Locating Domestic Well Communities in California:

A Methodological Overview

Domestic Well Layer (version 1.0)

Water Equity Science Shop

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Introduction

An estimated 1.5-2.5 million Californians rely on unregulated drinking water sources,[2,3] including domestic wells and water systems with fewer than 5 service connections. These may be some of the most vulnerable communities, as they rely on and draw from aquifers that are often contaminated with nitrates, arsenic, and other agricultural and industrial groundwater contaminants.[3]

Universal access to clean, affordable drinking water is legally recognized by California's Human Right to Water law (Assembly Bill 685).[1] Yet a lack of information on the exact location of domestic well communities is a major hurdle to knowing if these communities are achieving this right, as this data gap represents a significant barrier to linking water quality data to the actual location of domestic well communities. Additionally, recent state legislative efforts, such as the State Water Board's Needs Assessment (SB 862)[2] and the Safe and Affordable Drinking Water Fund (SB 200),[3] further underscore the importance of having information on the location of domestic well communities.

The Water Equity Science Shop (WESS) is a community-academic partnership that conducts research to address health risks associated with drinking water contamination among California residents. The WESS's community collaborator, the Community Water Center, has led multi-stakeholder engagement efforts to inform the development of a spatial tool to locate domestic well communities and to integrate this information with data on estimated water quality in these communities.

This document describes the first part of this WESS domestic well layer project—the approach taken to locate domestic well communities throughout California.

Methods overview

To locate domestic well communities, we began with the Bureau of Land Management (BLM) Public Land Survey System (PLSS) section grid as the geographic unit of analysis. The PLSS section grid provides the finest geographic resolution at which reliable information on the location of domestic wells are available.[4] PLSS sections are approximately 1x1 mile areas that encompass the entire State of California. We then combined three data sources to spatially locate likely and potential domestic well areas throughout the state: 1) domestic well locations, 2) census block-level population estimates, and 3) community water system locations.

Data sources and processing

Domestic well locations were obtained from the Department of Water Resource's Online System for Well Completion Reports (OSWCR),[5] which contains records for over 900,000 wells drilled in California since 1927. We downloaded OSWCR data in October 2018. The majority of wells were registered to the center of 1x1 mile PLSS sections.[4] Well reports include information on the location, drill date, depth, and intended use of the well. We included only unique well completion reports for domestic wells. If the well location (latitude or longitude) was missing, we estimated it as the centroid of the PLSS section.

Population and housing unit data were downloaded for census blocks from the 2010 United States Census[6] and distributed to PLSS sections by aerial apportionment. This method evenly distributes the population in the census block to the PLSS sections that intersect with the census block geography, based on the overlapping area between the section and the census block. We used census block data to identify those PLSS sections where there were no people living, in order to exclude such sections from our analysis.

Parcel data, provided by the California Air Resources Board in February 2019, were derived from a proprietary dataset called Land Vision, which is maintained and updated quarterly by Digital Map Products.[7] This dataset contains all parcels in California, classified by type of use. We selected 31 unique residential use types from 278 total land use classifications. We used this data to refine our identification of populated PLSS sections from the census block data.

Community water system (CWS) service area boundaries were obtained from Tracking California's Drinking Water Systems Geographic Reporting Tool, also known as the Water Boundary Tool.[8] We selected those CWSs that were classified as active,[9] current, and complete[8] in the Water Boundary Tool as of October 5th, 2018. We cleaned the boundary data by removing systems with duplicate geographies, reconciling overlapping system boundaries, and removing wholesale systems.[10] Wholesale systems were not used because they treat water for delivery to retail systems but do not sell directly to customers. The CWS dataset was used to differentiate areas served by CWS from those areas not served by CWS and therefore likely served by domestic wells.

Analytical approach

To identify domestic well areas (DWA), we first removed CWS service area polygons from the PLSS section grid to reveal those sections and portions of sections not served by a CWS and therefore likely served by domestic wells. We assigned domestic wells to PLSS sections based on OSWCR data and cleaned the DWA boundaries by dissolving slivers in the domestic well layer into adjoining CWS polygons. Slivers were defined as PLSS sections with an area < 10% of the total area of the section (< 2,600 meters^2).

Population and housing unit counts from 2010 census data at the level of census blocks[6] were then joined to PLSS sections using aerial apportionment. Any sections with an estimated population of zero were excluded from further analysis. As census blocks in rural areas are very large relative to PLSS sections, aerial apportionment alone would assign their populations evenly across a large land area and multiple sections, when those populations are often clustered in specific portions of census blocks that correspond to only one or a few sections, surrounded by agricultural land, roads, and other areas without houses. To address this, we used parcel data to further refine our population estimates for PLSS sections by intersecting residential parcels with DWA polygons. The parcel data allowed us to avoid population underestimates in sections containing residential parcels and to identify and exclude those

PLSS sections that did not contain any residential parcels from our analysis. Those sections with no residential parcels were removed.

