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Tahoe Valley South Subbasin (6-005.01) Water Year 2022 Annual Report

30 March 2023

Prepared for

South Tahoe Public Utility District
1275 Meadow Crest Dr.
South Lake Tahoe, CA 96150

KJ Project No. 2368001

CERTIFICATION

The following report and analyses were prepared under the direction of:

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Contents

GLOSSARY

2012-2016 Event: Statewide drought emergency declared under the California Emergency Services Act

2014 GMP: Groundwater Management Plan prepared by the District in accordance with Assembly Bill

AB: Assembly Bill

AF: Acre-feet

AFY: Acre-feet per year

Alternative Plan: Alternative to a GSP developed pursuant to Part 2.75 of the Water Code

Alternative Materials: Additional plans, reports and other documents related to the 2014 GMP

BMOs: Basin Management Objectives specified in the Alternative Plan

BHHRA: Baseline Human Health Risk Assessment

CASGEM: California State Groundwater Elevation Monitoring

cfs: Cubic feet per second

Cleanup and Abatement Order: CAO

CSLT: City of South Lake Tahoe

CWC: California Water Code

CWS: Community Water System

CY: Calendar year

District: South Tahoe Public Utility District

DDW: California Division of Drinking Water

DRI: Desert Research Institute

DWR: California Department of Water Resources

EDC: El Dorado County

EPA: Environmental Protection Agency

Feasibility Study or FS: Engineering feasibility study of remedial alternatives to mitigate PCE groundwater contamination in the South Y Area

Feet MSL: Elevation in feet above mean sea level (NAVD88)

Ft bgs: Depth in feet below ground surface

GAC: Granular Activated Carbon

GDEs: Groundwater dependent ecosystems

GMP: Groundwater Management Plan

GSA: Groundwater Sustainability Agency

GSP: Groundwater Sustainability Plan

GSP Regulations: California Code of Regulations Title 23. Waters; Division 2. Department of Water Resources; Chapter 1.5. Groundwater Management; Subchapter 2. Groundwater Sustainability Plans

GWMP: Groundwater Management Plan

IRAP: Interim Remedial Action Plan; this is the preferred alternative of the Feasibility Study

Kennedy Jenks: Kennedy/Jenks Consultants, Inc.

LBWC: Lukins Brothers Water Company

LPA: Lakeside Park Association

LRWQCB: Lahontan Regional Water Quality Control Board

LTBMU: US Forest Service, Lake Tahoe Basin Management Unit

MBR: Mountain Block Recharge

MCLs: maximum contaminant levels

MDD: Maximum daily demand

MGD: Million gallons per day

mg/L: milligrams per liter

Model Domain: Areal extent of the South Tahoe Groundwater Model encompassing the TVS Subbasin and the surrounding watersheds to the watershed divide.

MOU: Memorandum of Understanding

MT3DMS: Modular three-dimensional transport model

MTBE: methyl tert-butyl ether

NRCS: National Resources Conservation Service

OW: Observation well

Parts per Billion: ppb, equivalent to micrograms per liter (μg/L)

Parts per Million: ppm, equivalent to milligrams per liter (mg/L)

PCA: Potential contaminating activity

PCE: Tetrachloroethylene

SAG: Stakeholders Advisory Group

SEZ: Stream environment zones

SGMA: Sustainable Groundwater Management Act

SNOTEL: NRCS snow telemetry station

South Y: Intersection of US Route 50 and California State Highway 89, in the City of South Lake Tahoe, CA

South Y Area: General area within a one-mile radius of the South Y

South Y Plume: Groundwater plume characterized by high concentrations of dissolved tetrachloroethylene contamination, above maximum contaminant levels, generally located between the South Y and the Tahoe Keys lagoon, in South Lake Tahoe, CA

STGM: South Tahoe Groundwater Model: Groundwater flow model developed by DRI for the TVS Subbasin and its surrounding watersheds using MODFLOW-NWT

SWRCB: California State Water Resources Control Board

SWRCB-DFA: SWRCB Division of Financial Assistance

TKPOA: Tahoe Keys Property Owners Association

TKWC: Tahoe Keys Water Company

TRPA: Tahoe Regional Planning Agency

TVS Subbasin: Tahoe Valley South Subbasin (6-005.01) of the Tahoe Valley Groundwater Basin (6-005)

USGS: U.S. Geological Survey

UWMP: South Tahoe Public Utility District 2020 Urban Water Management Plan

Water Agency: El Dorado County Water Agency (aka El Dorado Water Agency)

WBZs: Water-bearing zones

WSDA: Water Supply and Demand Assessment required of Urban Water Suppliers starting in 2022 (WCS §10632.1)

WY: Water Year

LIST OF FIGURES

LIST OF TABLES

APPENDICES

A. TVS Subbasin (6-005.01) Hydrographs

B. SAG Workshop Minutes

Executive Summary

The Tahoe Valley South Subbasin (6-005.01) of the Tahoe Valley Groundwater Basin (TVS Subbasin) is a discrete, highly productive sedimentary geologic basin located in the City of South Lake Tahoe (CSLT) and portions of El Dorado County, California (EDC). The 2022 Annual Report presents a management level summary of groundwater conditions within the TVS Subbasin using collected groundwater production and hydrologic data and results from numerical hydrologic models. This report also discusses District progress on implementation of Basin Management Objectives (BMOs) as described in the first five-year update to the Alternative Plan (Rybarski et al, 2022).

In 2016, the South Tahoe Public Utility District (District) submitted the 2014 Groundwater Management Plan (2014 GMP) and Alternative Materials to the California Department of Water Resources (DWR) for assessment as an existing plan Alternative under section 10733.6(b)(1) of the Water Code. On July 17, 2019, DWR formally accepted the District's 2014 GMP and Alternative Materials as an approved Alternative to a Groundwater Sustainability Plan (Alternative Plan) for the TVS Subbasin, renaming the 2014 GMP.

This is the eighth annual report issued since adoption of the 2014 GMP and fourth annual report since DWR approval of the Alternative Plan for the TVS Subbasin in 2019. During Water Year (WY) 2022 the first five-year update to the Alternative Plan was prepared and adopted by the District and El Dorado Water Agency (Water Agency) Board of Directors. The adopted first five-year update of the Alternative Plan was submitted in April 2022 and is under review by DWR.

Groundwater Conditions

This Annual Report provides hydrologic data for WY 2022, which is the 12-month period starting October 1, 2021, through September 30, 2022.

Water Year Classification. In terms of precipitation, WY 2022 was a normal water year, which followed a below normal water year (WY 2021), a dry water year (WY 2020), an above normal water year (WY 2019), and a normal water year (WY 2018).

Groundwater Recharge. Groundwater recharge to the TVS Subbasin is the sum of areal recharge over the TVS Subbasin and the subsurface inflow of groundwater to the TVS Subbasin from the adjoining mountains [Mountain Block Recharge (MBR)]. For WY 2022, total groundwater recharge to the TVS Subbasin was calculated at 21,545 acre-feet (AF). Of this amount, 16,457 AF is from MBR and 5,089 AF is from areal recharge.

Groundwater Levels. WY 2022 groundwater elevations were generally within the normal range relative to the 10-year base period for groundwater levels (WY 2001 – WY 2010). May 2022 groundwater levels increased on average about 1.21 feet compared to May 2021 groundwater levels.

Degraded Groundwater Quality. Groundwater in the TVS Subbasin is typically of excellent quality; however, there is a history of groundwater contamination from both naturally occurring contaminants, including arsenic and uranium, and regulated industrial and commercial chemicals, especially tetrachloroethylene (PCE) and methyl tert-butyl ether (MTBE). Several drinking water supply wells now have treatment systems installed for arsenic, uranium, and/or PCE.

During WY2022, the District and the Lahontan Regional Water Quality Control Board (LRWQCB) continued a variety of plume characterization efforts including:

- October 2021 and April 2022 sampling of sentry wells installed upgradient of drinking water supply wells
- Non-municipal well sampling in July 2022
- A soil gas investigation to evaluate the potential human health risks associated with potential soil vapor intrusion resulting from the South Y Plume in August 2022
- Proposed Cleanup and Abatement Orders for three additional sites: Lake Tahoe Laundry Works, Big O Tires, and Former Norma's Cleaners.

Groundwater Production. Metered groundwater production from major community water system wells [District, Tahoe Keys Water Company (TKWC), Lukins Brothers Water Company (LBWC) and Lake Park Association (LPA)] totaled 6,035 AF in WY 2022. This is approximately 19% below average (WY 2005 – WY 2022). Groundwater extraction from these wells, which account for more than 90% of groundwater extractions in the TVS Subbasin, is substantially less than the sustainable yield [13,200 AF per year (AFY)].

Groundwater Storage. For WY 2022, the annual change of groundwater in storage for the TVS Subbasin is -952 AF. Since WY 2005, the cumulative change of groundwater in storage for the TVS Subbasin is +8,157 AF. The storage threshold for the TVS Subbasin is -32,050 AF relative to WY 2005.

Groundwater Supply. The current year available supply for WY 2021 is 40,207 AF. Since WY 2005, the groundwater supply has ranged from 31,858 AF (WY 2009) to 48,604 AF (WY 2019).

Basin Management Objectives

Groundwater management activities performed during WY 2022 included items required for ongoing compliance with Sustainable Groundwater Management Act (SGMA) and other efforts to address Basin Management Objectives (BMOs) under the Alternative Plan. WY 2022 accomplishments included:

- ❖ Fulfilled the Alternative annual reporting requirements for the preceding water year for the TVS Subbasin.
- ❖ Fulfilled monitoring entity groundwater level elevation monitoring and reporting requirements for the TVS Subbasin under the California State Groundwater Elevation Monitoring (CASGEM) program.

- ❖ Continued conducting Stakeholders Advisory Group (SAG) workshops for collaboration around groundwater-related activities occurring within the TVS Subbasin.
- ❖ Reconciled projected water budgets between the Alternative Plan and the District's 2022 Annual Water Supply and Demand Assessment.
- ❖ Updated the South Tahoe Groundwater Model (STGM) and used the updated model to
    - Develop a projected water budget over a 50-year planning and implementation horizon,
    - Assess potential climate change impacts,
    - Assess depletions of interconnected surface waters; and
    - Assess current available groundwater supply.
- ❖ Developed sustainable management criteria for the assessment of undesirable results.
- ❖ Conducted administrative, technical, and public engagement tasks for the first five-year update of the Alternative Plan, submitted in April 2022.

Comparison of current groundwater conditions to the quantitative criteria defined for the TVS Subbasin demonstrates that the sustainability goals for the TVS Subbasin are currently being met.

1. Introduction

Kennedy/Jenks Consultants, Inc. (Kennedy Jenks), on behalf of the District, has prepared this report for the TVS Subbasin. The WY 2022 Annual Report presents a management level summary to assess groundwater conditions and supplies within the TVS Subbasin, using groundwater production and hydrologic data and results from numerical hydrologic models. Progress on implementation of BMOs defined in the Alternative Plan is also reported.

The 2014 GMP was prepared in accordance with Assembly Bill 3030 (AB 3030) pursuant to CWC §10750 et *seq*. The 2014 GMP was adopted by the District and an accompanying Groundwater Ordinance was added as Division 7 to the District's Administrative Code on December 4, 2014. On December 28, 2016, the District concurrently submitted to DWR its 2014 GMP and Alternative Materials as an existing plan Alternative pursuant to California Water Code (CWC) §10733.6(b)(1) and an analysis of basin conditions as an analysis Alternative pursuant to CWC §10733.6(b)(2) for public comment and DWR review and evaluation.[1] On July 17, 2019, DWR determined that the existing plan Alternative satisfied the objectives of SGMA and approved it as an Alternative Plan for the TVS Subbasin (DWR, 2019a), renaming the 2014 GMP. The first five-year update of the Alternative Plan was submitted to DWR in April 2022 and is currently under review.

This report was prepared in compliance with the annual reporting requirements of a Groundwater Sustainability Agency (GSA) to submit an annual report by April 1 of each year (CWC §10728). Since 2016, DWR has required GSAs which have submitted Alternative Plans to DWR for evaluation to also submit annual reports. As described in more detail in section 3.3.3.1 of this 2022 Annual Report, the District is the GSA for the majority of the TVS Subbasin, with the Water Agency acting as the GSA for the portions of the TVS Subbasin outside of the District's jurisdiction.

The WY 2022 Annual Report is the eighth annual report issued since adoption of the 2014 GMP and the fourth annual report issued since DWR approval of the Alternative Plan for the TVS Subbasin in 2019. Table 1-1 lists the components required for inclusion in annual reports submitted by a GSA to DWR. Also listed are the corresponding section(s) where this information is found in this report. Information about GSA Formation, development of the first five-year update of the Alternative Plan and outreach efforts are described in Section 3.3 BMO #3 – Building Collaborative Relationships.

[1] As part of its submittals, the District indicated its preference to DWR that the review be sequenced in such a manner that its existing plan Alternative be reviewed first, and should DWR agree that the existing plan Alternative is functionally equivalent to a GSP, review of the analysis Alternative would not be necessary.

§ 356.2	ANNUAL REPORT COMPONENT	SECTION(s)
(a)	General information, including an executive summary and a location map depicting the basin covered by the report	Executive Summary; Section 1.1; Fig. 1-1; Fig. 1-2
(b)	A detailed description and graphical representation of the following conditions of the basin managed in the Plan:	
(1)	Groundwater elevation data from monitoring wells identified in the monitoring network shall be analyzed and displayed as follows:	
(A)	Groundwater elevation contour maps for each principal aquifer in the basin illustrating, at a minimum, the seasonal high and seasonal low groundwater conditions.	Section 2.4.2; Fig. 2-6
(B)	Hydrographs of groundwater elevations and water year type using historical data to the greatest extent available, including from January 1, 2015, to current reporting year.	Section 2.4; Fig. 2-4; Appendix A
(2)	Groundwater extraction for the preceding water year. Data shall be collected using the best available measurement methods and shall be presented in a table that summarizes groundwater extractions by water use sector and identifies the method of measurement (direct or estimate) and accuracy of measurements, and a map that illustrates the general location and volume of groundwater extractions.	Section 2.6; Table 2-5; Fig. 2-8, Fig. 2-9. All reported water use in Section 2.6 is for single-family and multi-family residential, commercial and landscape uses.
(3)	Surface water supply used or available for use, for groundwater recharge or in-lieu use shall be reported based on quantitative data that describes the annual volume and sources for the preceding water year.	Not Applicable; surface water for recharge or in-lieu use is not used as a source of supply, except for Lakeside Park Association. The annual volume of surface water used by this system is not provided in this report.

§ 356.2	ANNUAL REPORT COMPONENT	SECTION(s)
(4)	Total water use shall be collected using the best available measurement methods and shall be reported in a table that summarizes total water use by water use sector, water source type, and identifies the method of measurement (direct or estimate) and accuracy of measurements. Existing water use data from the most recent Urban Water Management Plans or Agricultural Water Management Plans within the basin may be used, as long as the data are reported by water year.	Section 2.6.1; Table 2-5; The water use data provided in Section 2.6 is from the District's customer service database and is representative of more than 80% of the groundwater use in the TVS Subbasin. These data are presented in calendar years.
(5)	Change in groundwater in storage shall include the following:	
(A)	Change in groundwater in storage maps for each principal aquifer in the basin.	Section 2.7- The annual change of groundwater in storage is presented as a single value for the entire basin which is derived from the water budget calculated by the South Tahoe Groundwater Model (STGM). As the model calculates groundwater storage for all layers within the principal aquifer (e.g. Basin-fill Aquifer), a storage map is not provided. A graph depicting annual and cumulative change of groundwater in storage is provided as Figure 2-10.
(B)	A graph depicting water year type, groundwater use, the annual change in groundwater in storage, and the cumulative change in groundwater in storage for the basin based on historical data to the greatest extent available, including from January 1, 2015, to the current reporting year.	Section 2.7; Fig. 2-10. All water use, in terms of groundwater production, shown in Figure 2-10 is for residential, commercial, and landscaping uses.
(C)	A description of progress towards implementing the Plan, including achieving interim milestones, and implementation of projects or management actions since the previous annual report.	Section 3.0[2]

Table 1-1. Component requirements of Annual Reports submitted to DWR by GSAs (§356.2).

1.1 TVS Subbasin

The TVS Subbasin is part of the larger Tahoe Valley Groundwater Basin, which is located within the Lake Tahoe Hydrologic Basin and incorporates the sediment-filled basins bordering Lake Tahoe. The Tahoe Valley Groundwater Basin is subdivided into three sub-basins: the TVS Subbasin, the Tahoe Valley West

[2] The discussion in Section 3.0 of this Annual Report applies to the Alternative Plan.

Subbasin, and the Tahoe Valley North Subbasin (Figure 1-1). Of these three subbasins, the TVS Subbasin is the largest and most productive.

Elevations within the TVS Subbasin range from 6,225 feet at lake level, rising to above 6,500 feet within the groundwater basin. Elevations extend above 10,000 feet within the surrounding mountains along the Carson Range and Sierra Nevada Range. Portions of seven watersheds overlie the TVS Subbasin; the largest of these is the Upper Truckee River watershed. The Upper Truckee River flows north across the entire length of the TVS Subbasin and drains into Lake Tahoe after crossing the Upper Truckee Marsh. The Upper Truckee River is joined by Grass Lake Creek and Big Meadow Creek along the southern extent of its course, Angora Creek centrally, and Trout Creek near Lake Tahoe.

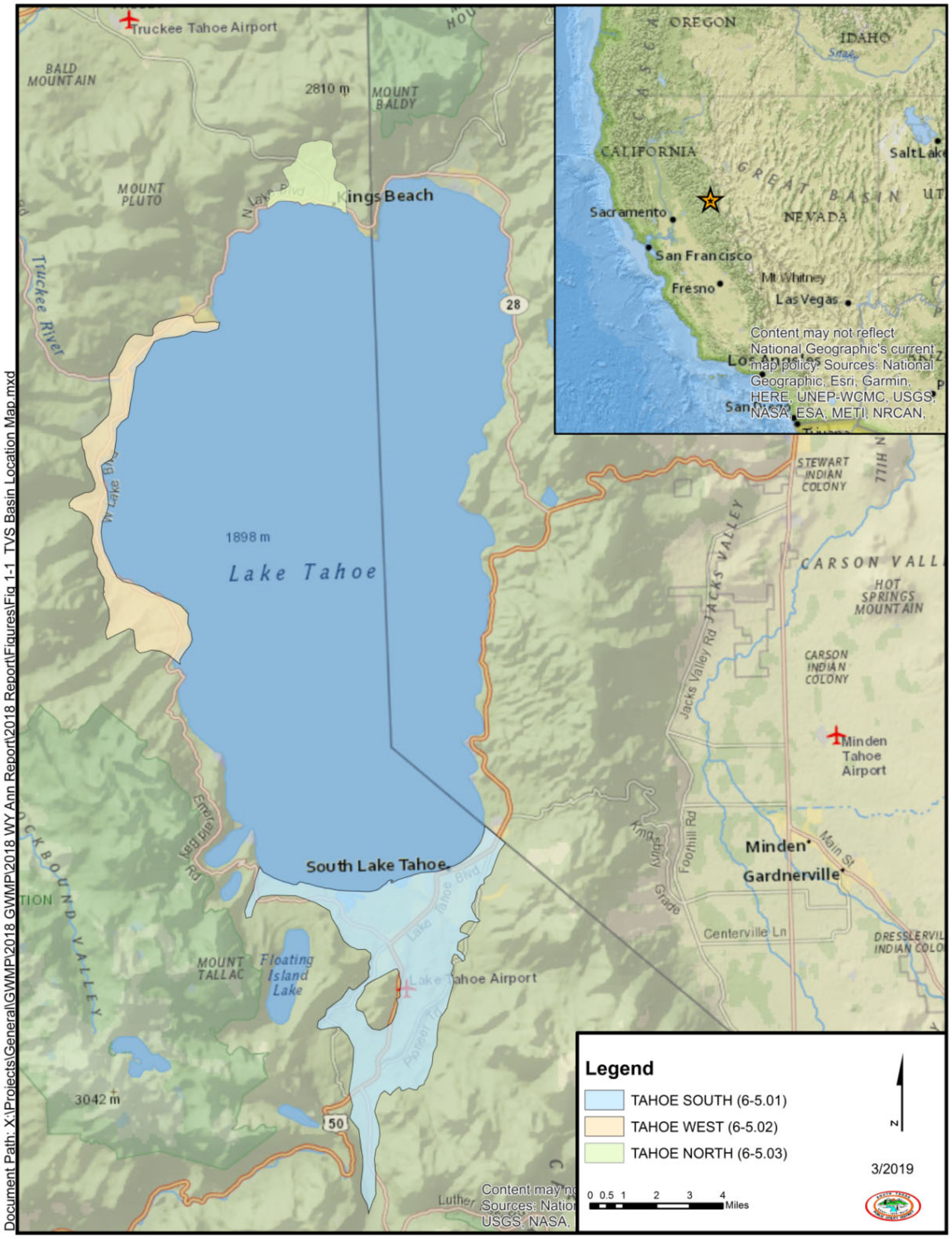

Figure 1-1. Lake Tahoe area regional map with DWR-designated groundwater subbasins.

The TVS Subbasin has an area of approximately 23 square miles (14,814 acres) and is in EDC (Figure 1-2). The TVS Subbasin is roughly triangular-shaped, bounded on the southwest by the Sierra Nevada Range, on the southeast by the Carson Range, and on the north by the southern shore of Lake Tahoe. The TVS Subbasin generally conforms to the valleys of the Upper Truckee River and Trout Creek. The TVS Subbasin does not share a boundary with any other DWR groundwater basin or sub-basin. The CSLT overlies the northern portion of the TVS Subbasin. The southern boundary extends about 3 miles south of the unincorporated town of Meyers. The northeast boundary of the TVS Subbasin is defined by the California-Nevada state line. For ease of description, the TVS Subbasin is subdivided into six geographically based sub-areas, referred to as the Tahoe Keys, South Lake Tahoe, Bijou, Angora, Meyers, and Christmas Valley sub-areas. The location and extent of these sub-areas are shown on Figure 1-2.

The TVS Subbasin includes the CSLT and portions of eastern EDC, which encompasses the unincorporated communities of Meyers, Angora Highlands and Christmas Valley. Within the greater South Lake Tahoe area, most of the land use is classified as Conservation area, followed by Residential, Recreation, Commercial and Public Service, and Tourist areas. Most of the Conservation areas are federal lands managed by the United States Forest Service - Lake Tahoe Basin Management Unit (LTBMU). Most of the federally managed land is located outside of the TVS Subbasin but does include large areas around the Camp Richardson/Fallen Leaf Lake area within the northwest portion of the TVS Subbasin; and along the basin margin on the east side of the TVS Subbasin.

Groundwater is the primary source of drinking water for the communities overlying the TVS Subbasin. Surface water for recharge or in-lieu use is not presently used, except by Lakeside Park Association (LPA). In January 2020, the District submitted Amended Application No. A023393 to the State Water Resources Control Board Division of Water Rights (SWRCB-DWR) to secure water rights based on a water demand analysis of future water needs for the greater South Lake Tahoe area (BHFS, 2020). This amended application is currently pending.

Most water wells drilled in the TVS Subbasin are completed in basin-fill deposits that generally consist of unconsolidated glacial, lake and stream sediments. These sedimentary deposits fill the lower reaches of the canyons that drain toward Lake Tahoe and underlie the relatively flat lying valley floors. These deposits can be over 1,000 feet thick in the deeper portions of the TVS Subbasin, but thin toward the basin margins where they cover shallow bedrock areas. Numerous water-bearing zones (WBZs) have been identified using lithologic and geophysical logs and interpreted correlations to divide the basin-fill into multiple layers, representing regionally correlated units of high and low permeability. Units of relatively high permeability typically correspond to coarse-grained glacial outwash, fluvial and deltaic deposits forming the basin-fill aquifer. The laterally continuous fine-grained lacustrine (lake bed) deposits form local confining layers or aquitards that affect groundwater flow between these higher permeability deposits.

Figure 1-3 is a conceptual hydrogeological cross section across the northern portion of the TVS Subbasin used to illustrate the WBZs. The different WBZ designations are informal and are based on the local geographic area and the stratigraphic order in which the unit occurs. This is indicated as a subscript from deep to shallow depth (1 = lowermost zone; 5 = uppermost zone). The deepest zone (WBZ1) occurs in the deepest portions of the basin, generally at depths below 600 feet, and may act as a confined aquifer and show artesian conditions in some areas. The middle two zones (WBZ2 and WBZ3) represent the interval at depths between 200 to 600 feet and the shallowest two zones (WBZ4 and WBZ5) represent depths from 0 to 200 feet (Bergsohn, 2011).

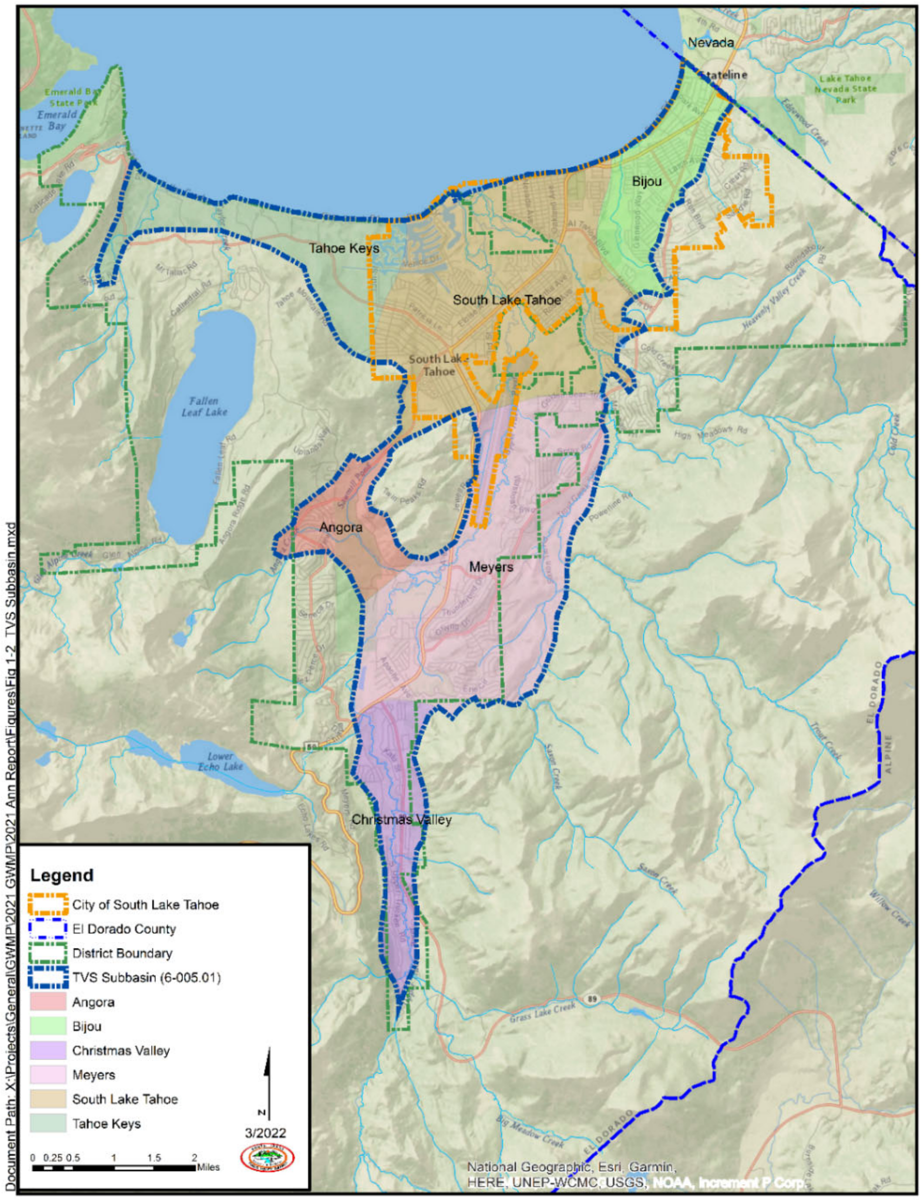

Figure 1-2. TVS Subbasin showing jurisdictional boundaries and geographically based sub-area designations used in this report.

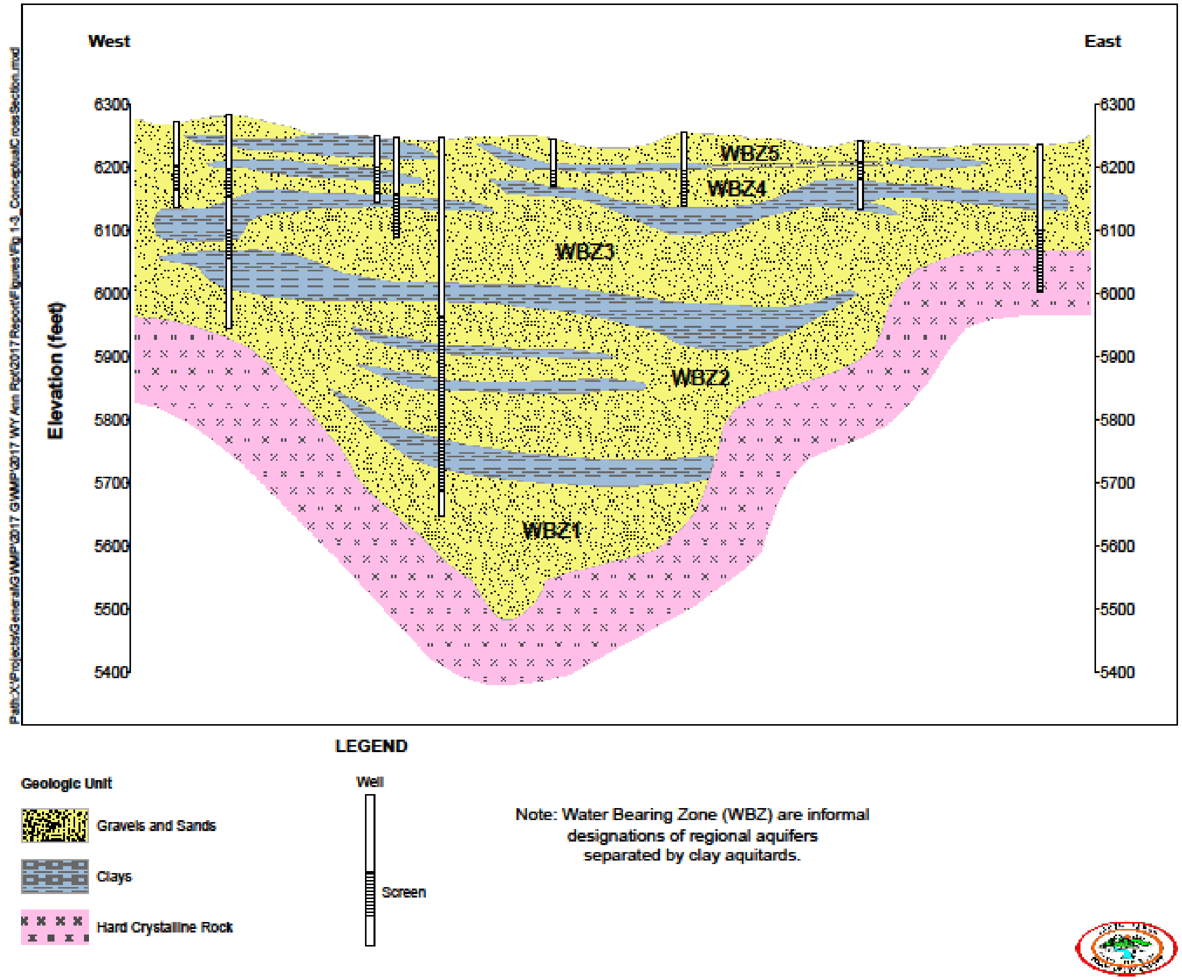

Figure 1-3. Conceptual geologic cross-section oriented east-west showing typical WBZs within the TVS Subbasin (Adapted from Kennedy Jenks, 2014).

1.2 Water Year Classification

In terms of precipitation, WY 2022 was a normal water year using the water year classification developed for the TVS Subbasin. Under the Groundwater Sustainability Plan (GSP) Regulations, annual precipitation in a basin is required to be described in terms of water year type. DWR generally assigns water year type based on river flow indices or precipitation amounts and has developed water year classification systems for several hydrologic basins in California. For example, for the Sacramento Valley hydrologic basin, SWRCB developed five categories based on runoff forecasts and previous water year's index: 1) wet, 2) above normal, 3) below normal, 4) dry, and 5) critical (SWRCB, 1978).

The water year classification for the TVS Subbasin was created by the Desert Research Institute (DRI) following initial development of the STGM and a water budget for the TVS Subbasin. During development of the water budget, a strong linear correlation was identified between simulated precipitation from the Groundwater and Surface Water Flow (GSFLOW) Regional Model for the Truckee River Basin (GSFRM) and groundwater recharge to the TVS Subbasin. Linear correlation was also found between groundwater recharge to model calculated change of groundwater in storage. Using these relationships from the modeling analysis, total accumulated precipitation measured at four National Resources Conservation Service (NRCS) SNOTEL stations within the model domain were further evaluated to find the SNOTEL station with the best correlation to the simulated precipitation from the GSFRM. SNOTEL 508: Hagan's Meadow, CA was found to have the best correlation with model simulated groundwater recharge and change in groundwater storage. Therefore, NRCS precipitation records for this station were used as a reference station to classify water year type for the TVS Subbasin (Carroll et al., 2016b). The regression equation between annual total precipitations at SNOTEL 508: Hagan's Meadow, CA to groundwater recharge within the TVS Subbasin and surrounding watersheds is shown below in Figure 1-4.

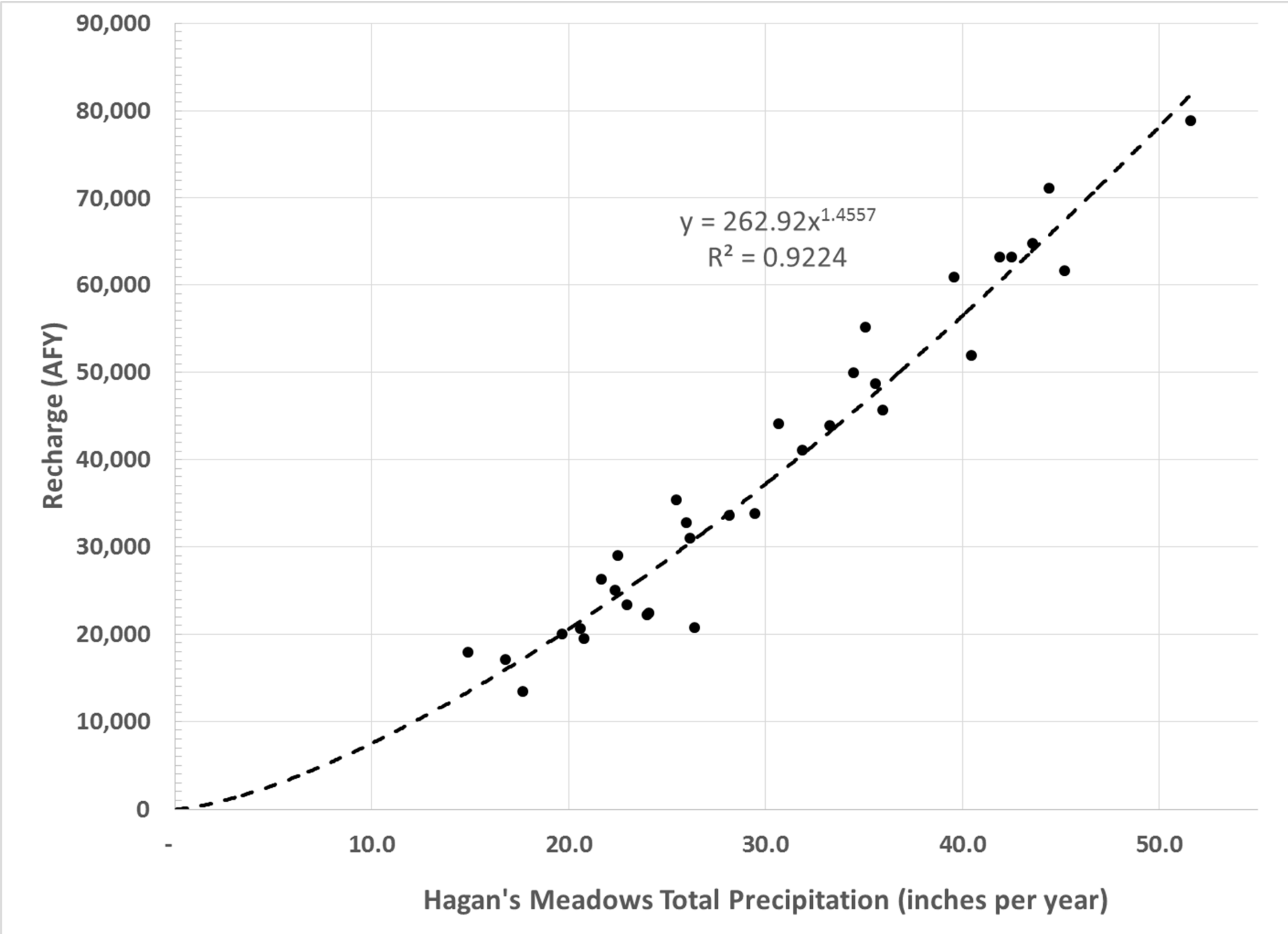

Figure 1-4. SNOTEL 508: Hagan's Meadow, CA annual precipitation versus modeled groundwater recharge within the model domain (G. Pohll et al., 2016)

For the TVS Subbasin, precipitation for WY 1979 – WY 2017 was categorically defined by assuming a normal distribution and establishing ranges based on the z-statistics in Table 1-2. To allow more flexibility in WY type, seven categories were established: 1) very wet, 2) wet, 3) above normal, 4), normal, 5) below normal, 6) dry, and 7) critical. The very wet periods are indicated by a z-statistic > 1.5 and occur in 1982 WY, 2011 WY and 2017 WY. The critical water year is indicated by a z-statistic – 1.5 and occurs when total accumulated precipitation is less than 14 inches. During the 2022 WY, total accumulated precipitation measured at SNOTEL 508: Hagan's Meadow, CA was 31.1 inches, within the normal range. Table 1-2 shows the z-statistics, the calculated precipitation range for each water year type, and the number of each water year type (count) occurring over the period of record (1979 – 2022) for this station. Figure 1-5 shows a graphical representation of this record.

