Small Water Systems and Rural Communities Drought and Water Shortage Contingency Planning and Risk Assessment

Part 2 – Drought and Water Shortage

Vulnerability Assessment and Risk Scoring

REPORT PURSUANT TO
SECTION 10609.42 OF THE CALIFORNIA WATER CODE
March 2021

California Department of Water Resources
Water Use Efficiency Branch

Notes: This report developed pursuant to Section 10609.42 of the California Water Code was informed by documents that provide methodology, assumptions, data, estimates, and other information. These supporting documents are provided as appendices in the back of this report. Definitions and key concepts used in this report are listed in the Glossary on page 22.

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Abbreviations and Acronyms

AB	Assembly Bill
CAL OES	California Office of Emergency Services
CDAG	County Drought Advisory Group
CDFA	California Department of Food and Agriculture
CEC	California Energy Commission
CPUC	California Public Utilities Commission
CWC	California Water Code
DWR	California Department of Water Resources
GSA	Groundwater Sustainability Agency
HSC	California Health and Safety Code
IHS	Indian Health Services
OEHHA	Office of Environmental Health Hazard Assessment
OPR	Governor's Office of Planning and Research
SB	Senate Bill
State Water Board	State Water Resources Control Board
WSCP	Water Shortage Contingency Plan

Executive Summary

This report is submitted pursuant to California Water Code (CWC) Section 10609.42 which directs California Department of Water Resources (DWR) to identify small water suppliers and rural communities that may be at risk of drought and water shortage vulnerability and propose recommendations and information in support of improving the drought preparedness of small water suppliers and rural communities. The report is published in two parts: Part I dealing with drought and water shortage contingency planning recommendations, and Part II presenting a methodology and results of drought and water shortage vulnerability assessment and risk scoring.

Specifically, Section 10609.42 requires:

1. DWR, in consultation with the State Water Resources Control Board (State Water Board) and other relevant State and local agencies and stakeholders, identify small water suppliers and areas of households on private supplies (termed "rural communities" in the legislation, and also called "self-supplied communities in this report") that may be at risk of drought and water shortage. DWR must then notify counties and groundwater sustainability agencies (GSA) of suppliers or communities that may be at risk within its jurisdiction and may make the information publicly accessible on the website (CWC Section 10609.42[a]).

2. DWR, in consultation with the State Water Board and stakeholders, develop recommendations and guidance relating to the development and implementation of countywide drought and water shortage contingency plans to address the planning needs of small water suppliers and rural communities. The legislation directs DWR to explain how the planning needs of small water suppliers and rural communities can be integrated into complementary existing planning processes (CWC Section 10609.42[b]).

To assess drought and water shortage vulnerability, a methodology for analyzing risk was developed and small water suppliers and self-supplied communities statewide were evaluated for their relative risk of drought and water shortage. Each supplier and community examined received a numeric risk score, which is derived from a set of indicators developed from extensive input during the stakeholder process. Indicators used to estimate

risk are represented within three groupings or key components: (1) the exposure of suppliers and communities to hazardous conditions and events, (2) the physical and social vulnerability of suppliers and communities to the exposure, and (3) recent history of shortage and drought impacts. The risk scores for individual small water suppliers and self-supplied communities were calculated separately, using the same methodological approach but different risk indicators and equations. The calculated risk score must not be perceived as a performance grade, as it merely represents a measure of the level of risk a supplier or a community is exposed to combined with attributes of the supplier's organization and infrastructure.

Importantly, the methodology used for analyzing risk, and this report as well, do not define thresholds whereby certain small water suppliers and self-supplied communities are considered "at risk" of drought and water shortage and others are not. Instead, the methodology inherently recognizes that all communities in California face some risk of drought and water shortage and thus provides a tool to calculate the relative risk of these suppliers and communities. Future thresholds may be defined and utilized to determine which suppliers and communities are particularly at risk of drought and water shortage; but for now, DWR believes the State is best served by understanding the relative risk of its small water suppliers and self-supplied communities and, perhaps more importantly, having a common methodology for calculating risk that can be applied at different levels of government and in different contexts.

In total, 2,419 small water suppliers were examined for their relative risk of drought and water shortage. The results show that a vast majority of the State's counties (47 of the 58 counties) have small water suppliers in the top 10 percent of risk scores (240 suppliers). As indicated above, the 10% cut-off is not intended to be viewed as a threshold whereby small water suppliers scoring in the top 10% are considered at risk of drought and water shortage and those outside the top 10% are not at risk. Instead, the 10% cut off is useful for summarizing results and providing an example of how the scoring methodology can be used. The primary benefit of this scoring exercise is to offer local and regionally specific information to assist with drought and water shortage planning. Below, are some statistics among those scoring in the top 10% risk that offer a snapshot of patterns notable statewide:

- 52% are in a fractured rock area, and many of these high-risk suppliers on fractured rock rely on groundwater only.
- 100% of the highest at-risk systems have no intertie, which is an interconnection infrastructure for receiving imported water. All but one high risk system has one or fewer sources of water (not counting hauled water as a source).
- The majority of high-risk suppliers (84%, 204) rely primarily on groundwater.
- Over half (61%, 149) of the top at-risk suppliers are in high or very high-risk zone for wildfire, as defined by CalFire.

To evaluate rural community risk (referred to as *self-supplied community risk*), 5000 Census Block Groups (the geographical unit used by the United States Census Bureau, typically between 600 and 3,000 people) with record of a domestic well installed within the last 50 years (1970-2019) were examined. These block groups covered an estimated 283,742 domestic wells. The median household income is lower among the block groups with domestic wells compared to the average statewide.

To develop recommendations and guidance on drought planning, and to identify drought and water shortage risk indicators for small water systems and self-supplied communities, DWR utilized a public process involving state agencies, cities, counties, small communities, small water suppliers and other stakeholders in forming a stakeholder advisory group, the County Drought Advisory Group (CDAG). The CDAG had many discussions on the best ways to improve small communities' preparation for the next drought. The group offered a venue and process for close collaboration between state agencies and local agencies, as well as a place to accept input from other key stakeholders.

