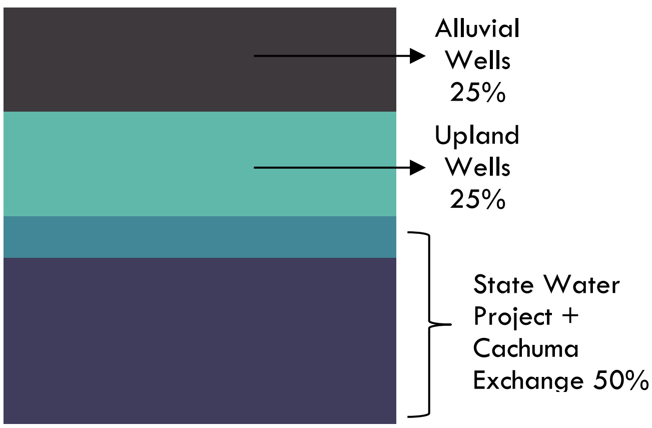
To develop an updated and viable water supply optimization plan for Santa Ynez River Water Conservation District, Improvement District No. 1 (or ID1) recommending strategies for long-term management that protect the future stability of ID1 water supplies by:

- Constructing a model that determines system reliability as a function of water sources and water demand,
- Assessing how various scenarios affect system reliability and resilience,
- Analyzing the cost and feasibility of Cr(VI) treatment for ID1 wells, and
- Reviewing alternatives to Cr(VI) treatment.

District Overview

To accomplish these objectives, we began by gathering data based on current supply and demand conditions within ID1.

The District is unique in that it has four sources of water, which provide some flexibility in the supply. Alluvial and upland wells draw water from sources within District boundaries while water obtained from the California State Water Project (SWP) is brought to the District from a long distance transfer pipeline. Cachuma Project water is traded to another local water district in exchange for an equivalent amount of SWP water. The amount of water available to ID1from the SWP varies annually based on climate conditions in Northern California. The amount that each of these sources contributes to total supply is shown in the graphic below.



The only source that currently contains trace amounts of chromium is the upland wells, though all measured concentrations are below the current total chromium MCL.

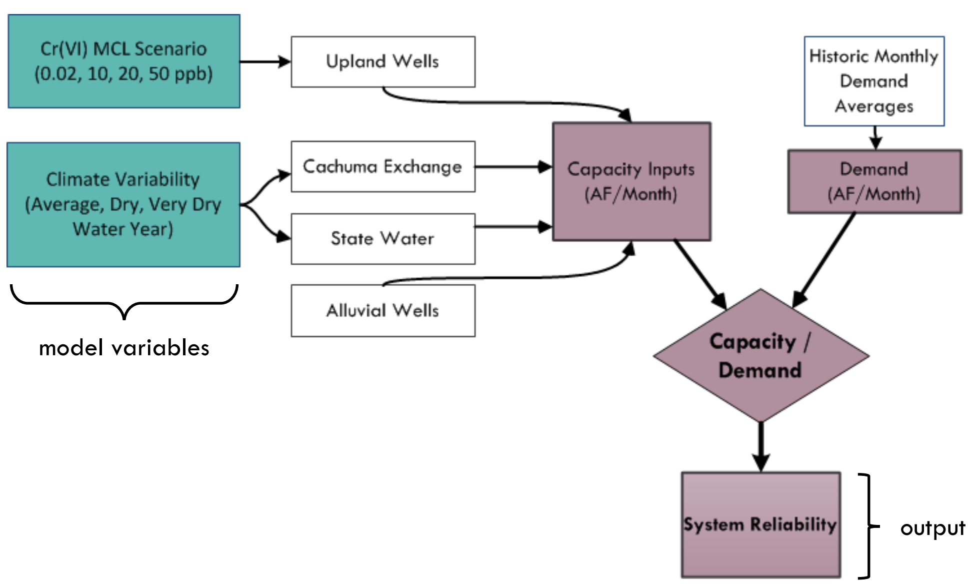
Demand for water in ID1 is split evenly between residential and agricultural users, and is higher in the summer months. Data from the period January 1998 – September 2012 was used to calculate the mean monthly demand which was used in this project.

Using this information, we developed a model to determine the impact that changing water availability would have on the District due to either a more restrictive MCL or different amounts of available SWP water. To compare between these different scenarios, we used system reliability as a metric.