WY Type	z (upper)	Precipitation (in) (WY 1979-WY 2017)		Count = (1979 -2022)
		>	≤	
Very Wet	> 1.5	49	-	3
Wet	1.5	43	49	4
Above Normal	1.0	37	43	5
Normal	0.5	26	37	14
Below Normal	-0.5	20	26	14
Dry	-1.0	14	20	4
Critical	-1.5	0	14	0

Table 1-2. Classification system for Water Year (WY) Type based on observed WY accumulated precipitation at SNOTEL 508: Hagan's Meadows, CA. Upper bound of z-statistic and ranges in precipitation (inches) (Adapted from Carroll *et al.,* 2016b).

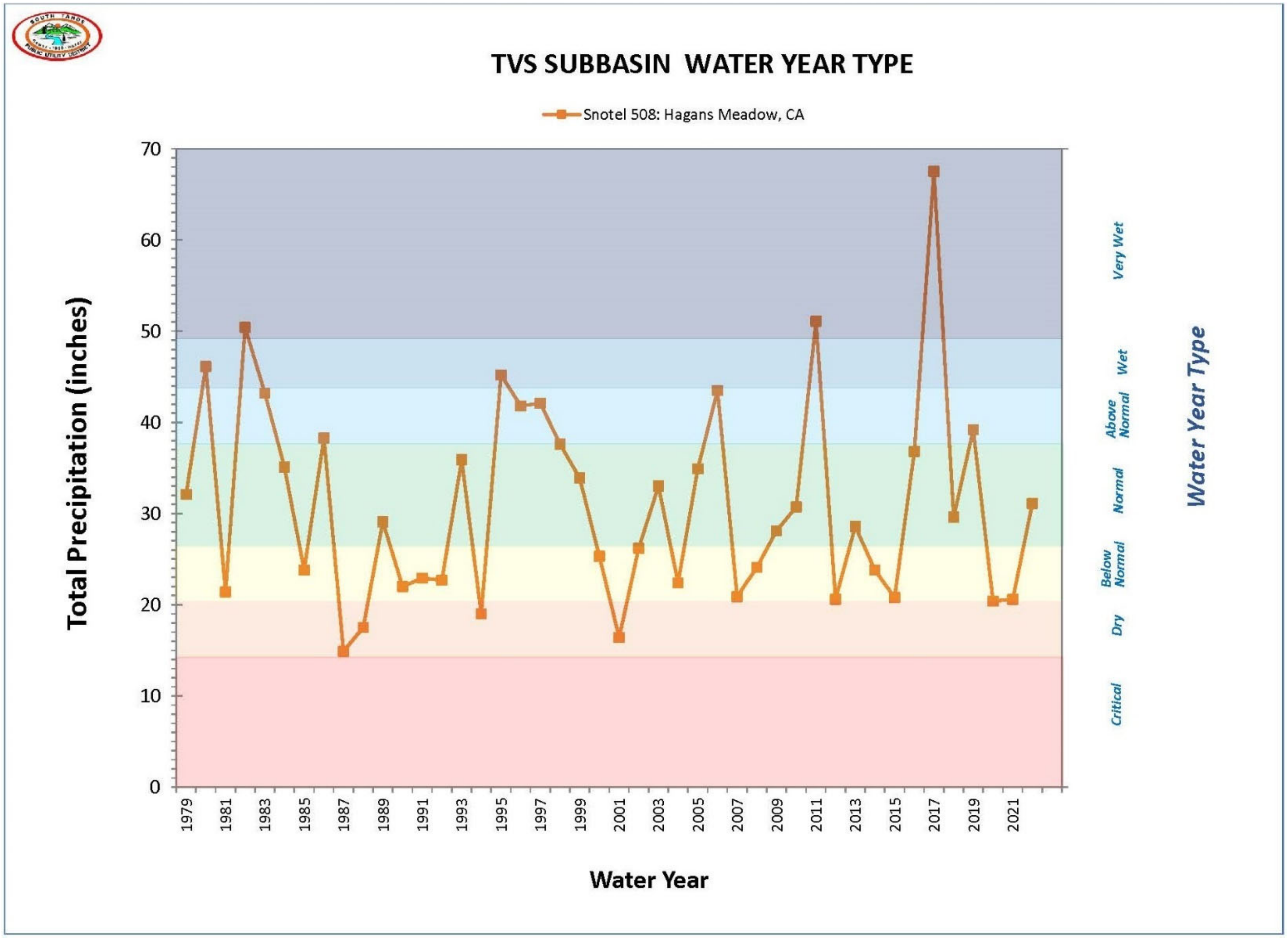

Figure 1-5. The annual accumulated precipitation measured at SNOTEL 508: Hagan's Meadow, CA and water year type indicated on the vertical axis along the right-side of the graph. Precipitation ranges for each water year type are listed in Table 1-2.

2 Groundwater Conditions

The following section presents data collected by the District and information derived from numeric groundwater models to show the current state of the TVS Subbasin. Hydrographs showing groundwater elevation trends across the TVS Subbasin are provided in Appendix A.

2.1 South Tahoe Groundwater Model

The STGM was originally developed by DRI (Carroll, et al., 2016a; Carroll, et al., 2016b; Pohll, et al., 2018) to address BMOs identified in the 2014 GWMP. For use in the first five-year update of the Alternative Plan, it was updated to represent more recent years of the historical record and to extend predictive modeling scenarios further into the future. The model is used to quantify the TVS Subbasin conditions and is based on the U.S. Geological Survey (USGS) Newton-Rhapson formulation for MODFLOW -2005, referred to as MODFLOW-NWT (Niswonger et al., 2011) software. MODFLOW-NWT relies on an unstructured, asymmetric matrix solver to calculate groundwater head. MODFLOW-NWT is specifically designed to work with the Upstream Weighting Package to solve complex, unconfined groundwater flow simulations to maintain numerical stability during the wetting and drying of model cells.

The model grid is oriented north-south and contains 342 rows and 251 columns. Horizontal cell size is 100 meters (328 feet) and is based on the need to capture steep topography, narrow canyons, and potentially steep hydrologic gradients. The model is subdivided into four subsurface layers to maintain reasonable computation time. Layers are determined based on production well screen intervals. Land surface elevations are based on 30-meter (98 feet) Digital Elevation Model (DEM) aggregated to a 100-meter (328 feet) spatial resolution. Layer thicknesses are 40 meters (131 ft) for layer one and layer two, and 100 meters (328 feet) for layer three. Layer four bottom elevation is set to a constant 1,600 meters (5,248 feet) to produce variable thickness ranging from approximately 114 meters (274 feet) along the northern boundary with Lake Tahoe to 1,300 meters (4,264 feet) at watershed divides.

The model grid (i.e., model domain) covers an area of 99,907 acres commensurate with the South Lake Tahoe area (Figure 2-1). For ease of reporting the model domain is differentiated into two spatial zones (Zone 1 and Zone 10). Zone 1, referred to as the Mountain Block, covers an area of 85,093 acres encompassing the surrounding watersheds extending to the watershed divides, outside the TVS Subbasin. Zone 10 covers an area of 14,814 acres encompassing the TVS Subbasin as defined by DWR in Bulletin 118 (DWR, 2021). Organization of the model domain into spatial zones allows for comparison and reporting of discrete water budgets (including changes of groundwater in storage for the model domain (Zone 1 + Zone 10), the Mountain Block (Zone 1) and the TVS Subbasin (Zone 10). Reporting of water budgets specifically for the TVS Subbasin rather than the surrounding watershed area inclusive of the TVS Subbasin was a recommended action identified by DWR for the first five-year update of the Alternative Plan.

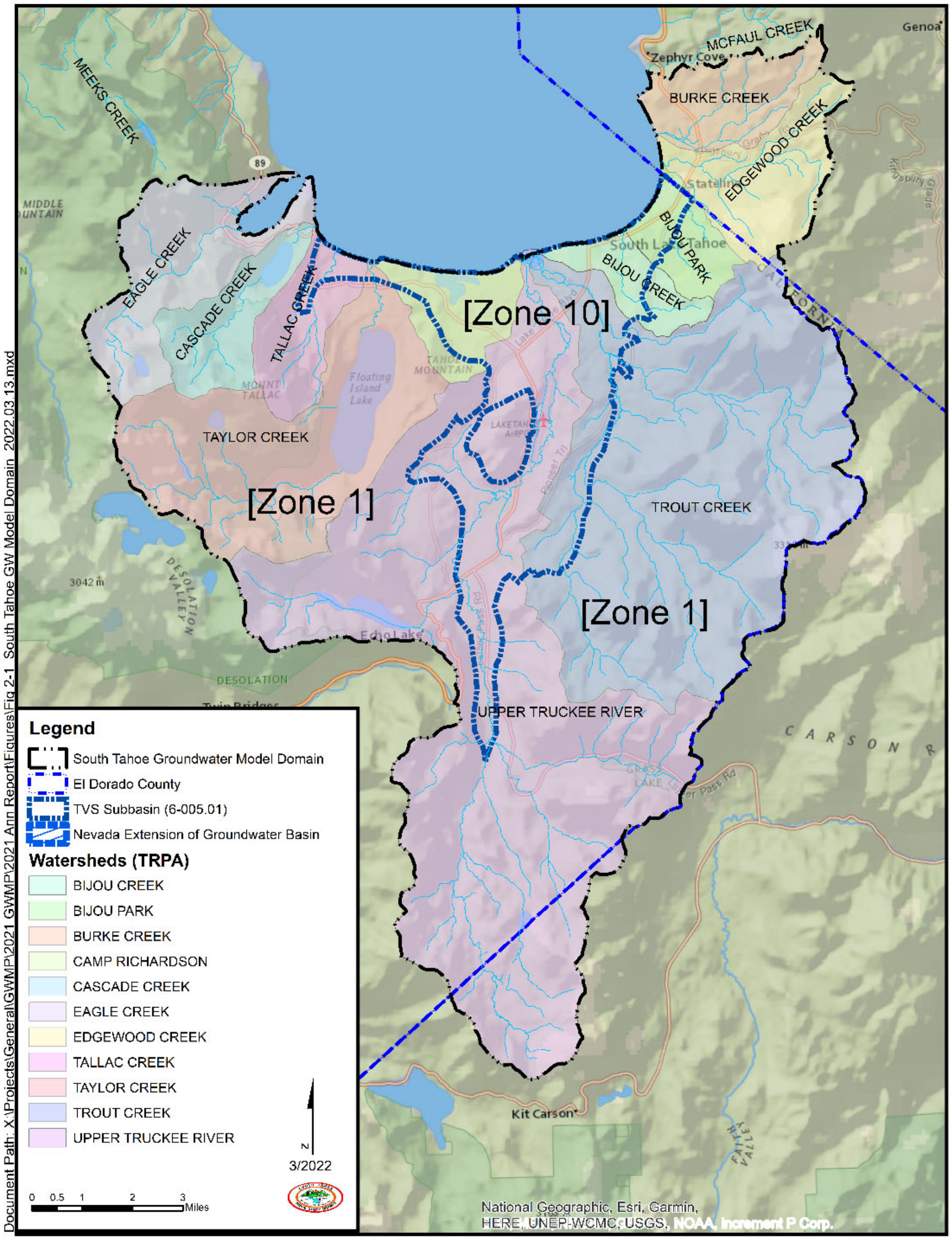

Figure 2-1. The model domain for the South Tahoe Groundwater Model encompasses the TVS Subbasin as defined by DWR (Zone 10) and the surrounding watersheds extending to the watershed divides (Zone 1).

2.2 Groundwater Recharge

Groundwater recharge to the TVS Subbasin is the sum of areal recharge over the TVS Subbasin (Zone 10) and the subsurface inflow of groundwater from the adjoining mountains (Zone 1) to the TVS Subbasin (Zone 10), referred to as Mountain Block Recharge (MBR). MBR is calculated in the water budget as the difference between the areal recharge within Zone 1 and the sum of the baseflow to streams plus discharge to Lake Tahoe within Zone 1.

Recharge for the TVS Subbasin was extracted from the transient model of the STGM. Figure 2-2 shows annual total recharge, areal recharge and MBR over the simulation period of the transient model (WY 1983 WY- WY 2022). For WY 2022, total groundwater recharge to the TVS Subbasin is calculated at 21,545 acre-feet (AF) or about average over the simulation period (WY 1983 WY – WY 2022). Of this total, about 24% (5,089 AF) is areal recharge and 76% (16,457 AF) is MBR.

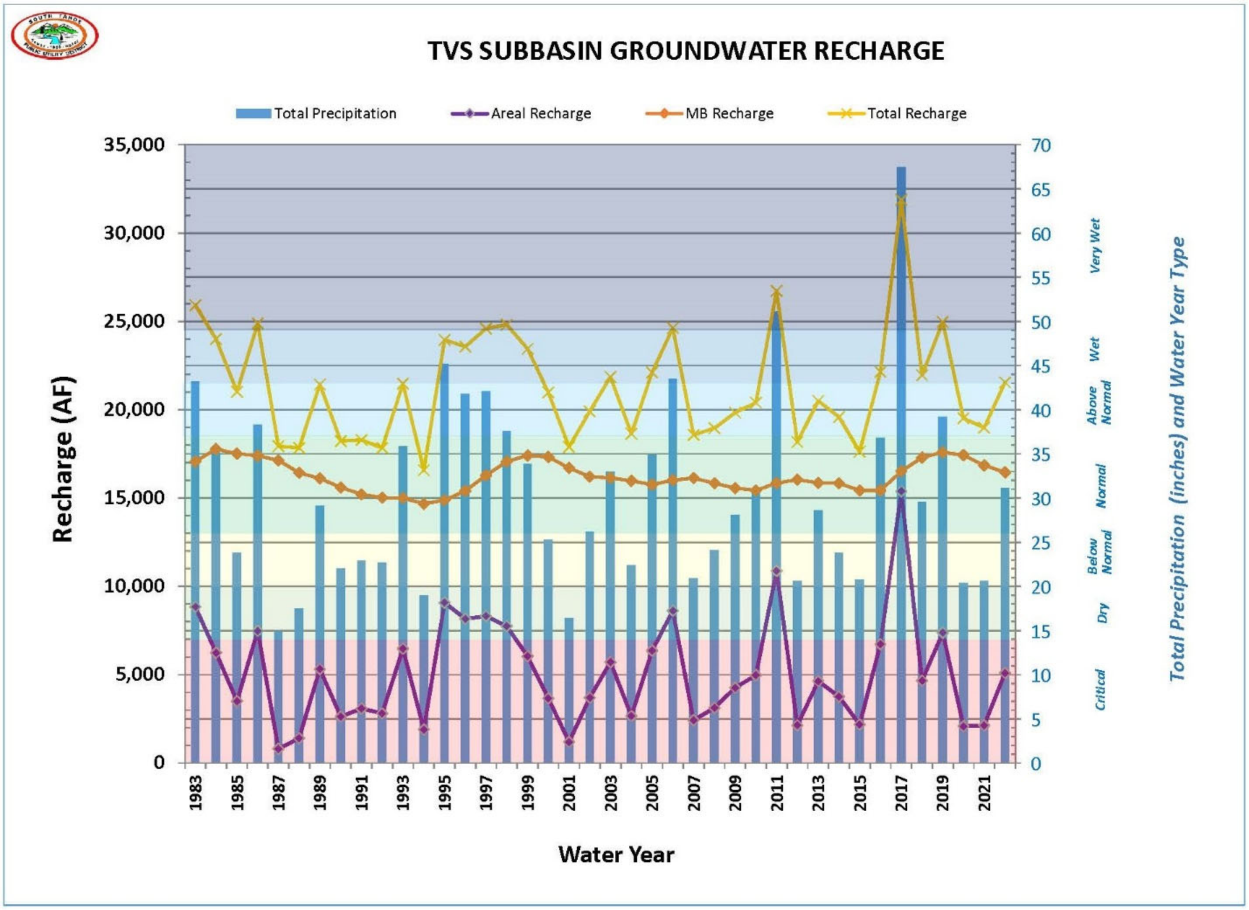

Figure 2-2. Areal, mountain block and total recharge (AFY) for the TVS Subbasin (WY 1983 – WY 2022).

Water year type using the TVS Subbasin classification from total precipitation measured at SNOTEL 508 Hagan's Meadow, CA is indicated on the secondary vertical axis on the far right-side of the graph.

2.3 Groundwater Level Monitoring

The District is the designated monitoring entity for the TVS Subbasin under the CASGEM program. As such, groundwater level elevation monitoring data is reported semi-annually to DWR through the CASGEM online reporting system, including in WY2022. Groundwater levels are regularly measured in forty-seven (47) wells located throughout the TVS Subbasin. The District well network includes thirty-two (32) observation wells and fourteen (14) Community Water Supply (CWS) wells (Figure 2-3). Eleven (11) of the CWS wells are actively used for drinking water supply. Three of these wells are on stand-by status, used only for emergency purposes. The observation wells include monitoring wells, sentinel wells and test wells, as well as former drinking water supply wells that have been removed from service and are no longer connected to the District's water distribution system. Only the observation wells are used for reporting to the CASGEM program.

Construction details for selected wells for which hydrographs are provided (Appendix A) are set forth in Table 2-1. The sub-areas, shown in Table 2-1, are informal designations using the geographically based designations (Christmas Valley, Meyers, Angora, South Lake Tahoe, Tahoe Keys and Bijou) shown on Figure 1-2. The Christmas Valley sub-area is in the southernmost portion of the TVS Subbasin, south of Lake Valley and US Route 50. The Meyers sub-area is in the southern portion of Lake Valley from US Route 50 north to Twin Peaks. The Angora sub-area is in the northern portion of Lake Valley west of Twin Peaks. The South Lake Tahoe sub-area is located north of Lake Valley. The Tahoe Keys sub-area is located at the north end of the TVS Subbasin, west of the South Lake Tahoe sub-area, while the Bijou sub-area is located east of the South Lake Tahoe sub-area.

Basin monitoring generally involves the collection and evaluation of groundwater level, groundwater quality, groundwater production and climate data from numerous sources for the TVS Subbasin. A detailed description of the groundwater monitoring conducted in the TVS Subbasin is provided in Section 9.0 of the Alternative Plan. As part of the groundwater level monitoring effort, the District uses both hand and continuous readings to monitor groundwater elevation trends across the TVS Subbasin. Hand readings are collected from each of the TVS Subbasin groundwater elevation monitoring wells in the fall and spring of each water year. Hand readings from active CWS wells are collected a minimum of 12 hours after well pumps are turned-off for static water level measurements. A smaller number of observation wells (13) are fitted with dedicated water-level monitoring equipment. The data loggers are programmed to collect pressure head and temperature readings at 6:00 AM and 6:00 PM daily to provide a continuous record of groundwater levels in the TVS Subbasin.

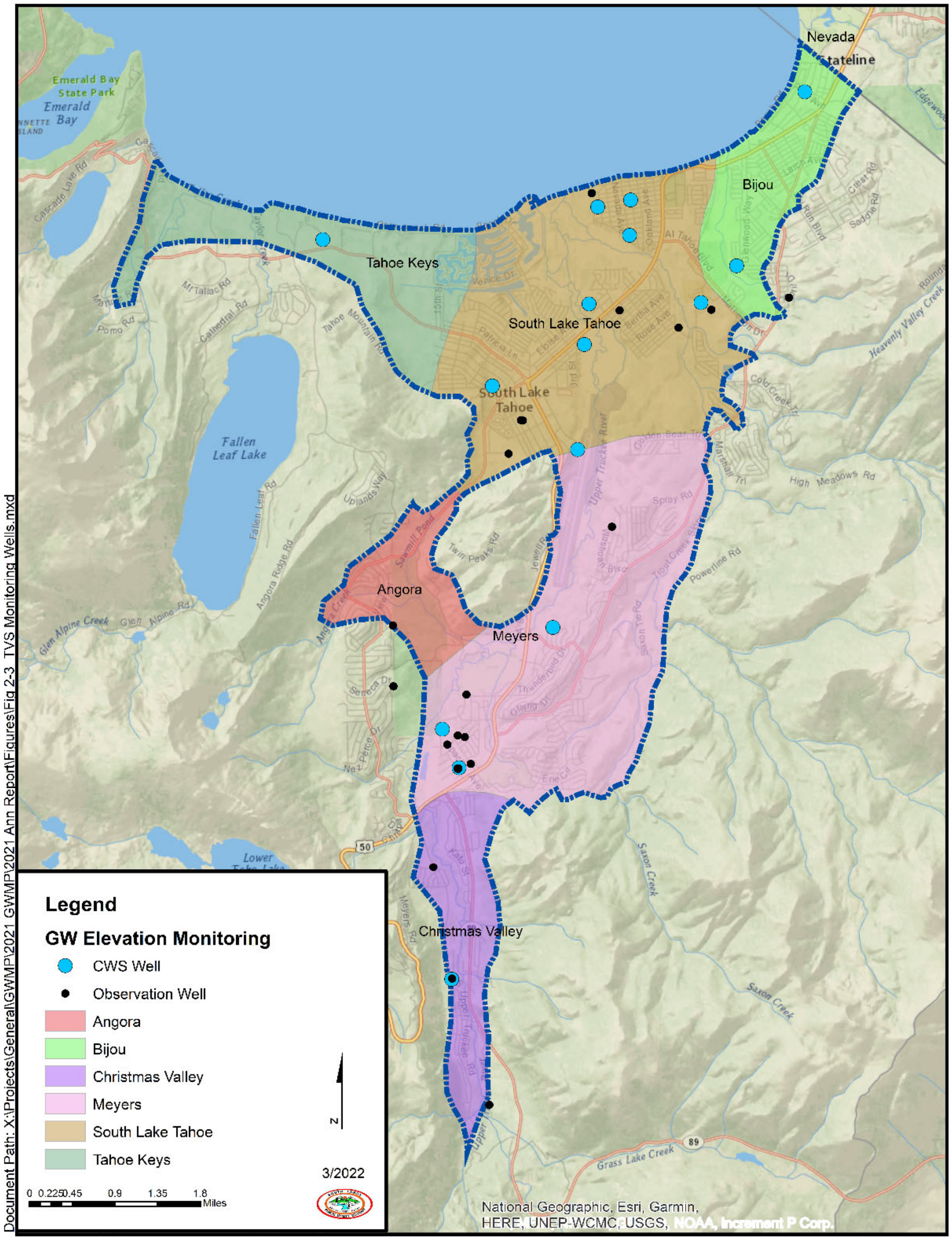

Figure 2-3. Locations of wells used for monitoring changes in groundwater elevation within the TVS Subbasin.

Well	Sub-Area	Reference Point Elevation (ft msl)	Top of Screen Depth (ft bgs)	Bottom of Screen Depth (ft bgs)
Mountain View	Angora	6313.14	95	164
Blackrock Well #1	Bijou	6242.72	168	180
Glenwood Well #3	Bijou	6261.68	112	192
Henderson OW	Christmas Valley	6369.78	79	100
			142	205
Bakersfield	Meyers	6310.50	130	170
			180	240
Elks Club Well #1	Meyers	6284.63	110	142
Washoan OW	Meyers	6307.84	102	144
			165	186
			207	228
			249	270
CL-1	South Lake Tahoe	6278.37	104	114
CL-3	South Lake Tahoe	6278.49	39	49
Paloma	South Lake Tahoe	6267.10	188	248
			268	408
Sunset	South Lake Tahoe	6249.00	275	430
Martin OW	South Lake Tahoe	6262.42	95	115
			125	145
			160	180
			200	240
USGS TCF-1-1	South Lake Tahoe	6296.48	325	340
USGS TCF-1-2	South Lake Tahoe	6296.47	245	260
USGS TCF-1-3	South Lake Tahoe	6296.65	158	163
USGS TCF-1-4	South Lake Tahoe	6296.63	130	140
USGS TCF-1-5	South Lake Tahoe	6296.63	88	98
Lily OW	South Lake Tahoe	6236.08	35	37.5
Valhalla	Tahoe Keys	6256.50	110	170

NOTES:

feet msl: Elevation in feet above mean sea level (NAVD88).

ft bgs: Depth in feet below ground surface.

Table 2-1. Screen intervals for selected groundwater elevation wells within the TVS Subbasin. Hydrographs for these wells showing groundwater level trends within each sub-area are provided in Appendix A.

2.4 Groundwater Levels

Hydrographs of continuous groundwater elevation readings collected from four observation wells across the TVS Subbasin are provided below on Figure 2-4. The Henderson Observation Well (OW) is located near the south end of the TVS Subbasin at the north end of the Christmas Valley sub-area. The Washoan OW is located near the center of the TVS Subbasin, within the north half of the Meyers sub-area. The Martin OW and Lily OW are both located at the north end of the TVS Subbasin, within the South Lake Tahoe sub-area. The Martin OW is located near the east margin of the TVS Subbasin within the south half of the sub-area; and the Lily OW is located nearest the south shore of Lake Tahoe within the north half of the sub-area.

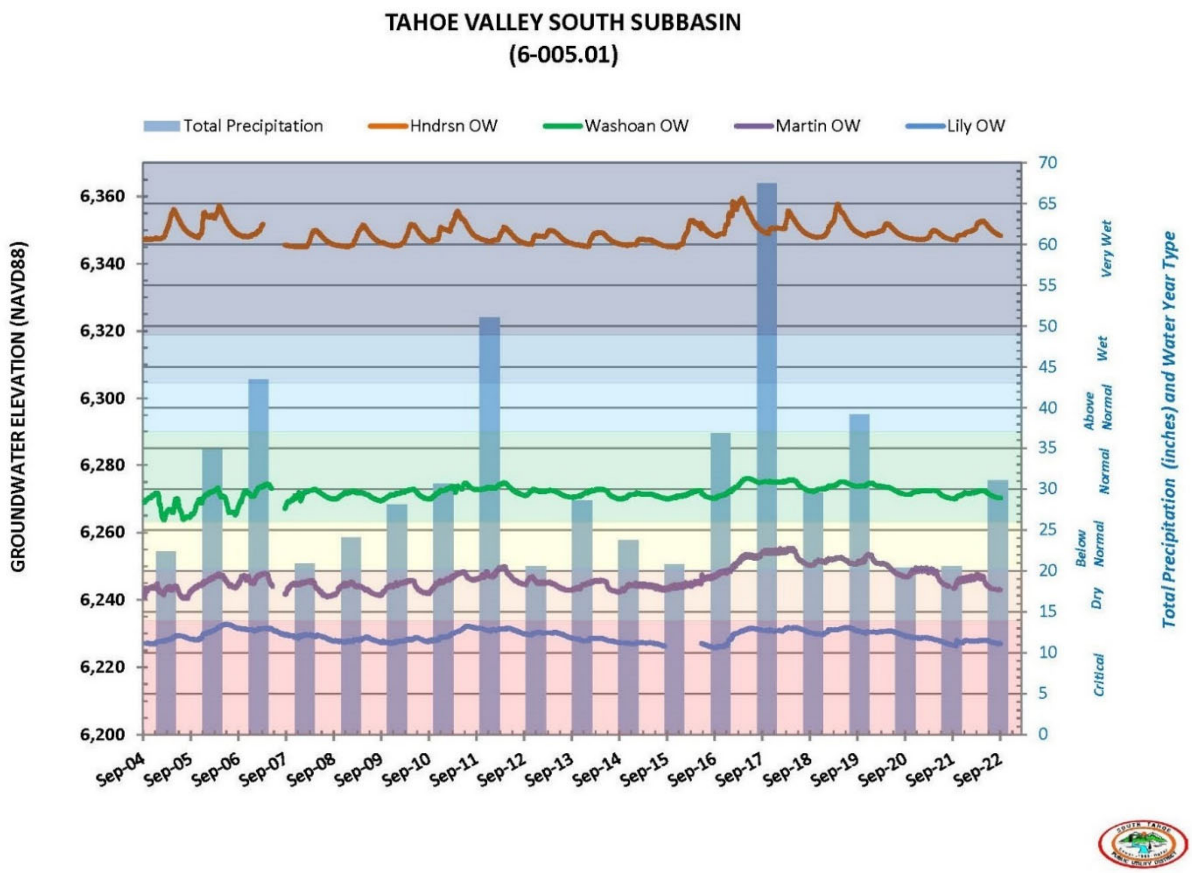

Figure 2-4. Continuous groundwater level readings collected from selected wells distributed across the TVS Subbasin.

Over the period of record (WY 2005 WY – WY2022), the continuous readings show that groundwater elevations have been relatively stable. During this period, there were seven below normal water years; seven normal water years; one above normal water year; one wet water year; and two very wet water years (see Figure 1-5). Regular fluctuations representing seasonal changes in groundwater elevations are most pronounced in the Henderson OW. This may be due to its remote location, away from the pumping influence of neighboring wells and away from the groundwater elevation influence of Lake Tahoe. Groundwater elevations tend to rise during the winter storm season when precipitation exceeds evaporation, evapotranspiration is at its lowest and groundwater production is at or near seasonal low water demands. As a result, seasonal high groundwater levels typically occur between early-April through mid-June. Groundwater levels then tend to decline during the summer and into the fall, when evapotranspiration exceeds precipitation and groundwater production is at or near seasonal high water demands. Seasonal low groundwater elevations typically occur at the end of this seasonal cycle, between mid-September through mid-November.

2.4.1 Basin Condition (Groundwater Levels)

Hand readings collected in May from the groundwater elevation monitoring wells of each water year were compared to hand readings collected during a ten-year period (WY 2001 – WY 2010) prior to the statewide drought emergency declared in California during a five-year period spanning WY 2012 through WY 2016 (https://water.ca.gov/Water-Basics/Drought).

This analysis was used to ascertain the current condition of groundwater levels compared to the ten-year base period (WY 2001 – WY 2010) selected for the TVS Subbasin. This base period was selected because groundwater level data for the basin monitoring wells during that time-period were relatively complete and were collected prior to the 2012-2016 drought event. During the base period, accumulated precipitation measured at SNOTEL 508: Hagan's Meadow, CA averaged 29.3 inches, which is within the normal range of precipitation for the TVS Subbasin. During the base period for groundwater levels there were one dry water year, three below normal water years, five normal water years, and one wet water year (see Figure 1-5).

Hand readings collected during WY 2022 were used to define current basin conditions as being either normal, above normal, or below normal with respect to the record of groundwater levels collected during the base period (WY 2001 – WY 2010). The percentile rank of the May 2022 groundwater elevation at each well was determined for more than thirty (30) of the groundwater elevation monitoring wells using the record of hand readings collected for that well during the base period. The percentile rank of the May 2022 groundwater elevation for each well was then plotted on a cumulative frequency diagram to show the current state of the TVS Subbasin in terms of groundwater levels (Figure 2-5).

Figure 2-5 shows the distribution of groundwater elevations measured in May over the past five water years (WY 2018 – WY 2022) using their respective percentile ranks within the record of groundwater levels measured for the same wells during the base period (WY 2001 – WY 2010).

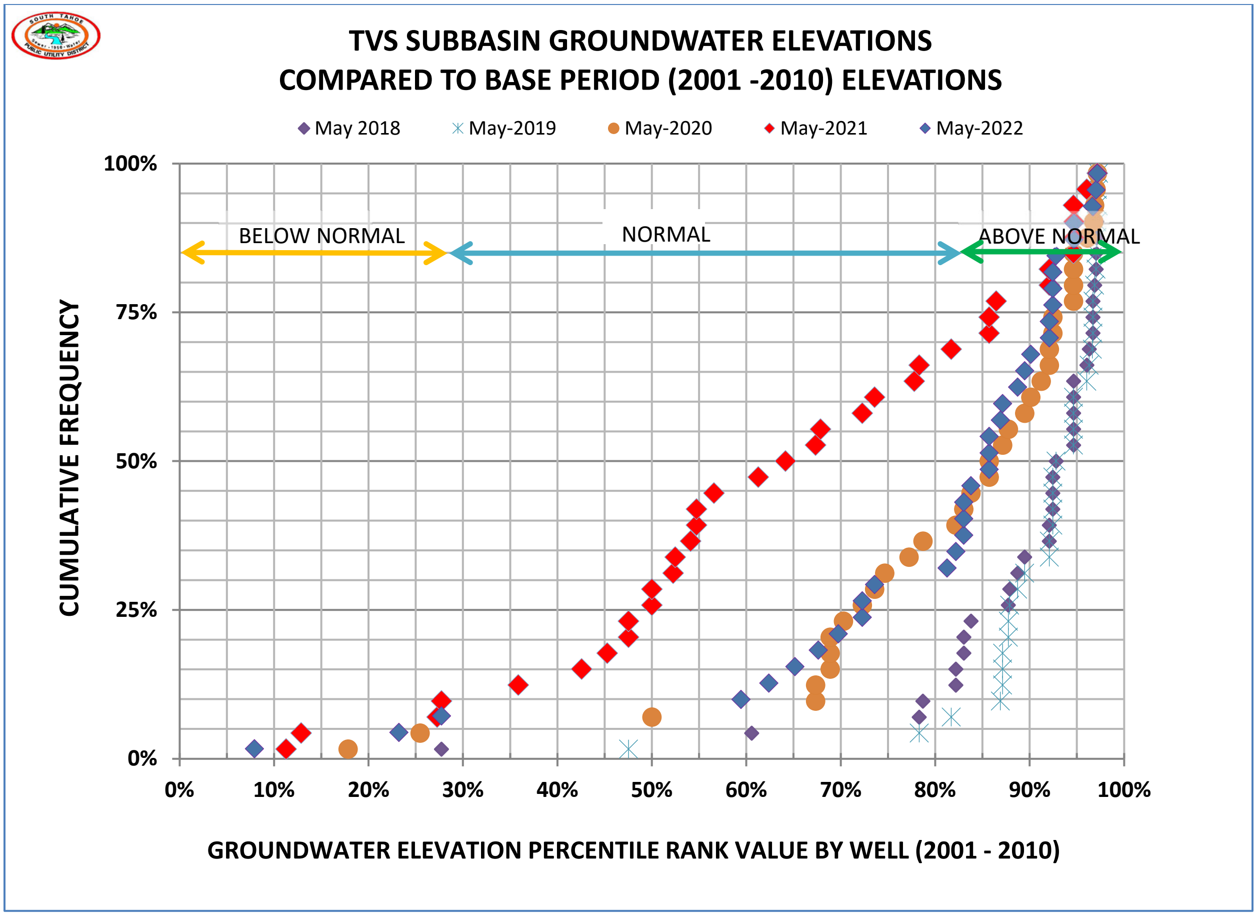

Figure 2-5. Hand readings collected during the May groundwater elevation monitoring event for WY 2017 through WY 2022 compared to the record of hand readings for the same wells collected during the base period for groundwater elevations (WY 2001 through WY 2010).

In WY 2022, the basin conditions generally returned to normal with respect to the base period (WY 2001 – WY2010). The May 2022 groundwater elevations indicated that three (3) wells fell in the below normal range (Seneca Test Well, USGS TCF-5, and Sunset); fourteen (14) wells fell in the normal range; and nineteen (19) wells fell in the above normal range.

Between May 2017 and May 2022, the difference in groundwater elevations averaged -3.88 feet (a decrease). Table 2-2 summarizes the minimum, maximum, and average change in groundwater elevations over the past five years. Localized conditions can greatly impact individual wells, but overall groundwater elevations across the basin have only changed a few feet on average. The annual changes in field measured differences in groundwater elevation readings are consistent with the annual changes in total precipitation measured at the TVS Subbasin reference station (SNOTEL 508) and the changes in groundwater recharge observed in the flow budgets derived from the STGM.

Comparison Period	Groundwater Elevation Change (feet)		
	Minimum	Maximum	Average
May 2017 – May 2018	-18.55	3.44	-1.85
May 2018 – May 2019	-7.6	36.65	0.79
May 2019 – May 2020	-7.17	16.96	-1.82
May 2020 – May 2021	-6.65	4.09	-2.21
May 2021 – May 2022	-3.58	6.7	1.21

Table 2-2. Groundwater Elevation Change (feet)

2.4.2 Groundwater Elevation Contours

Isocontours of groundwater elevations for October 2021 and May 2022 are presented in Figure 2-6 and represent seasonal low and seasonal high groundwater elevation conditions. The typical pattern is for seasonal low groundwater conditions to occur in the late summer and early fall due to low recharge following the relatively dry summer months and increased groundwater pumping to meet high water demands. Seasonal high groundwater conditions typically occur in the spring following the spring snowmelt runoff and lower groundwater pumping needed to meet low water demands.

The STGM simulates the period WY 1983 – WY 2022 to calculate changes in groundwater levels and flux due to variations in precipitation and groundwater extractions. Model simulated groundwater levels were used to generate the groundwater elevation contours presented in Figure 2-6. These contours are considered appropriate to illustrate the general pattern of groundwater flow in the TVS Subbasin. Comparison of contours shows that the generalized pattern of groundwater flow remains very similar between October 2021 and May 2022. This is consistent with the hydrograph data (Appendix A) that shows the typical variation in groundwater levels is on the order of only a few feet.