Throughout the stakeholder process a four-phase model of disaster risk management helped to frame the drought and water shortage planning approach. This model includes the following phases: (1) Mitigation, Preparation, and Capacity Building; (2) Forecasting and Monitoring; (3) Drought and Water Shortage Response; and (4) Recovery and Relief (Wilhite 2000 and 2014).

1.0 Introduction

1.1 Purpose

The California Department of Water Resources (DWR) seeks to identify small water suppliers and rural communities that may be at risk of drought and water shortage vulnerability, and to propose recommendations and information in support of improving their drought preparedness. In that effort, this report has been prepared pursuant to the requirements of California Water Code (CWC) Section 10609.42, which states:

a) *No later than January 1, 2020, the department, in consultation with the board and other relevant state and local agencies and stakeholders, shall use available data to identify small water suppliers and rural communities that may be at risk of drought and water shortage vulnerability. The department shall notify counties and groundwater sustainability agencies of those suppliers or communities that may be at risk within its jurisdiction, and may make the information publicly accessible on its Internet Web site.*

b) *The department shall, in consultation with the board, by January 1, 2020, propose to the Governor and the Legislature recommendations and guidance relating to the development and implementation of countywide drought and water shortage contingency plans to address the planning needs of small water suppliers and rural communities. The department shall recommend how these plans can be included in county local hazard mitigation plans or otherwise integrated with complementary existing planning processes. The guidance from the department shall outline goals of the countywide drought and water shortage contingency plans and recommend components including, but not limited to, all of the following:*

    1) *Assessment of drought vulnerability.*
    2) *Actions to reduce drought vulnerability.*
    3) *Response, financing, and local communication and outreach planning efforts that may be implemented in times of drought.*
    4) *Data needs and reporting.*

5) *Roles and responsibilities of interested parties and coordination with other relevant water management planning efforts.*

This Part II of the *Recommendations for Drought and Water Shortage Contingency Plans* report addresses the directives in CWC 10609.42(a), and a companion Part I addresses the directives contained in CWC Section 10609.42(b).

1.2 Background

In June 2018, AB 1668 and Senate Bill (SB) 606 were passed as part of efforts to make water conservation a California way of life. The legislation tasked DWR and the State Water Resources Control Board (State Water Board) with implementing several directives related to urban and agricultural water use efficiency and countywide drought resiliency.

To initiate and coordinate the implementation of the legislation, a five-agency coordination team (Agency Coordination Team) was formed comprising DWR, the State Water Board, the California Department of Food and Agriculture (CDFA), California Public Utilities Commission (CPUC), and California Energy Commission (CEC). In September 2018, listening sessions were held in Sacramento, Fresno, and Los Angeles to solicit public input and stakeholder engagement in implementing the legislation.

In November 2018, a County Drought Advisory Group (CDAG) was formed to advise DWR on the implementation of the legislative mandates specific to (1) identifying small water suppliers and rural communities at risk of drought and water shortage and (2) developing recommendations and guidance for countywide drought and water shortage contingency plans to address the planning needs of those communities.

DWR kept its partner state agencies informed about CDAG activities through the Agency Coordination Team. This team was formed to coordinate SB 606- and AB 1668-related projects aimed at long-term improvements in water conservation and drought planning. These projects will serve to help California adapt to climate change and the increasingly frequent and more intense droughts throughout the state.

Some of these agencies actively participated on the CDAG Project Team and were actively involved in planning and attending Advisory Group meetings. In addition to legislatively mandated criteria, the state agencies and CDAG

advised DWR to also consider the following related directives and policies in developing the drought and water shortage vulnerability assessment indicators, and the proposed recommendations and guidance for contingency planning:

- Governor Newsom's Executive Order N-10-19 (April 2019), which directs agencies to recommend a suite of priorities and actions to build a climate-resilient water system and ensure healthy waterways. In implementing the directive, the California Natural Resources Agency, California Environmental Protection Agency, and CDFA solicited extensive public input to prepare the Water Resilience Portfolio released by the Governor on July 28, 2020. The portfolio consists of a water policy roadmap to guide state efforts to meet the water needs of California's communities, economy, and environment as the climate changes.

- Senate Bill 200 (Monning 2019, Health and Safety Code Section 116686), which establishes the Safe and Affordable Drinking Water Fund in the State Treasury to help water systems provide an adequate and affordable supply of safe drinking water in both the near and long terms and authorized water system administrators to provide an adequate supply of affordable, safe drinking water to disadvantaged communities and to prevent fraud, waste, and abuse.

- SB 862 Budget Act of 2018, which appropriates funding for State Water Board to implement a needs analysis on the state of drinking water in California.

- AB 685 (2012, CWC Section 106.3), which declares that everyone in California has a right to clean, safe, affordable, and accessible water adequate for human consumption and sanitary purposes. The legislation instructed all relevant state agencies—including State Water Board—to consider the human right to water when revising, adopting, or establishing policies, regulations, and grant criteria pertinent to water uses. Recently, the State Water Board enlisted the expertise of the Office of Environmental Health Hazard Assessment (OEHHA) to develop a framework for evaluating the quality, accessibility, and affordability of the state's domestic water supply.

As required by the AB 1668 legislation, and in addition to identifying communities at risk of drought and water shortage, this effort focuses on the planning needs for small water suppliers and rural communities to prepare

for drought and water shortage events. It is important to recognize that this effort is one of several complimentary state efforts which include:

- The State Board's Needs Assessment effort, through which the Board is working on prioritizing assistance and funding for vulnerable water systems and aiming at implementing resiliency measures and infrastructure improvements.

- OEHHA's Human Right to Water Assessment effort to conduct a baseline assessment and create a data tool for evaluating the quality, accessibility, and affordability of drinking water supply and the associated challenges that water systems face.

1.3 Agency and Stakeholders Roles

To gather input, DWR consulted with state agencies—State Water Board, OEHHA, CPUC, Governor's Office of Emergency Services (Cal OES), Governor's Office of Planning and Research (OPR), California Department of Public Health (CDPH), and CEC—and the federal agencies Indian Health Services (IHS) and the U.S. Environmental Protection Agency, along with the 32-member CDAG stakeholder advisory group acknowledged in this report.