In sum, we defined **likely DWA** as PLSS sections that met all the following criteria**:** 1) not within the service boundary of a CWS; 2) estimated population ≥1; 3) contains at least one domestic well; 4) intersects with at least one residential parcel. We defined **potential DWA** as PLSS sections that met criteria 1 and 2 but failed to meet either criteria 3 or criteria 4. Thus excluded PLSS sections show no evidence of a domestic well, are most likely unpopulated (e.g. no residential parcels or have very small population estimates (<1 person in the PLSS section)).

Figure 1: Summary of data sources and methods used to define boundaries of CA domestic well communities

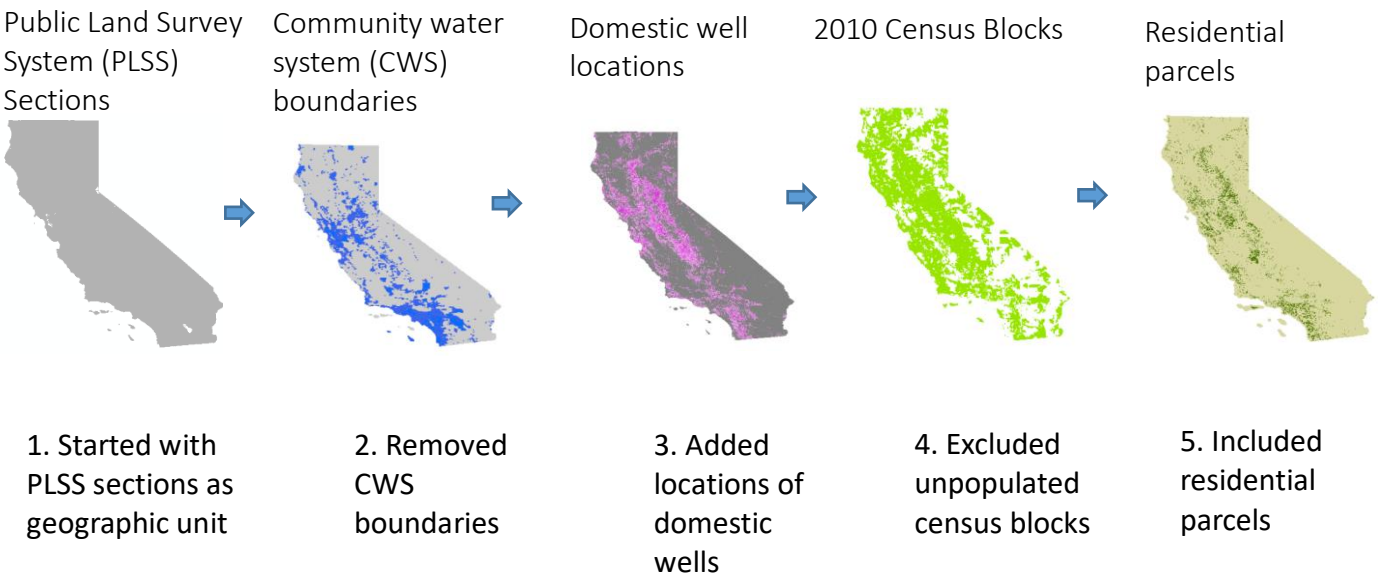
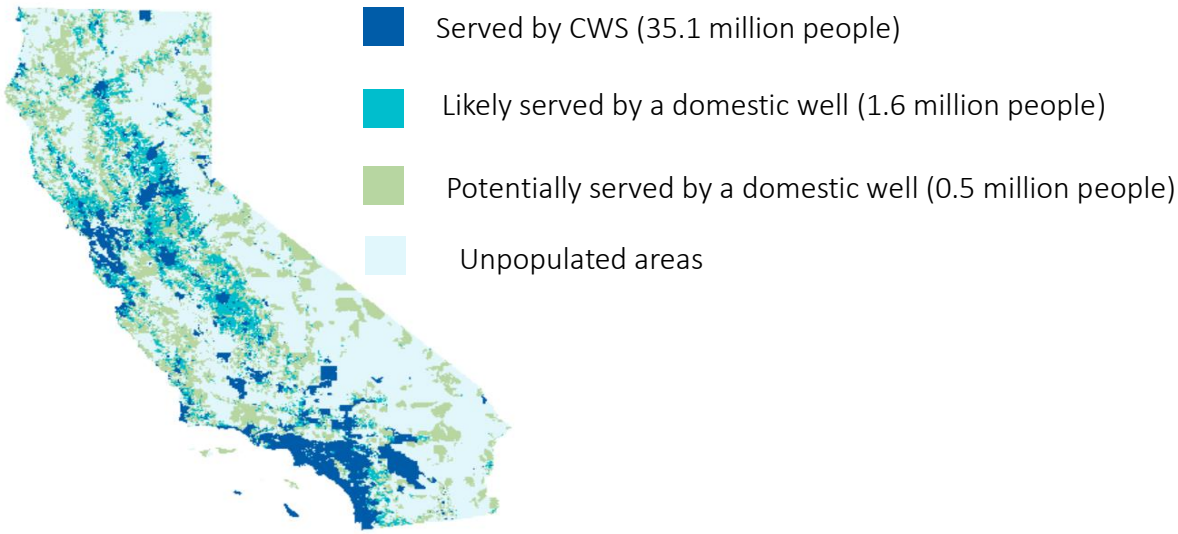


