Developing a water supply optimization strategy for the Santa Ynez River Water Conservation District, Improvement District No. 1

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Project Motivation

Hexavalent chromium (Cr(VI)) is a carcinogenic contaminant that can be found in drinking water sources worldwide, occurring from both natural and anthropogenic sources. In California, a maximum contaminant level (MCL) currently exists for total chromium (Cr(III) + Cr(VI)), and the California Department of Public Health is expected to announce a draft 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, located in Santa Barbara County, California, which has recently tested positive for trace levels of hexavalent chromium in one of its four drinking water sources.

Objective

Given the high cost of Cr(VI) treatment, this project seeks to develop an updated and viable ***Water Supply Optimization Plan*** for the Santa Ynez River Water Conservation District, Improvement District No. 1 recommending strategies for long-term management that protect the ***future stability*** of ID1 water supplies.

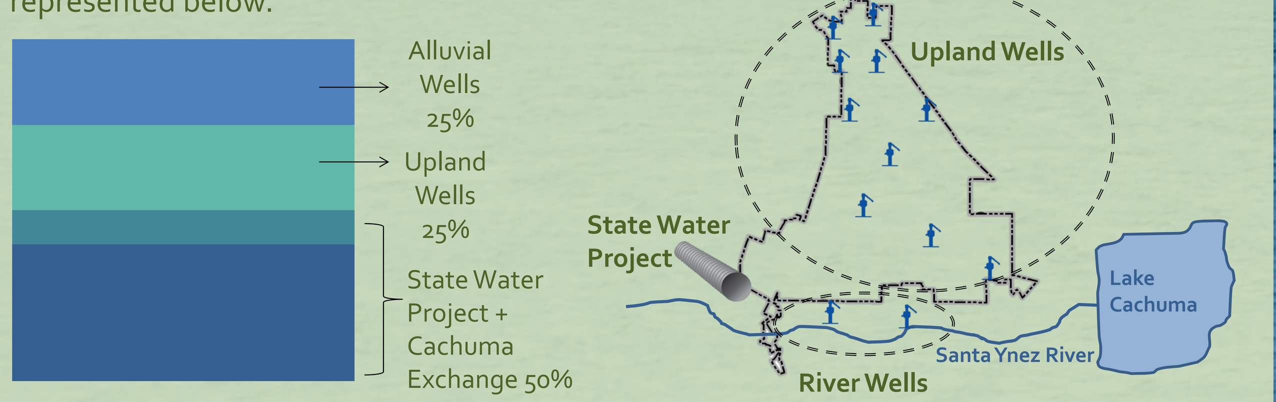
Key Regulatory Terms

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.

District Overview

The Santa Ynez River Water Conservation District, Improvement District No. 1 is located in central Santa Barbara County, California. The District's unique water supply portfolio includes four distinct sources of water, which allows for flexibility in supply. Alluvial and upland wells draw from local sources. Cachuma water is exchanged for an equal amount of water from the State Water Project, which relies on imported water from Northern California. The relative contribution and the geographic distribution of each source are represented below.



How will impending hexavalent chromium legislation affect a local water supplier?

Water Supply Optimization Model

Based on the unique characteristics of the District, 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 water available from the State Water Project. 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.