For the duration of this project, DWR worked closely with the State Water Board and OEHHA. Close agency coordination was beneficial, as there is significant overlap between this effort and the State Water Board, Division of Drinking Water's Drinking Water Needs Assessment project and the effort led by OEHHA to develop *A Framework and Tool for Evaluating California's Progress in Achieving the Human Right to Water*.

The CDAG stakeholder advisory group included representatives from counties, cities, water districts, academia, environmental justice and environmental organizations, tribes, and third-party assistance organizations and associations. Advisory group meetings were open to the public and announcements of public meetings were posted on DWR's website and listservs. The advisory group met bimonthly, as necessary, for the duration of the project, starting in December 2018.

Two workgroups were created to focus on the two legislative mandates to identify those at risk, and to give recommendations for water shortage contingency planning, they became the:

- Risk Assessment Technical Workgroup
- Water Shortage Contingency Plan (WSCP) Workgroup

Both workgroup meetings were planned as needed, and participation was solicited from the advisory group. Participation was in-person and online and focused on technical details and discussion of options. Information collected from the workgroup meetings was shared with the advisory group through draft documents and presentations at bimonthly meetings.

1.4 Drought Planning Approach: Phase Model of Disaster Risk Management

Throughout the stakeholder process, a four-phase model of disaster risk management helped to frame the drought and water shortage planning approach (Wilhite 2000 and 2014):

Phase 1: Mitigation, Preparation, and Capacity Building. This pre-disaster learning phase includes risk assessment, risk reduction, improving coping capacity, and improving emergency and water shortage plans.

Phase 2: Forecasting and Monitoring. This pre-disaster phase includes ongoing forecasting and monitoring, improving scientific data, and accounting for precipitation, water supply, and climate changes.

Phase 3: Drought and Water Shortage Response. This phase includes communication, seeking assistance, and implementing any emergency response procedures that are defined for use during a disaster.

Phase 4: Recovery and Relief. This post-disaster response phase includes impacts' assessment, assistance to households and suppliers, and funds to in-boundary organizations to distribute assistance.

Figure 1 presents the four-phase model of disaster risk management. The recommendations throughout this report reference the phases, acknowledging all drought and water shortage planning, monitoring, response, and mitigation actions fall within one or more of these phases.

Many of the items listed in the four-phase cycle are addressed by existing federal, state, and local efforts and reporting processes.

Note: This framework is based on Ekstrom et al. (2020) and informed by Baird (1975); Carter (2008); Coetzee and Niekerk (2012); and Van Dongeren et al. (2018)

Figure 1. Disaster Risk Management Framework

2.0 Vulnerable Small Suppliers and Rural Communities: Scoring of Drought and Water Shortage Risk

CWC Section 10609.42(a) requires DWR, in consultation with other agencies and stakeholders, to identify small water suppliers and rural communities (areas of households on private supplies, also called "self-supplied communities in this report") that may be at risk of drought and water shortage. DWR must then notify counties and groundwater sustainability agencies (GSA) of suppliers or communities that may be at risk within its jurisdiction and may make the information publicly accessible on the website.

Appendix 1 provides the indicators, datasets, and methods used for constructing this deliverable, as well as the tools created during this project that can be used going forward to assess drought and water shortage vulnerability periodically as-needed basis.

The risk of drought and water shortage vulnerability is recognized as a problem derived from a combination of hydrological and sociological factors. The indicators of risk and methods adopted into the drought vulnerability explorer tools developed as part of this project evolved in close coordination and through an iterative feedback process with the State Water Board, CDAG, and several other state and local agencies and stakeholders. The aggregation method to combine these indicators and the overall process taken to develop these is recorded in Appendix 1 in detail.

This is the first statewide effort to systematically and holistically consider drought and water shortage risk of small water suppliers and households. As with any first major effort, it is important to recognize that the indicators and construction of the scoring should be revised as more data becomes readily available and knowledge advances on droughts and water resilience. The scoring system should allow for monitoring changes in risk over time. At the same time, as the collective understanding of what risk of drought and water shortage advances, so too should the scoring system. Understanding

and perspectives on drought may be informed by future drought experiences.

This section presents results of calculating initial risk scores using existing statewide datasets and the newly developed tools to estimate risk of drought and water shortage for small water suppliers and self-supplied communities. The risk was assessed based on a multi-pronged definition; this offers valuable information beyond helping to prioritize which suppliers and communities need assistance. Further, delivering not only the aggregated risk scores, but also the disaggregated measures of risk to water suppliers, counties, groundwater sustainability agencies, integrated regional water management programs, the State Water Board, and other stakeholders can be valuable for planning, prioritizing and improving drought and water shortage resilience.

Risk scores were calculated for the following categories:

1) Small water suppliers examined include community water systems and noncommunity non-transient water systems that are schools.

2) Self-supplied communities.

Recognizing that the risk assessment conducted as part of this project is based on available data and reflects a snapshot of drought and water shortage risk, it is recommended that this assessment is updated periodically. Recommendation G1, in Section 2.4 in the companion Part I of this report, discusses this further.

2.1 Small Water Suppliers – Risk Assessment

Urban water suppliers are required to develop a comprehensive urban water management plan, which must include a section on drought and water shortage contingency planning (CWC Section 10644(b)).

The risk assessment developed during this project was done for 2419 community and noncommunity non-transient water systems that are schools. Our assessment required spatial information in order to include it in the analysis because of the nature of the data included to represent several of the risk factors. Therefore, some relevant water systems may not be included at this time. This assessment covers 2,244 small community water systems in California and 175 schools with their own water systems which

are classified as non-transient non-community water systems under the regulatory jurisdiction of the State Water Board.

Because of data availability constraints, those systems with fewer than 15 service connections are classified for this report under the self-supplied communities (referred to in legislation as "Rural Communities"). The analysis includes those suppliers that have spatial boundaries of their service areas recorded in the State Water Board's *California Drinking Water Systems Area Boundaries* dataset, as of July 1, 2020, available through the California State Geoportal at: https://gis.data.ca.gov/datasets/fbba842bf134497c9d611ad506ec48cc_0. It must be noted that the water system boundary geospatial layers have not been verified by DWR to ensure the accuracy of the location of the small water supplier or that the boundary itself is accurate, but at the time of analysis this was considered the best available data. The State Water Board is currently undertaking this verification process.