Figure 2: Water source types and estimated population served in CA



Results

We estimate that 1.6 million Californians live in areas served by a domestic well (i.e., a likely DWA). An additional 0.5 million people live in a potential DWA and could be served by a domestic well, surface water source, or community water system not yet mapped in the Tracking California's Drinking Water Systems Geographic Reporting Tool. Regionally, the San Joaquin Valley has the largest total population reliant on domestic wells, with an estimated 527,570 people living in DWA. However, as a fraction of the population in each region, the Eastern Sierra and Northern CA have a larger proportion of their respective regional populations relying on domestic wells, (37.8% and 28.4%, respectively).

Figure 3: Regional estimates of population relying on domestic wells in CA

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Region	Estimated domestic well population	% of regional population using a domestic well
1. San Joaquin	527,570	13.3
2. Northern CA	298,707	28.4
3. Southern CA	210,223	1.2
4. SF Bay Area	183,983	2.5
5. Northern Sierra	167,641	7.2
6. Central Coast	111,908	7.8
7. Eastern Sierra	72,342	37.8
8. Imperial	57,564	1.3

Limitations

Our approach to locating DWA and estimating the number people who rely on domestic wells in CA uses the best available data, yet each data source has limitations. Our community water system boundaries rely on what is available in the Water Boundary Tool. Currently no statewide database exists for state small water systems (serving fewer than 15 connections), so "state smalls" are not represented in this version of the domestic well layer. Therefore, it is likely that some locations classified as DWA may in fact include state small systems. Known issues with the OSWCR data include missing and duplicate values for domestic well locations, some misclassification of well type, and a lack of information on whether or not a domestic well is currently in use. As a result of OSWCR data limitations, our layer may include inactive or duplicate wells which could overestimate the likelihood that an area is served by a domestic

well. Nevertheless, we have sought to minimize this possibility by incorporating parcel and population data to refine how we identified domestic well areas. Our population estimates stem from census block geography. Census blocks in rural areas are large and our method of aerial apportionment from census blocks to PLSS section geography assumes that people are evenly distributed throughout the census block, which can result in low population estimates in PLSS sections in rural areas. We attempted to decrease uncertainty in our estimates of where domestic wells are used by excluding PLSS sections in which the population is < 1 person and by including parcel data to further refine the geography in which we believe people actually live.

Discussion, applications and next steps

Our estimate that 1.6 -2.1 million CA residents rely on a domestic well aligns with estimates published by the USGS.[11] The USGS estimates that in 2010, 2.5 million people in California were "self-supplied", meaning that they relied on a private well or water captured as rainwater in a cistern. The USGS estimate was calculated as the number of people not served by a public water system. Our method is novel in that it further divides the "self-supplied" population into two categories based on our level of certainty that they actually use a domestic well (i.e., likely DWA versus potential DWA).

The DWA geography described here is publically available and intended to assist statewide efforts toward achieving the Human Right to Water. This data layer is currently being used in the Community Water Center's Drinking Water Tool, an online resource funded by the Department of Water Resources that shares information about ways that communities across CA might be vulnerable to groundwater challenges that impact their access to long-term safe and affordable drinking water. Our domestic well area layer is also being used by the Department of Water Resources in their County Drought Advisory Plan (AB 1168 / SB 600) and by the State Water Board's Needs Assessment (SB 200 / SB 682). Our data can also assist groundwater sustainability agencies in developing groundwater sustainability plans under the Sustainable Groundwater Management Act (AB 1739 / SB 1168 / SB 1319).[12–14]

The next step in this project is to assess water quality risks for populations reliant on domestic wells (forthcoming white paper). We are also refining the geography of our domestic well layer by relying more extensively on the parcel data in order to locate populations using domestic wells more accurately.

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