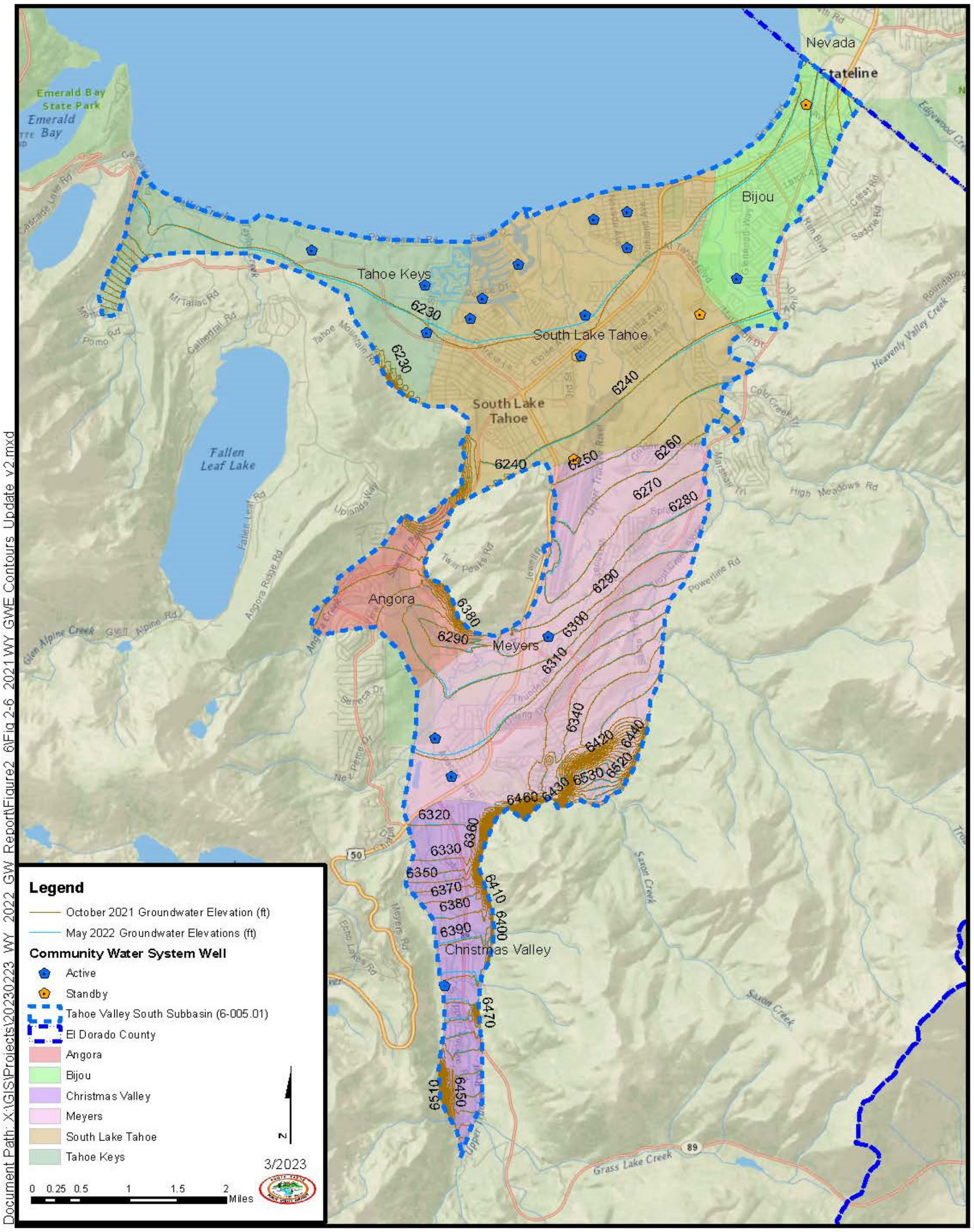

Figure 2-6. Model simulated groundwater elevations (upper 300 ft) for the TVS Subbasin, representing. seasonal low (October 2021) and seasonal high (May 2022) groundwater conditions. Contour interval is 10 ft.

2.5 Degraded Groundwater Quality

Groundwater in the TVS Subbasin is typically of excellent quality; however, there is a history of groundwater contamination from both naturally occurring contaminants (for example arsenic, iron manganese and uranium) and regulated industrial and commercial chemicals (for example petroleum hydrocarbon and chlorinated hydrocarbon compounds). An overview of groundwater quality based on available water quality records from 2011 – 2020 was completed for periodic evaluation of groundwater conditions in conjunction with the update of the Alternative Plan (Rybarski et al, 2022). The following section summarizes important findings from this evaluation, including updated information from WY 2022, with an emphasis on the impact of degraded water quality on groundwater sources and beneficial use and users of groundwater (in terms of available source capacity) within the TVS Subbasin.

2.5.1 General Constituents

Groundwater from water supply wells is relatively low in total dissolved solids with typical values on the order of 100 milligrams per liter (mg/L). Average values for chloride and sulfate are very low at about 10.4 mg/L and 3.3 mg/L, respectively. Maximum nutrient concentrations for Nitrate (NO3 as N) and Nitrite (NO2 as N) are also low at 1.36 mg/L and 0.07 mg/L, respectively, well within MCLs for these constituents. There were no water supply wells with detections of regulated general constituents above primary and secondary maximum contaminant levels (MCLs).

2.5.2 Inorganic Constituents

Inorganic constituents detected in water samples collected from water supply wells above primary or secondary MCLs include aluminum (1 well); arsenic (5 wells), iron (8 wells), and manganese (3 wells). Arsenic has been detected in three wells within the District and TKWC water systems. Well head treatment (ferric-oxide adsorption) is presently used to remove arsenic from groundwater produced at one active District well (Arrowhead Well #3). A second District well with elevated levels of arsenic above MCLs (Airport Well) is an emergency stand-by source. Arsenic concentrations above MCLs have also been detected in TKWC #2. During WY 2022, there was no pumpage from the Airport Well.

2.5.3 Radioactive Constituents

Radioactive constituents detected in water samples collected from water supply wells above primary or secondary MCLs include total soluble uranium (3 wells) and gross alpha activity (12 wells). Of the three wells with detections of uranium above MCLs, two of those wells are within the TKWC water system (TKWC #2 and TKWC #3), the third well is a private well (CA0900673-001) no longer used for potable use. Uranium treatment went online for TKWC #3 in April 2022 and TKWC #2 in June 2022.

Of the twelve wells with historic detections of gross Alpha particle activity, eight are within the District water system, three are within the TKWC water system and one is a private well (CA0900673-001) no longer used for potable use. Of the eight wells within the District water system, four are active (Arrowhead Well #3, Bakersfield, Sunset, and South Upper Truckee Well #3), three are stand-by (Airport, Blackrock Well #2, and College) and one has been removed from service, converted to an observation well (Chris). The TKWC wells continued to have gross Alpha particle activity above the MCL in WY2022.

2.5.4 Regulated Chemicals

Regulated chemicals detected in water samples collected from water supply wells above primary or secondary MCLs include 1,2-Dichloroethane (1,2-DCA) (one well) and Tetrachloroethylene (PCE) (five wells). The one well with detections of 1,2-DCA above MCLs is an inactive well (Clement Well) in the District's water system. Of the five wells with detections of PCE above MCLs, three of these wells are within the LBWC water system (LBWC #2, LBWC #4 and LBWC #5), one is located within the TKWC water system (TKWC #2) and one is a private well (PW02909303). PCE contamination impaired the LBWC wells in 2014, and in 2020, LBWC #2 and LBWC #4 were abandoned and properly destroyed. LBWC #5 was returned to service in 2021 following construction of a well head treatment system [Granular Activated Carbon (GAC)] for the removal of PCE from groundwater. TKWC #2 is also fitted with a GAC well head treatment system installed in 2012. Each of these wells, except the private well, are located within the South Y Plume (Figure 2-7).

The District, in partnership with LBWC and TKWC, undertook multiple investigations between 2016 and 2019, as detailed in the Alternative Plan, to estimate the extent of PCE contamination and develop a three-dimensional model to evaluate contaminant migration in the vicinity of the South Y Plume (Rybarski et al., 2022). The District conducted a Feasibility Study, starting in 2018 under a Proposition 1 Groundwater Planning Grant Agreement with the SWRCB, to identify and evaluate the effectiveness of remedial alternatives to remove PCE contamination from groundwater and protect the drinking water supply. The South Y Feasibility Study, and an accompanying Interim Remedial Action Plan (IRAP), were completed in WY 2020 and are available on the District's website.

In March 2019, the Lahontan Regional Water Quality Control Board (LRWQCB) was awarded a $4.6 million grant under the Site Cleanup Subaccount Program (SCAP) to investigate the South Y Plume (Figure 2-7). The South Y Plume is believed to have resulted from spills and releases associated with the use of commercial grade dry cleaning and metal degreaser solvents in the South Y Area starting in the 1970s. The SCAP grant tasks included regional PCE plume investigation, vertical conduit evaluation and destruction, non-municipal supply well sampling, soil vapor sampling, and sentry well network installation and monitoring.

During 2019 and 2020, the LRWQCB undertook a regional plume characterization that involved the drilling and sampling of 79 borings to determine the lateral and vertical extent of PCE contamination; identify contaminant pathways; and development of detailed graphics show the distribution of PCE in groundwater at the time of the investigation (Figure 2-7). During WY 2021, the LRWQCB continued regional plume characterization activities that involved the installation of nine sentry wells for 1) LBWC #1 (three wells total); LBWC #5 (two wells total); TKWC #1 (two wells total); and TKWC #2 (two wells total). The purpose of sentry well installation and monitoring are to provide water purveyors advanced warning of potential PCE migration upgradient from water supply wells. The siting and design of the sentry wells for LBWC #1, LBWC #5, TKWC #1, and TKWC #2 was based on lithology and PCE groundwater data from the 2019 and 2020 regional plume characterization investigation. Following sentry well installation in July and August of 2021, the wells were developed, surveyed, and sampled for volatile organic compounds (VOC) including PCE.

In WY 2022, two sentry well monitoring events occurred in October 2021 and April 2022. The groundwater sampling results from the October 2021 and April 2022 sentry well monitoring events showed the following maximum detections:

- PCE was not detected in the three sentry wells installed for LBWC #1.
- PCE was detected at a maximum of 160 ppb in the deepest sentry well for LBWC #5 (approximate sample depth interval: 148.6 to 151.4 feet bgs).
- PCE was detected at a maximum of 43 ppb in the shallowest sentry well for TKWC #2 (approximate sample depth interval: 145.6 to 148.4 feet bgs).
- PCE was detected at a maximum of 120 ppb in the shallowest sentry well for TKWC #1 (approximate sample depth interval: 115.6 to 118.4 feet bgs).

Non-municipal well sampling occurred in July 2022, and PCE was detected below the MCL in one well east of the known PCE plume boundary (AECOM, 2022). A soil gas investigation to evaluate the potential human health risks associated with potential soil vapor intrusion resulting from the PCE contamination occurred in August 2022. The report concluded that shallow groundwater contamination in South Lake Tahoe is causing soil gas contamination that has the potential to migrate into overlying buildings, and that further characterization of the shallow groundwater and soil gas contamination is warranted, as well as a limited vapor intrusion investigation near the highest PCE, TCE and benzene concentrations (AECOM, 2023).

The anticipated SCAP field tasks that will be completed during the WY 2023 field season include:

- Continue to develop a private and small-community water supply well inventory to identify additional supply wells to be sampled to ensure the water supply wells are providing water that is safe for human consumption.
- Subject to available funding, properly destroy priority municipal, private, and small-community water supply wells that have been identified as a vertical conduit(s) (i.e., responsible for the vertical migration of PCE in groundwater impacting deeper water-bearing unit[s]). Inactive wells, including monitoring wells installed for site-specific investigations that have not been properly destroyed, are included in the evaluation.
- Conduct two sentry well semi-annual groundwater monitoring events.
- Update the PCE contamination contours based on new data collected since the 2019-2020 investigations. As noted above, PCE has now been detected above 100 micrograms per liter (µg/L) at the sentry wells upgradient of TKWC #1, which is inconsistent with the estimated contours developed from the earlier investigations (Figure 2-7).

Regulatory activities and environmental data for the South Y Regional Contamination investigation (T10000007984) are available online through the SWRCB GeoTracker website at: https://geotracker.waterboards.ca.gov/profile_report.asp?global_id=T10000007984.

During WY2022, the LRWQCB also issued proposed Cleanup and Abatement Orders related to PCE contamination in the TVS Subbasin for three additional sites: Lake Tahoe Laundry Works, Big O Tires, and Former Norma's Cleaners. Additional information about these site-specific regulatory efforts is available at the following websites:

- Lake Tahoe Laundry Works
  https://geotracker.waterboards.ca.gov/profile_report?global_id=SL0601754315
- Big O Tires
  https://geotracker.waterboards.ca.gov/profile_report?global_id=SL0601729739
- Former Norma's Cleaners
  https://geotracker.waterboards.ca.gov/profile_report?global_id=SL0601790916.

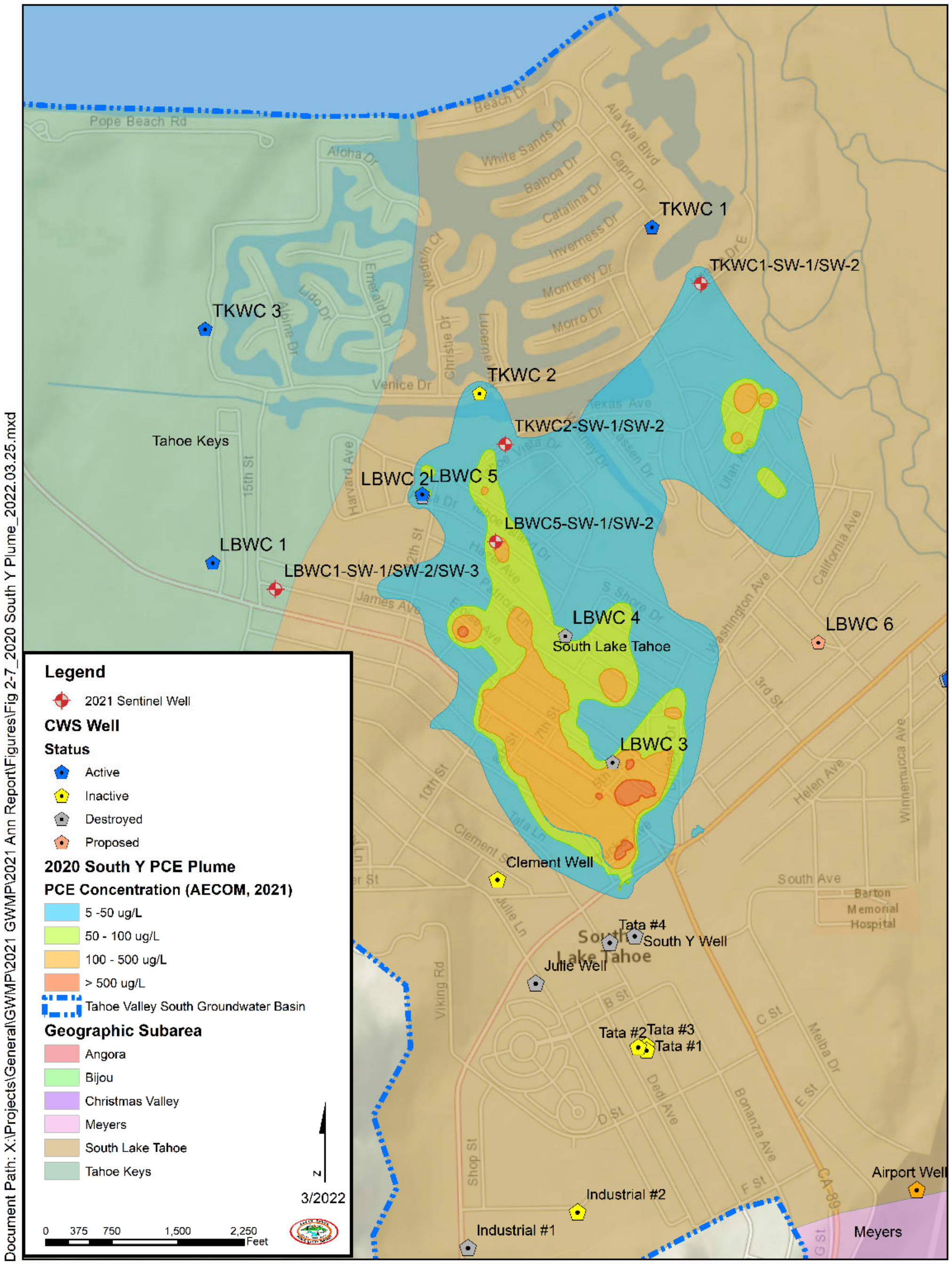

Figure 2-7. Approximate location of the South Y Plume within the TVS Subbasin, as defined by PCE in groundwater detected above 5 µg/L, using data from the 2019 – 2020 investigations provided by LRWQCB.

2.5.4.1 Impact on Beneficial Users

High reliance on groundwater requires that CWS wells must have sufficient source capacity to meet water system demands. When contamination impairs a well, the required treatment systems reduce the available capacity of that well. Because of this reliance and susceptibility of groundwater sources to contamination, the total source capacity of active CWS wells is used as an indicator to describe current basin conditions with respect to degraded groundwater quality (Pohll *et al.,* 2016; Rybarski et al., 2022).

Impacts of Water Quality on Well Source Capacity

Table 2-3 shows the WY 2022 source capacity and maximum day demands, in million gallons per day (MGD) for the District, TKWC and LBWC water systems. Per §64551.40 of the California Code of Regulations Title 22, “source capacity” means the total amount of water supply available, expressed as a flow, from all active sources permitted for use by the water system, including approved surface water, groundwater, and purchased water. The MDD is calculated every five years as part of the periodic review for District, TKWC and LBWC wells operating in the TVS Subbasin to establish a current minimum threshold for chronic lowering of groundwater levels (Rybarski et al., 2022). The LPA is primarily reliant on surface water to meet its water system demands. LPA has one active well (LPA #3), which is used as a back-up source to augment or help temporarily replace surface water supplies. As the LPA is generally regarded as a surface water system, production from the LPA #3 is not included in the MDD calculations as it is rarely used.

The maximum day demand (MDD) for the District, TKWC and LBWC water systems is calculated using the month with the highest water usage (maximum month) for each water system over the preceding 10-years (WY 2011 – WY 2020). The maximum month is divided by the number of days within that month to derive an average daily usage for the maximum month. This value is then multiplied by a peaking factor which is the quotient of the average daily use for the maximum month and the average daily use for that year. The difference between current source capacity and maximum day demand is shown as a surplus/deficit in the right end column of the table. The District, TKWC and LBWC water systems are inferred to account for more than 90% of the total groundwater pumpage extracted from the TVS Subbasin on an annual basis. To account for the beneficial users of groundwater not connected to these water systems, a 10 percent safety factor is added to the MDD derived for these water systems to determine the minimum threshold for the TVS Subbasin (Pohll *et al.,* 2016; Rybarski et al., 2022).

Community Water System	Water System No.	Active Wells	Connections$_1$	Population Served$_1$	Source Capacity (MGD)$_3$	Maximum Day Demand (MGD)$_2$	Surplus (+) or Deficit (-) (MGD)$_4$
South Tahoe Public Utility District (District)	CA0910002	10	14,235	33,124	17.698	9.862	7.836
Tahoe Keys Water Company (TKWC)	CA0910015	3	1,566	1,420	3.168	2.383	0.785
Lukins Brother Water Company (LBWC)	CA0910007	2	982	3,200	2.189	0.634	1.555
TVS SUBBASIN (6-005.01) TOTALS		15	16,783	37,744	23.054	12.879	10.176
Degraded Water Quality Minimum Threshold (110% of MDD)						**14.167**	**8.887**

Notes:

1) Source: SWRCB Drinking Water Branch Drinking Water Watch (https://sdwis.waterboards.ca.gov/PDWW/).

2) 10 Year (WY 2011 – WY 2020) Water System Maximum Day Demand, in million gallons per day (MGD), based on monthly water use as per CA Waterworks Standards (§ 64554).

3) Source capacity of active wells, in MGD (stand-by or offline sources not included). The Paloma well was excluded in WY2022 because of the ongoing well casing maintenance issue, but is expected to return to active status in the future.

4) (Source Capacity) – (Maximum Day Demand) in MGD.

Table 2-3. WY 2022 source capacity and maximum day demands for the District, TKWC and LBWC water systems, in millions of gallons per day (MGD).

Inspection of Table 2-3 shows that current WY2022 source capacity for the District, TKWC and LBWC water systems is sufficient to meet water system MDD and meet the MDD for all beneficial users in the TVS Subbasin (see Figure 3-1). However, the impairment of TKWC water system wells by inorganic (arsenic), radioactive (uranium) constituents and regulated chemicals (PCE) severely limited this water system's source capacity.

Source Capacity at TKWC

In response to impairment of TKWC wells, TKPOA completed a long-range planning study to investigate options for providing a reliable water supply which would also serve as a long-term facility plan for TKWC (MC Engineering, 2021). In April 2021, TKPOA requested that the District determine what improvements were needed to the District's water system to provide sufficient water supply to meet TKWC peak hour demands through its intertie with TKWC (TKPOA, 2021b). The District is currently working with TKPOA to develop and evaluate alternatives to meeting TKWC water needs. During WY 2021, a new intertie connection was constructed between the LBWC and TKWC water systems. Uranium treatment went online for TKWC #3 in April 2022 and for TKWC #2 in June 2022.

Source Capacity at LBWC

In July 2021, LBWC was able to return LBWC #5 to service following the installation of a GAC well head treatment system adding 0.893 MGD of source capacity for the LBWC water system. In January 2022, LBWC submitted a Drought Relief Assistance Application to DWR for grant funding to construct a new 500-gpm well outside the South Y Plume for source redundancy. The District provided a letter of support for this project as the added pumpage from operation of the proposed well (500 GPM) would not cause total groundwater withdrawals to exceed the sustainable yield (see Figure 2-8).

2.6 Groundwater Production

Groundwater is the primary source of drinking water throughout the TVS Subbasin, provided primarily for residential and commercial water uses (see Section 2.6.1). More than ninety percent (90%) of groundwater produced from the TVS Subbasin is from drinking water wells operated by the District, TKWC, LBWC and Lakeside Park Association (LPA). The remaining balance of groundwater production is pumped from small community water system, state small water system, noncommunity water system, nontransient noncommunity water system and domestic wells. Pumpage from the District, TKWC, LBWC and LPA wells is metered using propeller or turbine type flowmeters with a register for total flow and a flow rate indicator. Totalizer readings are recorded daily by the District and monthly by TKWC, LBWC and LPA. Accuracy of measurement for these flow meters is typically on the order of +/- 2%. Pumpage from small community water system, state small water system, noncommunity water system, nontransient noncommunity water system and domestic wells is typically not metered.

Table 2-4 shows the monthly and total pumping volumes of groundwater produced by District, TKWC, LBWC and LPA wells during WY 2022. During this year, a total of sixteen (16) CWS wells were active, an additional four (4) wells were on stand-by status, but not used (restricted for emergency use only).

PUBLIC WATER SYSTEM (CWS)	UNITS	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JLY	AUG	SEPT	2022 WY
South Tahoe Public Utility District (STPUD)	AF	352	286	324	313	281	300	273	439	599	690	649	535	5,040
Tahoe Keys Water Company (TKWC)	AF	20	12	10	18	16	17	19	48	108	135	142	137	681
Lukins Brothers Water Company(LBWC)	AF	25	14	19	19	12	14	14	28	42	46	44	37	313
Lakeside Park Association (LPA)	AF	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TVS Subbasin CWS **TOTALS**		397	312	353	349	309	331	306	515	748	872	835	709	6,035

Table 2-4. Monthly pumping volumes for District, TKWC, LBWC and LPA wells in the TVS Subbasin during WY 2022, reported in AF.

Annual groundwater production from each of the CWS included in Table 2-4 above is shown below on Figure 2-8. The sustainable yield for the TVS Subbasin is 13,200 AFY, which is the maximum quantity of water that can be drawn annually from a groundwater supply without causing an undesirable result.

During WY2022, total metered production from CWS wells was 6,035 AF, the lowest recorded since WY 2005, and about 19% below the average since 2005 of 7,474 AFY. Figure 2-8 shows that metered groundwater pumpage within the TVS Subbasin is consistently less than sustainable yield, and was less than 50% of the sustainable yield in WY 2022. Figure 2-9 shows the locations of the active District, TKWC, LBWC and LPA wells and their pumping volumes for WY 2022.

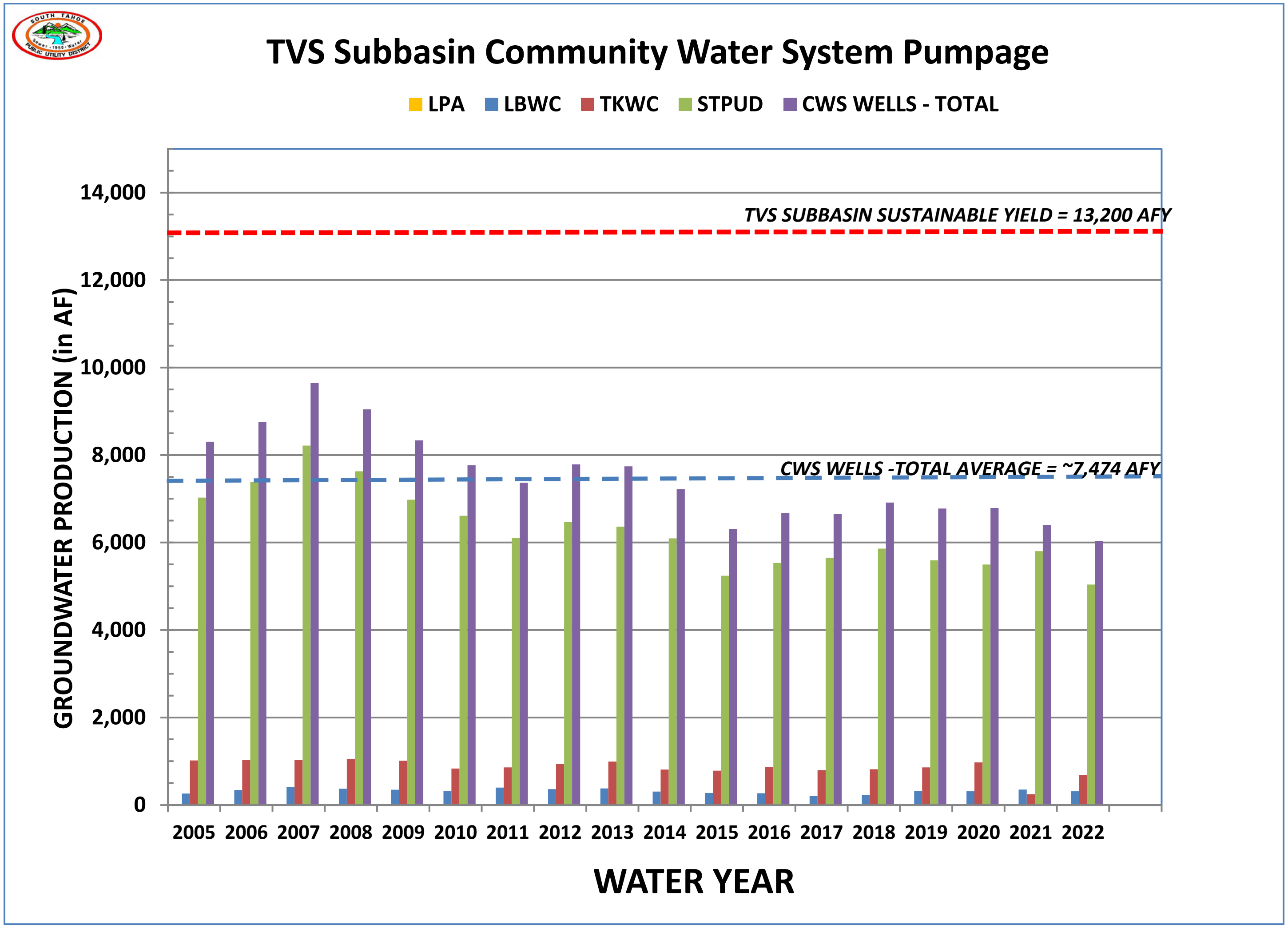

Figure 2-8. Groundwater production trends for major community water system wells in the TVS Subbasin since WY 2005, in AF.

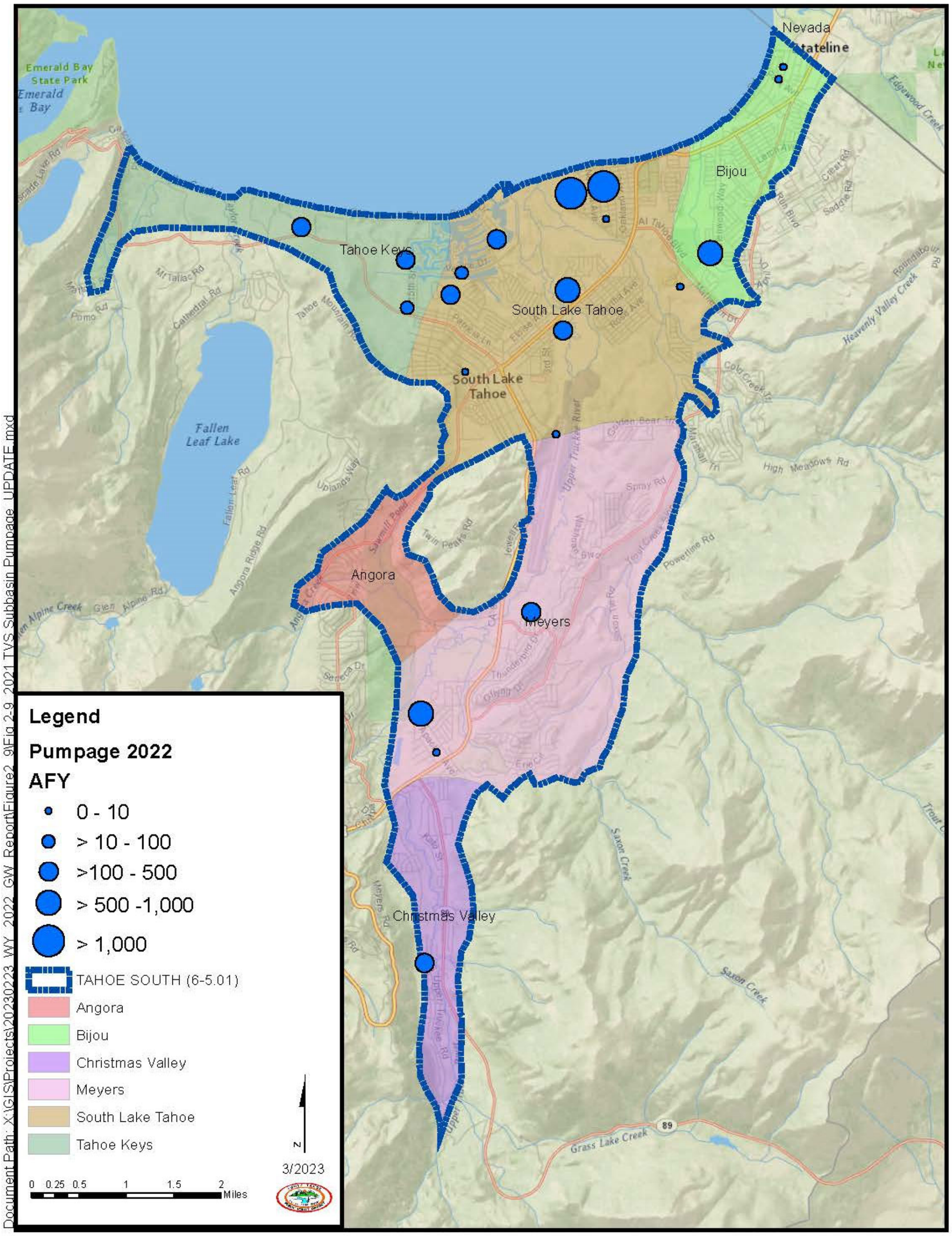

Figure 2-9. Groundwater pumpage from major CWS wells during WY 2022, in AF. Pumpage from major CWS wells accounts for more than 90% of the groundwater extracted from the TVS Subbasin.

2.6.1 Water Use

Water use information provided in this section is from the District's customer service database. As indicated in Table 2-4, the District produces most of the drinking water used within the TVS Subbasin, typically accounting for more than 80% of total groundwater production. Although not complete, information from the District's customer service database is believed to be adequate to show the general pattern of water use within the TVS Subbasin.

Table 2-5 shows water use by sector from metered data for the District's water system during the 2022 calendar year. The District is in the process of installing meters on all connections and is planned to be fully metered by 2024. The 2022 data captures about 98% of the total number of water accounts in the District's water system. The majority of the District's customers are residential. The District's commercial category includes office and retail, resorts (including hotels, restaurants, and snowmaking) and government customers. The "Other" category is for water transfers through the District's intertie to the LBWC and TKWC water system under its Mutual Aid and Assistance Agreements with these respective water systems. "Losses" are the non-revenue water system losses calculated from the difference between total groundwater production from District wells and consumption from the District meter data.

Use Type	2022 Actual		
	Additional Description	**Level of Treatment When Delivered**	**Volume, AF**
Single Family	Residential	Drinking Water	2,493.90
Multi-Family	Multi-Family Residential	Drinking Water	741.11
Commercial	Commercial, Hospitality (Motel, Hotels, other Tourism), Government	Drinking Water	1,258.47
Other	Mutual Aid Transfers	Drinking Water	0.09
Losses	non-revenue water	Drinking Water	617.60
		TOTAL	**5,111.17**

Table 2-5. 2022 water use by sector for the District water system, in AF.

The total volume accounts for about 98% of the District's total water accounts which were metered in 2022. Losses are estimated as the difference between District groundwater production and consumption from the meter data.

Because recycled water use within the Lake Tahoe basin is prohibited by the Porter-Cologne Act, there is no recycled water use in the TVS Subbasin.

2.7 Groundwater in Storage

The annual change of groundwater in storage is the difference in the volume of water in an aquifer from one year to the next. Figure 2-10 shows the annual trends of groundwater production from District, TKWC, LBWC and LPA wells and the changes of groundwater in storage, as derived from the annual water budget calculated by the STGM from WY 2005 through WY 2022. The main components of the water budget include groundwater recharge, groundwater discharge to streams (baseflow), groundwater flux to Lake Tahoe, and groundwater pumping. Changes of groundwater in storage for the TVS Subbasin (Zone 10) are calculated from the differences in total inflow (recharge) and total outflows (baseflow, flux to Lake Tahoe and groundwater pumpage) over a specified period (Carroll, *et al.*, 2016a).

Groundwater in storage changes in response to changes in groundwater recharge (Figure 2-2) and groundwater production (Figure 2-8). Figure 2-10 shows that long-term reduction of groundwater in storage is not occurring. Since WY 2005, the annual change of groundwater in storage has ranged from a 4,127 AF decrease during a below normal water year (WY 2021) to a 11,469 AF increase during a very wet water year (WY 2017). During WY 2022, the annual change of groundwater in storage for the TVS Subbasin was a 952 AF decline. Groundwater levels respond to these annual changes of groundwater in storage, decreasing slightly when the annual change of groundwater storage is negative and increasing slightly when the annual change of groundwater in storage is positive (see Section 2.4). Since WY 2005, the cumulative change of groundwater in storage within the TVS Subbasin is +8,157 AF. These year-to-year fluctuations in groundwater in storage have minimal impact on the groundwater available for supply (Section 2.8) and the ability of the aquifer to satisfy community production demands (Section 2.6).

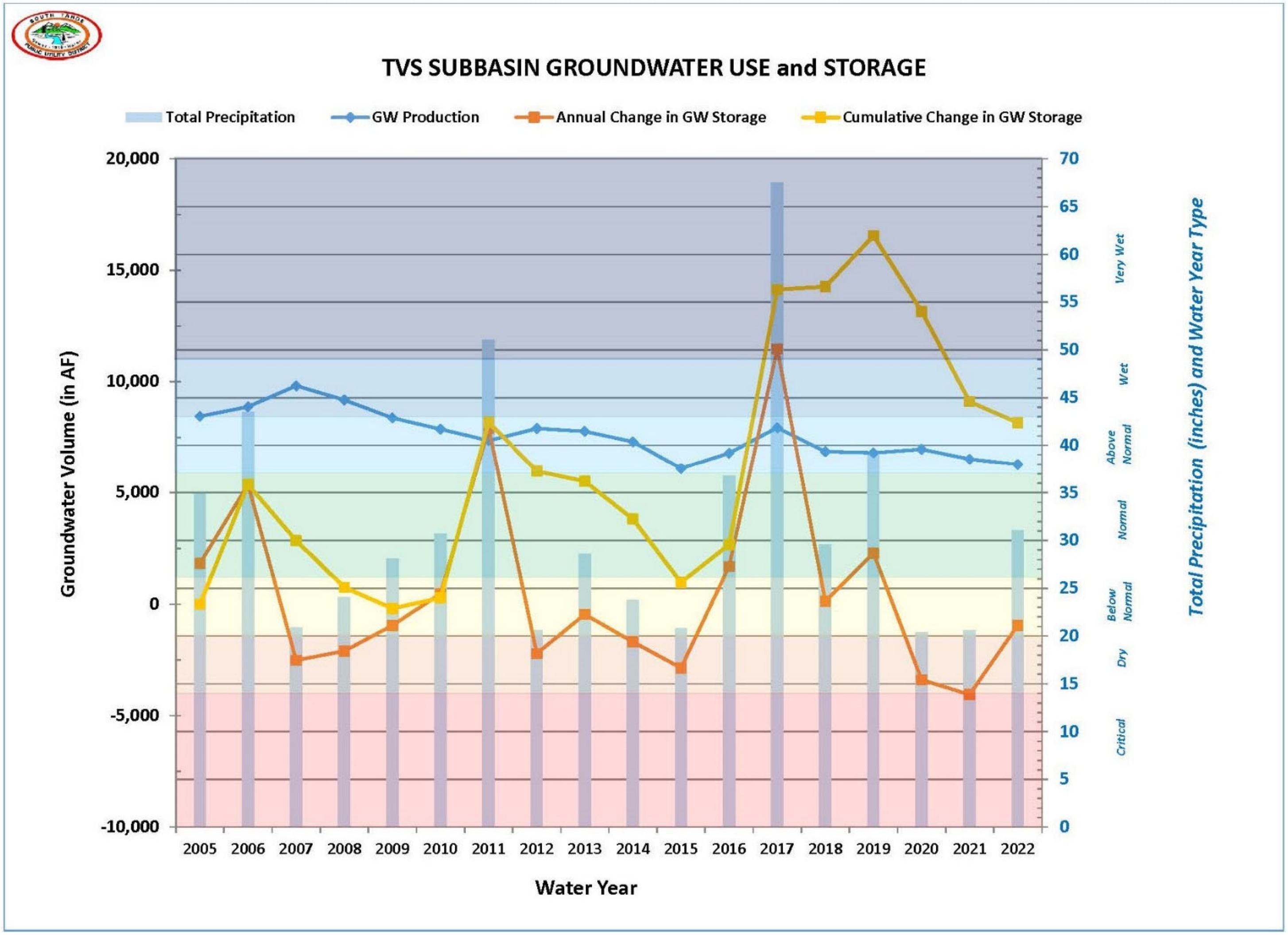

Figure 2-10. Annual groundwater production from community water supply wells and modeled annual and cumulative change of groundwater in storage, in AFY, for the TVS Subbasin (WY 2005 through WY 2022). Water year type using the TVS Subbasin classification is indicated on the vertical axis along the right-side of the graph. Positive annual changes in groundwater storage indicate periods of rising groundwater levels.