2.2 Water Shortage Risk Indicators: Exposure, Vulnerability, and Observed Shortages

To evaluate the relative risk of drought and water shortage vulnerability for small water systems, DWR collaborated with the State Water Board and CDAG to develop a tool that applies a common risk and vulnerability framework with indicators.

A total of 29 indicators, listed in Table 1-7, were used to analyze drought and water shortage risk for small water suppliers.

Table 1. Risk Indicators Used to Analyze Drought and Water Shortage Risk for Small Water Suppliers

COMPONENT 1 – Exposure to Climate Change	Metric	Data Source
SC1a – Projected Temperature Shift	Projected change in temperature by mid-century	Pierce et al. 2018
SC1b - Projected Sea Level Rise	Presence of salt into coastal aquifers with projected 1-meter sea level rise	Befus et al. 2020a and 2020b
SC1c - Projected Wildfire Risk	Projected acres burned from wildfire for each system boundary or community	Westerling et al. 2018

Table 2. Risk Indicators Used to Analyze Drought and Water Shortage Risk for Small Water Suppliers

COMPONENT 2 – Exposure to Recent Conditions & Events	Metric	Data Source
SC2a – Current Wildfire Risk	Modelled current risk for each system (based on vegetation)	CalFire
SC2b - Drought Early Warning Forecast Water Year 2020	Annual Risk of Local Drought (precipitation)	PRISM OSU
SC2c - Fractured Rock Area	Fractured rock	DWR
SC2h - Projected Population Growth	Near term population growth rate	DWR
SC2i – Water Quality in Surrounding Basin	Water quality problems in surrounding basin	USGS GAMA
SC2d - Basin-Subsidence	Susceptibility to subsidence	DWR
SC2e - Saltwater Intrusion	Saltwater intrusion into coastal aquifers, present day	Befus et al. 2020a and 2000b
SC2f - Critically Overdrafted	Critically overdrafted basin	DWR
SC2g - Chronic Declining Water Levels	Declining groundwater levels	DWR
SC2j -Surrounding Agricultural Land Use	Amount of irrigated agriculture in service area	DWR

Table 3. Risk Indicators Used to Analyze Drought and Water Shortage Risk for Small Water Suppliers

COMPONENT 3a Connectivity – Infrastructure Vulnerability	Metric	Data Source
SC3a - Interties	Presence of one or more intertie	SDWIS 2020
SC3b – Emergency interties	Presence of one or more emergency intertie	SDWIS 2020
SC3e – Single Water Source	Water sources more than one	SDWIS 2020
SC3f – Single Source Types	Water source types more than one	SDWIS 2020

Table 4. Risk Indicators Used to Analyze Drought and Water Shortage Risk for Small Water Suppliers

COMPONENT 3b – Other Infrastructure Vulnerability	Metric	Data Source
SC3c - Baseline monitoring	Level of monitoring reported	eAR 2018
SC3d – Customers metered	% system connections unmetered	eAR 2018
SC3i – Distribution Outage Record	Distribution problems related to water outage	eAR 2018
SC3j – Water Level Status	Levels of water source-recovering, steady, declining, blank	eAR 2018

Table 5. Risk Indicators Used to Analyze Drought and Water Shortage Risk for Small Water Suppliers

COMPONENT 4 – Organization Vulnerability (ID)	Metric	Data Source
Rate Last Updated (SC4a)	Year rate structure was last updated	SWRCB
Rate Type (SC4b)	Type of rate structured used by supplier. Survey question in eAR 2018 (flat base rate =1; other =0)	SWRCB
Supplier Size (SC4c)	Service connections rescaled and inverted	SWRCB
Drought Preparedness Plan (SC4d)	Have drought plan or WSCP; year written or updated	SWRCB
Customer Base Socioeconomics (SC4e)	Multiple population characteristics combined score	DWR Private vendor data

Table 6. Risk Indicators Used to Analyze Drought and Water Shortage Risk for Small Water Suppliers

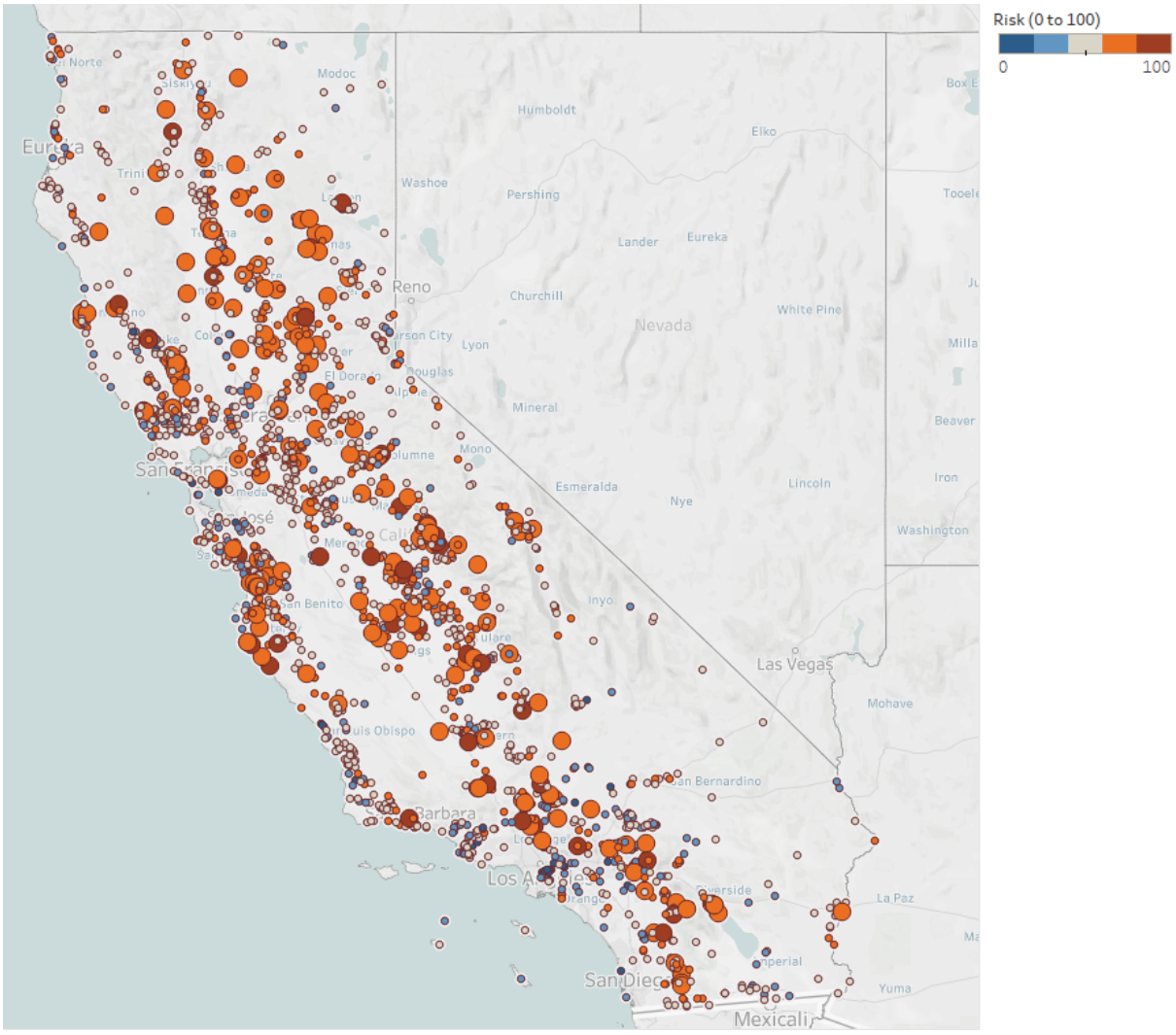
COMPONENT 5 – Recent Observed Shortage	Metric	Data Source
SC3h – Shortage: Self-Reported Projected	Supplier-reported projected shortage	eAR 2011-2018
SC3k – Shortage: Curtailment and Compliance Order	Systems under order of compliance for curtailment (2014) or building moratoriums	SWRCB
SC3L – Shortage: Drought Assistance Record	Systems that received drought assistance on record	SWRCB