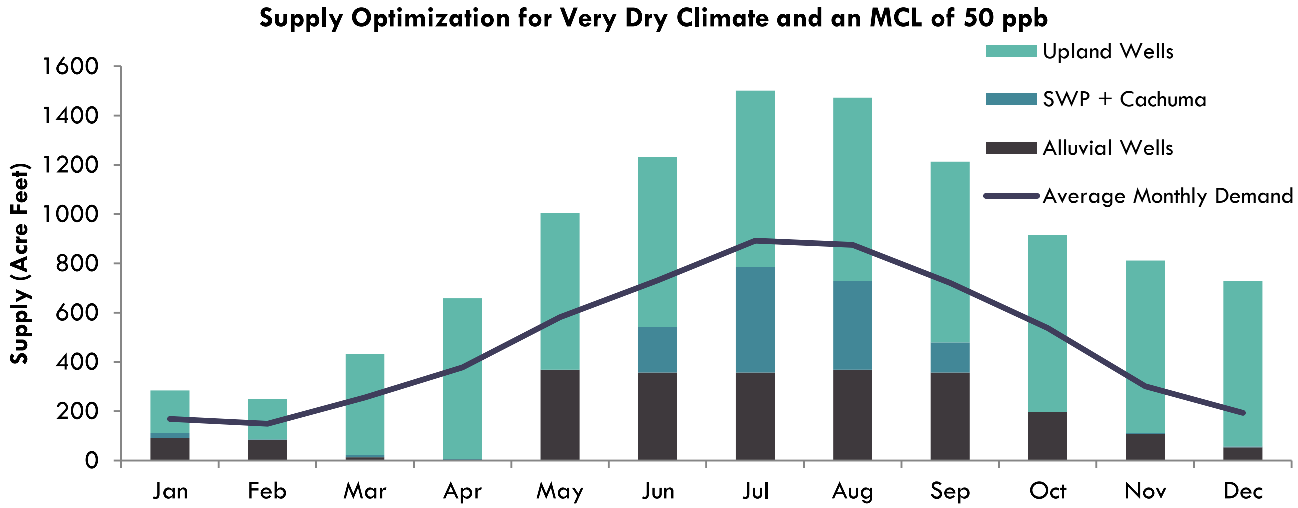
System reliability is defined as the ratio of supply capacity, the total amount of water available to the District, to demand. A reliability of 1 indicates the point at which supply is exactly equal to projected demand though in ID1's case, this does not represent ideal conditions because it leaves no flexibility to adapt to future sudden changes in the system. Because of this, reliability numbers used in this project are frequently greater than 1. We established baseline reliability by determining what the reliability in each climate condition was at the current MCL of 50 ppb.

Conceptual Model

We combined the parameters described above and created the conceptual model shown below:



Methods and Results



Sample model output for monthly optimization of water supply sources. The solid line represents average monthly demand. In this scenario, capacity is greater than demand for all months representing a reliability value greater than 1.

We used our model to develop a set of baseline scenarios representing the expected water available under each potential MCL and each climate condition. Out of these scenarios, the minimum monthly reliability in a very dry year at the current MCL of 50 ppb was chosen to represent the minimum acceptable reliability threshold to ID1. To date, District managers have not implemented operational changes, suggesting this level achieves an acceptable margin of safety above anticipated demand.

For any baseline scenario that did not meet this reliability threshold, we decided to apply different management options to raise reliability. While it is hard to compensate for the amount of SWP water that is lost in a dry year, water that cannot be used because it violates the expected MCL could be treated and brought back into the system. Treating chromium, however, is an extensive operation that would require installation of new infrastructure at high capital costs.