2.8 Groundwater Supply

During WY 2021, the District reconciled different water demand projections between the first five-year update of the Alternative Plan and the 2020 UWMP. As part of this process, the District updated water budgets derived from the STGM and used the updated water budget to assess current year available groundwater supply. The current year available supply is needed to inform the annual Water Supply and Demand Assessment (WSDA) required of Urban Water Suppliers starting in 2022 (WCS §10632.1).

Figure 2-11 shows the available groundwater supply for the TVS Subbasin. The current year available supply for WY 2022 is 40,207 AF. Since WY 2005, available groundwater supply has ranged from 31,858 AF (WY 2009) to 48,604 AF (WY 2019). This is a conservative estimate as the change of groundwater in storage accounts for groundwater production from confirmed active public and private water wells operating within the TVS Subbasin. Under the reporting requirements for the WSDA, only groundwater production from water wells serving the District's water system need to be accounted.

Current year available supply is calculated as the difference between the current volume of groundwater in storage and the storage threshold for the TVS Subbasin. The storage threshold (-55,687 AF) is the minimum threshold for reductions of groundwater in storage in the TVS Subbasin, which is equivalent to a cumulative change of groundwater in storage of -32,050 AF relative to WY 2005 (Rybarski et al., 2022). This reduction of groundwater in storage would correspond to a seven (7) foot basin-wide decline in groundwater levels compared to WY 2005. The undesirable result from a basin-wide reduction of groundwater level elevations of this magnitude would cause the District to reduce well pumping rates to prevent pumping water levels to decline below top of screen intervals thereby inhibiting the District's ability to ensure a sustainable groundwater supply. Basin-wide groundwater level declines of this magnitude are not expected during interannual climate variations but may be expected during an extended long-term drought (Rybarski et al., 2022).

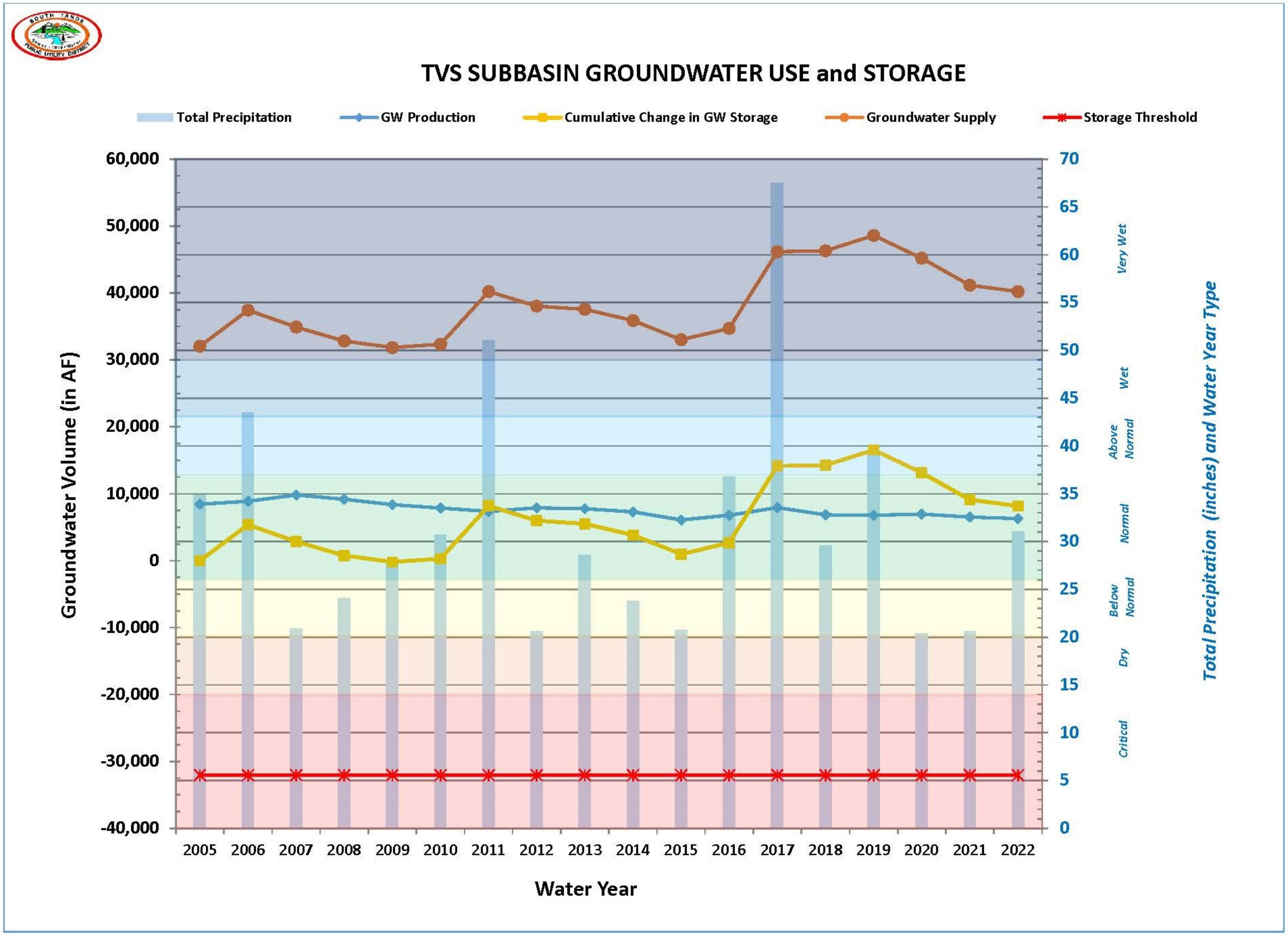

Figure 2-11. WY 2022 groundwater supply for the TVS Subbasin (40,207 AF) is calculated as the difference between the storage threshold and the current volume of groundwater in storage.

3 Basin Management Objectives

BMOs are flexible guidelines for the management of groundwater resources that describe specific actions to be taken by the District to meet locally developed objectives at the basin or sub-area scale. Under the Alternative Plan, eight BMOs are defined for sustainable groundwater management of the TVS Subbasin. Along with these BMOs, sustainable management criteria and quantitative criteria are defined to objectively determine compliance of the Alternative Plan with the objectives of SGMA.

- BMO #1 – Maintain a sustainable long-term groundwater supply.
- BMO #2 – Maintain and protect groundwater quality.
- BMO #3 – Strengthen collaborative relationships with local water purveyors, governmental agencies, businesses, private property owners and the public.
- BMO #4 – Integrate groundwater quality protection into local land use planning activities.
- BMO #5 – Assess the interaction of water supply activities with environmental conditions.
- BMO #6 – Convene an ongoing Stakeholder's Advisory Group (SAG) as a forum for future groundwater issues.
- BMO #7 – Conduct technical studies to assess future groundwater needs and issues.
- BMO #8 - Identify and obtain funding for groundwater projects.

The following section describes current groundwater conditions using sustainable management criteria in accordance with SGMA. Comparison of current groundwater conditions to quantitative criteria defined for the TVS Subbasin demonstrates that the sustainability goal for the TVS Subbasin is currently being met. Figure 2-8 shows that groundwater production from the TVS Subbasin is significantly less than the calculated sustainable yield.

3.1 BMO #1- Maintain a Sustainable Supply

The purpose of BMO #1 is to implement measures to manage the groundwater levels for long-term sustainability and reliability of the water supply for all users within the TVS Subbasin. The measurable goal for tracking groundwater levels is to sustain groundwater levels within the range of historical data. If long-term groundwater levels show a consistent declining trend that falls below the historical range indicating a potential overdraft condition, then an assessment of the cause for the decline would be conducted. If excessive groundwater pumping is found to be the cause, then measures would need to be taken to either redistribute the pumping to other portions of the basin or reduce pumping at the implicated well(s). No action would be required if the condition described above is not observed.

Sustainable management criteria (sustainability goals, undesirable results, sustainability indicators and minimum thresholds) for establishing quantitative criteria for chronic lowering of groundwater levels;

reduction of groundwater storage and land subsidence are defined for the TVS Subbasin in the first five-year update of the Alternative Plan (Rybarski et al., 2022).

3.1.1 Chronic Lowering of Groundwater Levels

- Sustainability Goal: To maintain a sustainable supply of groundwater by keeping groundwater water levels a safe distance above well screens.
- Undesirable Result: Regional water level declines such that water demands cannot be met.
- Sustainability Indicator: The total source capacity of community water supply wells
- Minimum Threshold: Having water levels above the screen intake at enough water supply wells such that the total source capacity meets or exceeds the Maximum Daily Demand (MDD).

A high reliance on groundwater within the TVS Subbasin necessitates that active wells have sufficient source capacity to meet water demands. Groundwater levels must be sustained adequately above the top of the uppermost screen interval and pump intake to prevent operational problems that would lead to a loss of production. Minimum water level targets for individual wells are based on the depth to the top of screen plus an additional amount to account for drawdown while pumping at source capacity. As discussed in section 2.5.4.1, the MDD is calculated every five years as part of the periodic review for District, TKWC and LBWC wells operating in the TVS Subbasin to establish a current minimum threshold for chronic lowering of groundwater levels (Rybarski et al., 2022). The current minimum threshold for chronic lowering of groundwater levels in the TVS Subbasin is 14.167 MGD as shown in Table 2-3.

Table 3-1 shows the minimum water level targets and range of depth to water readings measured during WY 2022 in active District wells within the TVS Subbasin. Inspection of Table 3-1 shows that maximum water depths did not exceed minimum water level target depths for each active District well. The cumulative available source capacity for the active wells (excluding the Paloma Well) is 23.054 MGD, which is greater than the current minimum threshold for chronic lowering of groundwater levels in the TVS Subbasin (14.167 MGD).

Well Name	Water System	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Average Depth to Water[1] (WY 2011 - 2022) in ft bgs	Water Level Min Target[2] in ft bgs	Range of Depth to Water for WY 2022 Min (ft bgs)	Range of Depth to Water for WY 2022 Max (ft bgs)	Above Water Level Min Target (Y/N)	Source Capacity (MGD)[3]
SOUTH TAHOE PUBLIC UTLITY DISTRICT (District) WELLS: Total Capacity = 17.698 MGD									
Al Tahoe Well #2	District	110	140	33	61	32.62	33.29	Yes	3.600
Arrowhead Well #3	District	250	280	48	140	44.90	48.10	Yes	1.152
Bayview Well	District	180	300	29	106	27.95	28.61	Yes	5.184
Bakersfield Well	District	130	170	29	92	25.91	28.81	Yes	2.160
Elks Club Well #2	District	110	160	23	55	13.95	15.17	Yes	0.720
Glenwood Well #5	District	150	180	32	39	21.19	24.93	Yes	1.440
Helen Ave. Well #2	District	90	150	20	73	18.32	19.84	Yes	0.346
Paloma Well	District	188	248	44	110	41.90	45.19	Yes	2.628
Sunset Well	District	275	430	23	221	27.73	21.88	No	0.936
SUT #3	District	70	90	19	47	22.41	nr	Yes	1.296
Valhalla Well	District	110	170	27	73	34.88	31.76	No	0.864
TAHOE KEYS WATER COMPANY (TKWC) WELLS: Total Capacity = 3.168 MGD									
TKWC #1	TKWC	125	312	**20**	86	Nr	nr	nr	1.440
TKWC #2	TKWC	138	188	**20**	84	Nr	nr	nr	0.576
TKWC #3	TKWC	175	300	**20**	129	Nr	nr	nr	1.152
LUKINS BROTHER WATER COMPANY (LBWC) WELLS: Total Capacity = 2.189 MGD									
LBWC #1	LBWC	132	182	**20**	50	nr	nr	nr	1.296
LBWC #5	LBWC	132	182	**20**	75	nr	nr	nr	0.893
TOTAL CUMULATIVE AVAILABLE SOURCE CAPACITY (MGD)									23.054

Notes

1. Based on average WY 2011-2022 measurements. Bold values are estimates based on nearby wells.
2. Water level minimum threshold based on top of screen - expected drawdown at full well capacity.
3. From Tahoe Key Water System Analysis (Carollo, 2022)

nr - no eading

Table 3-1. Minimum water level targets and range of depth to water readings for WY 2022 measured in active production wells within the TVS Subbasin.

3.1.2 Reduction of Groundwater in Storage

- Sustainability Goal: To maintain groundwater levels storage reserves to ensure a sustainable supply of groundwater.

- Undesirable Result: A groundwater overdraft condition causing water levels to trend downward making it more difficult to extract sufficient groundwater for water supply purposes.
- Sustainability Indicator: Cumulative change of groundwater in storage.
- Minimum Threshold: Cumulative groundwater storage –reduction of 32,050 AF relative to WY 2005, which would indicate undesirable results.

During WY 2022, the annual change of groundwater in storage for the TVS Subbasin was -952 AF (a reduction). The minimum threshold for reduction of groundwater in storage was not exceeded because the cumulative change of groundwater in storage relative to WY 2005 is +8,157 AF (an increase). See Figures 2-10 and 2-11.

3.1.3 Land Subsidence

- Sustainability Goal: To maintain groundwater level elevations within the historical range.
- Undesirable Result: A land subsidence of 1 foot due to a reduction of groundwater levels
- Sustainability Indicator: Change in groundwater levels measured in Basin Monitoring Network observation wells.
- Minimum Threshold: Negative change of more than 100 feet compared to groundwater elevations measured in Basin Monitoring Network observation wells in May 2015.

Table 3-2 shows the minimum and maximum groundwater elevations for observation wells within the Basin Monitoring Network with a negative change in May 2022 groundwater levels relative to May 2015 groundwater levels. For each of these wells the negative change of groundwater elevation is less than 3 feet, significantly less than the minimum threshold value of -100 feet. Fewer wells had a relative decline in WY2022 than in previous water years.

Well Name	Period of Record	Groundwater Elevation (NAVD 88)				(May- 22) - (May-15)	WL Change > - 100 Feet
		Minimum	Maximum	May-15	May-22	(ft)	(Y/N)
College Well	2001 - 2022	6225.97	6256.92	6248.75	6247.38	-1.37	No
EX-1	2010 - 2022	6467.79	6471.59	6470.74	6470.58	-0.16	No
Glenwood Well #3	2002 - 2022	6212.89	6254.63	6240.16	6238.46	-1.70	No
Paloma Well	2001 - 2022	6216.17	6227.94	6222.52	6221.83	-0.69	No
Seneca Test Well	2001 - 2022	6391.54	6407.32	6392.42	6392.04	-0.38	No
USGS TCF-5	2005 - 2022	6239.62	6249.43	6246.49	6243.73	-2.76	No

Table 3-2. Wells within the basin monitoring network with negative changes of groundwater elevation relative to May 2015 groundwater levels.

3.2 BMO #2 – Maintain and Protect Groundwater Quality

Groundwater in the TVS Subbasin is typically of excellent quality; however, there is a legacy of groundwater contamination from regulated industrial and commercial chemicals, which continue to impair water supplies (Section 2.5). The nature of the aquifer makes it highly vulnerable to groundwater contamination as evidenced by these impacts.

The purpose of BMO #2 is to implement measures to maintain and protect groundwater quality to sustain the beneficial use of groundwater within the TVS Subbasin. These measures would address contamination from manmade contaminants and not natural constituents intrinsic to the aquifer. This would include setting measurable goals and continuing proactive measures to protect groundwater quality.

Sustainable management criteria (sustainability goals, undesirable results, sustainability indicators and minimum thresholds) for establishing quantitative criteria for degraded water quality are defined for the TVS Subbasin in the first five-year update of the Alternative Plan (Rybarski et al., 2022). As the TVS Subbasin is a headwater basin within the Sierra Nevada Region with elevations ranging from 6,223 feet at lake level rising to about 6,500 feet near the basin margin, significant and unreasonable seawater intrusion is not an issue. Therefore, sustainable management criteria for this groundwater condition were not developed.

3.2.1 Degraded Quality

- Sustainability Goal: To ensure that groundwater quality is maintained to support continued extraction for water supply purposes.
- Undesirable Result: Degraded water quality threatens the ability to produce groundwater of sufficient quality and quantity to meet the demands of the community.

- Sustainability Indicator: The total source capacity of community water supply wells.
- Minimum Threshold: Degraded water quality concerns within the TVS Subbasin should not rise to a level that threatens the ability of groundwater sources to meet maximum daily demand (MDD).

As discussed in section 2.5.4.1, the MDD is calculated every five years as part of the periodic review for all community water system wells operating in the TVS Subbasin to establish a current minimum threshold for degraded water quality in the TVS Subbasin (Rybarski et al., 2022). The source capacity for active community water system wells in the District, TKWC, and LBWC water systems operating in the TVS Subbasin is provided in the first five-year update of the Alternative Plan (Rybarski et al., 2022). For WY 2022, the source capacity of the District, TKWC, and LBWC water system wells is 23.054 MGD which exceeds the minimum threshold for degraded water quality, demonstrating that current groundwater sources are sufficient to meet water demands of all users within the TVS Subbasin (Figure 3-1).

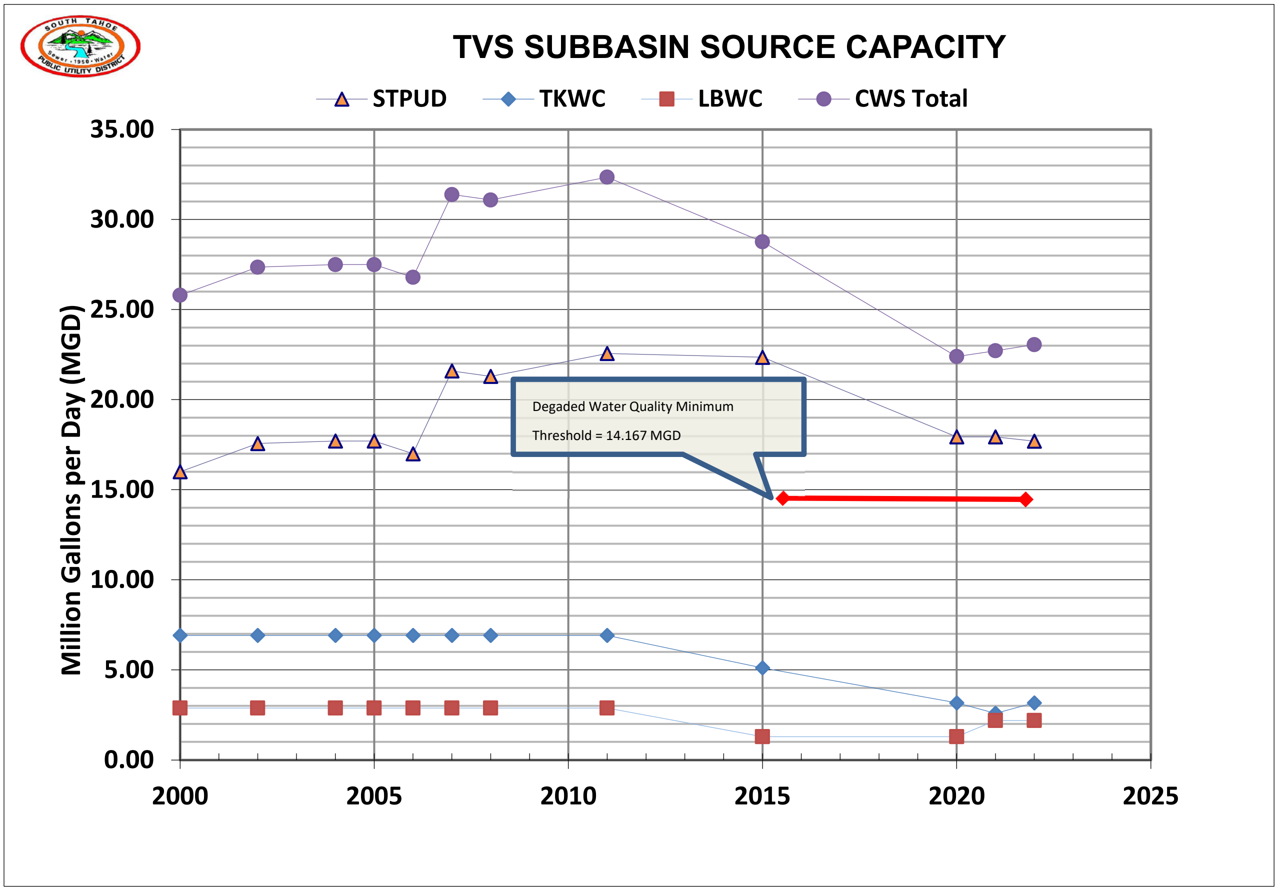

Figure 3-1. WY 2022 source capacity (23.054) and degraded water quality threshold (14.167) in MGD for the TVS Subbasin.

3.3 BMO #3 – Building Collaborative Relationships

The TVS Subbasin includes a wide range of stakeholders in addition to the District, including private well owners and environmental users of groundwater. Government agencies, local business interests, environmental groups and private citizens also have interests in local groundwater management. Collaboration and coordination with other local agencies and stakeholders for implementation of the Alternative Plan is achieved through the Stakeholders Advisory Group (SAG). SAG members during WY 2022 are listed in Table 3-3.

Member	Title	Affiliation
Ivo Bergsohn, PG	Hydrogeologist/SAG Coordinator	South Tahoe Public Utility District
Jason Burke	Storm Water Coordinator	City of South Lake Tahoe
Kyle Ericson, PE	Water Resources Engineer	El Dorado Water Agency
Robert Lauritzen, PG	Geologist	El Dorado County Environmental Management Division
Russell Wigart	Stormwater Coordinator	El Dorado County Department of Transportation
Brian Grey, PG	Engineering Geologist	Lahontan Regional Water Quality Control Board
Nicole Bringolf	Hydrologist	USFS-Lake Tahoe Basin Management Unit
Jennifer Lukins	Manager	Lukins Brothers Water Company and Tahoe Keys Water Company
Nakia Foskett	Water Systems Manager	Lakeside Mutual Water Company
Scott Carroll	Environmental Planner	California Tahoe Conservancy/Real Property Owner
Jacob Stock	Senior Long-Range Planner	Tahoe Regional Planning Agency
Harold Singer	Retired	Non-Business Community Rate Payer

Table 3-3. WY 2022 Stakeholder Advisory Group members.

3.3.1 GSA Formation

The TVS Subbasin lies entirely within EDC, and largely within the jurisdiction of the District. Since November 17, 2015, the District has been recognized as the exclusive GSA for the portion of the TVS Subbasin within its jurisdiction (South Tahoe Public Utility District GSA 1). During the summer of 2016, the El Dorado County Water Agency (Water Agency) and the District began discussing options to form a GSA in the portion of the TVS Subbasin outside of the District's jurisdiction. Pursuant to these discussions—as well as additional conversations with DWR—the Water Agency and the District determined that it would be appropriate for the District to become the GSA for the portion of the TVS Subbasin outside of its jurisdiction (i.e., within the Water Agency's jurisdiction). Concurrent with this decision, the Water Agency and the District drafted a Memorandum of Understanding (MOU) setting forth the Water Agency's and the District's agreement to cooperatively manage and coordinate implementation and enforcement of SGMA in this portion of the Basin. On September 16, 2016, the Water Agency and the District subsequently entered this MOU, the District elected to become a groundwater sustainability agency for the portion of the TVS Subbasin outside of its jurisdiction (Resolution No. 3040-16) and GSA formation notice was submitted to DWR (STPUD, 2016).

On December 28, 2016, the District was recognized as the exclusive GSA for the portion of the TVS Subbasin located outside of its service area jurisdiction (South Tahoe Public Utility District GSA-2). In March 2017, discussions with the SWRCB raised concerns about an agency forming a GSA outside of its jurisdiction. These concerns raised the risk that the South Tahoe Public Utility District GSA-2 may be considered invalid and that the TVS Subbasin could potentially be designated as "probationary" by the SWRCB and be put under state management. To ensure that the Water Agency and the District can retain local control of the TVS Subbasin's groundwater resources, the District agreed to rescind its 2016 GSA Formation Notice and the Water Agency agreed to act as the GSA for the portion of the TVS Subbasin covered by the District's 2016 GSA Formation Notice.

On May 4, 2017, the District adopted Resolution No. 3055-17 rescinding its 2016 GSA Formation Notice. The withdrawal notice had no effect on formation of the South Tahoe Public Utility District GSA -1 or its status as the exclusive GSA for the portion of the TVS Subbasin within its service area. On June 14, 2017, the Water Agency held a public hearing and elected to become the GSA for the portion of the TVS Subbasin outside of the District's service area; and the District submitted to DWR its notice of intent to withdraw the South Tahoe Public Utility District GSA-2 for the portion of the TVS Subbasin outside of its service area. On June 15, 2017, the Water Agency GSA formation notice for the El Dorado Water Agency GSA was posted on the DWR website through the SGMA Portal.

On June 4, 2017, concurrent with the Water Agency GSA formation notice for the Water Agency GSA and the District's notice of intent to withdraw the South Tahoe Public Utility District GSA-2, the District and Water Agency entered an Amended and Restated MOU to work collaboratively to sustainably manage groundwater resources and implement SGMA throughout the TVS Subbasin. With execution of the MOU, the TVS Subbasin is in full compliance with GSA formation requirements.

On June 4, 2020, the Amended and Restated MOU was amended a second time to acknowledge DWR's approval of the Alternative Plan; formalize the District's and EDWA's agreement to continue to manage groundwater resources cooperatively and sustainably within the TVS Subbasin; and to jointly implement the Alternative Plan in accordance with SGMA (District, 2020).

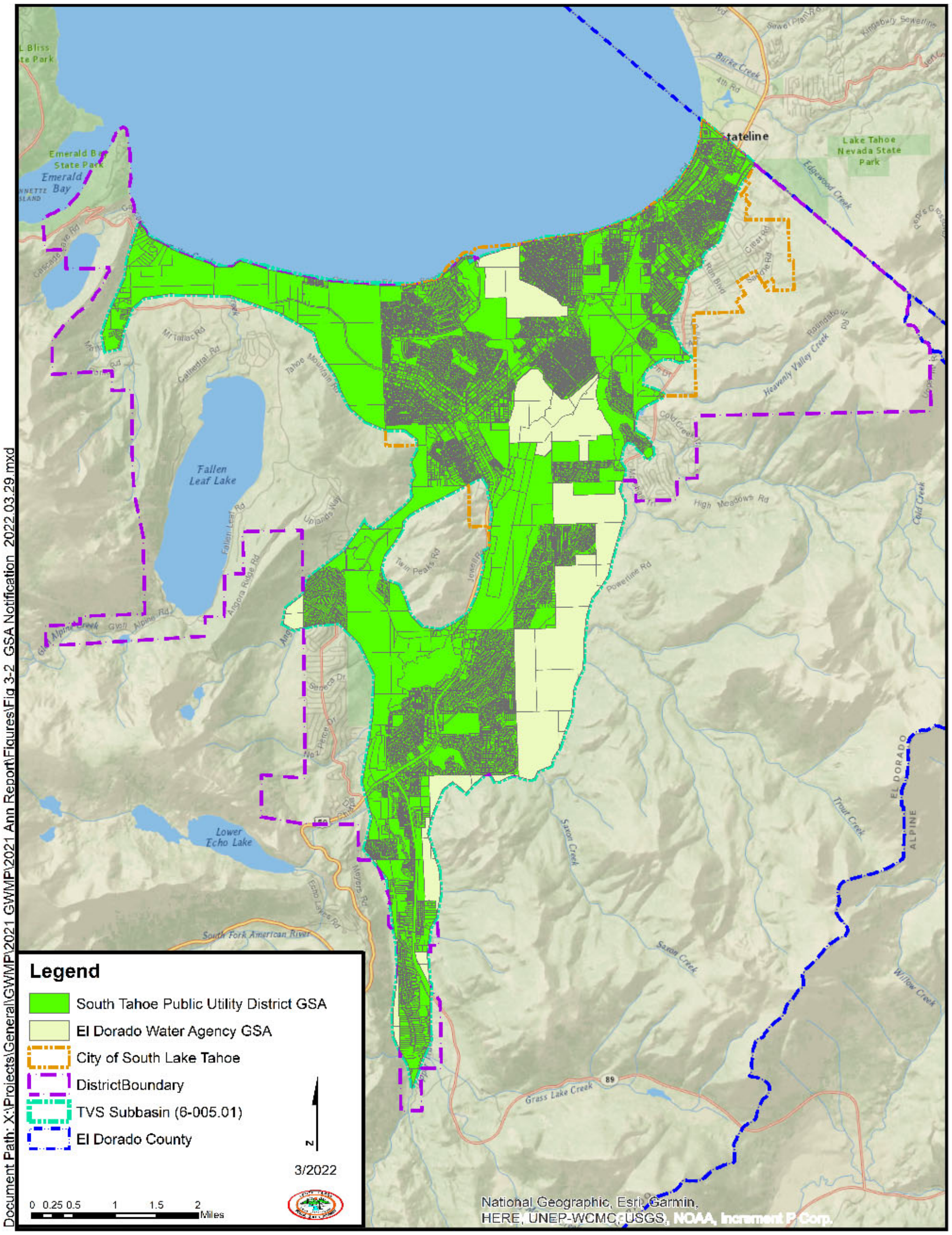

Figure 3-2. GSA boundaries for the TVS Subbasin. The District is regarded as the exclusive GSA for portions of the basin within its service area. The Water Agency is regarded as the exclusive GSA for portions of the basin outside the District's service area. Through an MOU, the District and Water Agency GSAs implement SGMA across the full extent of the TVS Subbasin.

3.3.2 Alternative Plan

Under SGMA, local agencies are authorized to submit an Alternative, in lieu of a GSP, for review by DWR. SGMA identifies the following three Alternatives to a GSP: (1) a GWMP developed pursuant to Part 2.75 of Division 6 of the CWC (§10750 *et seq*.), (2) management pursuant to an adjudication action, or (3) an analysis of basin conditions (CWC § 10733.6(b)).

To be eligible to submit any of the above Alternatives, the local agency must be able to demonstrate that (1) the Alternative applies to the entire basin, and (2) the basin is compliant with §10733.6 of CWC. (23 California Code of Regulations, § 358.2(a).) Additionally, the local agency must demonstrate that its Alternative is "functionally equivalent to the elements of a [GSP] required by Articles 5 and 7... [and is] sufficient to demonstrate the ability of the [Alternative] to achieve the objectives of [SGMA]." (23 California Code of Regulations, §358.2(d).)

On December 28, 2016, the District concurrently submitted (1) its 2014 GWMP and Alternative Materials to DWR as an existing plan alternative pursuant to CWC §10733.6(b)(1) and (2) an analysis of basin conditions pursuant to CWC §10733.6(b)(2) to DWR for evaluation and assessment.[3]

On July 17, 2019, DWR determined that the 2014 GWMP and Alternative Materials satisfied SGMA's requirements for an existing plan alternative and approved it as an Alternative Plan for the TVS Subbasin in compliance with CWC §10733.6(b). (DWR, 2019a.) In its approval of the Alternative Plan, DWR issued a set of Recommended Actions, summarized below in Table 3-4, to be addressed in the Alternative Plan.

During WY 2020, the District and EDWA started the procedural, technical and public outreach activities needed for the first five-year update of the TVS Subbasin Alternative. In April 2020, the District and DRI met with DWR staff (conference call) to discuss Recommended Actions. On May 21, 2020, the District adopted Resolution 3140-20 establishing its intent to draft an update to the 2014 GWMP (aka first five-year update of the Alternative Plan) for resubmittal to DWR. On June 25, 2020, the District submitted a Notice of Intent (NOI) to draft an update to the 2014 GWMP to DWR (STPUD, 2020. On July 8, 2020, the Water Agency adopted its own Resolution WA-6-2020 establishing its intent to draft an update to the 2014 GWMP. On July 22, 2020, the Water Agency submitted an NOI to DWR informing DWR of its intent to draft an update to the 2014 GWMP (EDWA, 2020).

[3] As part of its submittals, the District indicated its preference to DWR that the review be sequenced in such a manner that its 2014 GWMP and Alternative Materials be reviewed first and should DWR agree that the 2014 GWMP and Alternative Materials are functionally equivalent to a GSP, review of the analysis of basin conditions would not be necessary.

Recommended Action	Description
RA-1	Provide water budget information in Tabular Form for historical, current and projected water budgets.
RA-2	Provide a projected water budget over the 50-year planning and implementation horizon, incorporating climate change effects.
RA-3	Reconcile the different future water demand projections between the Groundwater Management Plan (GMP) and Urban Water Management Plan (UWMP) and incorporate the reconciliation in the projected water budget.
RA-4	To understand change in groundwater storage for the Subbasin, the water budget calculated by the South Tahoe Groundwater Model should be calculated within the Subbasin boundary rather than the surrounding watershed area inclusive of the Subbasin.
RA-5	Provide additional explanation in the first five-year update for how pumping may impact plume migration or cause degraded water quality.
RA-6	Provide estimates of the quantity and timing of depletions of interconnected surface water; define what would cause depletions to become significant and unreasonable.
RA-7	Define quantitative criteria for groundwater levels, storage and depletion of interconnected surface water that can be used to objectively determine compliance of the Plan with the objectives of SGMA on an on-going basis.
RA-8	Provide a description of how the data gaps identified will be addressed; specifically the projects identified in Table 10-1 for BMO 5 - dependent upon District funding.

Table 3-4. Summary of Recommended Actions presented in the Alternative Assessment Staff Report for the Alternative Plan (DWR, 2019a).

On October 1, 2021, the District provided 90-day notice to the CSLT and EDC of its intent to hold public hearings to consider adopting the first five-year update of the Alternative Plan, pursuant to CWC §10728.4 (STPUD, 2021). On February 9, 2022, Notice of Availability for the draft first five-year update of the Alternative Plan was provided to CSLT and EDC (STPUD, 2022). No public comments were received, and the District Board of Directors adopted the Alternative Plan First Five-Year Update on April 21, 2022 (Resolution 3215-22). The Alternative Plan was submitted to DWR in April 2022 and is currently under review.

Groundwater studies conducted during WY 2022 involved, but were not limited to, the following activities prescribed by first five-year update of the Alternative Plan (Rybarski et al., 2022).

- Update of the STGM including extending the transient historic model through WY 2022.
- Differentiation of the STGM into spatial zones for reporting water budget terms specifically for the TVS Subbasin (Section 2.1).
- Addition of groundwater budget terms (pumpage from private wells, MBR, baseflow to streams and discharge to Lake Tahoe) to provide greater detail in reporting water budget.
- Development of projected 50-year water budgets for the TVS Subbasin.
- Estimation of sustainable yield.
- Development of model input terms to evaluate impacts of climate change on projected water budgets.
- Assessment of the interaction of water supply activities on interconnected surface waters and groundwater dependent ecosystems.
- Development of sustainable management criteria and definition of quantitative criteria to determine compliance of the Alternative Plan with SGMA.

Periodic evaluation of groundwater conditions involved, but were not limited to, the following activities which are detailed in the first five-year update of the Alternative Plan (Rybarski et al., 2022):

- Combined results of private well owner findings from surveys of private well owners conducted during WY 2017 and WY 2020.
- Updated groundwater elevation hydrographs through WY 2020
- Updated groundwater pumpage, well densities and groundwater demand projections.
- Reconciliated water budgets between the District's 2020 UWMP and the Alternative Plan
- Updated evaluation of groundwater quality (2011 – 2020)
- Updated evaluation of Potential Contaminating activity (PCA) sites and drinking water well source area zones.
- Updated Implementation Plan

3.3.3 Public Outreach

Over the past year, the District convened the following presentations, public hearings and/or workshops to inform the interested public and agencies of groundwater management activities being performed in the TVS Subbasin.

1. October 1, 2021: 90-Day Notice to Cities and Counties (CWC §10728.4)
2. November 4, 2021: Groundwater Management Plan Update – Staff Report
3. January 12, 2022: SAG Workshop No. 1
4. August 24, 2022: SAG Workshop No. 2

In addition to these public meetings, the District regularly updates its website which includes a Groundwater Page used to post information about current groundwater management issues within the TVS Subbasin and activities being performed by the GSAs (https://stpud.us/groundwater/). Plan documents, workshop agendas, meeting materials and meeting notes are linked to this web page, which are available for download at http://stpud.us/news/groundwater-management-process/.

Plan notices posted over the past year on the Groundwater Management Plan webpage related to the first five-year update of the Alternative Plan include:

- Public Notice of Public Hearings to Adopt the First Five Year Update of the Alternative Plan for the Tahoe Valley South Subbasin (6-005.01) Pursuant to the Sustainable Groundwater Management Act of 2014 (03/17/2022)

- Notice of Availability South Tahoe Public Utility District Alternative Plan for the Tahoe Valley South Subbasin (01/31/2022)

3.3.3.1 Survey of Well Owners

From past efforts to identify private wells within the GSA, a total of 578 domestic and 56 small community water system wells were inferred to be located on parcels located within or surrounding the TVS Subbasin (Figure 3-3). As part of its outreach efforts, during WY 2020 the District conducted the second phase of a survey of private well owners within the TVS Subbasin.

Combined results of the survey of well owners conducted in WY 2016/2017 and WY 2020 are presented in the first five-year update of the Alternative Plan (Rybarski et al., 2022). No further outreach activities to private well owners occurred in WY 2022.