Table 7. Demographic and Socioeconomic Characteristics Estimated to Represent the Customer Base Served by the Small Supplier. Spatial Analysis used to Associate Census Data to Service Area Boundaries

Variable Names	Brief Description of What Variable is	Data Source
PERCAP	Average per capita income for all Block Groups (BG) that intersected with the service areas	ACS 2012-2016
AvgMHI	Average Median Household Income (MHI) for all BGs that intersected with the service areas	ACS 2012-2016
Q65yr	Percentage of population of 65 and older of all BGs that intersected with the service areas	ACS 2012-2016
Qpov	Percentage of population of living at or under the poverty level of all BGs that intersected with the service areas	ACS 2012-2016
Q5y	Percentage of population of under 5 years age of all BGs that intersected with the service areas	ACS 2012-2016
Qmobile	Percentage of mobile households of all BGs that intersected with the service areas	ACS 2012-2016
NoVeh	Percentage of households with no vehicles of all BGs that intersected with the service areas	ACS 2012-2016
Qedu	Percentage of population over 25 years of age with no high school diploma of all BGs that intersected with the service areas	ACS 2012-2016
Qparent	Percentage of population with single parent with children under 18 of all BGs that intersected with the service areas	ACS 2012-2016
Qunempl	Percentage of population of civilian unemployed of all BGs that intersected with the service areas	ACS 2012-2016
Qgroup	Percentage of all census Block population with Group Quarters (GQ) that intersected with the service areas	Census 2010
Qrenters	Percentage of renter households of all BGs that intersected with the service areas	ACS 2012-2016

2.3 Relative Risk Findings

Based on statewide risk score results, Figure 2 shows small water suppliers in the top 10 percent of those identified to be at risk of drought and water shortage (based on statewide available datasets).



Note: Large circles indicate top 10%, small circles indicate location of other water systems examined. Colors range by risk score, where the highest is dark red and the lowest is dark blue. Risk scores indicated by color ramp ranging from dark (high relative risk) to light (low relative risk).

Figure 2. Small Water Suppliers Examined for Risk of Drought and Water Shortage

Out of the small water suppliers in the top 10 percent of drought vulnerability risk scores (242 suppliers) shown in Figure 2, the following statistics are provided:

- 210 are community water systems

- 32 are non-community non-transient systems that are schools
- 91% (219) have groundwater as primary water supply

47 of the 58 counties have a small water system with a risk score in the top 10% of risk scores for these types of suppliers. In terms of how the top 10% at-risk systems compared to the lower 90%, the following lists the risk factors for which the means were significantly different between the two groups.

- Mean household income – Lower in high-risk group
- Non-basin areas (fractured rock, SC2c) – Higher portion of high-risk group located in fractured rock
- Connectivity indicators of no interties (SC3a), no emergency interties (SC3b), single water source (SC3e), and single type of source (SC3f) were all more frequent in high risk group
- Rate structure update (SC4a) – Higher risk group have rates updated longer ago on average than lower risk group

More details are provided in Appendix 2.

2.4 Rural Communities (referred to here as "self-supplied communities") – Risk Assessment

"Self-supplied communities" for this analysis are households on private supplies (such as a domestic well) and other customers that are supplied by systems with fewer than 15 service connections. This category is intended to cover what is labeled as the "rural communities" in the legislation, and hereafter referred to as self-supplied communities.

The self-supplied communities grouping also includes households with private or domestic wells or houses supplied by surface water such as rivers, lakes, and the like. Some private wells are located in urban areas; so, the term "rural" is not adequate, and CDAG chose "self-supplied communities" as an alternate term for clarity.

This category (self-supplied communities) is intended to cover populations that rely on self-supplied groundwater, surface water residential water use, or State Small Water Systems, the latter of which supply customers with fewer than 15 service connections (see Glossary for full technical definition).

These communities were identified using U.S. Census Block groups. Block groups that have zero population and those that have no domestic wells recorded between 1970-2019 were excluded from the self-supplied communities' category. Approximately 5,000 Census Block groups are considered self-supplied communities that meet the above criteria.