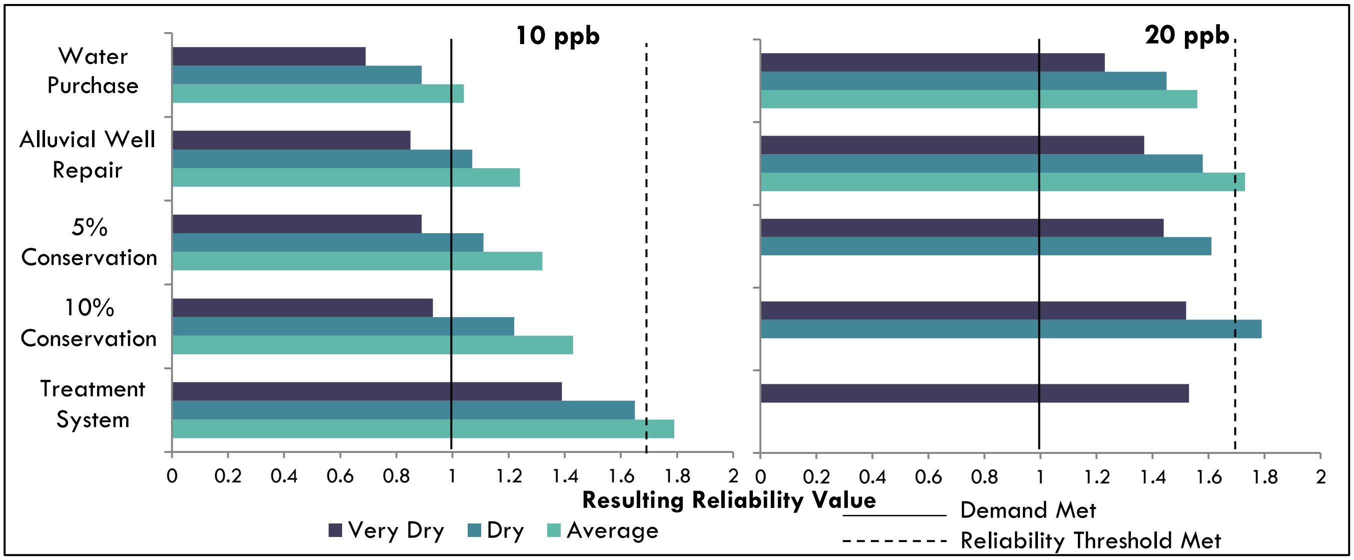
With this in mind, we first considered using other non-treatment options meant to increase reliability including purchasing water and repairing broken alluvial wells. We also examined the effect of increasing participation in existing water conservation programs which would amount to first a 5%, and then a 10% reduction in demand. These options were applied in a cumulative manner and their effect was assessed to determine what conditions would most likely result in the need to invest in a treatment system.

Common Chromium Treatment Options:

Strong Base Anion Exchange (SBA) and **Weak Base Anion Exchange (WBA)** systems remediate chromium by passing the water through an ion exchange resin. This resin preferentially bonds the chromium over other ions in solution. SBA and WBA also differ in the amount of water they can treat before system maintenance is required, the amount of pretreatment that is required, and how they are affected by other water quality parameters.

Reduction Coagulation Filtration (RCF) systems (pictured below) use chemical treatment to reduce Cr(VI) to Cr(III). This reduction causes the compound to precipitate out of solution making it easier to filter and remove. The chemical characteristics of ID1's water make RCF the best treatment option.

Results Continued



Our results for two potential MCLs under each climate condition are shown above. As soon as a scenario reached our predetermined reliability threshold (dashed line), no additional management actions were applied. While not every scenario was able to meet the threshold, reliability did increase by applying our management actions. Importantly, while some scenarios were initially unable to achieve even a reliability of 1 (solid line), by the end all scenarios were able to supply a buffer over average demand.

After we examined our results, we recognized some additional benefits of treating Cr(VI) that were not captured when using reliability as the sole metric for determining the viability of a system. District managers should not be satisfied with their supply portfolio based solely on the fact that it achieves a high level of system reliability. The best supply systems will also be able to withstand sudden threats and quickly recover from system upsets. This idea represents what we define as system resilience, the second factor captured by our optimization model.

Applying our management options through Cr(VI) treatment increases system resilience by diversifying the supply sources that ID1 can use at any one time. In this particular case, the upland wells can act as a buffer if one of the other sources becomes unavailable. In general, a system that is not only reliable, but also resilient, is better at responding to supply challenges, such as impending Cr(VI) regulations.

Final Recommendations

Based on our findings, we suggest that both ID1 and other small water districts facing supply constraints due to upcoming regulations consider the following recommendations:

- Incorporate use of a water supply optimization model such as the one we developed, when planning, to help expose system weaknesses before they become a problem.
- Take care to consider the implications of management actions on both reliability and resiliency.
- Note that adaptation to new regulations may best be met by addressing changes in demand rather than just supply.

Acknowledgements

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