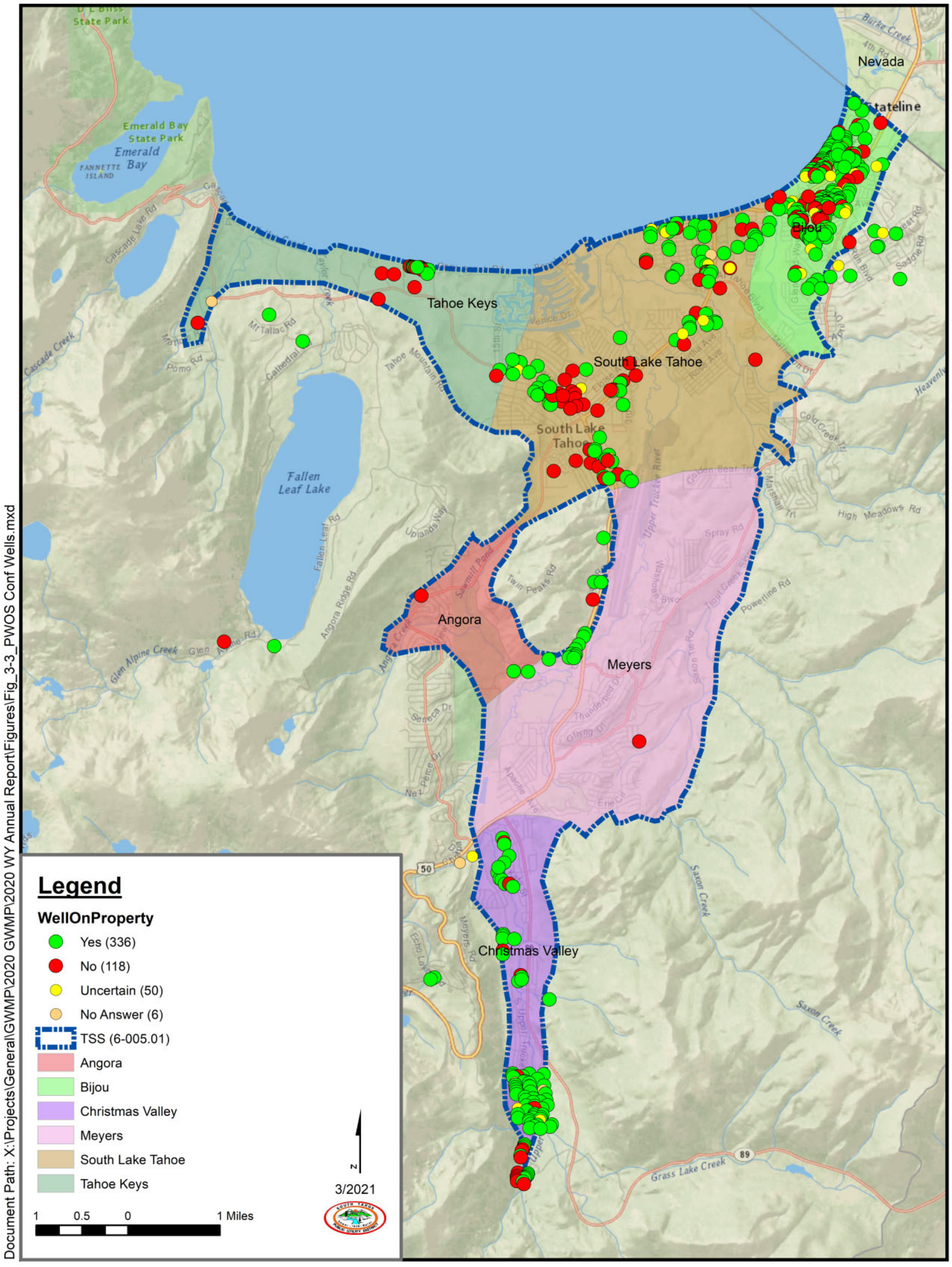

Figure 3-3. Confirmed locations of private wells identified by the 2017 and 2020 surveys of well owners.

3.4 BMO #4 – Integrating Groundwater Quality Protection and Land Use Planning

A key element of the Alternative Plan is an ongoing program of monitoring groundwater conditions and the potential threat of groundwater contamination within the TVS Subbasin. To better understand this potential threat, the locations of potential contaminating activity (PCA) sites operating within the TVS Subbasin were updated in WY 2017 and again in WY 2021 in preparation for the Alternative Plan update in WY 2022. The PCA site locations were compared to source water production zones surrounding active District, TKWC, LBWC and LPA wells, generated using the modified calculated fixed radius method (CDHS- DDW, 1999). Descriptions of these zones are as follows:

- **Zone A: Microbial/Direct Chemical Contamination Zone.** Protects the drinking water supply from viral, microbial, and direct chemical contamination and is defined by the surface area overlying the portion of the aquifer that contributes water to the well within a two-year time-of-travel.

- **Zone B5: Chemical Contamination Zone.** Prevents chemical contamination of the water supply, and to protect the drinking water source for the long term, encompassing the area between the two- and five-year time-of-travel. This zone provides for more response time for chemical spills.

- **Zone B10: Chemical Contamination Zone.** Prevents chemical contamination of the water supply, and to protect the drinking water source for the long term, encompassing the area between the five- and ten-year time-of-travel. This zone allows for some attenuation or remediation of contaminant sites, or if necessary, time to develop alternate sources of water supply.

The number and types of PCA found within each source water protection zone are summarized in Table 3-5. The 2021 Drinking Water Source Assessment and Protection (DWSAP) map for the TVS Subbasin is presented in the first five-year update of the Alternative Plan and is presented in this report as Figure 3-4. Well source area zones will be reevaluated in WY 2026 as part of the next five-year update to the Alternative Plan.

Possible Contaminating Activity Sites		
Number of Sites (Count)	**Type(s)**	**Possible Contaminants (DDWEM-CDHS, 1999)**
Zone A		
1	Apartments and condominiums	Swimming pool maintenance chemicals: pesticides for lawn and garden maintenance and cockroach, termite, ant, rodent, and other pest control wastes from on- site sewage treatment plants; household hazardous wastes.
1	Cellular Site	Diesel fuel (Diesel generator back-up); sulfuric acid (Battery back-up)
1	Clean-Up Program Site - Open	Diesel fuel; gasoline; kerosene
3	Clean-Up Program Site - Closed	Diesel fuel; gasoline; kerosene
2	Gas Stations/sumps	Soaps; detergents, waxes; miscellaneous chemicals, hydrocarbons
19	Injection Wells/ Dry Wells/ Sumps	Stormwater runoff; spilled liquids; used oils; antifreeze; gasoline; solvents; other petroleum products; pesticides; and a wide variety of other substances
1	Motor Pools	Automotive wastes: solvents; waste oils; hydrocarbons from storage tanks
3	Sewer Pump Station	Sewage, treatment chemicals
1	Utility Stations/ Maintenance Areas	PCBs from transformers and capacitors; oils; solvents; sludges; acid solution; metal plating solutions (chromium, nickel, cadmium); herbicides from utility rights-of-way

Possible Contaminating Activity Sites		
Number of Sites (Count)	**Type(s)**	**Possible Contaminants (DDWEM-CDHS, 1999)**
1	Wells	Storm water runoff; solvents; nitrates; septic tanks
Zone B5		
2	Boat Services/repair/refinishing	Diesel fuels; oil; septage from boat waste disposal area; wood preservative and treatment chemicals; paints; waxes; varnishes; automotive wastes
1	Body Shops/repair shops	Waste oils; solvents; acids; paints; automotive wastes; miscellaneous cutting oils
2	Clean-Up Program Site - Closed	Diesel fuel; gasoline; kerosene
1	Gas Stations/sumps	Soaps; detergents, waxes; miscellaneous chemicals, hydrocarbons
10	Injection Wells/ Dry Wells/ Sumps	Stormwater runoff; spilled liquids; used oils; antifreeze; gasoline; solvents; other petroleum products; pesticides; and a wide variety of other substances
1	Sewer Pump Station	Sewage, treatment chemicals
Zone B10		
1	Body Shops/repair shops	Waste oils; solvents; acids; paints; automotive wastes; miscellaneous cutting oils
1	Cellular Site	Diesel fuel (Diesel generator back-up); sulfuric acid (Battery back-up)
6	Clean-Up Program Site - Closed	Diesel fuel; gasoline; kerosene

Possible Contaminating Activity Sites		
Number of Sites (Count)	**Type(s)**	**Possible Contaminants (DDWEM-CDHS, 1999)**
2	Dry Cleaners	Solvents (perchloroethylene, petroleum solvents, Freon); spotting chemicals (trichloroethane, methylchloroform, ammonia, peroxides, hydrochloric acid, rust removers, amyl acetate)
1	Fire Station	General building wastes; hydrocarbons from test burn areas
1	Hardware/lumber/parts stores	Hazardous chemical products in inventories; heating oil and forklift fuel from storage tanks; wood-staining and treating products such as creosote; paints; thinners; lacquers; varnishes
3	Injection Wells/ Dry Wells/ Sumps	Stormwater runoff; spilled liquids; used oils; antifreeze; gasoline; solvents; other petroleum products; pesticides; and a wide variety of other substances

Table 3-5. The numbers and types of potential contaminating activity sites found within source water protection zones delineated within the TVS Subbasin (Rybarski et al., 2022).

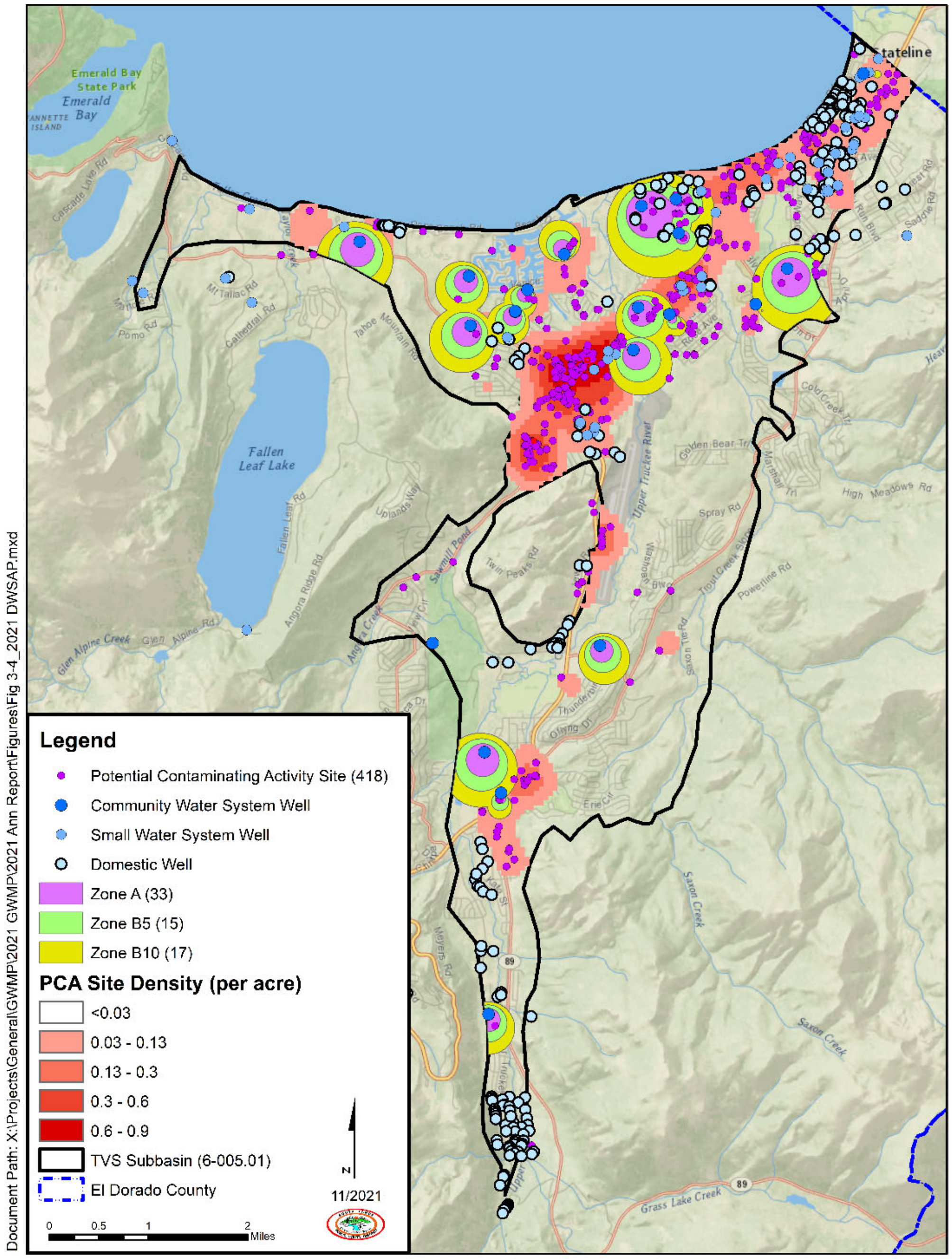

Figure 3-4. Well source area zones and potential contaminating activity sites within the TVS Subbasin. Well source area zones surrounding wells are generated using the modified calculated fixed radius method (CDHS- DDW, 1999) and the average groundwater production rate for each active well (WY 2011 -WY 2020) (Rybarski et al., 2022).

3.5 BMO #5 – Interaction of Water Supply Extractions on Environmental Conditions

Groundwater in the TVS Subbasin is inextricably linked to environmental conditions, and management of groundwater resources will affect both interconnected surface water (ISW) and groundwater dependent ecosystems (GDEs). The purpose of BMO #5 is to implement measures to maintain and protect the ecological communities – both plants and animals – that are dependent on in-stream surface flows and shallow groundwater.

Sustainable management criteria (sustainability goals, undesirable results, sustainability indicators and minimum thresholds) for establishing quantitative criteria for ISW and GDEs are defined for the TVS Subbasin in the first five-year update of the Alternative Plan (Rybarski et al., 2022).

3.5.1 Interconnected Surface Water

- Sustainability Goal: To maintain spatial and temporal continuity of surface flows to support existing beneficial uses.
- Undesirable Result: Reduction of flow sufficient to negatively impact wildlife
- Sustainability Indicator: Current 10-year average stream discharge recorded at USGS Gage 103366092; 10336610 and 10336780 for Oct – May (winter)/Apr- July (peak)/ and July – Sept (late season) flows.
- Minimum Threshold: Both the 10-year average annual discharge and 10-year average late season (Aug-Sept-Oct) discharge are maintained within the range of historical variability (defined as ±25 percent of historical mean discharge), and statistically significant negative trends in discharge are not induced by groundwater pumping.

The sustainability indicator is the measured flow at three active USGS gages within the TVS Subbasin: the Upper Truckee River at Highway 50 above Meyers, CA (USGS Gage No. 103366092); the Upper Truckee River at South Lake Tahoe, CA (USGS Gage No. 10336610); and Trout Creek near Tahoe Valley, CA (USGS Gage No. 10336780) (Rybarski et al., 2022). Salmonid species require cooler water temperatures (<79 °F; 26 °C) year-round (Rohde et al. 2019). Groundwater contributions to streams, i.e., baseflow, helps to maintain suitable temperatures for these species. The sustainability goal for ISW is therefore to maintain sufficient baseflow in streams to provide spatially and temporally continuous flows at the water temperatures required to support the needs of fish and wildlife species in the TVS subbasin.

Stream discharge in mountain basins and salmonid life cycles both exhibit both high seasonality and high interannual variability. To account for the seasonality of measured discharge in the TVS Subbasin, multiple season-specific thresholds have been developed for each stream gage, representing in-stream flows occurring during different times of the year. To account for the interannual variability of measured discharge, the minimum thresholds are based on a ten-year average (or thirty-year median) of discharge measurements rather than a single year (Table 3-6). These ten-year or thirty-year averages are recalculated with each 5-year update to the Alternative Plan.

With each update, the 10-year mean discharge will be calculated for each gage and season and compared to the thresholds noted in Table 3-6. If the 10-year average discharge at any gage falls below the minimum threshold, the threshold has been exceeded.

Gage No.	Location	1 October – 31 March		1 April – 15 July		16 July – 30 September	
		Threshold	10-yr Mean	Threshold	10-yr Mean	Threshold	10-yr Mean
103366092	Upper Truckee River above Meyers	30	42.8	80	194.4	10	17.6
10336610	Upper Truckee River at South Lake Tahoe	40	61.3	140	226.8	10	19.3
10336780	Trout Creek	15	23.0	30	77.2	15	24.9

Table 3-6. Threshold discharges and most recently updated (WY 2011 – WY 2020) 10-year average flows in cubic feet per second (cfs) for each season and gage (Rybarski et al., 2022).

The first five-year update to the Alternative Plan evaluated 10-year average flows as part of the periodic assessment of groundwater conditions (Rybarski et al., 2022). Inspection of Table 3-6 demonstrates that the current 10-year mean flows remained above threshold values at each gage and for each season evaluated.

3.5.2 Groundwater Dependent Ecosystems

GDEs are ecological communities or species that depend on groundwater emerging from aquifers or on groundwater occurring near the ground surface (23 California Code of Regulations, § 351 (m)). GSAs are responsible for identifying GDEs within a groundwater basin.

- Sustainability Goal: To maintain a shallow water table that supports riparian vegetation in areas where riparian vegetation currently exists
- Undesirable Result: Replacement of riparian vegetation by upland vegetation and loss of associated ecosystem services
- Sustainability Indicator: Water table elevation
- Minimum Threshold: Having average groundwater elevations within the interquartile range of historical variability

Stream environment zones (SEZs) are defined in Chapter 90 of the Tahoe Regional Planning Agency (TRPA) Code of Ordinances as "Generally an area that owes its biological and physical characteristics to the presence of surface or ground water." As SEZs and GDEs are both dependent on the presence of groundwater, there is substantial overlap in the spatial distributions of SEZs as defined by the TRPA and of GDEs as delineated by The Nature Conservancy in the TVS Subbasin. Because SEZ is an established term, commonly used in land planning and environmental resource management across regulatory and environmental agencies working within the TVS Subbasin, SEZ is used as a proxy for describing the spatial distribution of GDEs in the first five-year update of the Alternative Plan (Rybarski et al., 2022). The spatial distribution of SEZs within the TVS Subbasin is depicted below in Figure 3-5.

Because GDEs are defined by their access to shallow groundwater, the sustainability indicator is the depth to groundwater. As groundwater levels exhibit interannual variability, this minimum threshold is based on a ten-year average of measurements rather than a single year. For each monitored GDE, the ten-year average groundwater elevation and the ten-year average late-season (Aug-Sept-Oct) groundwater elevation must be greater than 25th percentile of the historical record.

As there are few established monitoring wells with the long-term record needed to establish historical variability of the shallow groundwater that sustains GDEs, simulated groundwater levels from the updated historical STGM were evaluated to identify GDEs that may be vulnerable to declining groundwater levels for the first five-year update of the Alternative Plan. Findings from this evaluation show that negative trends in groundwater levels were not found in either a 30-year or 10-year time scale. Based on simulated groundwater levels, the GDEs within the TVS Subbasin currently appear to be stable or improving (from Rybarski et al., 2022).

The findings presented in the first five-year update of the Alternative Plan are regarded as preliminary, as they are based on hydrologic modeling rather than on field observations. Local stakeholders, including the California Tahoe Conservancy (CTC) and USFS LTBMU, are actively monitoring groundwater levels in and around GDEs, and have provided monitoring data to the District. Data from these wells will be used to provide the initial basis for monitoring GDEs. Additional work is also planned to evaluate potential new locations for monitoring the impact of groundwater withdrawals on ISWs, with special emphasis on GDEs. This evaluation will include both field evaluation and further hydrologic modeling, contingent on future grant funding.

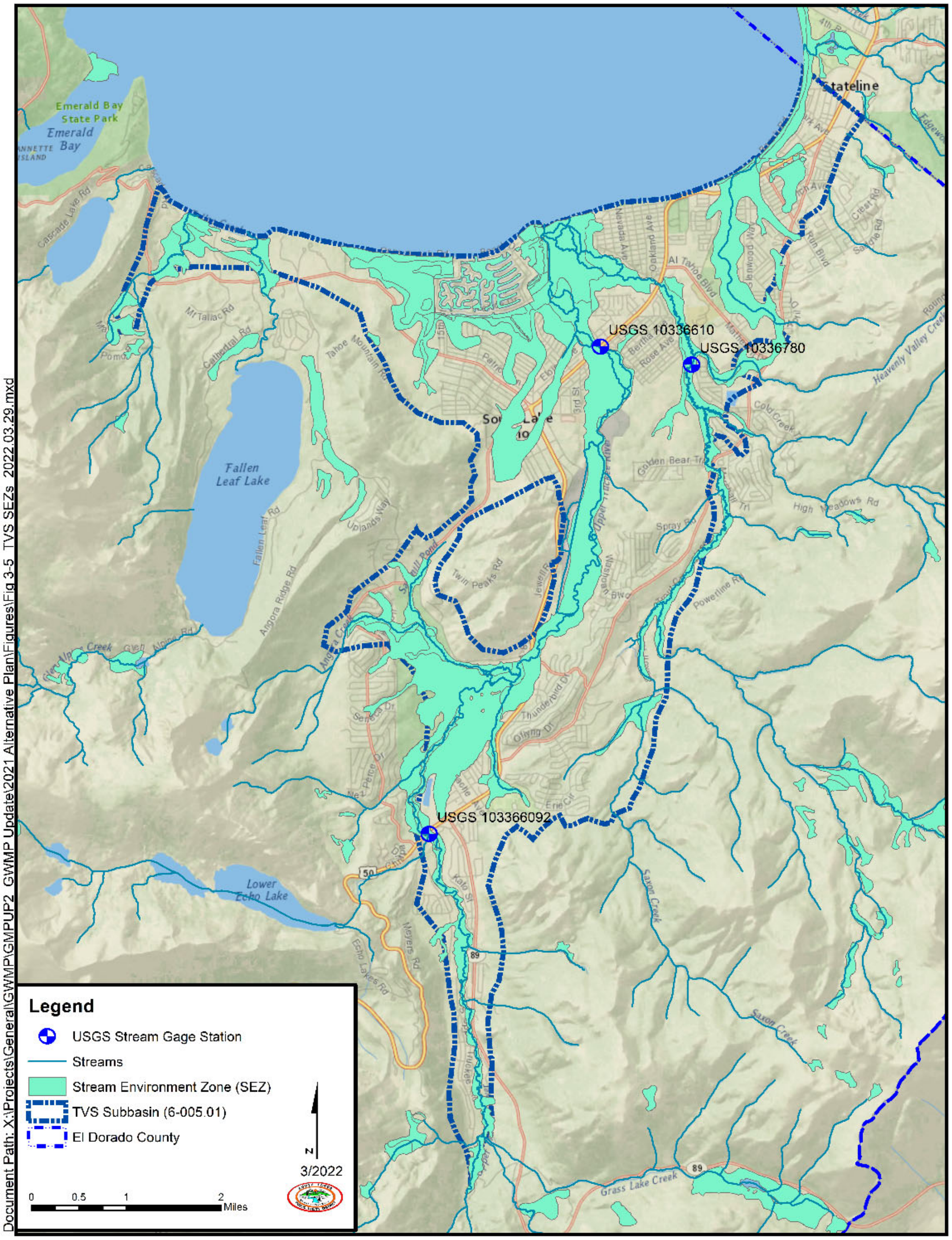

Figure 3-5. Stream Environment Zones as mapped by the Tahoe Regional Planning Agency using land capability. Mapping is for general use only, requiring verification at the individual parcel scale (Rybarski et al., 2022).

3.6 BMO #6 – Stakeholders Advisory Group (SAG)

The purpose of BMO #6 is to provide guidance regarding the role of the SAG in plan implementation. This includes hosting regular SAG workshops to provide a forum for discussion of groundwater management issues in the TVS Subbasin and receive a regional perspective from different members of the community (see Table 3-1). Other important functions of the SAG include:

1. Facilitation for interagency collaboration.
2. Assessing groundwater supply issues.
3. Assessing groundwater protection issues.
4. Data sharing; and
5. Developing regional support for groundwater projects.

During WY 2022, SAG workshops were convened in January and August. Major topics discussed during these workshops are listed in Table 3-7, and minutes from these workshops are provided in Appendix B.

WORKSHOP 1 (January 12, 2022)	**TOPICS**
	First five-year update of the Alternative Plan for TVS Subbasin – Status Update and Comment Review
WORKSHOP 2 (August 24, 2022)	**TOPICS**
	Groundwater Dependent Ecosystems (GDEs) Drought Planning and Water Conservation Activities affecting TVS Subbasin The South "Y" Plume Regional Plume Characterization – Recent findings and Future work status Potential projects for application to DWR for Sustainable Groundwater Management (SGM) Grant Program Funding.

Table 3-7. Major discussion topics for SAG Workshops convened during WY 2022.

3.7 BMO #7 – Technical Studies

Understanding the factors that control groundwater conditions in the TVS Subbasin is important to inform sustainable management. Table 3-8 provides a list of technical reports used to inform groundwater management activities since 2014. All these reports were available for download in WY 2022 through the District's Groundwater web pages https://stpud.us/groundwater/ and https://stpud.us/news/groundwater-management-plan/) The list of technical reports is organized using several different subject matter categories as follows.

- Alternative Plan - technical studies which include detailed evaluation of groundwater conditions and/or provide information on groundwater use within the TVS Subbasin.

- Annual Reports – summaries of hydrologic conditions including groundwater elevation, groundwater extraction, total water use and change of groundwater in storage and groundwater management activities during the preceding water year in accordance with SGMA (§ 10728).

- South Y Plume – technical studies undertaken to address PCE groundwater contamination in the South Lake Tahoe subarea of the TVS Subbasin.

- STGM – technical studies which detail development of the South Tahoe Groundwater Model.

Subject	Name	Date	Author
Alternative Plan	Alternative Plan for Tahoe Valley South Subbasin (6-005.01) - First Five-Year Update	Apr-22	District
Annual Report	Tahoe South Subbasin (6-005.01) Annual Report 2021 Water Year	Mar-22	District
Annual Report	Tahoe South Subbasin (6-005.01) Annual Report 2020 Water Year	Mar-21	District
South Y Plume	Feasibility Study Report	May-20	Kennedy Jenks
South Y Plume	Interim Remedial Action Plan	May-20	Kennedy Jenks
Annual Report	Tahoe South Subbasin (6-005.01) Annual Report 2019 Water Year	Apr-20	District
South Y Plume	Groundwater Fate and Transport Modeling Report - Addendum	Sep-19	Desert Research Institute
South Y Plume	Pre-Design Investigation Report	Jul-19	Kennedy Jenks
South Y Plume	Groundwater Fate and Transport Modeling Report	Jun-19	DRI
Annual Report	Tahoe Valley South Subbasin (6-5.01) Annual Report 2018 Water Year	Mar-19	District
South Y Plume	Baseline Health Risk Assessment	Jan-19	Kennedy Jenks
Alternative Plan	TVS Groundwater Basin Survey of Well Owners	Dec-18	Allegro Communications
Annual Report	Tahoe Valley South Subbasin (6-5.01) Annual Report 2017 Water Year	Mar-18	District
Alternative Plan	Addressing Basin Management Objectives for the Tahoe Valley South (TVS-6.5.01) Groundwater Basin	Feb-18	DRI
Annual Report	Tahoe Valley South Subbasin (6-5.01) Annual Report 2016 Water Year	Mar-17	District

Subject	Name	Date	Author
Alternative Plan	Analysis of Basin Conditions Tahoe Valley South (6-5.01) Groundwater Basin, California	Dec-16	DRI
STGM	South Lake Tahoe Groundwater Model – Technical Memo Update	Aug-16	DRI
South Y Plume	South Y Extraction Well Suitability Investigation	Jun-16	GEI Consultants
Annual Report	Tahoe Valley South Subbasin (6-5.01) Annual Report 2015 Water Year	Mar-16	District
STGM	South Lake Tahoe Groundwater Model – Phase 1 Report	Feb-16	DRI
Alternative Plan	Tahoe Valley South Basin (6-5.01) 2014 Groundwater Management Plan	Dec-14	Kennedy Jenks

Table 3-8. Technical reports completed in support of sustainable groundwater management for the TVS Subbasin (https://stpud.us/groundwater/ and https://stpud.us/news/groundwater-management-plan/)

During WY 2022, periodic evaluation of groundwater conditions within the TVS Subbasin continued in accordance with the first five-year update of the Alternative Plan (Section 3.3.2).

3.8 BMO #8 – Funding

Groundwater projects require funding. In addition to funding from local sources, there are state and federal grants and other funding programs available. These types of opportunities require effort to prepare, and process grant funding applications. Over the first seven years of implementation, groundwater management actions under the Alternative Plan have been funded through the District's Water Enterprise Fund, the EDWA Cost Share Program and state funding through the Proposition 1 Groundwater Program.

3.8.1 Proposition 1 Groundwater Grant

On March 20, 2018, SWRCB-DFA and the District executed Agreement D1712508 funding a feasibility study of remedial alternatives to mitigate PCE contamination. The Proposition 1 Groundwater Planning Grant was used to evaluate whether existing and/or new wells can be used to provide hydraulic control and removal of PCE from groundwater in the TVS Subbasin.

The South Y Feasibility Study was completed during WY 2020. All grant requirements under Agreement D1712508 were completed to the satisfaction of the SWRCB-DFA. Copies of all technical documents prepared as deliverables for the South Y Feasibility Study are available for download from the Groundwater web page of the District's web site: (https://stpud.us/groundwater/).No Proposition 1 Groundwater Planning Grant funds were expended in WY 2022.

3.8.2 2022 Costs

GSA administration, including Alternative Plan, costs are primarily incurred by the District's Water Enterprise Fund. Development and implementation costs for groundwater management activities have been supported by the Water Agency under its Cost Share Grant program. Under this program, the Water Agency assists projects eligible under Section 96-11 of the El Dorado County Water Agency Act and Board Expenditure Priority Policy (No. B-1003). Grants used for these projects are typically at a 50% matching fund level.

Figure 3-6 shows Alternative Plan costs expended during the calendar year ending December 31, 2022. Costs for groundwater management projects and activities totaled $234,070. Most costs expended during CY 2022, including legal expenses, were on technical studies, public outreach and GSA administration required for preparation of the first five-year update of the Alternative Plan. Since 2015, the total cost to implement the Alternative Plan is $2,683,489.

3.8.3 Future Funding Opportunities

Future funding opportunities supporting groundwater management activities include the Sustainable Groundwater Management (SGM) Grant Program managed by the DWR Division of Regional Assistance, Proposition 68 grant funds and remaining Budget Act of 2021 funds. The following information is provided from the *SGM Grant Program SGMA Implementation Proposal Solicitation Package* (DWR, 2021b).

Under the SGM Grant Program, $114 million will be available for grant awards that will be directed to projects that benefit medium and high priority groundwater basins (including COD basins) that support implementation of SGMA. Priority in future funding grant solicitations will be given to applicants in basins that have not previously been awarded SGMA Implementation funding (DWR, 2021b). Proposition 68 authorizes the Legislature to appropriate a total of $120 million to DWR for drought and groundwater investments to achieve regional sustainability. After the administrative cost and previous funding awards, approximately $71.5 million is available for drought and groundwater investments to achieve regional sustainability through investments in groundwater recharge with surface water, stormwater, recycled water, and other conjunctive use projects, and projects to prevent or clean up contamination of groundwater that serves as a source of drinking water (Public Resources Code § 80146(a)). Of the approximately $71.5 million, a minimum of $15 million is reserved for projects located within and solely supporting a Severely Disadvantaged Community (SDAC) (DWR, 2021b).

The $114 million in future General Fund appropriations, the remaining $17 million in FY 2021/2022 General Fund appropriation, and the remaining $71.5 million in Proposition 68 grant funds will be combined in a single funding round (Round 2) for the medium and high priority basins. The minimum and maximum grant awards range from between $ 1 million to $20 million per basin. Round 2 Grant Solicitations for this funding open in October 2022. Eligible projects include those activities associated with the planning and implementation of a GSP or Alternative to a GSP and must also be consistent with the goals within the GSP or Alternative to a GSP (DWR, 2021b).

Projects presented in the Implementation Plan of the first-five-year update of the Alternative Plan which may be eligible for Round 2 funding beginning with WY2023 are listed below (Table 3-9).

Basin Management Objective (BMO)	Potential Projects
BMO#1: Maintain a sustainable long-term Groundwater Supply	• Planning and development of groundwater sources to maintain a sustainable water supply
BMO #2: Maintain and Protect Groundwater Quality	• Update the South Y PCE Model using new data collected during the LRWQCB Regional Plume Investigation.
BMO #3: Strengthen Collaborative Relationships	• Conduct a third phase of the survey of private well owners. • Collaborate with local Storm Water Managers to develop outreach materials highlighting the detrimental impact of illicit discharges to storm water systems on groundwater. • Develop an interagency database and public web portal to share local groundwater data and issues
BMO#5: Assess the interaction of water-supply activities with environmental conditions	• Refine monitoring protocols to detect potential changes in baseflow and GDEs due to groundwater pumping.
BMO #7: Conduct Technical Studies to assess future groundwater needs and issues	• Monitor degraded water quality in the South Y Regional Plume and near the Meyers Landfill. • Investigate the occurrence of PFOA and PFOS in stormwater within the TVS Subbasin. • Investigate the impact of wildfire on groundwater recharge within the TVS Subbasin

Table 3-9. Potential projects for SGM Grant Program Round 2 funding in WY 2023.

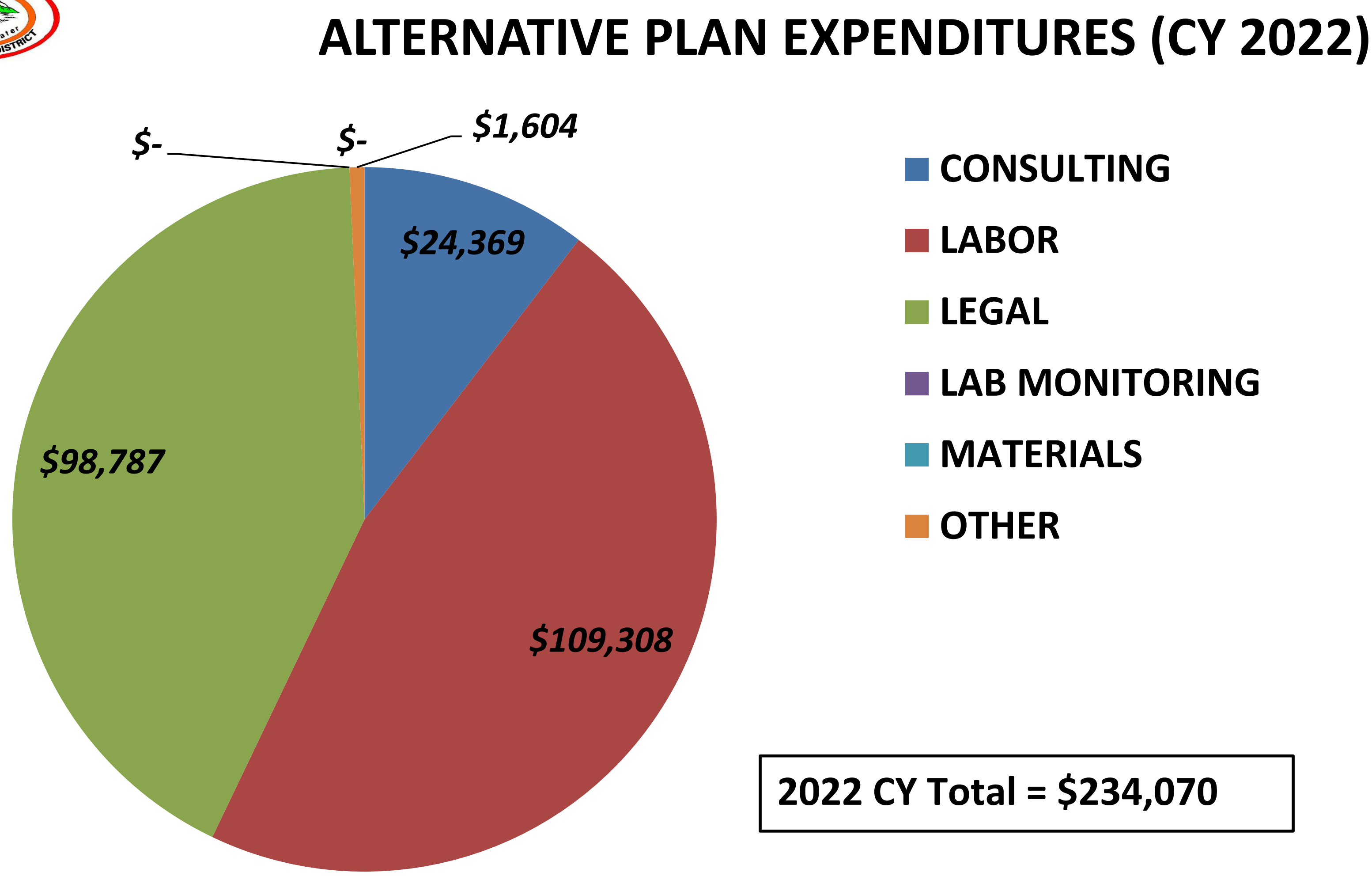

Figure 3-6. Alternative Plan costs for CY 2022.

4 Proposed Actions (WY 2023)

Groundwater management activities for WY 2023 will generally involve continuing the progress of on-going work from WY 2022 and the proposed actions listed below.

1. Continue to monitor new regulations and Basin Monitoring Program guidance issued by the DWR and SWRCB for implementation of SGMA.
2. Continue to monitor basin conditions and groundwater supplies and plan for future observation wells.
3. Continue to update the SAG on the progress of Alternative Plan-related activities, seeking active participation of its members.
4. Continue to inform the public of groundwater management activities through public hearings, SAG workshops, notifications through its interested parties list, and the District's web page.
5. Maintain the contacts list of stakeholders interested in receiving notices regarding plan preparation, meeting announcements and availability of draft documents developed for the first five-year update of the Alternative Plan.
6. Apply for Round 2 SGM Grant funding for grant administration, shallow groundwater monitoring, surface water quality monitoring, investigation of PCE contaminated soil, sentinel well monitoring, PCE wellhead treatment, and public outreach and engagement.
7. Continue groundwater management actions and activities presented in the adopted Alternative Plan.

5 Alternative Plan Changes

Under SGMA, existing groundwater management plans remain in effect until a GSP or GSP Alternative is adopted (CWC § 10750.1). As DWR has determined that the 2014 GWMP and Alternative Materials satisfied the objectives of SGMA and was approved as an Alternative Plan for the TVS Subbasin, the District proceeded with preparing the first five-year update of the Alternative Plan, which was adopted by the District and Water Agency and submitted to DWR in April 2022. The District is now operating under the first five-year update of the Alternative Plan.

The first five-year update of the Alternative Plan includes numerous changes, additions, and modifications compared to the approved existing plan Alternative, adopted in 2014. The most significant changes occur in Section 8 of the first five-year update of the Alternative Plan. In the 2014 GWMP Section 8 provides a description of basin management objectives, strategies, and actions for qualitative management of groundwater resources within the TVS Subbasin. Under the first five-year update of the Alternative Plan, Section 8 has been updated using sustainable management criteria consistent with SGMA and developed for the TVS Subbasin within the framework of basin management objectives. The sustainable management criteria presented in the Alternative Plan provide quantitative criteria that are used to determine compliance of the first five-year update of the Alternative Plan with the objectives of SGMA.

Other important changes presented in the first five-year update of the Alternative Plan include, but are not limited to, the following items.