2.5 Water Shortage Risk Indicators: Exposure, Vulnerability, Observed Shortages, and Domestic Well Reliance

To evaluate the relative risk of drought and water shortage vulnerability for the self-supplied systems, DWR also collaborated with the Water Board and CDAG to develop a tool that used a common framework with indicators. A total of 20 indicators, listed in Table 6, were used to analyze drought and water shortage risk for self-supplied communities.

Table 8. Risk Indicators Used to Analyze Drought and Water Shortage Risk for Self-Supplied Communities

Component 1: Climate Change Risk Indicators	Indicator	Indicator Description	Data Source
RC1a – Temperature Shift	Projected change in heat by mid-century	Projected change in max temperatures by mid-century (averaged across models)	DWR
RC1b – Wildfire Risk	Projected severe or high severe risk for each system boundary or community	Projected area burned (averaged across all GCMs) by 2035-2064, RCP8.5; spatial join with Block groups	UC Merced
RC1c – Saline Intrusion Risk	Susceptibility to seawater intrusion -- 1-meter sea level rise into coastal aquifers	Spatial extent of projected SLR under RCP 8.5 by 2040 (1 m) into coastal aquifers; spatial join with Block groups	University of Wyoming (coordinated with USGS)

Table 9. Risk Indicators Used to Analyze Drought and Water Shortage Risk for Self-Supplied Communities

Component 2: Exposure to Current Conditions and Event Risk Indicators	Indicator	Indicator Description	Data Source
RC2a – Drought Early Warning 2019	Annual Updated Early Drought Risk Warning	Less than 70% of average precipitation by January 31st for that water year = high risk of drought	PRISM OSU
RC2b – Wildfire Risk	Modelled current risk maximum for each Census Block Group	Use CalFire Scoring HAZ_CODE: Moderate (1)= .33; High (2)= .67; Very High (3) =1; no score =0 (no or low risk); Took max for each Census BG with spatial join in ArcGIS	CalFire
RC2c – Fractured Rock Area	Fractured Rock Area	Communities in Fractured Rock Areas (1) or not (0)	DWR
RC2h – Population Growth	Projected population growth	Census data estimates of growth rate between 2016 to 2021, estimated by service area	DWR
RC2i – Water Quality Index	Domestic well water quality risk (includes areas outside of alluvial basins)	Indication of likelihood that groundwater likely accessed by domestic wells may contain concentrations of constituents above regulatory levels.	SWRCB
RC2d – Subsidence Presence	Record of subsidence	Documented Impacts #7.b Subsidence Points; recoded to 0,.5,1 from original points of 0,3,10, then associated to Block groups	DWR

Table 10. Risk Indicators Used to Analyze Drought and Water Shortage Risk for Self-Supplied Communities

Component 2: Exposure to Current Conditions and Event Risk Indicators	Indicator	Indicator Description	Data Source
RC2e – Salt Presence (basin)	Record of salts	Documented Impacts #7.c Salt Intrusion Points	DWR
RC2f – Overdrafted Basin	Critically overdrafted groundwater basin	Yes (1)/no (0) of whether area is in critical overdrafted basin	DWR
RC2g – Declining Water Levels	Declining groundwater levels	Documented Impacts #7.a - Declining GW levels Points	DWR
RC2j – Surrounding Irrigated Agriculture	Presence of irrigated agriculture in surrounding basin	Irrigated Acres Priority Points	DWR

Table 11. Risk Indicators Used to Analyze Drought and Water Shortage Risk for Self-Supplied Communities

Component 3: Physical Vulnerability (aggregated as RC3)	Indicator	Data Source
RC3a – Well Depth Flag	Well-depth flag – if any portion of the groundwater unit(s) that intersect with the Census BG has relatively shallow domestic wells, marked whole BG as '1' (high risk) (0,1)	OSWCR-DWR
RC3b – Well Depth Proportion	Proportion of Public Land Survey Sections in Block Group where the max depth of domestic wells is 10% or more shallow than max of public wells (0-1)	OSWCR-DWR

Table 12. Risk Indicators Used to Analyze Drought and Water Shortage Risk for Self-Supplied Communities

Component 4: Social Vulnerability Risk Indicators (aggregated as RC4)	Indicator	Data Source
PERCAP	Average per capita income for all block groups (BG). Combined to create RC4a.	ACS 2012-2016
AvgMHI	Average Median Household Income (MHI) for all BGs. Combined to create RC4a.	ACS 2012-2016
Qpoverty	Percentage of population living at or below poverty level. Combined to create RC4a.	ACS 2012-2016
Q65yr	Percentage of population of 65 and older of all BGs. Combined to create RC4b.	ACS 2012-2016
Q17yr	Percentage of population of under 17 years of all BGs. Combined to create RC4b.	ACS 2012-2016
Q5y	Percentage of population of under 5 years age of all BGs. Combined to create RC4b.	ACS 2012-2016
Qmobile	Percentage of mobile households of all BGs. Combined to create RC4c.	ACS 2012-2016
QnoVeh	Percentage of households with no vehicles of all BGs. Combined to create RC4c.	ACS 2012-2016
Qedu	Percentage of population over 25 years old with no high school diploma of all BGs	ACS 2012-2016
Qparent	Percentage of population with single parent with children under 18 years old of all BGs. Combined to create RC4b.	ACS 2012-2016
Qunempl	Percentage of population of civilian unemployed of all BGs. Combined to create RC4b.	ACS 2012-2016
Qlang	Percentage of population who speak English less than well of all BGs. Combined to create RC4b.	ACS 2012-2016
Qgroup	Percentage of all census block group population with Group Quarters (GQ). Combined to create RC4c.	Census 2010
Qrenter	Percentage of households that are renters. Combined to create RC4c.	ACS 2012-2016

Table 13. Risk Indicators Used to Analyze Drought and Water Shortage Risk for Self-Supplied Communities

Component 5: Water Shortage Record	Indicator	Data Source
RC5a – Reported Household Outages on Domestic Well	Presence of one or more households with reported outages in Census Block Group	DWR
RC5b – Reported Household Outages on Private Well	Proportion of households with reported outages in Census BG (compared to total households in BG) (0-1 scalar)	DWR

Risk Findings

Figure 3 provides a map of the Census Block Groups by risk score. For these block groups, the following statistics are provided:

- Block groups analyzed in this assessment covered an estimated 3,048,140 households
- Domestic wells within these block groups total 283,742
- 480 block groups have a record of one or more domestic well outage in the last decade
- Within the block groups analyzed, there are an estimated 24,779 tribal homes, based on information received from Indian Health Services
- Median per capita income of block groups with domestic wells (all examined – approximately $29,000) is substantially lower than the median statewide (approximately $39,000)

More details are provided in Appendix 3.