Scenario Inputs

MCL

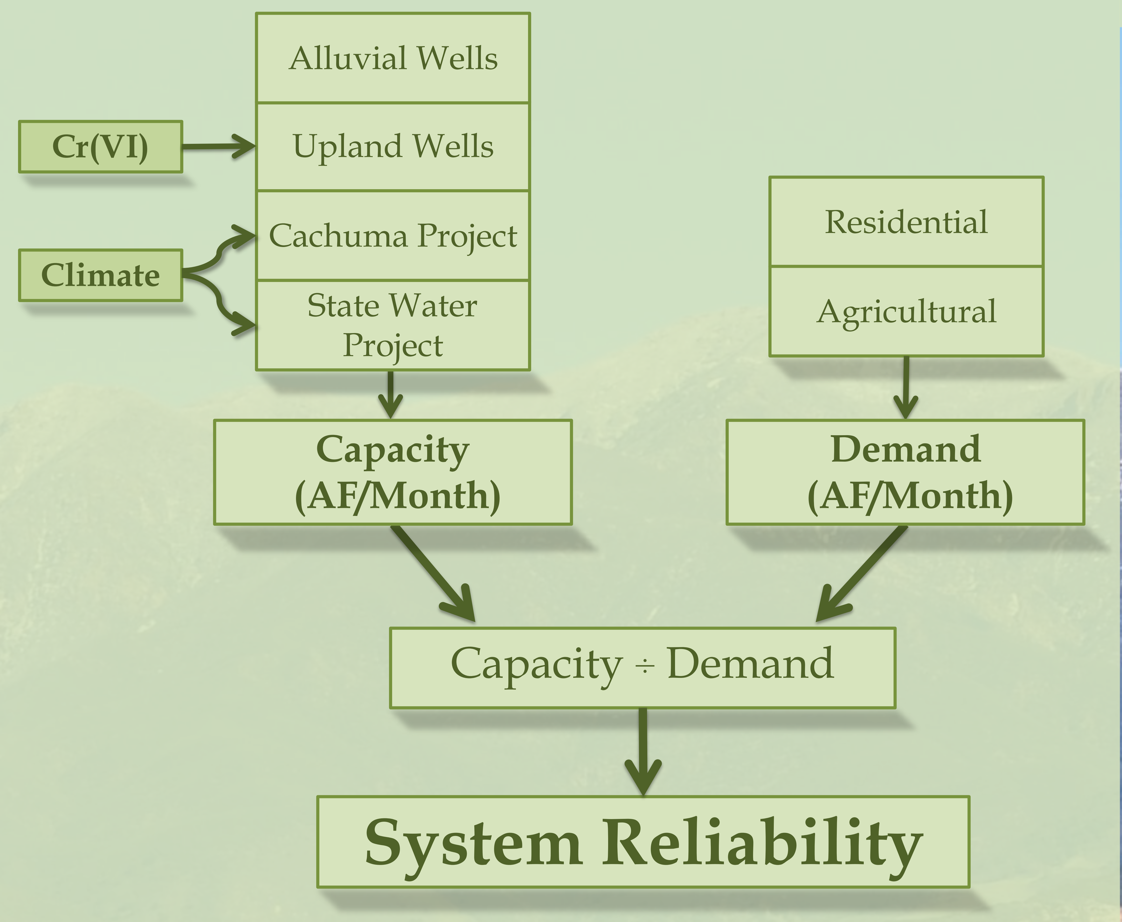
Cr(VI) is currently only affecting the upland wells. We chose four hypothetical Cr(VI) MCLs, ranging from the PHG to the current *total* chromium MCL.

0.02 – 10 – 20 – 50 ppb

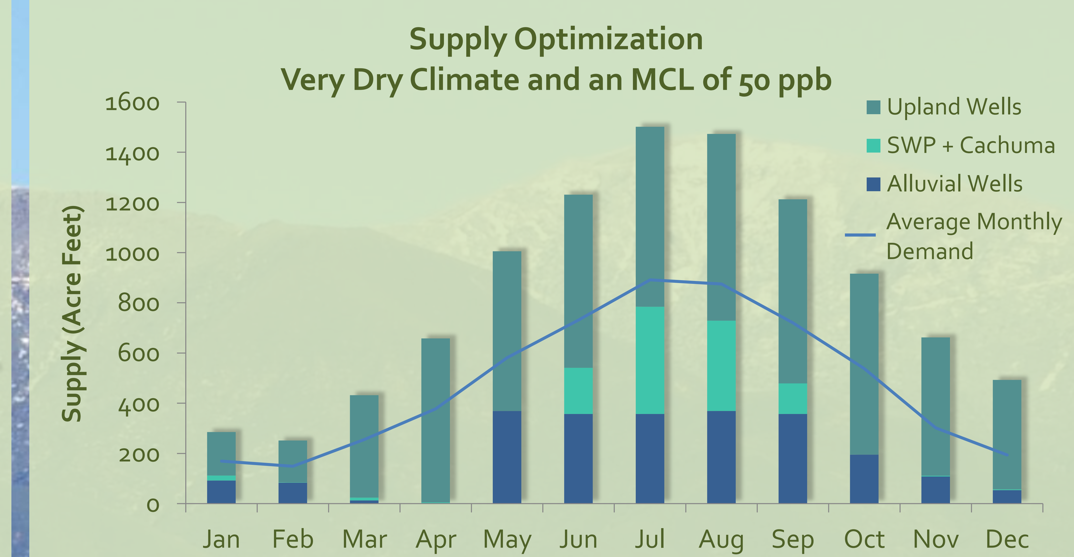
Climate

We chose four climate conditions to serve as a proxy for State Water Project availability.