- Section 1: Information has been updated and reorganized into Sections 1.1 Background, and Section 1.2 Development and Adoption Process. New Sections 1.3 Existing Plan and DWR Approval and 1.4 SGMA Compliance have been added.
- Section 2: A new Section 2.3 Soils and 2.5 Description of Basin Aquifers has been added. Surface Features and ecological resources are discussed under Section 2.6 Surface Water Features. All subsections have been updated.
- Section 3: Information has been updated and reorganized into new Sections 3.1 Population and Economy; and Section 3.2 Land Use. Water purveyors are discussed under new Section 3.3 Groundwater Uses and Users. A new Section 3.4 Demand Projections has been added.
- Section 4: Information has been updated and reorganized into new Section 4.2 Overlying Jurisdictions, Section 4.3 Regulatory Agencies, Section 4.4 Regulatory Programs and Policies, and Section 4.5 Analysis of Limits Imposed by Existing Water Resource Monitoring and Management Programs.
- Section 5: A new Section 5.5 Sustainable Yield has been added. All subsections have been updated.
- Section 6: Groundwater Contamination and Stormwater Infiltration Potential are discussed under new Section 6.3 Groundwater Quality Issues. All subsections have been updated.
- Section 7: Convene an Ongoing SAG has been updated and discussed under new Section 7.3 Future/Ongoing Stakeholder Involvement Opportunities.
- Section 8: Information has been updated and reorganized into new Sections 8.1 Maintain a Sustainable Long-Term Groundwater Supply; 8.2 Maintain and Protect Groundwater Quality; and 8.3 Assess the Interaction of Water Supply Activities with Environmental Conditions.
- Section 9: Information has been updated and reorganized into Sections 9.1 Groundwater Monitoring and Section 9.2. Identification and Description of Data Gaps.
- Section 10: Information has been updated and reorganized into Sections 10.1 Projects, Section 10.2. Funding the Alternative Plan and 10.3 Reporting.

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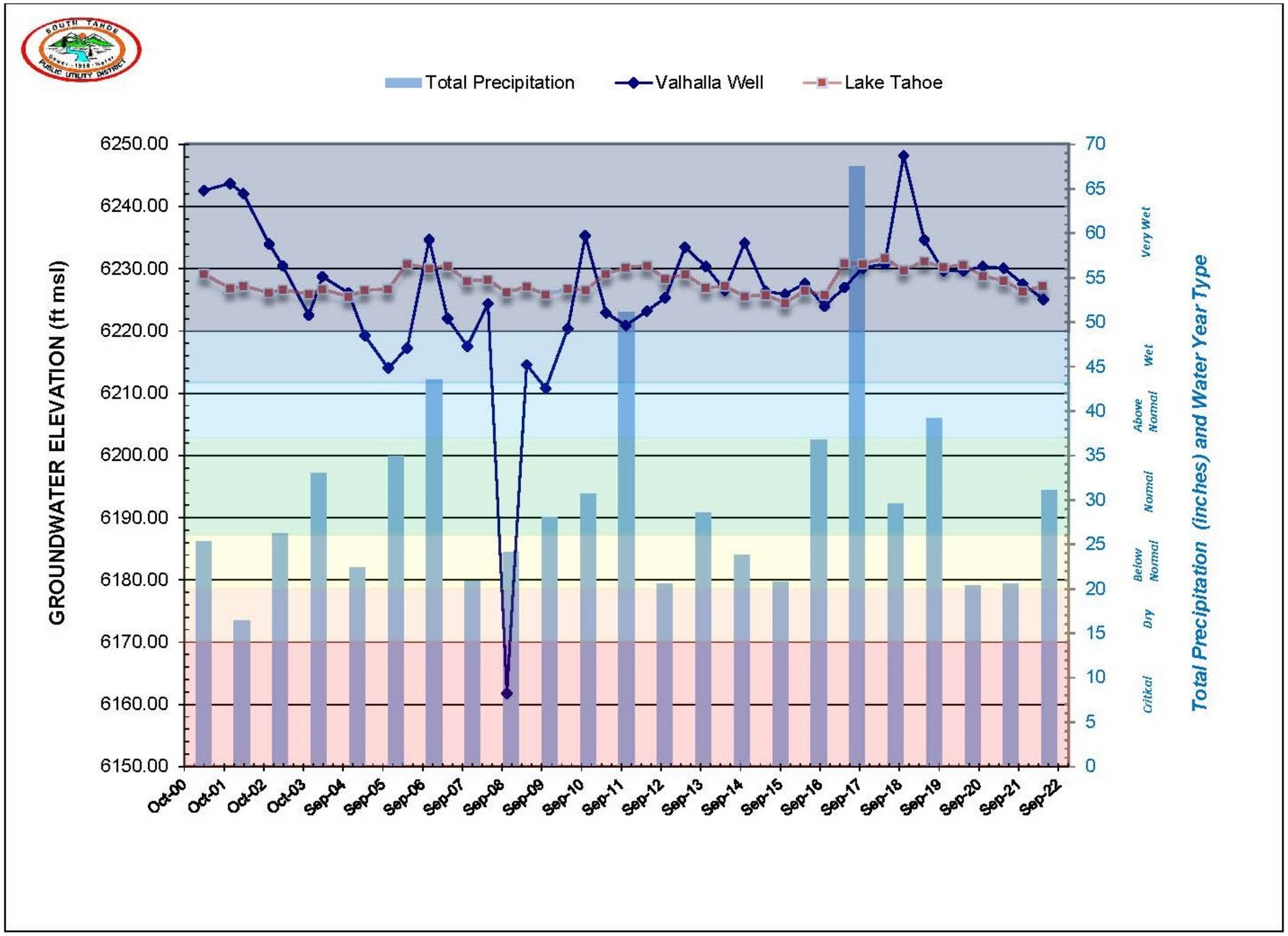
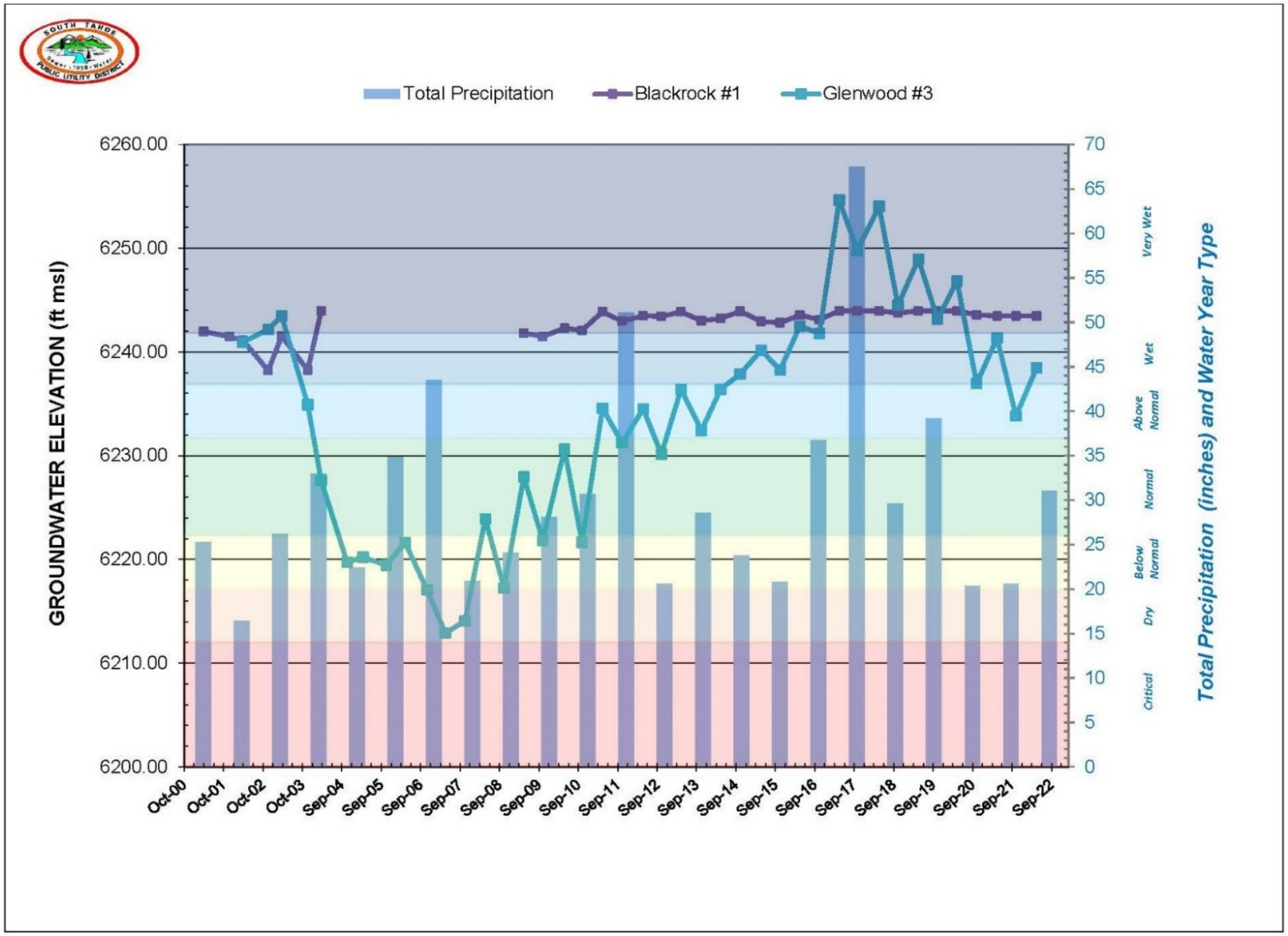
APPENDIX A

TVS Subbasin (6-005.01)

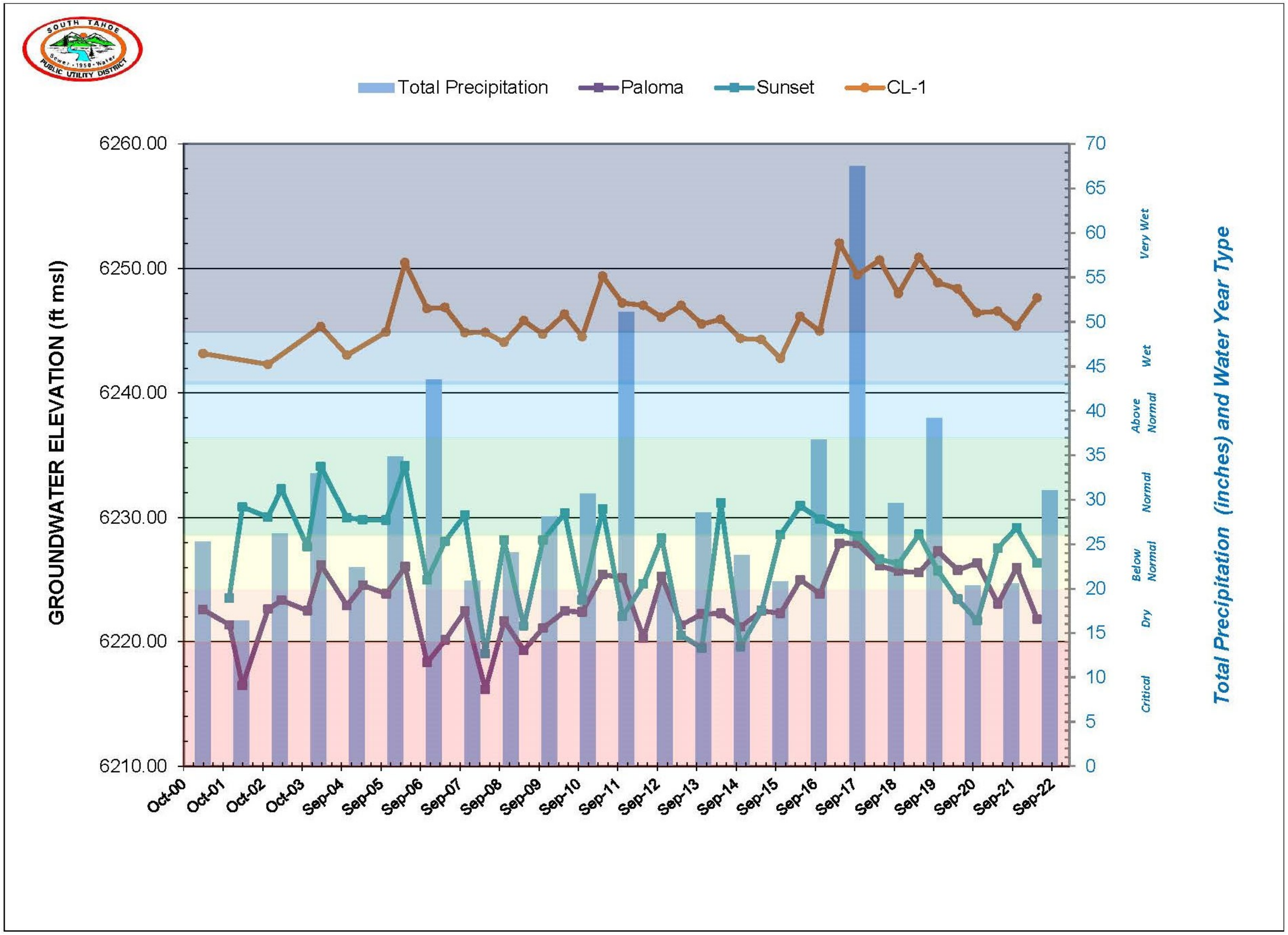
Hydrographs



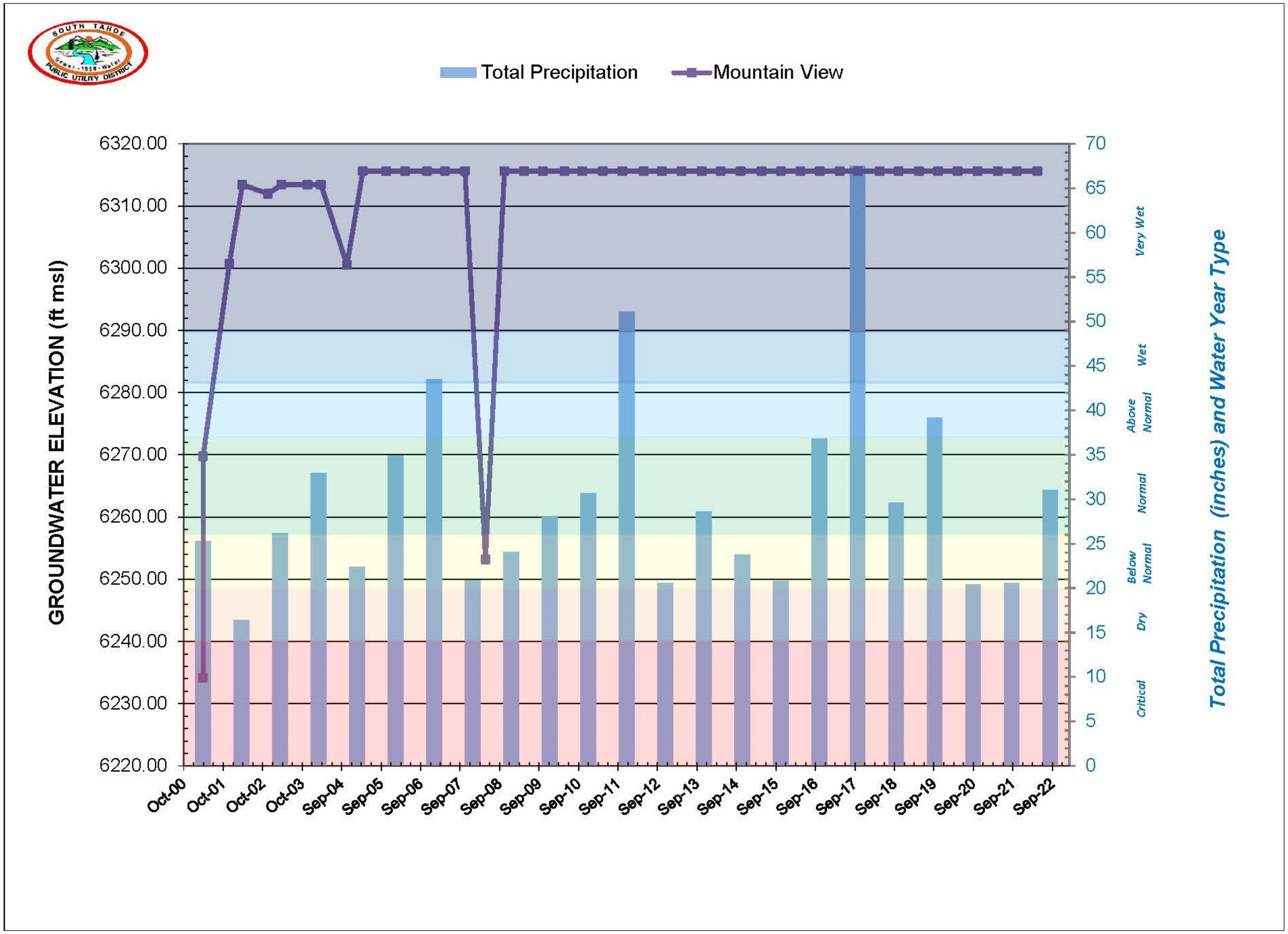
- **Appendix A – 1.** Groundwater hydrograph for the Valhalla Well (6,257 feet msl) within the Tahoe Keys sub-area. Also shown is the water level (stage) of Lake Tahoe measured at USGS 10337000. All readings are static water levels collected following a minimum 12-hour recovery time, except for the May 2007 reading, which is a pumping water level measured at a well pumping rate of 700 gallons per minute (gpm). Water year type for the TVS Subbasin is indicated using the bar chart, with the upper bound of total precipitation in inches displayed on the secondary-y axis.



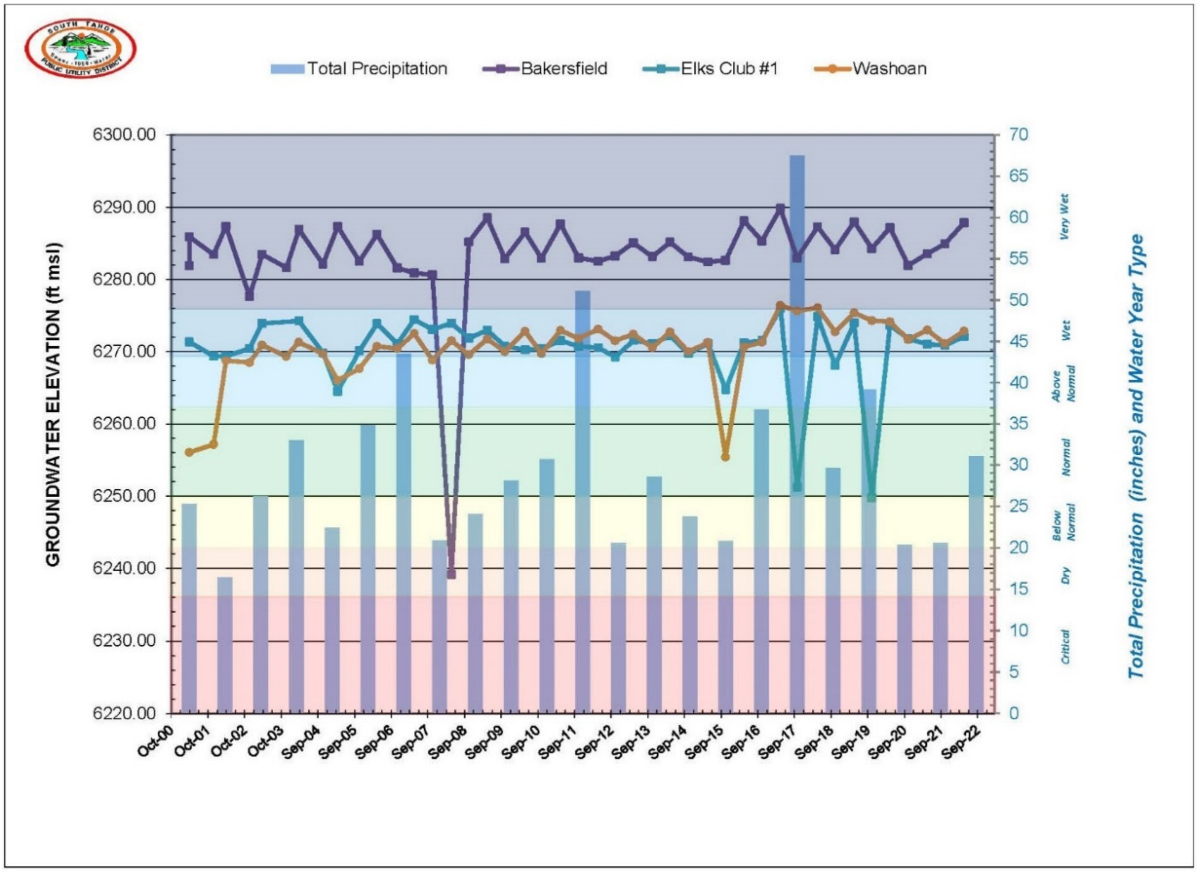
Appendix A – 2. Groundwater hydrograph for the Blackrock #1 (6,241 feet msl) and Glenwood #3 (6,260 feet msl) wells within the Bijou sub-area. Static water levels in the Blackrock #1 well are stable and slightly rise above ground surface (6,240 feet msl). The Glenwood #3 well is used to monitor water levels near an active CWS well (Glenwood #5). In 2007, the District restricted water production from Glenwood #5 to sustain groundwater production from this sub-area. The water level response in Glenwood #3 shows that this change in operation has been successful in allowing groundwater levels to recover to sustainable levels.



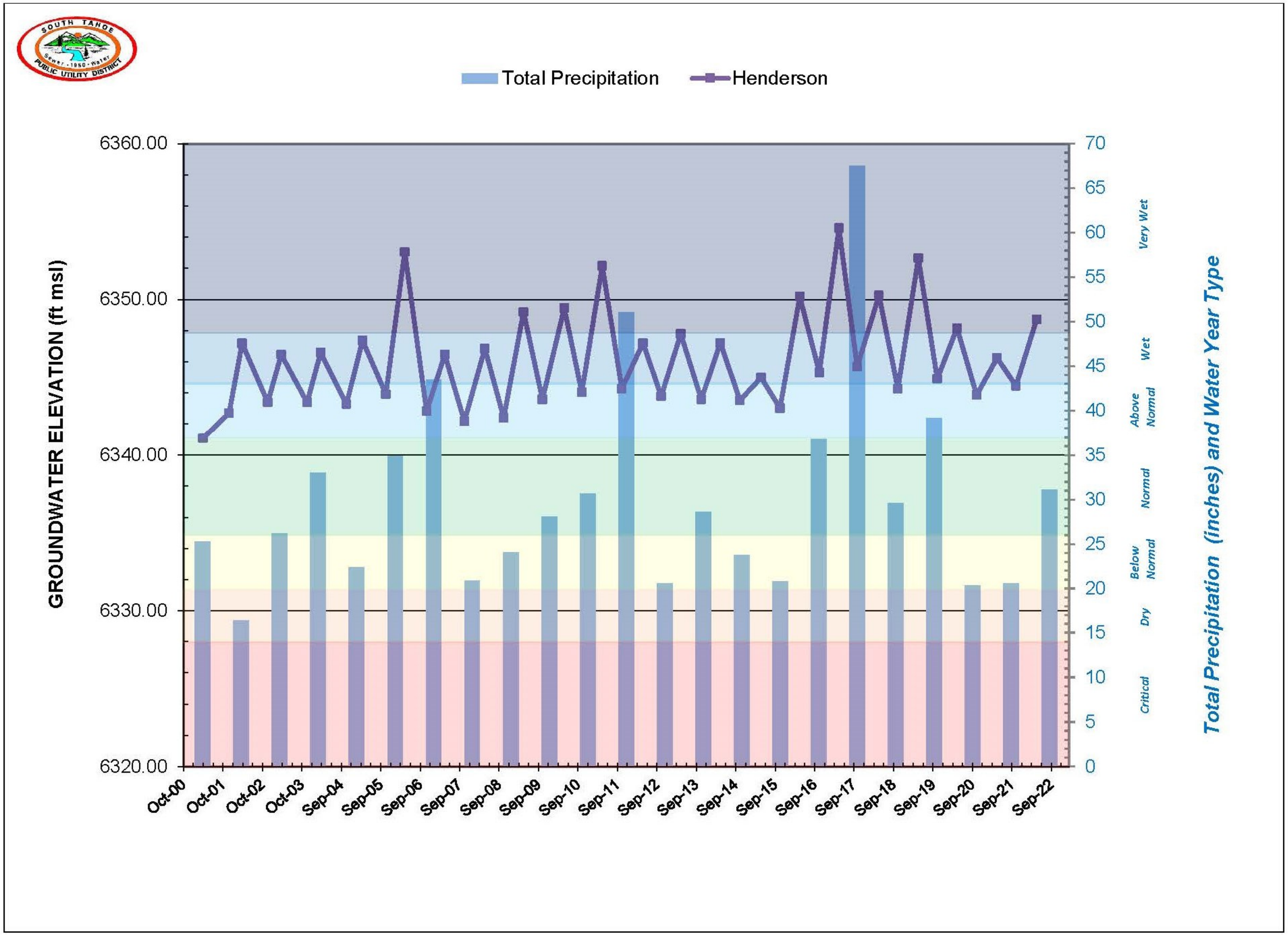
Appendix A – 3. Groundwater hydrograph for the Paloma (6,267 feet msl); Sunset (6,249 feet msl) and CL-1 (6,279 feet msl) wells in the South Lake Tahoe sub-area. Groundwater levels in these wells appear stable. Since 2017, groundwater production from the Sunset well has increased by about 59 million gallons per year. Groundwater levels for the Sunset Well are on-watch for possible groundwater production restrictions.



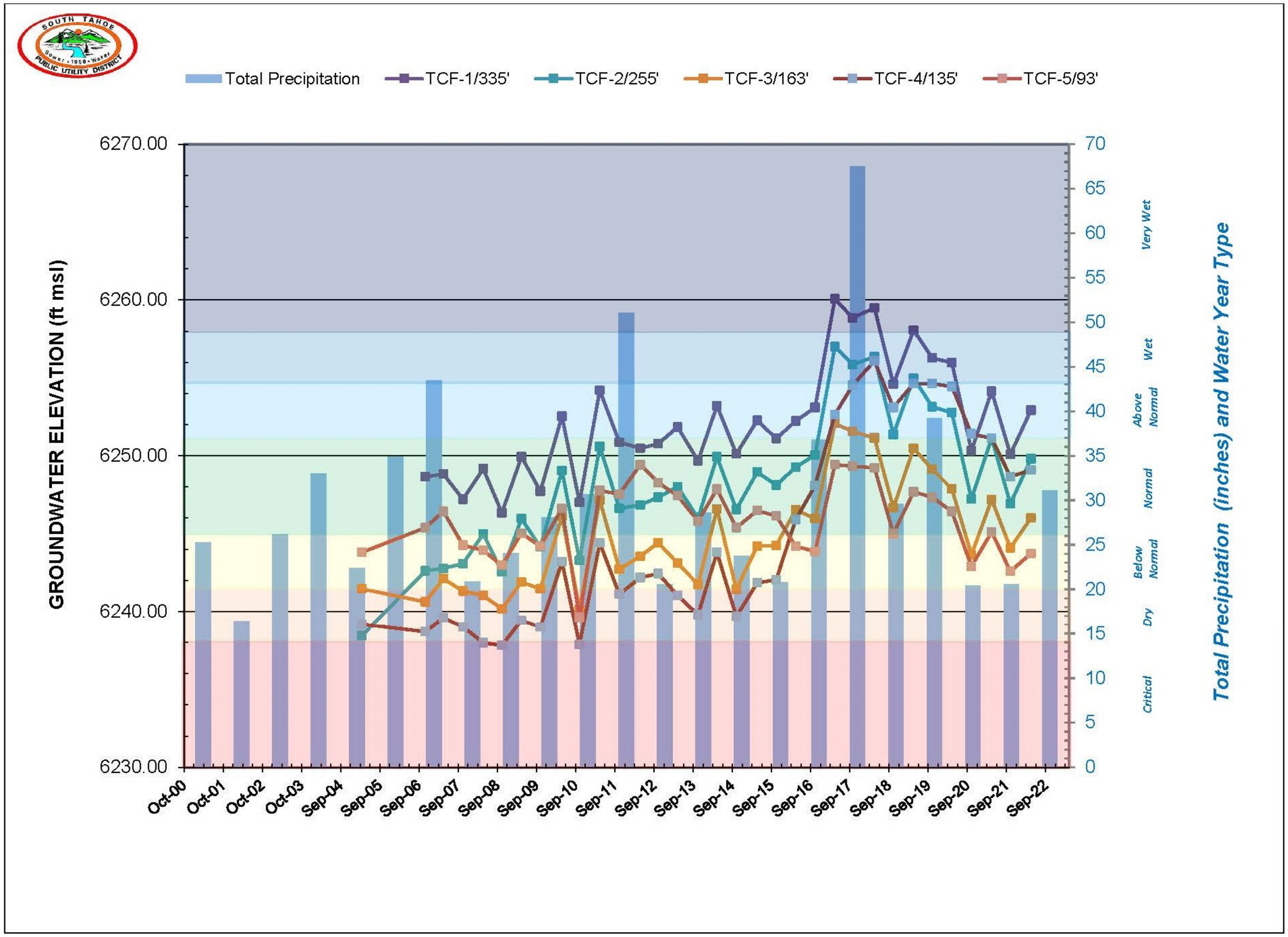
Appendix A – 4. Groundwater hydrograph for the Mountain View (6,313 feet msl) well (artesian flowing well) in the Angora sub-area.



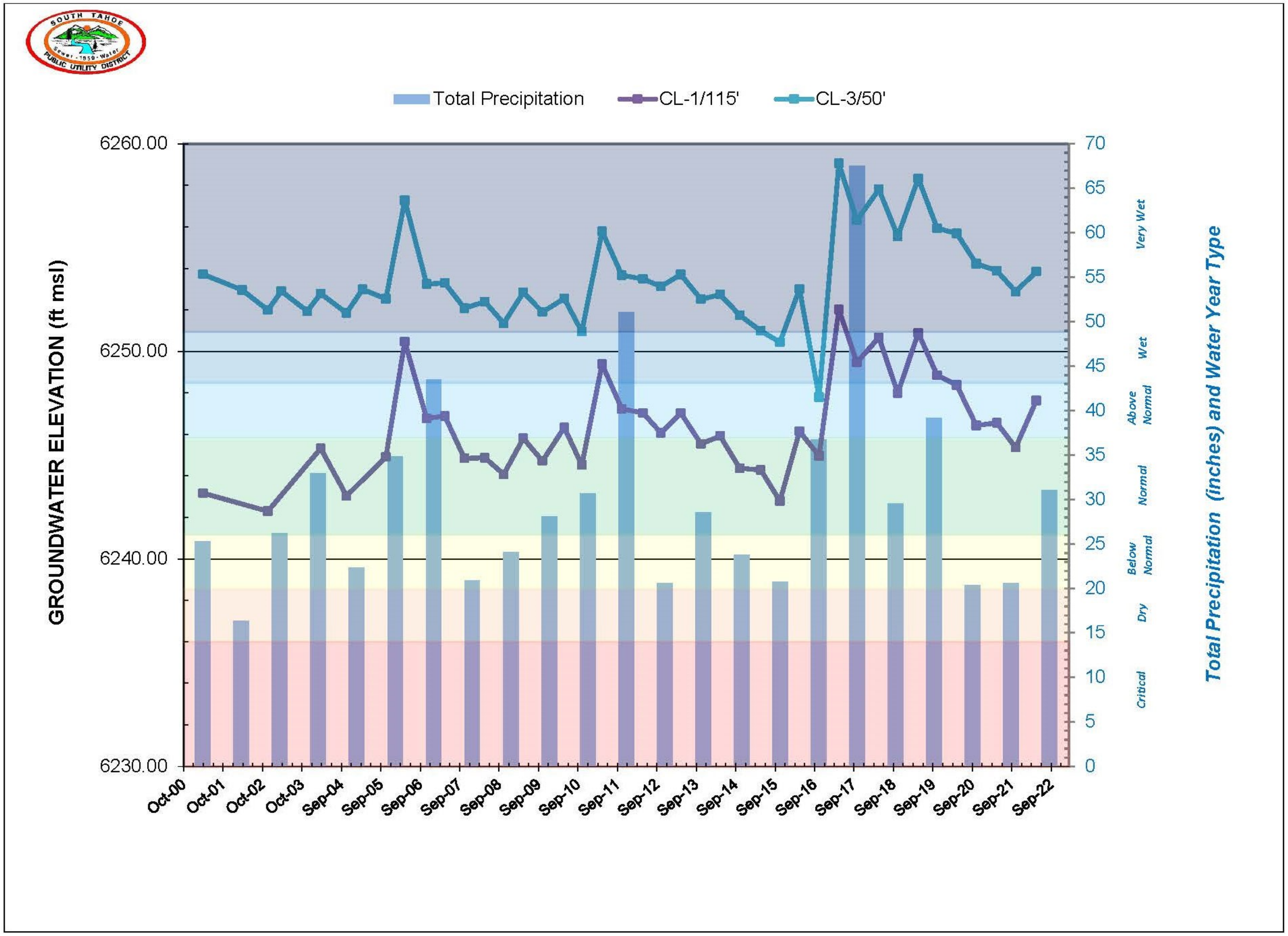
Appendix A - 5. Groundwater hydrograph for the Bakersfield (6,311 feet msl); Elks Club #1 (6,283 feet msl) and Washoan (6,308 feet msl) wells in the Meyers sub-area. Groundwater levels in the Meyers sub-area are relatively stable with short periods of declining water levels in response to increased pumping rates. Static water levels collected from the Bakersfield Well are following a minimum 12-hour recovery time, except for the May 2008 reading (pumping water level at 1,500 gpm). The Elks Club #1 Well is situated near an active pumping well (Elks Club Well #2). Static water levels collected from the Elks Club #1 are typically collected when the Elks Club Well #2 is off. The October 2017 and November 2019 readings are water levels measured when the Elks Club #2 Well was pumping at a rate of 310 gpm and 389 gpm, respectively.



Appendix A-6. Groundwater hydrograph for the Henderson Well (6,370 feet msl) within the Christmas Valley sub-area. Groundwater levels in this well are stable and do not exhibit a long-term downward trend.



Appendix A – 7. Groundwater hydrograph for the USGS TCF nested well (6,296 feet msl) within the South Lake Tahoe sub-area. Total well depths for the observation wells completed within the common borehole are as indicated. The complex vertical flow directions indicated by differences in groundwater levels in this well are believed to result from lowered head in WBZ 4 induced by pumping of the Glenwood #5 well.



Appendix A - 8. Groundwater hydrograph for the Clement Well cluster (6,279 feet msl) within the South Lake Tahoe sub-area. Total well depths for the observation wells comprising the well cluster are as indicated. Both CL-1 and CL-3 monitor groundwater levels from the uppermost water-bearing zone (TKZ5). Vertical flow is directed downward indicative of recharge adjacent to Tahoe Mountain.

APPENDIX B

SAG Workshop Minutes

Workshop 1 (January 12, 2022)

Workshop 2 (August 24, 2022)

Workshop 1 (January 12, 2022)

Tahoe Valley South Subbasin (6-005.01) Alternative
MEETING NOTES
Wednesday, January 12, 2022; 2:00 pm - 4:00 pm
Location: MS Teams On-Line Meeting
https://teams.microsoft.com/l/meetup-join/19%3ameeting_MjI0ZWIyZGMtNTcxMy00MDBhLWJmMzctNTZmMTNlODBhMDMy%40thread.v2/0?context=%7b%22Tid%22%3a%2292ca86aa-8881-4bb8-854c-e311e8fff029%22%2c%22Oid%22%3a%22b657b939-cc03-4f0d-b3a1-5f0eca12485f%22%7d

RECORD MEETING

SAG ATTENDEES:
John Thiel, PE; Ivo Bergsohn, PG, HG (STPUD); Kyle Ericson, PE (El Dorado Water Agency); Karen Bender, REHS (El Dorado County – EMD); Brian Grey, P.G., (Lahontan Regional Water Quality Control Board); Jason Burke (City of South Lake Tahoe); Jacob Stock (Tahoe Regional Planning Agency; Nicole Bringolf (USFS-LTBMU); Jennifer Lukins (Lukins Brothers Water Co)

Participants:15

BASIN MANAGEMENT OBJECTIVES:
1. Maintain a sustainable long-term groundwater supply.
2. Maintain and protect groundwater quality.
3. Strengthen collaborative relationships with local water purveyors, governmental agencies, businesses, private property owners and the public.
4. Integrate groundwater quality protection into local land use planning activities.
5. Assess the interaction of water supply activities with environmental conditions.
6. Convene an on-going Stakeholders Advisory Group (SAG) as a forum for future groundwater issues.
7. Conduct technical studies to assess future groundwater needs and issues.
8. Identify and obtain funding for groundwater projects.

WORKSHOP OBJECTIVES
1. Gather initial review comments for the first five-year update of the Alternative Plan for the Tahoe Valley South Subbasin (6-005.01) (Draft, 12/17/2021).

Roll Call
Jason Burke (CSLT), Jacob Stock (TRPA), Kyle Ericson (EDWA); Susan Rybarski; Gary Kvistad (General Counsel); Karen Bender (EDC-EMD); Brian Gray (LRWQCB) Nicole Bringolf (USFS-LTBMU), Jennifer Lukins (Lukins/TKWA); Ivo Bergsohn (STPUD), Mark Hausner (DRI); Susie Rybarski (DRI)

TVS Basin (6-5.01) - Open Forum (Group)
Current groundwater-related topics outside Agenda

I. Bergsohn, STPUD
- 2022 SAG Roster Changes:
  - Thanks to
    - Joey Keeley, USFS-LTBMU - Retired;
    - Michael Conger, leaving TRPA
    - Daniel Larson, TKWC, - Employment change - working for City of Fernley, NV

Tahoe Valley South Subbasin (6-005.01) Alternative
MEETING NOTES
Wednesday, January 12, 2022; 2:00 pm - 4:00 pm
Location: MS Teams On-Line Meeting
https://teams.microsoft.com/l/meetup-join/19%3ameeting_MjI0ZWIyZGMtNTcxMy00MDBhLWJmMzctNTZmMTNlODBhMDMy%40thread.v2/0?context=%7b%22Tid%22%3a%2292ca86aa-8881-4bb8-854c-e311e8fff029%22%2c%22Oid%22%3a%22b657b939-cc03-4f0d-b3a1-5f0eca12485f%22%7d

- Welcome to
  - Jacob Stock, Senior Long-Range Planner, TRPA (Replacing M. Conger)
  - Kyle Ericson, PE, Water Resources Engineer, EDWA
  - Russ Wigart, Stormwater Coordinator, EDCDOT

J. Lukins, LBWC

- Jennifer Lukins is also representing TKWC as interim Water Manager. She took over in December and reported that she is getting things up to speed in preparation for the Summer**.**

I. Bergsohn, STPUD

- 2021 SAG Workshop 2 Meeting Notes and Presentations (June 30, 2021) are posted on District's Groundwater Page. This would have been about the time we were all coming back from COVID. We have cranked out a lot of work since then.