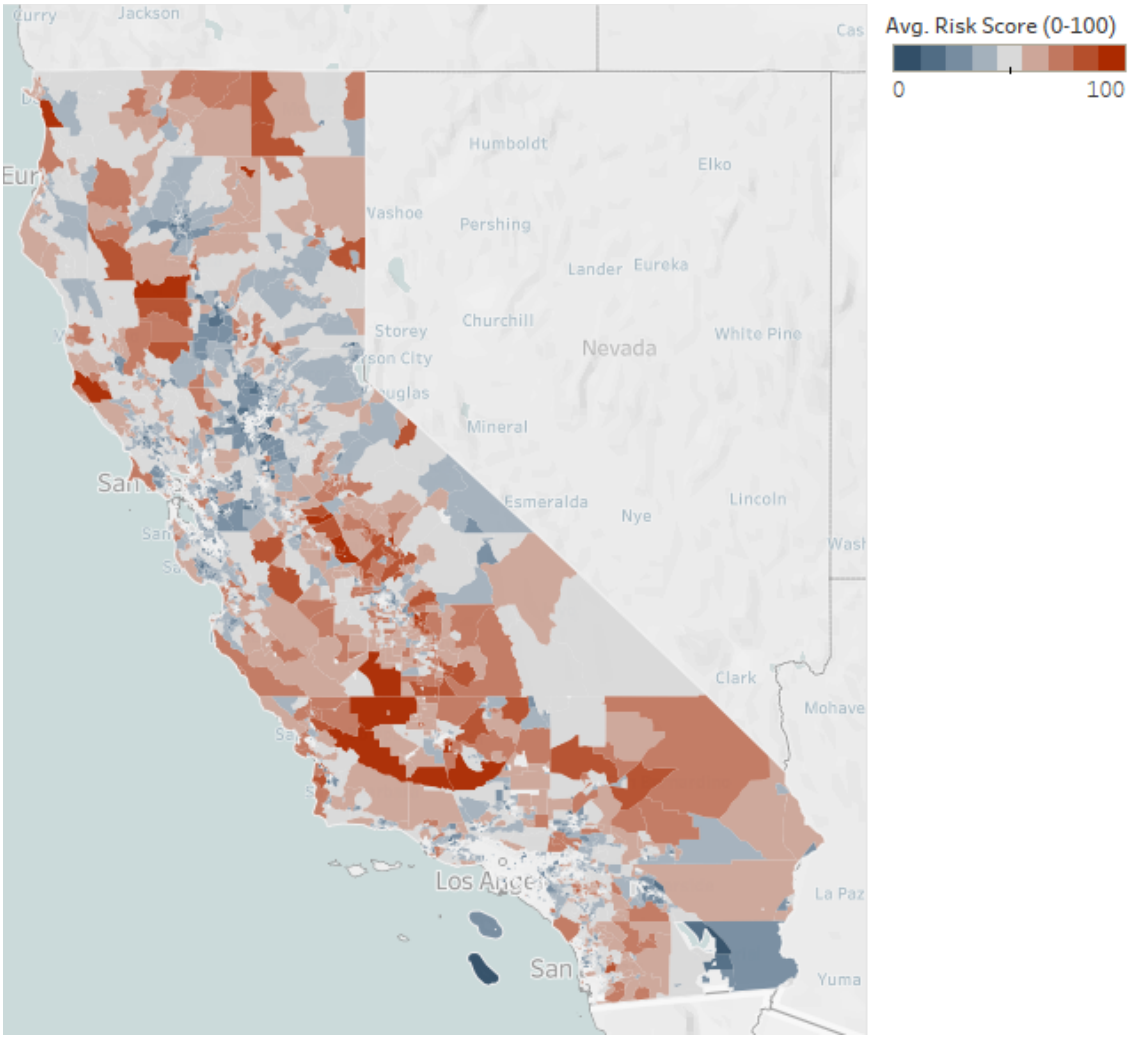


Figure 3. Self-Supplied Communities Risk Scores

2.6 Tribal Water Systems – Risk Assessment

Indian Health Services is a federal partner that DWR worked closely with during this project. During the recent drought, IHS developed a tool to help identify and prioritize vulnerable tribal water suppliers. In previous years, IHS used similar concepts that are consistent with the risk and vulnerability framing and shared their indicators with CDAG. During the CDAG process, IHS updated their analysis to be consistent with the CDAG methodology because many of the CDAG-identified risk factors were not yet included in the IHS methodology. The tribal water system risk scores can be calculated but require permission from each tribal government if they wish to participate. DWR will be conducting outreach with IHS to engage with tribal governments on this option. If any permissions are granted, the next iteration of this risk assessment may incorporate these suppliers, depending on the nature of the permissions.

3.0 Glossary

3.1 Key Definitions

Community water system refers to a public water system that serves a minimum of 15 service connections used by yearlong residents, or regularly serves a minimum of 25 yearlong residents of the area served by the system. Health and Safety Code (HSC) Section 116275(i).

Drought is defined in various ways depending on the needs (Moreland 1993). Generally, a drought is when supply does not meet demand for water, which has been met in the past. Drought tends to be associated with lower-than-average precipitation periods, though it can be driven by increases in demand and ambient temperatures (which can influence demand and timing of supplies). Dry or warm periods can lead to reduced surface water flows, reduced surface and groundwater storage, and increased water quality challenges (e.g., from harmful and other algal blooms or increased disinfectant biproduct concentrations). Additionally, dry periods can lead to shifts in pollutant blooms in aquifers. These water quality issues are important drought risks to consider when planning and preparing for droughts, especially as temperatures increase under the changing climate.

Local primacy agency means a local health officer that has applied for and received primacy delegation pursuant to Section 116330. HSC Section 116275(r).