Wet – Average – Dry – Very Dry



Results

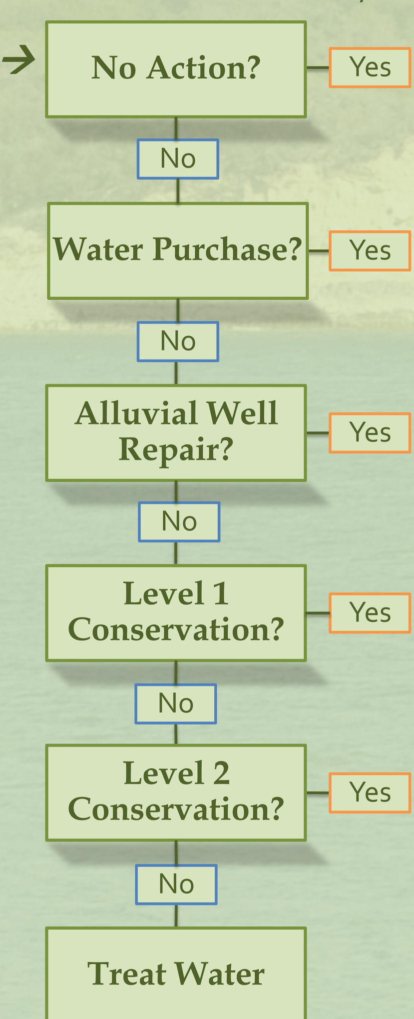


Current operating conditions indicate that supply greatly exceeds demand, resulting in a desirable threshold level of reliability. A level of reliability greater than 1 allows for a margin of safety against water delivery system upsets.

Options to Increase Reliability

Among the various climate and hypothetical Cr(VI) MCL scenarios, we chose the minimum monthly reliability of a very dry year under the current total chromium MCL (50 ppb) as the baseline threshold. For each scenario that did not meet this reliability threshold, we applied various management options in a cumulative and stepwise manner beginning with the most feasible and relatively economical short-term solution and ending with the most cost-intensive long-term solution. With the high cost of Cr(VI) treatment in mind, we assessed the effect of each option to determine what conditions would most likely result in the need to invest in a treatment system. As soon as a scenario reached our predetermined reliability threshold, no additional management actions were applied.

Is threshold reliability met through →



Water Purchase

Unused water that is held in State Water Project storage facilities is available for purchase, the availability of which is highly dependent on climate conditions and seasonal variability.

Well Repair

Repairing a broken pipeline would bring a currently inoperable alluvial well field back online; however, this option is limited by river conditions and environmental regulations.

Conservation

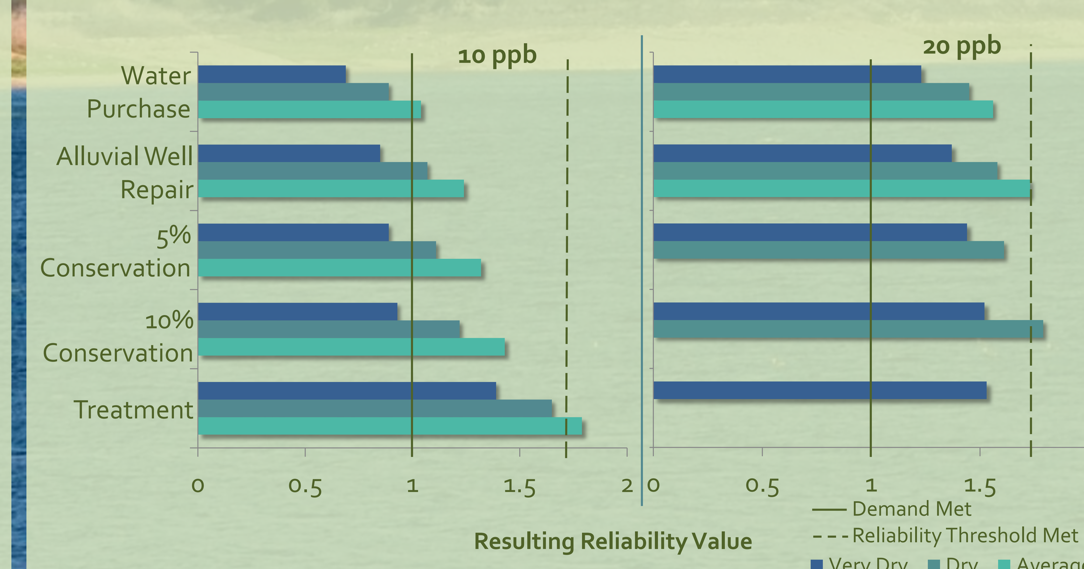
Increasing participation in existing water conservation programs – like installing low-flow fixtures and converting to native landscape – would reduce demand, alleviating pressure on existing water sources.

Common Cr(VI) Treatment Options

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

Reduction Coagulation Filtration systems 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



Our results for two potential MCLs under each climate condition are shown above. While not every scenario was able to meet the threshold (dashed line), 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.

Discussion

After examining 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 the 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***, or the system's ability to respond to outside disturbances.

Applying all of our management options, including 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 future supply challenges, including:

- Changes in water quality regulations
- Natural disasters
- Population and land use changes
- Climate change

Recommendations

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

- Incorporate use of a ***Water Supply Optimization Model*** such as the one we developed in planning, which can 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.

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