Alternative Plan – SAG Comments

Handouts: Alternative Plan for TVS Subbasin (6-005.01)

- Ivo Bergsohn, STPUD (IB) introduced the working draft document and encouraged SAG participants to provide initial comments on the draft document by next Thursday, January 20th. For today the wish is to field initial comments from the SAG starting with General Comments on the draft Document and then walking-through for SAG comments on specific sections.
- Before fielding comments from the SAG, did anyone happen to read the entire document?
  - Nicole did read most of the beginning of the document. She wanted to discuss Section 2 on the Ground Water Basin. Should we use lake level at elevation? The document mentioned lake level as 6,225 feet, but in Section 2.62 it is listed as 6,22.3 feet. Should we use the 6,225 number in both places to be consistent? Ivo said we will take a look at that.
  - Karen Bender just texted Russell Wigart. He did not get the invitation that she had forwarded him for the SAG meeting but will joining momentarily.

- General (Note: Document has been paginated since release of the 12/17 draft)
- Any thoughts on the organization of content in the Document?
  - Ivo asked the group about the organization of the document. Is there anything that needs to be rearranged or changed in the sequencing in the document.
  - No comments.
- Suggested additions to the Glossary?
  - Ivo pointed out the Glossary at the beginning of the document after the Table of Contents. He would like any recommendations for improvement or comments.
  - Nicole Bringolf (USFS-LTBMU) thinks the glossary is more of an acronym list. Ivo asked if she would prefer something with greater detail in the Glossary rather than just the identifiers? Nicole said the word Glossary is fine if that is the way Ivo wants

to go.

General suggestions for Improvement?
- No comments

Section 1 – Introduction (Regulatory Context) :

- Any Comments on Section 1?
  - Ivo reported that this section is to primarily to provide the reader with the regulatory context for the Alternative Plan. It talks about the background and evolution of the Alternative Plan. It is also to point out the changes and new additions added to the Alternate Plan.
  - It starts with the 2014 Ground Water Management Plan (GWMP) submitted to the Department of Water Resources (DWR) in 2016. It took some time for DWR to review it and approve it as the Alternative Plan for our Subbasin. There is a description of the recommended actions in the introduction from DWR as far as some of the things that they wanted to see in the alternative. Then we are required to incorporate those changes in the Alternative Plan. This is the first 5-year update that will need to be submitted to DWR. Also, of note is the changes that were made between the 2014 plan and the current draft
- Any needed corrections/clarifications?
  - No comments
- Any thoughts on the evolution of the Alternative Plan described in Section 1.2?
  - Brian Grey (LRWQCB) thought that things came across pretty clearly in Section 1.2, but in terms of looking at table 1-2 it is not quite consistent with the section headings right now. We probably want to go through and make sure that it is consistent in the final document.
  - Ivo has made some updates since the time this was released and now.
  - Brian said that is in terms of the titling of Section 1.2, it might be good to point out to the reader that the actions were recommended by DWR and not another entity. Also, on the list of projects in Section 1.2.1, is there additional work that should be included there?
  - Ivo said we talk about it more in depth in section 7.
- Any thoughts on the presentation of new content added to the Alternative Plan described in Sections 1.3 and 1.4; does it adequately alert the reader to these changes in the document?
  - Brian asked if the fact that the subjects are introduced and further discussed later in the document is consistent?
  - Ivo said that in Table 1 we were trying to set the table to let the reader know what was coming in the document in subsequent sections. He appreciates the comment that introducing it early and discussing it in later sections may be problematic to some readers, but does highlighting the new content in Sections 1.3 and 1.4 adequately alert the reader to those changes in the document? Brian said it seemed that way.
- Suggestions for improvement?
  - See above

Section 2 – Groundwater Basin (Physical Description of Subbasin):

- This is pretty much the physical description of the Subbasin. Any comments?
- Does it adequately describe the basin boundaries and geographic sub-areas?
  - Jacob Stock (TRPA) said that speaking on behalf of other colleagues at TRPA, there was a question regarding Figure 2-14. The question is what data was used to show the TRPA delineated SEZ Zones if using land? The mapping needs to specify.
  - Ivo believes this is from the TRPA special data set. That was the layer that we used.
  - Jacob can confirm with his colleagues. She may have just meant that we need a disclaimer when dealing with specific parcels. He will follow up with her and pass it on.
  - It is thought that we all use a similar delineation for SEZ's to delineate parcels. Jason Burke (City of SLT) said he knows it is a very sensitive topic.
  - Ivo asked that if anyone in the group has comments to him as far as typos and such to submit them to him in writing before 1/20.
  - Ivo told Mark Hausner (DRI) that this would probably be a good place to mention that GDE's are one aspect of it. Mark said we can certainly refer to that and address that in that section
- Did you find any portions of Section 2 confusing/difficult to read such as the descriptions of the Geology, Basin Aquifers and/or Surface Water Features?
  - No comments
- Suggestions for improvement?
  - No other suggestions for improvement

Section 3 – Plan Area (GW Use within Subbasin):

- Focused on describing groundwater use within the Subbasin. Have kind of an odd fit section in 3.5 to talk about Wastewater management with lack of a better place to include it.
- Any thoughts comments on descriptions of population or population growth land use and groundwater use within the basin?
  - No comments
- Were there Water Demand Projections presented in a clear manner?
  - Section 3.3 is devoted to different groundwater users primarily public water systems being changed to community water systems and individual water systems. It also includes the Well Owners Surveys.
  - Brian said that there had been some discussion of clarification of public vs community. Whatever is chosen should mirror what is used in the other sections. He is not sure if it is more appropriate to break out public vs unregulated. In terms of the intro to Section 3.3 it is a little bit mixed, interchanging public vs community, and Individual being lumped with Unregulated. Are we really talking about unregulated wells or individual wells? Global comment as far as domestic vs private. We should pick one or the other.
  - Ivo has been working on that section to take care of those wrinkles. If you take a look at how the water systems are described by other agencies. STPUD is the only public water system. Section 3.3.2 goes from public to community.
  - Karen Bender (EDC EMD) said we might want to list them as small or large community systems. Less than 200 connections for a small system regulated by the County and 200 or more for large Systems regulated by the State.

  - Nicole believes that El Dorado County Environmental Health has set a term for water systems. That would be the best way to go when describing water systems for this plan.
  - Ivo agrees. We did incorporate those definitions in that section. He likes the break between small and large. We can change Section 3.3.2 to large community water system and then individual water systems would be included in the small community water systems plus domestic wells.
  - Jennifer Lukins (LBWC/TKWA) asked if we want to group the small community water systems with the wells?
  - Ivo said that on Figure 3.5 we have the small water systems broken out which is included as part of the section describing individual water systems. In Section 3.3.1 is domestic wells. He thinks part of the confusion is that the well owner surveys were called “Private Well Owner Surveys”. In hindsight maybe it was not the best thing to do, but that is how it is organized in the document.
  - Ivo asked Karen to send comments on how we might improve that. She will look at it more closely and get back to him.
  - Jennifer’s concern is that the small water companies will get lumped in with single well motels or trailer parks or campgrounds for failing water systems. Karen agrees.
- Suggestions for improvement?
  - See above

Section 4 – Local Government Agencies (Regulatory Environment):

- This section describes regulatory agencies and descriptions.
- Any corrections/clarifications needed for the Agency descriptions?
  - Nicole said that the revised Land and Resource Management Plan is now finalized. It came out in 2016. Ivo asked that Nicole send in a comment on that. She has a bit more but thinks it is best to send in an email for this section.
  - Jason has some changes for the City including regulatory changes for the affordable housing act. He will send comments in a letter form before the deadline.
  - Brian said one notable omission was their Waste Discharge Requirement Program. Ivo asked that Brian please send in a comment on that.
  - Karen had no comment, but she has not looked at it.
  - Kyle Ericson (EDWA) did not look at it, but Rick is putting together some comments.
  - Jacob has reviewed this section and will send in comments. When talking about the thresholds, sort of change the language, to talking about them as environmental standards. Include TRPA rules and procedures under other administrative manuals? He will put his comments in writing and send them in.
- Any corrections/clarifications needed for the Regulatory Program and Policy descriptions?
  - Kyle had a colleague with comment on Section 4.1-in reference to the historic sources of groundwater contamination. There is a suggestion that we might consider referencing PCE contamination from the 70’s.
  - Ivo said that is described in length in Section 6. But again, any comments are useful to us so just because it is in Section 6 does not mean that it could not be noted in another section.

- Jason said that Section 4.3.1 should be moved to regulatory programs and policies. Ivo agrees maybe after Section 4.4.4. Jason thinks that would be better.
- Brian has a couple of minor things. Lahontan was not in love with the framing of the clean-up sites and how they closed it. Really the comment is the background for water clean-up not the drinking water standards. Also, MTBE policies and regulations that Lahontan enforces. He will do comments about the differences in the District's policies and Lahontan's regulatory obligations.

- Any thoughts comments on Section 4.5 Analysis of Limits Imposed?
  - No comments
- Suggestions for improvement?
  - Jacob was told by a colleague that Figure 4-2 is out of date. We could find updated information on Lake Tahoe. Also, the comment on page 112 Section 4.4.4 EIP project sites, we could reference the lake clarity tracker from Lake Tahoe Information. Ivo said it is a fairly recent map, Figure 4.1
  - Jason said he concurs with Jacob it is not complete. When we look at that table there are a lot of projects that are not there. He is trying to think of how to show that. Ivo asked Jason to provide any updated list that he has.
  - Scott Caroll said that Section 4-2 to him looks accurate, but it may change soon. Figure 4-1 and Table 4-2 where it lists the projects is not complete. He assumes that the County has a bunch of projects that would fall in the Subbasin
  - Jason said he sees the value of just trying to demonstrate the scope and amount of projects without making it overwhelming.
  - Ivo asked if he was looking at a more detailed level under a larger umbrella. Jason said there were many projects not on the list but kind of the purpose of the EIP Tracker is to dynamically update that as they move along . Ivo will look forward to suggestions. Jason will also put his head together with Jacob to put something together. Ivo downloaded the projects off of the EIP tracker last summer. Jason said updates are due on 1/15 so a lot of them are working on this.
  - Jacob suggested maybe having the download from EIP tracker but then adding the link so that they can go in and see current. Jason agrees that is a good idea.
  - Brian said that Sections 4.1.1 and 4.1.4 are duplicates. Ivo said that is why it is kind of grayed out it will get red lined

Section 5 – State of the Groundwater Basin (Groundwater Conditions):

- The first 4 sections outline the context of the GWMP. Whereas Sections 5, 6, 8, and 10 are really the meat of the Alternative Plan. Section 5's purpose is to describe groundwater conditions.
- Anywhere that the descriptions were lacking or could be improved? Are the terms presented in Section 5 adequately defined?
  - No comments
- Any thoughts on the descriptions of the Groundwater Model and Identification of Data Gaps in Section 5.1?
  - No comments
- Are any clarifications needed in the descriptions of Groundwater Conditions and Groundwater-Surface Water Interactions?

  - No comments
- Any thoughts/comments on the presentation of the Groundwater Budgets?
  - Jennifer has reviewed the budgets and thought the information was clear.
  - Ivo said that of particular note in section 5.5 the sustainable yield for the Sunbasin is calculated at 13,200 acre feet.

Suggestions for improvement?
  - Jason said that on Section 5.4.5, Changes in Groundwater Storage, from a Statewide perspective is that more of loss of groundwater stores?
  - Ivo said yes, but it is a secondary effect. They are looking at when you have major reductions in groundwater storage due to reductions in groundwater levels. It is hard to get the storage back. That is one of the main concerns as far as changes in groundwater storage.
  - Jason asked if it was worth putting in the report that there hasn't been any loss of groundwater storage as there has been in other parts of the State. Is it worth putting in here that there has not been a loss of water storage space? Ivo said it is addressed in section 8.
  - Susy will review the text and see if it can be clarified. Maybe we should put a line in there just stating that we are talking about water that is held in storage rather than storage capacity.

<u>Section 6 –Groundwater Quality (Current Water Quality Conditions):</u>
- This section is devoted to describing current ground quality conditions within the Subbasin.
- Any thoughts on the presentation of the water quality data using tables, maps, and plots.
  - No comments
- Any portions of Section 6 that need clarification?
  - Brian noticed a number of things in Section 6. Primarily site-specific summaries. For example, the 6.3.1.2 private residence site. PCE was discovered in 2007 after a resident complained and it is not really in the investigation stage it is in the verification/monitoring stage. Lahontan has conducted regular sampling of domestic wells from 2007 to 2019. They can provide and an update.
  - Similarly, Brian does not think that Section 6.3.3.2 is discussing the South Y Feasibility Study results. It appears to be referencing data collected by Lake Tahoe Laundry Works (LTLW). Not sure of the titling of the section and subsequent discussion. Maybe point out in the discussion that the Tucker Basin has received stormwater from Big O and LTLW and there needs to be more subsequent investigation to be performed.
- Any thoughts on the presentation of Ground Water Quality Issues in Section 6.3?
  - No comments
- Any thoughts on the presentation of the Potential Impacts of GW Pumping on Plume Migration in Section 6.3.1?
  - Jason said in the description of work done by AE com the century well installations were not discussed and then could also include planned activities still in works i.e., soil vapor investigation and non-municipal well sampling. He will provide these comments separately to.
  - Ivo asked for language on that. Have not seen much from last year into this year. Asked that he please share that, and we will roll it in there.

- Any thoughts on the discussion of Stormwater Infiltration in Section 6.3.3 (Figure 6-14 – stormwater detention basins)?
  - Ivo asked Jason about the map that shows the location of the city stormwater retention basins and the dry wells with respect to the community water supply wells.
  - Jason has not had time to look at it in detail, but it seems relevant. What Brian said before in terms of threading the needle between the various parties. Approaches to the investigation and trying to synthesize all of the available information seems kind of relevant.
- Any thoughts on the Groundwater Vulnerability Assessment in Section 6.4 (also Figure 6-15 – GW Recharge; Figure 6-16 DWSAP Map)?
  - Ivo wanted to bring a couple of maps in this section to the attention of the SAG group. The mean annual recharge across the basin map and the other one DSWAP Map the source areas protection areas around the large community supply wells in the basin and the potential contaminating activity sites. Last updated in 2017 and that will be made available to all the agencies if they would like it either electronically or pdf or both.
  - No further comments
- Suggestions for improvement?
  - No comments

Section 7 –Stakeholder Involvement:

- Any Comments on Section 7
  - Summary on stakeholder involvement
- Any needed corrections/clarifications?
  - No comments
- Any thoughts on Groundwater Management Collaboration Opportunities presented in Section 7.2?
  - Ivo would like feedback on Section 7.2 and if you agree with that or if we missed some things that should be added. Would like groups input on collaboration opportunities.
  - As discussed in an earlier workshop There is some real opportunities to work with some of the stormwater managers to increase awareness of the importance of preventing illicit discharge to stormwater especially in our area.
- Any thoughts on Coordination with Land Use Planning presented in Section 7.2.2?
  - No comments
- Any thoughts on Future SAG Topics presented in Section 7.3.1?
  - No comments
- Suggestions for improvement?
  - No comments

Section 8 –Characterization of Undesirable Results:

- In terms of SIGMA compliance this is probably the key section in the document. The Alternative is somewhat of a hybrid of the between a AD-3030 GWMP and a new SIGMA groundwater sustainability plan.
- Any Comments on Section 8
  - No comments
- Any needed clarifications?

  - No comments
- Any thoughts on the presentation of sustainable management criteria, such as undesirable results, sustainability indicators and minimum thresholds?
  - No comments
- Any thoughts on description of the Provisional Management area in Section 8.3.1.5.1?
  - Under the section of interconnected surface water. Ivo wanted to draw their attention to a description of a provisional management area.
  - Susie said essentially what DRI did was run a capture analysis on the steady state version of the model to see what the source of capture would be for a well that was continually pumped throughout the model domain. For every grid cell on the model, they simulated a hypothetical well pumping there to see where the water would come from (Figure 2-2). Since it is a steady state, the water would come from surface water or the lake. Delineated areas where water would come from interconnected surface water. Still provisional at this time but they are more concerned about this area than the model domain.
  - Mark said that the reason they are doing this is because a groundwater management area allows additional thresholds to be established. We are still trying to nail down where the thresholds are and how they can be managed. We will be monitoring the model over the next five years and sharing information with the SAG group.
- Any thoughts on description of the Groundwater Dependent Ecosystems (GDEs) in Section 8.3.2?
  - No comments
- Suggestions for improvement?
  - Jennifer said she was just getting through Section 7. She will have to email any comments on sections 8-10.
  - Ivo said to please let us know if additional clarifications would be helpful.

<u>Section 9 –Groundwater Monitoring:</u>

- This was in the original 2014 Groundwater Management Plan. There have been additions because the data and information that we have collected are a lot broader in scope and application. Any Comments on Section 9?
  - No comments
- Any needed clarifications?
  -
- Any thoughts on description of Data Gaps in Section 9.2?
  - Ivo would appreciate it if the SAG group would focus on the data gaps in S9.2 if they get to that section.
  - A far as monitoring for degraded water quality. Right now, the basin monitoring network does not collect water quality data from those wells. Doing so would probably have a big impact on the cost of our monitoring program. We try to rely on the sharing of information especially from the County and Lahontan to stay abreast of water quality issues. Last way we know about it is when it shows up in a drinking well which is too late.

- Did you recognize any other data gaps in the document that should be considered in Section 9.2?
  - Jason had a question that is somewhat related to the Section 9.2 area data gaps regarding the general data gaps. Everything that he does now he is being pushed to talk about climate change. Is that not a legal requirement or outside the scope of this document? Is this a spot to put a placeholder for that type of discussion?
  - Ivo said that is a good idea. We have looked at impacts of climate change on groundwater in the basin. It is in another part of the document. Maybe we need to consolidate, but it is not really part of what the monitoring does which is why it is handled in a different part of the report. We will think about that and see if there is some kind of middle ground to refer back to that because it is kind of a data gap.
- Suggestions for improvement?
  - No further comments

Section 10 –Implementation Plan:

- The meat of Section 10 is the projects for implementation labeled appendix N. Refer to this table as our kind of summary of projects. Focus on that.
- Also review Section 10.2. In particular Section 10.2.1 which talks about use of SIGMA fees to use for implementation of the Alternative Plan. Ivo would appreciate comments.
  - No comments at this time.

Meeting closed due to technical difficulties with the Internet and TEAMS (~3:45 PM)

TVS SUBBASIN (6-005.01)
2022 SAG Workshop 1
January 12, 2022

Alternative Plan for

Tahoe Valley South Subbasin (6-005.01)

First Five-Year Update

(Draft, 12/17/2021)

Section 1 - Introduction

Section 2 - Groundwater Basin

- 2.1 TVS Subbasin Delineation
  - 2.1.1 Basin Boundaries
  - 2.1.2 Geographic Sub-Areas
  - 2.1.3 Provisional Management Areas
- 2.2 Climate
  - 2.2.1 Climatology
  - 2.2.2 Water Year Classification
  - 2.2.3 Climate Change
- 2.3 Soils
- 2.4 Geology
- 2.5 Description of Basin Aquifers
- 2.6 TVS Subbasin Surface Water Features
  - 2.6.1 Watersheds
  - 2.6.2 Lakes
  - 2.6.3 Groundwater Dependent Ecosystems (GDE)

Section 3 - TVS Subbasin Alternative Plan Area

- 3.1 Population and Economy
- 3.2 Land Use
  - 3.2.1 Land Use Designations
- 3.3 Groundwater Uses and Users
  - 3.3.1 Groundwater Uses
  - 3.3.2 Public Water Systems
  - 3.3.3 Individual Water Systems
  - 3.3.4 Well Owners Findings
  - 3.3.5 Groundwater Pumpage/Well Densities
- 3.4 Demand Projections
- 3.5 Wastewater Management

Section 4 - Local Governmental Agencies and Groundwater – Related Programs

- 4.1 History of Collaboration and Collaboration Opportunities
  - 4.1.1 Potential Collaboration on Groundwater Protection
  - 4.1.2 Potential Collaboration on Land Use Planning
  - 4.1.3 Potential Collaboration on Groundwater Quality Monitoring and Management
  - 4.1.4 Potential Collaboration on Groundwater Protection
- 4.2 Overlying Jurisdictions
- 4.3 Regulatory Agencies
  - 4.3.1 Groundwater Sustainability Agencies
  - 4.3.2 State Water Resources Control Board/ Lahontan Regional Water Quality Control Board
  - 4.3.3 El Dorado County
  - 4.3.4 El Dorado Water Agency
  - 4.3.5 South Tahoe Public Utility District
  - 4.3.6 Tahoe Regional Planning Agency (TRPA)
  - 4.3.7 City of South Lake Tahoe
  - 4.3.8 United States Forest Service
  - 4.3.9 TROA: Office of the Federal Watermaster
  - 4.3.10 Stormwater Management and Monitoring
    - 4.3.10.1 Tahoe Resource Conservation District

Section 4 - Local Governmental Agencies and Groundwater – Related Programs (continued)

- 4.4 Regulatory Programs and Policies
  - 4.4.1 Urban Water Management Plan
  - 4.4.2 County Small Water System Program
  - 4.4.3 County Well Construction and Abandonment Policies
  - 4.4.4 Lake Tahoe TMDL
  - 4.4.5 Environmental Improvement Program – Stream and Wetland Restoration
  - 4.4.6 Integrated Regional Water Management Planning
- 4.5 Analysis of Limits Imposed by Existing Water Resources Monitoring and Management Programs

Section 5 – State of the Groundwater Basin

- 5.1 Background
  - 5.1.1 South Tahoe Groundwater Model
  - 5.1.2 Identification of Data Gaps/Uncertainty
- 5.2 Groundwater Conditions
  - 5.2.1 Groundwater Level History
  - 5.2.2 Groundwater Flow Directions
  - 5.2.3 Hydraulic Parameters
  - 5.2.4 Groundwater-Storage
- 5.3 Groundwater-Surface Water Interactions
- 5.4 Groundwater Budget
  - 5.4.1 Recharge
  - 5.4.2 Groundwater Withdrawals
  - 5.4.3 Discharges to Streams and Lakes
  - 5.4.4 Increases from Streams and Lakes
  - 5.4.5 Changes in Groundwater Storage
  - 5.4.6 Historical Groundwater Budgets
  - 5.4.7 Current Groundwater Budget
  - 5.4.8 Projected Water Budget

Section 5 – State of the Groundwater Basin (continued)

- 5.5 Sustainable Yield
- 5.6 Assessment of Potential Overdraft Issues
  - 5.6.1 Assessment of Potential Overdraft
  - 5.6.2 Assessment of Land Subsidence
- 5.7 Potential Climate Change Impacts
  - 5.7.1 CCCA4 Sierra Nevada Region
  - 5.7.2 Climate Action Plans

Section 6 – Groundwater Quality

- 6.2.1 General Water Quality
  - 6.2.2 Inorganic Constituents
  - 6.2.3 Radioactive Constituents
  - 6.2.4 Regulated Chemicals
- 6.3 Groundwater Quality Issues
  - 6.3.1 Migration of Contaminated Groundwater
  - 6.3.2 Emerging Contaminants
  - 6.3.3 Stormwater Infiltration
- 6.4 Groundwater Vulnerability Assessment
  - 6.4.1 Importance of Protecting Groundwater Quality
  - 6.4.2 Groundwater Recharge Areas
  - 6.4.3 Delineation of Well Source Area Zones
  - 6.4.4 Possible Contaminating Activity (PCA) Sites
  - 6.4.5 Groundwater Vulnerability Map

Section 7 – Stakeholder Involvement

- 7.1 Stakeholder Advisory Group
  - 7.1.1 SAG Workshops
- 7.2 Groundwater Management Collaboration Opportunities
  - 7.2.1 Protect Groundwater
  - 7.2.2 Coordination with Land Use Planning Agencies
  - 7.2.3 Sharing Data and Information
  - 7.2.4 SAG Accomplishments
- 7.3 Future/Ongoing Stakeholder Involvement Opportunities
  - 7.3.1 Future SAG Topics
- 7.4 Public Participation in the Five-Year Update of the Alternative Plan
  - 7.4.1 Notice and Communication

Section 8 – Characterization of Undesirable Results

- 8.1 BMO #1: Maintain a Sustainable Long-Term Groundwater Supply
  - 8.1.1 Chronic Lowering of Groundwater Levels
  - 8.1.2 Reduction of Groundwater Storage
  - 8.1.3 Land Subsidence
- 8.2 BMO #2: Maintain and Protect Groundwater Quality
  - 8.2.1 Seawater Intrusion
  - 8.2.2 Water Quality
- 8.3 BMO #5: Assess the Interaction of Water Supply Activities on Environmental Conditions
  - 8.3.1 Interconnected Surface Waters
  - 8.3.2 Groundwater Dependent Ecosystems

Section 9 – Groundwater Monitoring

- 9.1 Groundwater Monitoring
  - 9.1.1 Monitoring Network
  - 9.1.2 Monitoring Protocols
- 9.2 Identification and Description of Data Gaps
  - 9.2.1 Monitoring for Degraded Water Quality
  - 9.2.2 Monitoring for Depletions of Interconnected Surface Water

Section 10 – Implementation Plan

- 10.1 Projects
  - 10.1.1 Circumstances for Implementation
  - 10.1.2 Permitting and regulatory process
  - 10.1.3 Expected Benefits
- 10.2 Funding the Alternative Plan
  - 10.2.1 Budget and Funding for Past Groundwater Projects
  - 10.2.2 Projected Budget and Future Funding Opportunities
- 10.3 Reporting
  - 10.3.1 Annual Report
  - 10.3.2 5-Year Assessment and Resubmittal

Workshop 2 (August 24, 2022)

Tahoe Valley South Subbasin (6-005.01) Alternative
MEETING NOTES
Wednesday, August 24, 2022; 2:00 pm - 5:00 pm
Location: MS Teams On-Line Meeting

SAG ATTENDEES: (correct after workshop)
John Thiel, PE; Ivo Bergsohn, PG, HG (STPUD); Kyle Ericson, PE (El Dorado Water Agency); Karen Bender, REHS (El Dorado County – EMD); Russell Wigart (EDC DOT); Brian Grey, P.G., (Lahontan Regional Water Quality Control Board); Jason Burke (City of South Lake Tahoe); Jacob Stock (Tahoe Regional Planning Agency; Nicole Bringolf (USFS-LTBMU); Jennifer Lukins (Lukins Brothers Water Co); Harold Singer (Retired); Shelly Thompsen (STPUD); Jeff Brooks (Waterboards); Scott Carroll (CTC); Abby Cazier (Waterboards); John Thiel (STPUD); Barrett Kaasa (DWR); Gary Kvistad (STPUD); Paul Nickles (?); Jeffrey O'Connell (?); Rick Lind (?) Mark Hausner (DRI);

Participants: 22

BASIN MANAGEMENT OBJECTIVES:
1. Maintain a sustainable long-term groundwater supply.
2. Maintain and protect groundwater quality.
3. Strengthen collaborative relationships with local water purveyors, governmental agencies, businesses, private property owners and the public.
4. Integrate groundwater quality protection into local land use planning activities.
5. Assess the interaction of water supply activities with environmental conditions.
6. Convene an on-going Stakeholders Advisory Group (SAG) as a forum for future groundwater issues.
7. Conduct technical studies to assess future groundwater needs and issues.
8. Identify and obtain funding for groundwater projects.

WORKSHOP OBJECTIVES
1. Learn about plans for monitoring the potential impact of groundwater withdrawals on groundwater dependent ecosystems (GDEs)
2. Learn about drought planning and water conservation activities affecting the TVS Subbasin.
3. Learn about recent findings from the South "Y" Plume Regional Plume Characterization and the status of future work.
4. Consider potential projects for application to DWR for Sustainable Groundwater Management (SGM) Grant Program Funding.

TVS Basin (6-5.01) - Open Forum (Group)

Current groundwater-related topics outside Agenda

Attendee, Affiliation - note

I. Bergsohn, STPUD – Meeting Material Items -Drought related

- DWR Fact Sheet Drought Well Permitting Requirements (EO N722)
  - This came out of Governors Executive Order earlier this year. We will discuss it when we get into the drought portion of the workshop.
- California Water Supply Strategy (Ca Agencies, Aug 2022)
  - The Governor released this earlier this month. It is a high-level view of what the State would like to do to best manage this drought.
- Climate Change in increasing the risk of a California mega flood (Huang and Swain, August 2022)
  - Interesting topics, especially if you live in the Tahoe Basin, and consider how mega flood events could potentially isolate the Tahoe Basin. It is another impact of climate change 180 degrees from potential impacts from drought. Demonstrates extremes anticipated from climate change and need to considerat both sides of the coin.

- 2022 SAG Workshop 1 Meeting Notes and Presentations (January12, 2022) are posted on District's Groundwater Page

Consultant Report Groundwater Dependent Ecosystem Monitoring

Handouts: Groundwater Dependent Ecosystem Monitoring Plan Presentation Slides

GDE Monitoring, Mark Hausner, DRI – Presentation

- Based on site inspections DRI is proposing new monitoring wells near Pope Marsh at the bike path/walking path. The other SEZ locations on the map seem to be covered.
- Discussion was had on the installation and the functionality of the monitoring well which would be installed for a period of two years.
- We are looking at putting together a GDE Monitoring Program for a period of 5 years until the next required update to the plan.
- DRI would like to invite stakeholders to come out and see the site.

Q&A

- Scott Carrol said that he knows about 100 existing shallow groundwater monitoring wells that installed by CTC that could be considered for inclusion in the GDE monitoring program. What are the risks on the SEZ map based on?
- Mark Hausner said the risk maps are based on model simulated head results and allowable threshold values for shallow groundwater levels within SEZs. These are used to identify potentially vulnerable SEZs to shallow groundwater level changes caused by climate change including long-term changes in Lake Tahoe stage elevation.
-
- Jason Burke believes that the SEZ map is incorrect. He did provide a link in the chat to a the current SEZ shapefile used by TRPA. MH apologized for including old SEZ shapefile

in presentation, current SEZ shapefile is used in GDE evaluation presented in Alternative Plan.

2022 Drought Groundwater Management Activities in response to Drought

Handouts: Water Supply and Demand Assessment Presentation Slides

SB552 Drought Planning, K, Ericson, EDWA – Presentation

- Kyle Ericson reported that El Dorado County has established a SB552 Drought Task Force and an Implementation Schedule has been developed. The Consultant, Stantec, has been brought online to help gather data from all parties. The State Task Force, in conjunction with DWR, is developing, a guidebook that can be used state-wide by the County Task Force(s) with contacts and emergency protocols in the event of a drought emergency.

Q&A

- Ivo B. saw a reference to the domestic well mitigation plan. What is it and what might it entail.
- Kyle E. said that one element is that they have noticed that there are smaller properties that have new wells put on them but there are no records of old wells being decommissioned. There are other elements as well. It has been tough to get information.

Local Water Conservation Measures

- Lukins Brothers Water Company (LBWC), Jennifer Lukins
    - Last summer LBWC had their treatment plant at LBWC #5 go into operation. The GAC treatment plant is a major source for drinking water in the LBWC water system.
    - LBWC also installed an emergency intertie to the TKWA water system.
    - LBWC has seen a decrease of an average of 15% in water usage from 2020-2022. Their water conserve program puts out consistent messaging in conjunction with STPUD. Soil moisture sensors are being supplied along with toilet tablets, garden hose nozzles, and magnets with watering schedule on it. When they get a complaint from other customers LBWC will provide them with these tools and educate them that even though we live in Tahoe we are still having a drought.
- Tahoe Keys Water Company (TKWC), Jennfier Lukins
    - There was no irrigation allowed last summer in Tahoe Keys. This Summer they came out with a very strict emergency irrigation schedule by zone. So far it has been going very well.
    - Compared to 2020, free for all, Tahoe Keys watering to 2022 averaging about a 25% reduction in water usage. From 2021 when no irrigation was allowed to 2022 with the restrictions the increase is close to a 77% reduction. It is a noticeable difference in water usage.
    - Will see what the board decides to do for next summer utilizing this data. They did create a new landscape book of guidelines with drought tolerant landscaping.
    - Ken Payne from El Dorado Water Association (EDWA) thanked Jennifer L. for all the work she is doing.

- STPUD, Shelly Thomsen, South Tahoe Public Utility District (STPUD) – Presentation
  - Shelly L. Gave a slide presentation regarding STPUD efforts toward the drought and the Governors executive order on the water shortage contingency plan.
  - STPUD utilizes towers (AMI) that collect meter data that customers can log into and interface called WaterSmart. They can then see their usage and receive leak alerts. STPUD has saved 26 million gallons of water by utilizing the leak alerts.
  - STPUD has a free Waterwise Landscape Consultation available from a Staff member that is a Master Gardner (Seasonal). We also have Waterwise House calls where Staff will come out to the property and assist with water conservation efforts.
  - STPUD has a Turf Buyback Program where there is a rebate of $1.50 per square foot for folks to remove grass and put in drought friendly landscape.
  - STPUD has had a toilet and clothes washer rebate in effect since 2007, but most new clothes washers are water use efficient.

- Q&A
  - Ivo B. asked what triggers conservation measures used by the District. Is it something the District determines internally?
  - Shelly T. reported that to date CA has been very active during drought periods either mandating or asking for voluntary reductions. For us moving to the next tier of water conservation is watering two days a week instead of three days of week. Today it is mostly being driven by the State. That being said STPUD has water conservation measures in place year around all the time whether there is a drought or not. This has helped STPUD reduce production by 30% in the last 10-15 years.

- County Well Permitting, Karen Bender, El Dorado County Environmental Management Department (EMD)
  - There is a process for people to go through to apply for to drill a well. It is illegal to drill a well without a permit, but EMD is not really seeing a lot of well permits being issued in the Tahoe basin. Since 2007 we have had a total of 8 wells drilled in our area. Five of those have been in the Tahoma Area. Most recently last year on Grass Lake Road. Not a whole lot of well activity.
  - Only one well deepen permit was issued down by Stateline, NV. Their well was kind of shallow and not producing very good, however, they are planning to consolidate with either STPUD or LBWC.
  - In terms of dry wells there have been no reports in the basin. There have been some up on Echo Summit (outside of TVS Subbasin area).
  - EMD strongly pushes for consolidation. We have approx. ½ of the 141 small water systems mentioned by Kyle E. Have had 16 consolidations since 2013.
  - There was one permit denied early this year on Rubicon Drive in the Tahoma area. They were a Vacation Home Rental (VHR) and were denied because they were already in the area of a large water system.

- Water Supply and Demand Assessment, I. Bergsohn, STPUD
  - Ivo B. presented slides on the annual Water Supply and Demand Assessment for the current year. A Copy is available on the STPUD website (a link to the document is in the chat).

- On Water Supply and Demand Assessment that was released you see precipitation in our area that is normal or above normal but typically, at least for STPUD, the water conservation measures are State mandated action and may or may not reflect our actual local hydrological conditions.
- Starting in 2022, Urban Water Suppliers providing more than 3,000-acre feet of water, or having 3,000 connections, are required to produce an annual Water Supply Demand Assessment and report to the California Department of Water Resources by July 1st of each year. This is a new requirement going forward. The report is required to provide an assessment of local water supply including hydrogeologic conditions, water demands for the current year and also for a following dry year.
- Close to 100% of the water supply in our area is from Ground Water. The primary source of groundwater recharge to the TVS Subbasin is precipitation. STPUD uses Hagan's Meadow SNOTEL #508 station to monitor precipitation. It has proven to be reliable and has a strong correlation to recharge used in the South Tahoe Groundwater Model to calculate water balances.
- For the annual Supply and Demand Assessment for our current water year, based on precipitation, it is a normal year at 29.6 inches as of 8/18/22. For using a following dry year we used historical records from water year 2001 which was 16.4 inches and a historically dry year for our area.
- Ivo shared slides outlining how we obtained the data for the report.

Open Discussion-None

South "Y" PCE Plume progress of the Regional Plume Characterization of the South "Y" Plume (RPC) and status of the proposed CAO's recently issued by LRWQCB

Handouts: Regional PCE Plume Investigation Update Presentation Slides; Proposed Cleanup and Abatement Order Presentation Slides

- Regional Plume Characterization Report, Edmond Tarter, PE, AECOM
  - Edmond T. works for AECOM, the consulting engineer that has been working on this project for Lahontan Regional water Quality Control Board for the past 3 years now.
  - Edmond T provided a slide presentation and summary of what AECOM has been doing in the South Y area; An overview of the Site Cleanup Subaccount Program (SCAP); Observations from the Regional PCE Plume Groundwater Investigation; Current and Future SCAP Activities; and Recommended Future Actions.
  - Findings show that the PCE Plume roughly extends 8,000 feet South to North, just Southwest of the Y, and then up toward Tahoe Keys and then would go to the lake.
  - AECOM installed Sentry Wells at Tahoe Keys 1, 2 and at LBWC wells 1, 2, 3, 5 last summer. First sampling was in October 2021 and will sample again in April 2023.

Q&A

- Jennifer L. has been managing TKWA since December 2021 and one thing that what to the Board of Directors over there is that the contamination that TKWC Well #1 is seeing is not from the regional plume it is from a separate plume. Based on this presentation that is not apparent but shows TKWC Well #1 is part of the regional plume.
- Edmond T. said he is not aware of another plume out there that may be impacting Tahoe Keys Well #1

- Brian Grey (LRWCB) said Ed should talk about the data points and EBS Model where it does not look like there is a disconnected plume.
- Edmond T., there may be another source that is contributing, which would be the data gaps, but not in the data set that they have. It looks like just one plume.
- Abby Cazier (LRWQCB?), it is really important to note that there was limited boring coverage near Tahoe Valley Elementary and Tahoe Keys Blvd (data gap through this area). If we did have more investigation in that area the connectivity would be more clear.
- Tyler ?-EDWA, as far as the planning horizon goes what is the point where we will actually develop a mitigation plan on how we are going to contain this plume? Is there a timeline that has been established?
- Brian G. said the next portion of the presentation will show what they are planning with issuance of Cleanup and Abatement Orders (CAO) and compliance within the CAO's.