Noncommunity water system means a public water system that is not a community water system. HSC Section 116275(j).

Nontransient noncommunity water system means a public water system that is not a community water system and that regularly serves at least 25 of the same persons over six months per year. HSC Section 116275(k).

Public water system means a system for the provision of water for human consumption through pipes or other constructed conveyances that has 15 or more service connections, or regularly serves at least 25 individuals daily at least 60 days out of the year. HSC, Section 116275(h).

Self-supplied communities intends to cover what is regarded as the "rural communities" in the legislation. This is intended to cover those households and others with domestically used water (for dish washing, showering, drinking, and the like) from their own wells and surface water supplies. The unit of analysis for these communities is the U.S. Census Block group, omitting those with zero population (according to ACS 2012-2016) and those that have no domestic wells recorded (based on data from the DWR Well Report Database 2019). For the purpose of this risk and vulnerability assessment, this category also addresses communities served by water suppliers with fewer than 15 service connections.

Noncommunity water system that is a school refers to a school that is a permitted public water system because it has its own water supply.

Service connection means the point of connection between the customer's piping or constructed conveyance, and the water system's meter, service pipe, or constructed conveyance. HSC Section 116275(s).

Small water suppliers for this analysis are those with fewer than 3,000 service connections and serving less than 3,000 acre-feet per year. Urban water suppliers with 3,000 connections and/or those that serve over 3,000 acre-feet are required to develop an urban water management plan, which includes a section on drought and water shortage contingency planning. Those small water suppliers that are listed as participating in an urban water management plan were also excluded because they are expected to be covered by their plan.

State small water system means a system for the provision of piped water to the public for human consumption that serves at least five, but not more than 14, service connections and does not regularly serve drinking water to more than an average of 25 individuals daily for more than 60 days out of the year. HSC Section 116275(n).

Transient noncommunity water system means a noncommunity water system that does not regularly serve at least 25 of the same persons over six months per year. HSC Section 116275(o).

Urban water supplier means a supplier, either publicly or privately owned, providing water for municipal purposes either directly or indirectly to more than 3,000 customers, or supplying more than 3,000 acre-feet of water annually.

Water shortage is an insufficient quantity of water to meet indoor water uses such as drinking and sanitation, and other critical water needs, which can be caused by chronic conditions, extreme events, or both. This includes the physical lack of supply coming out of the tap, a problem that can be caused by dry wells or surface water, a regulatory restriction on accessing surface water, or some physical obstruction impeding water supply.

3.2 Key Concepts

Capacity (adaptive and coping): The capacity to adapt or cope is one of the two core sub-components necessary to understand vulnerability. This is the ability or potential of a system (or supplier, household, etc.) to respond successfully to climate variability and change and includes adjustments in both behavior and in resources and technologies. For this analysis, DWR represents capacity in Component 4: Organizational Vulnerability of the framework, which covers mostly social and economic vulnerability indicators.

Exposure to Hazard: Exposure in this risk framework represents the degree to which a water supplier's service area and a community is exposed to various hazardous environmental conditions and events that could lead to drought and/or water shortage.

Risk: Consistent with the Intergovernmental Panel on Climate Change 2012 Special Report (Cardona et al. 2012) and its upcoming Sixth Assessment Report, risk is the combination of vulnerability and the extent of exposure to a hazardous event or conditions, including projected future hazards (IPCC 2017). Vulnerability, as described below, is the combination of sociological and structure factors that make it more or less likely for people to be harmed when they are exposed to a hazard. The stakeholders in CDAG meetings agreed that risk is driven by both exposure to environmental events and conditions and social, political and economic factors, which is consistent with scientific literature on water shortage and scarcity (Kummu et al. 2016; Mekonnen and Hoekstra 2016) and disaster risk management.

Sensitivity: Sensitivity is one of the two core sub-components to understand vulnerability. This is the susceptibility of harm when exposed to hazardous conditions or an extreme event relating to drought and/or water shortage. This is often measured using characteristics of a population or a system. For this analysis, DWR represents sensitivity in Component 3 of the framework and it covers mostly physical vulnerability indicators.

Units of analysis: The final lists required by legislation must be in the form of listing small water suppliers and rural communities (referred to here as "self-supplied communities"). Because the risk factors differ between these groups, an analysis of each was conducted separately and separate lists were constructed. The unit of analysis used for small water suppliers is the service area boundary polygons available through the *California Drinking Water System Area Boundaries* site of the California State Geoportal. The unit of analysis for the self-supplied households is census Block Groups (ACS 2012-2016 Tiger Shapefile). The Census Block Groups do not necessarily represent individual communities, but they do cover areas where population resides. Using this spatial unit for this analysis allows DWR to access demographic information that is otherwise not available.

The analysis includes those suppliers that have spatial boundaries of their service areas recorded in the *California Drinking Water System Area Boundaries*, as of July 1, 2020 (https://gis.data.ca.gov/datasets/fbba842bf134497c9d611ad506ec48cc_0). Those "State Small Systems" (as defined by the State Water Board) with fewer than 15 service connections will be covered under the self-supplied communities represented by census Block Groups.

Vulnerability: Vulnerability is the propensity or predisposition to be adversely affected. Such predisposition constitutes an internal characteristic of the affected element, whereas exposure to a hazard is a condition or event to which the affected element (i.e., supplier or community) is subjected. In the field of disaster risk management, this includes the characteristics of a person or group and their situation that influences their capacity to anticipate, cope with, resist, and recover from the adverse effects of physical events (Wisner et al., 2004). For further reading on vulnerability, see *Key Concepts and Methods in Social Vulnerability and Adaptive Capacity* (Murphy et al. 2015) and Chapter 1 in IPCC Special Report on Extreme Events (Lavell et al. 2012). Vulnerability is typically estimated by combining sensitivity and capacity of the supplier or community or other grouping of population or assets.

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List of Appendices

The appendices to this report are in separate documents.

Appendix 1	Drought and Water Shortage Risk Scoring Methodology– California's Small Water Supplier and Self-Supplied Communities
Appendix 2	Small Water System Water Shortage Risk Results
Appendix 3	Rural Community Water Shortage Risk Results