LRWQCB CAOs, Brian Grey, LRWQCB

- Brian Grey is the -Engineering Geologist part of team overseeing the Lake Tahoe Laundry Works (LTLW), Former Norma's Cleaners, and Big O tires. He gave a slide show and discussed the three proposed (CAO's) that are currently out for public comment.
- Brian G. gave a brief background on the PCE contamination and Primary sources (Source Area Inventory). The comment period for all three CAO's has been extended to 9/19 and LRWQCB will review and respond to all comments and adjust the CAO's based on review of comments. Hopefully this will be done by the end of the year, but it is possible that there will be another 30-day extension.
- Jennifer L. Thanked LRWQCB for the thorough CAO.

Q&A

- John Thiel, at the coin operated dry cleaners is there a theory as to how the release actually occurred?
- Brian G., both Norma's Cleaners and LTLW both had similar operations. Based on the data that has been collected it does seem that releases did occur during delivery activities and the O&M of the unit itself. For example, the highest concentrations were found in the parking lot out front of the Dry Cleaner and not under the machine itself.
- Jason Burke asked if the release from the Big O site that went through the storm drain system into the Tucker Avenue Stormwater Retention Basin was before the basin was constructed and it was an open ditch or after the Tucker Avenue Basin was constructed and the stormwater pipe was extended.
- Brian G., the data that they have was at the storm drain inlet, The samples show elevated levels but in trying to determine time frame it is much more difficult.
- Ivo B., if as far as the expected migration pathways and PCE contaminant data that was provided, Is the finding greater than 500 micrograms per liter (µg/L) of PCE at 50ft consistent with infiltration of PCE in the dissolve phase from land surface or is there something else that should be added as a potential pathway?
- Brian G., with respect to the 500 µg/L, that dissolve phase concentration is below the 1% Dense Nonaqueous Phase Liquids (DNAPL) threshold that you expect to have DNAPL's observed at. So, with respect to other sources and concentration gradients that have been seen within the regional plume those concentrations can be attributed to

upgradient sources. The 500 µg/L is not necessarily an indication of a DNAPL source in that area.

- Ivo B., what type of dissolved concentration at the surface would you need to result at 500 µg/L at depth?
- Brian G., with the data that has been collected, the highest concentrations that they observed was above 5,000 µg/L at the LTLW site in shallow groundwater. In terms of concentration of 500 µg/L that would be reasonable to conclude that could be from dissolved phase transport.
- Edmond T. would agree with Briain and it is consistent with other locations in California.
- Ivo B., what does the apparent similar association of the plume with the Stormwater collection system indicate?
- Brian G., in terms of data collected there does seem that there is preferential transport that is occurring via the stormwater conveyance system and that is being illustrated through the shallow ground water concentrations that we are seeing.
- Ivo B., does that rule out the possibility of direct illicit discharges to the storm drains?
- Brian G., no, we just have indications that there is PCE in shallow ground water and it coincides with the stormwater drainage system alignment.
- Ivo B. thanked AECOM and LRWQCB for their presentations and Jennifer L. for all her efforts during this long process.

SGM Grant Program SGM Grant Program and potential projects for SGM grant funding consideration

Handouts: 2022 TVS Subbasin Implementation Projects List

- Round 2 Proposal Solicitation, Barrett Kassa, DWR
  - Barrett K. is the new point of contact at DWR for the TVS Subbasin. He will give a brief slide presentation. They are still waiting on the legislature to appropriate some funding so there is chance that the Proposal Solicitation Package requirements may change.
  - Round 2 solicitation is expected to be in late 2022 or early 2023. Minimum $200 million of funding with up to $50 million of additional funding. Barret gave an overview on how the solicitation will be conducted. Other than the funding questions the guidelines and scoring will be the same as Round 1.
  - Eligibility: GSAs and Member Agencies, other Agencies authorized to represent a GSA
  - Only one application per basin or subbasin but it can have multiple projects or components. Funding: minimum of $1 million with maximum of $20 million per basin or subbasin He believed there are 94 basins that are applying. It will be competitive so priority will go to subbasins that have not received funding before. Local cost share not required; If you have a min of 5% cost share you will obtain the max points for scoring. Projects must be consistent with the goals of the Budget Act of 2021 and Prop 68.
  - Applications with multiple projects/components will have each component scored individually then averaged to derive final application scoring.
  - Ivo B., no allowance for weighting when averaging individual projects/components? Is there some type of priority presented in the application?
  - Barrett K. there is leeway in the application process to award funding for certain components and not others.
  - Ivo B., any value in submitting the applications early? How would we start the process?
  - Barret K. does not believe you can submit early. He will email as soon as he hears.
  - DWR just announced Urban Community Drought Relief funding. You are able to look at the guidelines and PSP on the website now but it is not expected to be open until

September. Any public agency can apply for this funding but it does have a 25% cost share. The minimum award amount is 5 million because this has almost 300 million worth of funding. A lot of these have been first come first serve as long as the project scores well. Not part of the SGMA program.

Potential Projects List, I. Bergsohn, STPUD

- Ivo B. put together a table of potential projects that are derived from the Alternative Plan (included with meeting materials). He also created a scoring sheet with three different criteria based on scoring from 1-10. He will email out the scoring sheet and based on scores will rank them. Give an idea as to which one would be most favorable with respect to your agency's level of interest..
- There are 8 projects listed in table with a brief description of each project on the list. If anyone has other projects that they fill should be added please put them on the list with a description and eligibility for a SGM grant. Hopefully we can continue the evaluation and ranking process over the next few weeks.
- After we have a good idea on prioritizing these projects then we can have a better idea on how to put together a proposal package for the upcoming solicitation for SGM Grant Round 2 funding.
- All meeting materials will be compiled and posted to the District Webpage but if anyone would like to see them sooner email Ivo and he will send it to them.

Next Workshop: TBD 2023

ADJOURN (5:00 PM)

AGENDA

DATE	Wednesday, August 24th, 2022; 2:00 PM – 5:00 PM (PST)
LOCATION	Click here to join the meeting
STAKEHOLDER ADVISORY GROUP LIST	Ken Payne, P.E., (El Dorado Water Agency, Rick Lind (EN2R) ; Karen Bender, REHS, RD (El Dorado County -EMD); Russ Wigart (EDC DOT); Jason Burke (City of South Lake Tahoe); Scott Carroll (CA Tahoe Conservancy); Andrea Buxton (Tahoe Resource Conservation District); Brian Grey, P.G. (Lahontan Regional Water Quality Control Board); Jacob Stock (TRPA); Nicole Bringolf (USFS – LTBMU); Nakia Foskett (Lakeside Park Water Co.); Jennifer Lukins (Lukins Brothers Water Co); Open (Tahoe Keys Water Co.); Harold Singer (Community Rate Payer); and John Thiel, PE (South Tahoe PUD)
PLAN MANAGER	Ivo Bergsohn, PG, HG (South Tahoe PUD)

BASIN MANAGEMENT OBJECTIVES (BMO)

1. Maintain a sustainable long-term groundwater supply.
2. Maintain and protect groundwater quality.
3. Strengthen collaborative relationships with local water purveyors, governmental agencies, businesses, private property owners and the public.
4. Integrate groundwater quality protection into local land use planning activities.
5. Assess the interaction of water supply activities with environmental conditions.
6. Convene an on-going Stakeholders Advisory Group (SAG) as a forum for future groundwater issues.
7. Conduct technical studies to assess future groundwater needs and issues.
8. Identify and obtain funding for groundwater projects.

WORKSHOP OBJECTIVES

OBJECTIVES

1. Learn about plans for monitoring the potential impact of groundwater withdrawals on groundwater dependent ecosystems (GDEs)
2. Learn about drought planning and water conservation activities affecting the TVS Subbasin.
3. Learn about recent findings from the South "Y" Plume Regional Plume Characterization and the status of future work.
4. Consider potential projects for application to DWR for Sustainable Groundwater Management (SGM) Grant Program Funding.

SEE REVERSE FOR AGENDA

AGENDA

Time	Description	
2:00	**Roll call (5-Minutes)**	**SAG**
2:05	**TVS Subbasin (6-005.01) - Open Forum (10-Minutes)** **Topics outside the subject matter of the SAG and not listed on the Agenda.**	**Round Robin**
2:15	**Consultant Report** • **GDE Monitoring**	**M. Hausner/** **S. Rybarski** **DRI**
2:30	**2022 Drought** • **SB552 Drought Planning, K. Ericson** • **Water Conservation Measures, J. Lukins, LBWC, S. Thomsen, STPUD** • **County Well Permitting, K. Bender, EDC EMD** • **Water Supply Demand Assessment, I. Bergsohn, STPUD** • **Open Discussion**	**SAG Round Robin**
3:15	**South "Y" PCE Plume** • **Regional Plume Characterization Report** • **2022 Activities** • **LRWQCB CAOs** • **Q & A**	**E. Tarter** **AECOM** **B. Grey, P.G.** **LRWQCB**
4:00	**10-minute BREAK**	
4:10	**SGM Grant Program** • **Round 2 Proposal Solicitation** • **Potential Projects List** • **Q & A**	**B. Kaasa, DWR** **SAG Round Robin**
4:50	**Adjourn**	

Open Forum

Drought Well Permitting Requirements

Drought Executive Order N-7-22

On March 28, 2022 Governor Newsom issued Drought Executive Order N-7-22 that included new well permitting requirements for local agencies to prepare for and lessen the effects of drought conditions (Action 9).

Well Permitting Authority and Groundwater Management Oversight

In California, regulatory authority over well construction, alteration, and destruction activities resides with local agencies (cities, counties, or water agencies), who have the authority to adopt a local well ordinance. Well permits are administered and enforced by local agencies (or local enforcing agencies, LEAs), often the Department of Environmental Health within a given county.

With the enactment of the Sustainable Groundwater Management Act (SGMA) in 2014, local public agencies – called groundwater sustainability agencies or GSAs – formed to provide specific oversight and management of groundwater resources, and to achieve sustainable groundwater management within 20 years through the development and implementation of groundwater sustainability plans (GSPs) and associated projects and management actions. The local GSAs are required to include in their GSPs a discussion of how they will coordinate these efforts with local land use authorities, including local well permitting agencies.

Drought Well Permitting Requirements

Local well ordinances authorize the conditions for agencies to issue a well permit or permit modification. Given the record drought conditions the state has faced over the last three years, Drought Executive Order N-7-22 requires additional actions be taken by local well permitting agencies prior to issuing a well permit.

Excerpt of Action 9 from Drought Executive Order N-7-22:

9. To protect health, safety, and the environment during this drought emergency, a county, city, or other public agency shall not:

a. Approve a permit for a new groundwater well or for alteration of an existing well in a basin subject to the Sustainable Groundwater Management Act and classified as medium- or high-priority without first obtaining written verification from a Groundwater Sustainability Agency managing the basin or area of the basin where the well is proposed to be located that groundwater extraction by the proposed well would not be inconsistent with any sustainable groundwater management program established in any applicable Groundwater Sustainability Plan adopted by that Groundwater Sustainability Agency and would not decrease the likelihood of achieving a sustainability goal for the basin covered by such a plan; or

b. Issue a permit for a new groundwater well or for alteration of an existing well without first determining that extraction of groundwater from the proposed well is (1) not likely to interfere with the production and functioning of existing nearby wells, and (2) not likely to cause subsidence that would adversely impact or damage nearby infrastructure.

This paragraph shall not apply to permits for wells that will provide less than two acre-feet per year of groundwater for individual domestic users, or that will exclusively provide groundwater to public water supply systems as defined in section 116275 of the Health and Safety Code.

Local well permitting agencies retain existing well permitting authorities, including reviewing and administering well permits. Under the Executive Order Action 9, local well permitting agencies must take the following steps during the well permitting process for wells intending to extract groundwater:

1. Consultation with the GSA – If the proposed well would be in a high or medium priority groundwater basin, the well permitting agency must consult with the GSA and receive written verification from the GSA that the proposed well location is generally consistent (not inconsistent) with the applicable GSP and will not decrease the likelihood of achieving the sustainability goals that the GSAs have developed under SGMA.

2. Permit Evaluation – For every well permit application, the local well permitting agency must determine before issuing a well permit that extraction of groundwater from the proposed well is not likely to interfere with the production and functioning of existing nearby wells and is not likely to cause subsidence that would adversely impact or damage nearby infrastructure.

These requirements do not apply to wells that pump less than 2 acre-feet per year (de minimus users) and wells that exclusively provide groundwater to public water supply systems as defined in section 116275 of the Health and Safety Code.

State Resources Available to Local Agencies

The California Department of Water Resources (DWR) provides technical and other support services to local agencies to support decision-making. The following resources are available to help local agencies navigate the well permitting requirements in this Drought Executive Order:

- To find the **groundwater basins subject to SGMA** and classified as medium or high priority: Basin Prioritization Dashboard

- To find the **Groundwater Sustainability Agency** managing the applicable basin or area of the basin: GSA Map Viewer

- To find the **Groundwater Sustainability Plan** adopted by the local Groundwater Sustainability Agency: GSP Map Viewer

- To view **existing nearby wells** (domestic, irrigation, public supply and reported dry wells): California's Groundwater Live – Well Infrastructure

- To view **groundwater levels and trends**: California's Groundwater Live – Groundwater Levels

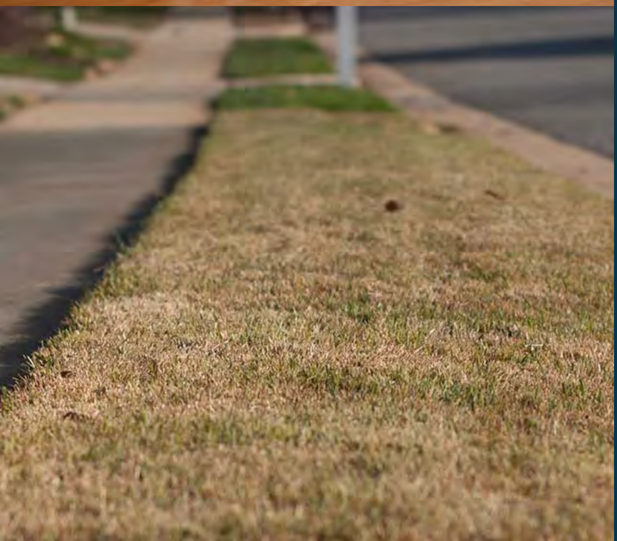
- To view **subsidence data** and nearby infrastructure: California's Groundwater Live – Subsidence Data

For more information or questions, please contact DWR's Sustainable Groundwater Management Office at: SGMPS@water.ca.gov.

AUG 2022

CALIFORNIA'S WATER SUPPLY STRATEGY

Adapting to a Hotter, Drier Future



CALIFORNIA NATURAL RESOURCES AGENCY

CALIFORNIA Water Boards

CalEPA California Environmental Protection Agency

cdfa CALIFORNIA DEPARTMENT OF FOOD & AGRICULTURE

Introduction

Our climate has changed. We are experiencing extreme, sustained drought conditions in California and across the American West caused by hotter, drier weather. Our warming climate means that a greater share of the rain and snowfall we receive will be absorbed by dry soils, consumed by thirsty plants, and evaporated into the air. This leaves less water to meet our needs.

This is our new climate reality, and we must adapt.

During his first months in office, Governor Newsom issued an **executive order** calling on State Agencies to create a comprehensive **Water Resilience Portfolio**. The Portfolio prioritized 10 key actions to secure California's water future. *Over the last two years we've **made major progress** that includes*: bringing our groundwater basins into balance; updating infrastructure to move water throughout the state; restoring river systems, including the nation's largest dam removal effort on the Klamath River; and improving water management through new voluntary agreements and technology improvements.

California is investing billions of dollars into these actions to secure the future of California's water supply.

Over the last three years, **state leaders have earmarked more than $8 billion to modernize water infrastructure and management**. The historic three-year, $5.2 billion investment in California water systems enacted in 2021-22 has enabled emergency drought response, improved water conservation to stretch water supplies, and scores of projects by local water suppliers to become more resilient to current and future droughts. The 2022-23 budget includes an *additional* $2.8 billion for drought relief to hard-hit communities, water conservation, environmental protection for fish and wildlife, and long-term projects to permanently strengthen drought resilience.

Over the last two years, scientists and water managers have been alarmed by the accelerating impacts of the warming climate on our water supply. **We now know that hotter and drier weather could diminish our existing water supply by up to 10% by 2040**. So we are ***taking action***.

We have invested billions in securing the future of California's water supply and this focused *Water Supply Strategy* updates state priorities based on new data and accelerating climate change.

To ensure California has the water needed for generations to come, this Strategy includes:

- **Create storage space for up to 4 million acre-feet of water**, allowing us to capitalize on big storms when they do occur and store water for dry periods

- **Recycle and reuse at least 800,000 acre-feet of water per year by 2030**, enabling better and safer use of wastewater currently discharged to the ocean

- Free up 500,000 acre-feet of water for new purposes each year by **permanently eliminating water waste** and using water more efficiently

- Make new water available for use by **capturing stormwater and desalinating ocean water and salty water in groundwater basins**, diversifying supplies and making the most of high flows during storm events

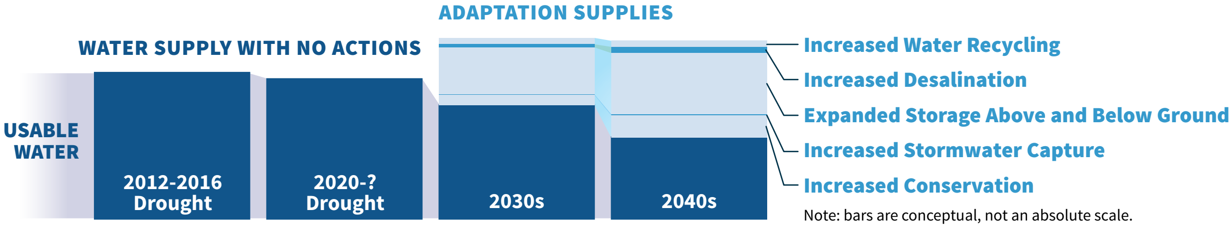
To match the pace of climate change, California must move smarter and faster to update our water systems. **The modernization of our water systems will help replenish the water California will lose due to hotter, drier weather, and generate enough water for more than 8.4 million households.**

CALIFORNIA'S WATER SUPPLY STRATEGY
Adapting to a Hotter, Drier Future

This document outlines California's strategy and priority actions to adapt and protect water supplies in an era of rising temperatures.

Over the next 20 years, California could lose 10 percent[1] of its water supplies.

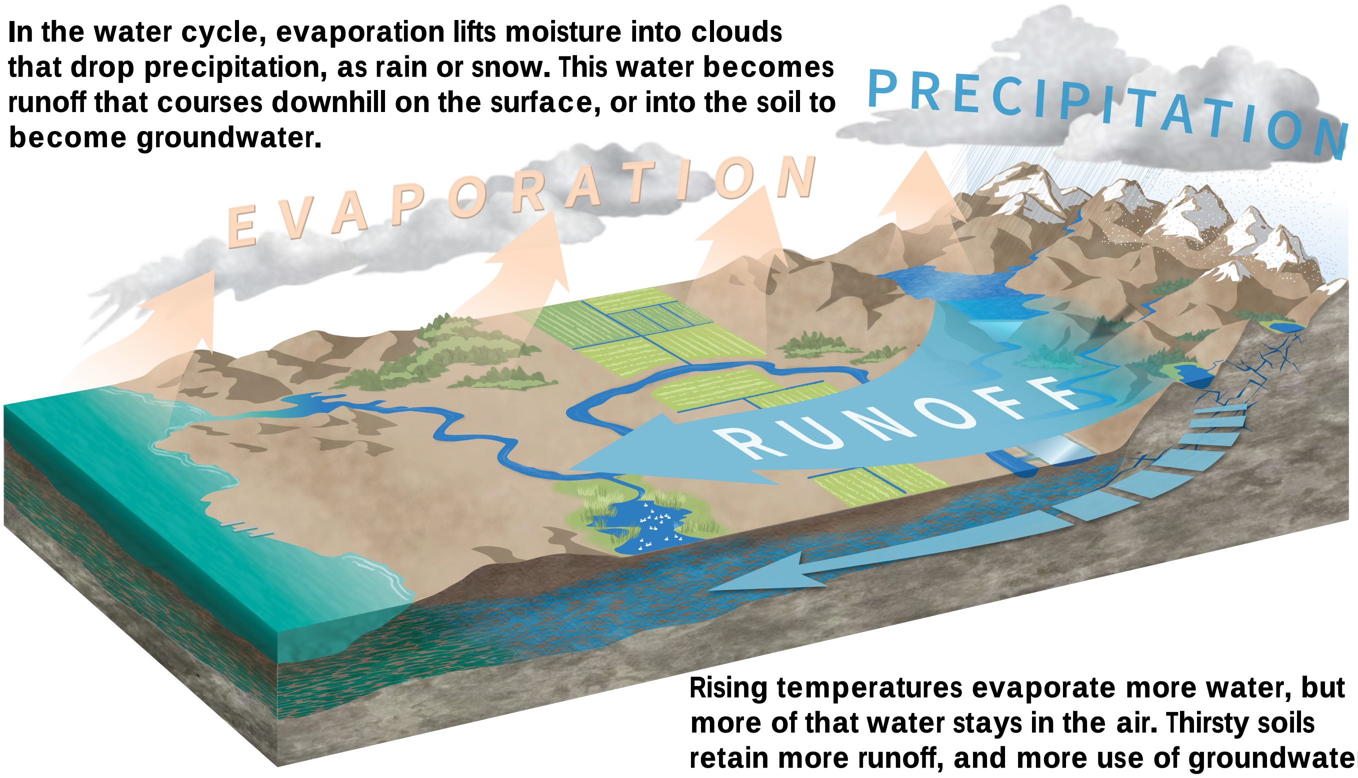
Our climate has changed, and the West continues to get hotter and drier. As it does, we will see on average less snowfall, more evaporation, and greater consumption of water by vegetation, soil, and the atmosphere itself.



In previous droughts the ratio of precipitation to evaporation to runoff has been similar. However, as temperatures rise, evaporation increases, with the consequence of a fall in runoff. As average temperatures continue to increase, the increase in evaporation will continue, with a concurrent drop in runoff.

The coming water cycle: the air claims more

In the water cycle, evaporation lifts moisture into clouds that drop precipitation, as rain or snow. This water becomes runoff that courses downhill on the surface, or into the soil to become groundwater.



Rising temperatures evaporate more water, but more of that water stays in the air. Thirsty soils retain more runoff, and more use of groundwater requires more water for recharging watertables.

[1] DWR estimates a 10% reduction in water supply by 2040 is a planning scenario that considers increased temperatures and decreased runoff due to a thirstier atmosphere, plants, and soils. According to the California Water Plan Update, California's managed water supply ranges from 60-90 MAF per year so the effect of a dryer climate results in a disappearance of about 6-9 MAF of water supply.

California's precipitation always has swung between drought and flood. Those swings are becoming more severe. Regardless of drought or flood, in this changed climate there will be less water available for people to use than there would have been in a cooler climate because of the way plants, soils, and the atmosphere use water as temperatures rise.

The volume of water used by people in California for agriculture, urban, and environmental purposes ranges from 60 million acre-feet per year to 90 million acre-feet per year. A loss of 10 percent of that volume to hotter, drier conditions could mean the disappearance of about six million acre-feet to nine million acre-feet of water supply. For comparison's sake, California's largest reservoir – Shasta – holds 4.5 million acre-feet.

Water underpins much of what we care about as Californians. To thrive and grow as a state, we will have to make up for a loss of supply. We must innovate, conserve, store, reuse, and repurpose water.

This document outlines four sets of actions the State will pursue to prepare California for its new climate reality.

These targeted actions aim to secure supplies for people, so that homes, schools, and businesses do not suffer disruptions, and the state's agricultural economy continues to thrive.

In concert with these actions, the State is working to protect fish and wildlife populations by removing stream barriers, restoring aquatic habitat, bolstering stream flows at ecologically important times, and expanding floodplains and wetlands.

The State also continues to make progress extending clean, safe drinking water to all Californians; in the last three years, the number of people impacted by failing water systems has fallen from 1.6 million to 934,000, and the state has delivered emergency drinking water assistance to 9,456 households and 150 water systems in this drought.

The actions in this strategy aim primarily to support the urban and suburban water systems that serve most Californians and to stabilize water supplies for agriculture. But benefits from these actions will extend to environmental protection and fulfillment of the right of every Californian to safe drinking water, and the State continues to advance those efforts apart from this strategy.

How California is taking action to protect community water supplies

The Water Resilience Portfolio has guided State water policy since July 2020 and will continue to do so. It is a comprehensive suite of actions that support local water resilience. However, the record-breaking temperatures and aridity of the 2012-16 drought, followed so closely by another stretch of similar conditions beginning in the winter of 2020-21, send a strong climate signal that we must heed. These new, more extreme conditions make clear that to secure water supplies, we must double down on a set of actions within the Water Resilience Portfolio, with haste.

Executing this strategy will require coordination with local, tribal, and federal partners to:

1) Develop new water through recycling and desalination.

2) Capture and save more stormwater, above ground and below ground.

3) Reduce use of water in cities and on farms.

4) Improve all water management actions with better data, forecasting, conveyance, and administration of water rights.

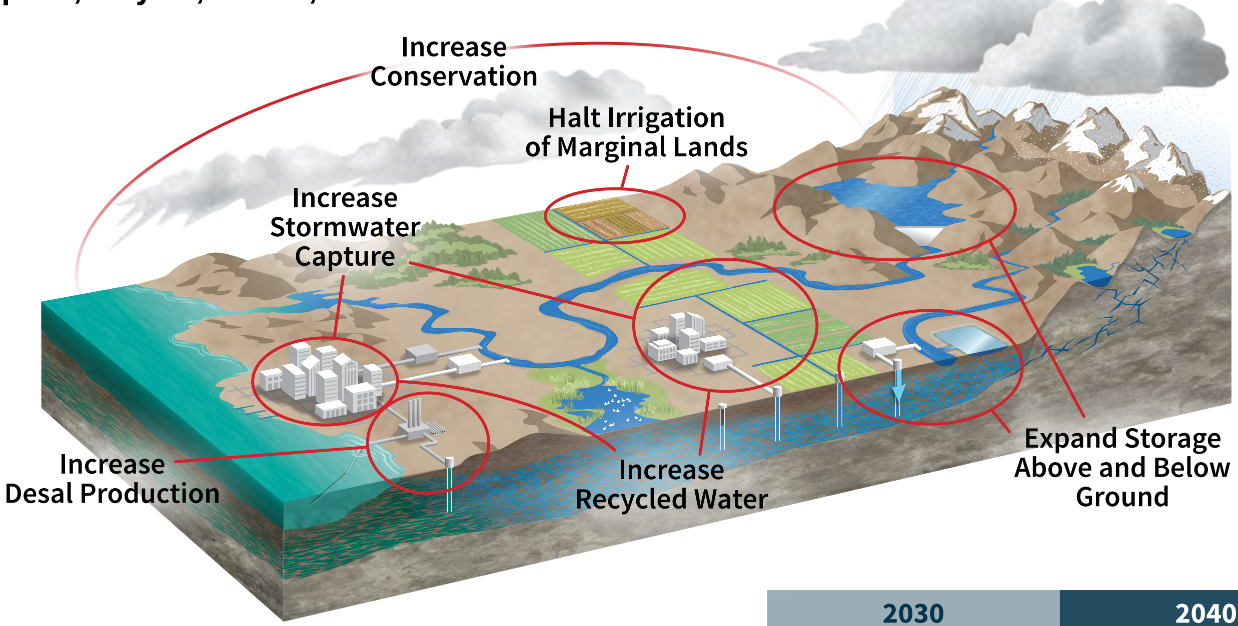
1. Develop New Water Supplies

With investments in technology, wastewater and saltwater can help drought-proof communities.

1.1 Reuse at least 800,000 acre-feet of water per year by 2030 and 1.8 million acre-feet by 2040, with most of that additional recycling involving direct wastewater discharges that are now going to the ocean.

Closing the evaporative gap

To offset increased evaporation tied to warmer average temperatures, California must capture, recycle, de-salt, and conserve more water.



	2030		2040	
Increase Recycled Water	.8 MAF	About 5 MAF	1.819 MAF	About 7 MAF
Increase Desal Production	44,000 AF		84,000 AF	
Increase Stormwater Capture	.25 MAF		.5 MAF	
Increase Conservation	.5 MAF		.5 MAF	
SUBTOTAL FOR RECYCLED, DESAL, STORMWATER AND CONSERVATION	1.1 MAF		2.9 MAF	
Expand Storage Above and Below Ground*	3.7 MAF		4 MAF	
Total	4.8 MAF		6.9 MAF	

*Additional storage capacity does not equate to a similar volume of new water supply. MAF – million acre-feet.

Currently, recycled water offsets about nine percent of the state's water demand, about 728,000 acre-feet per year. The State Water Resources Control Board (State Water Board) has invested a total of $1.8 billion in recycled water projects statewide over the last five years that are in various stages of development. Once completed, those projects will generate an additional 124,000 acre-feet of new water supply.

Approximately 1.5 million acre-feet per year of treated wastewater is currently discharged to California's ocean waters. Not all of this can be recycled, as some water is needed to discharge brine, and wastewater in some places provides critical streamflow for fish and wildlife. But in many places, communities can tap this resource to build water supply resilience.

Current regulations enable communities to use recycled water for drinking via a reservoir or aquifer, and in 2023, the State Water Board will establish direct potable reuse regulations that allow suppliers to distribute recycled water without first putting it into a reservoir or aquifer.

Implementation Steps:

- The State will consider greater investments and leverage federal dollars where possible to build on the $3.2 billion in financing for water recycling projects that the State Water Board has provided to 94 projects since 2012. At roughly $15,000 an acre-foot, it would require a state, local, and federal investment of approximately $10 billion to achieve the 2030 goal and $27 billion to achieve the 2040 goal of recycling an additional 1.8 million acre-feet of water.
- By January 1, 2024, the State Water Board will work with local water and sanitation agencies to identify recycled water projects that hold the potential to be operational by 2030 and by no later than 2040.
- The State Water board will formalize a process currently underway by convening a strike team to identify and resolve permitting and funding obstacles.
- The State Water Board will track the permitting and funding status of recycled water projects with a public, digital dashboard.
- The State will support local water sustainability plans that include water recycling, including (but not limited to):
  - Operation NEXT/Hyperion 2035 (city of Los Angeles)
  - Pure Water San Diego (city of San Diego)
  - Integrated Water Resources Plan and Climate Action Plan (Metropolitan Water District of Southern California)
  - Water Supply Management Program 2040 (East Bay Municipal Utility District)
- The State Water Board will act on direct potable reuse regulations by December 2023.

1.2 Expand brackish groundwater desalination production by 28,000 acre-feet per year by 2030 and 84,000 acre-feet per year by 2040 and help guide location of seawater desalination projects where they are cost effective and environmentally appropriate.

There are 14 seawater desalination plants across the state, with a combined production capacity of approximately 89,000 acre-feet per year. Some are not operating at full capacity and could be positioned to generate additional water supplies in drought, much as "peaker" power plants operate in short bursts to support electricity reliability at times of peak demand. Another 23 brackish groundwater desalination plants have a combined production capacity of 139,627 acre-feet per year. Brackish groundwater requires significantly less energy to treat than seawater.

Proposals to build desalination projects along the coast must be approved under the Coastal Act, in addition to other regulatory requirements. As California becomes hotter and drier, we must become more resourceful with the strategic opportunity that 840 miles of ocean coastline offer to build water resilience.

Implementation Steps:

- By January 1, 2024, the Department of Water Resources (DWR) and the State Water Board, in coordination with local agencies, will identify the brackish desalination projects that have the potential to be operational by 2030 and by no later than 2040. The State will consider investing in grants to local agencies for planning and building desalination projects.
- By January 1, 2024, the State Water Board will review groundwater basins impaired by salts and nutrients and determine the volume of water available for brackish groundwater desalination.
- As the State's representative on the U.S. Department of Energy's five-year, $100 million desalination innovation hub, DWR will continue to guide research investments towards technological breakthroughs that solve California desalination challenges.
- The State will help streamline and expedite permitting to provide better clarity and certainty to further desalination projects. To this end, by June 30, 2023, the State Water Board, Coastal Commission, DWR and other State entities (e.g. State Lands Commission) will develop criteria for siting of desalination facilities along the coast and recommend new standards to facilitate approval.
- Within the following year, these agencies will identify potential available mitigation sites to facilitate the expedited approval of desalination facilities. The State Water Board will consider amendments to the Desalination Policy in its Ocean Plan to streamline permits that meet the recommended siting and design standards for projects located in the identified priority areas.

2. Expand water storage capacity above and below ground by four million acre-feet.

While creating more space to store water in reservoirs and aquifers does not create more precipitation, and whether enough rain and snow fall to fill storage space is out of our control, we need diversion infrastructure, more places to park runoff, and the conveyance to eventually move the water to where it is needed to take advantage of fast-moving storms. Expanding storage capacity improves the ability to capture runoff when diversions cause the least harm to the environment. Furthermore, apart from a hotter and drier climate, capturing water runoff is needed to help correct decades of over-pumping of groundwater basins.

2.1 Expand average annual groundwater recharge by at least 500,000 acre-feet.

Vast capacity to store water exists underground in California. Intentional, directed recharge of groundwater is one of the fastest, most economical, and widely available ways to harness the bounty of wet years to cope with dry years. It has the additional advantage of helping to halt or prevent land surface collapse due to over-pumping, which can damage roads, canals, and bridges. Expanding groundwater recharge requires adherence to laws, so that the environment and water users upstream and downstream are not harmed when streamflow is directed underground. With the multi-faceted suite of actions below, the State intends to help local water agencies to accelerate the pace and scale of groundwater recharge. These actions center on helping local agencies understand the best locations for recharge, analyze the impact of their recharge proposals on the environment and other water users, and expeditiously permit their projects.

Local agencies are developing groundwater recharge projects around the state. By the end of next year, the State cumulatively will have invested $350 million in local assistance for recharge projects. In planning documents, local agencies have proposed more than 340 new recharge projects that, if built, could result in as much as 2.2 million acre-feet of additional stored water in a single wet year by 2030. Until those projects are permitted, it is unclear how much water those projects will have the capacity to divert to underground storage; multiple proposals may rely on the same sources of unappropriated water. But an additional 500,000 acre-feet is a reasonable estimate of the additional average annual recharge volume that may be obtained after these projects are vetted, permitted, and constructed.

California must be ready to respond to future wet winters. Fortunately, several processes already are in place that could be used to divert water from high-flow events to underground storage. Additional outreach, education, and technical assistance will be critical for preparing diverters for a potentially wet winter so that permits can be put in place before the start of the rainy season.

Should local actions become too fragmented or inefficient to maximize recharge opportunities, the state should consider a coordinated, state-level approach to provide for orderly, efficient disbursement of rights to high winter flows.

Implementation Steps: To help achieve this target, DWR and the State Water Board will continue to provide regulatory and technical assistance to local agencies that have received State funds to ensure that groundwater recharge project proponents can successfully navigate the regulatory processes. The State will weigh the following actions. Some would require additional investments and, possibly, regulatory changes.

- **Outreach:**
  - DWR and the State Water Board will conduct a series of outreach activities to highlight temporary permitting pathways in advance of winter, to assess the status of

proposed recharge projects, and to better align state and local agencies to advance groundwater recharge. The outreach would focus on the use of an existing 180-day temporary permit process and would note that permit applications should be received no later than October 1 to be ready for diversions in January.

- By December 2022, DWR will evaluate a process whereby it files for 180-day temporary permits in certain watersheds on behalf of local agencies, in order to advance the development of the permit terms and conditions. DWR also would pay the filing fee, which could help facilitate local willingness to participate.

Technical Assistance:

- DWR will provide outreach and assistance to help connect potential diverters with State Water Board permitting staff to answer specific questions and provide information that enables effective permit applications.
- By October 2022, the State Water Board water right permitting staff will prioritize groundwater recharge permits.

- **Incentives:**
  - The State will weigh immediate and long-term incentives for recharge project applicants to pursue the State Water Board's streamlined recharge permitting pathway. Incentives could include:
  - Waiving of application costs partially or fully for a two-year period.
  - Connecting infrastructure funding to applications that use the State Water Board's streamlined underground storage permitting approach.
  - Prioritization of State funding for groundwater recharge projects that target high-flow events, which raise fewer concerns about the environment and other water right holders than projects that seek to capture water in "shoulder" seasons of spring, summer, and fall.
  - DWR will expand its watershed modeling tools to better assess water available for recharge on a watershed basis.
- **Regulatory Streamlining:**
  - The State will streamline water right permits for recharge projects receiving DWR grants or conducted under DWR's Flood-Managed Aquifer Recharge Program.
  - The State Water Board will develop permanent regulations for water availability analyses that specify methodologies, data, and alternatives for conducting such analyses.
  - The Administration will pursue legislation to revise the water right application process to deliver decisions more quickly.
- **State Administration of Potential Recharge Flows**:
  - DWR and the State Water Board will develop a mechanism to create a more consistent, economical, and equitable approach for allocation of water rights for groundwater recharge. The initial proposal would focus on the State securing all reasonably available future flood flows in the Central Valley, allowing the State to

then allocate the available water in an orderly, holistic, equitable, and integrated approach. The process would:

- Level the playing field for local agencies, especially those that lack the resources to navigate the water right process.
- Set clear water availability metrics for every potential applicant, allowing for fair comparisons among applicants.
- Address equity concerns, including, for example, the need to protect domestic wells or abate subsidence.
- Leverage other funding opportunities.
- Spur tight coordination between the State Water Board and DWR in the allocation of water rights.

2.2 Work with local proponents to complete the seven Proposition 1-supported storage projects and consider funding other viable surface storage projects.

Seven locally-driven projects are underway to increase the state's overall capacity to store water by 2.77 million acre-feet – nearly three times the capacity of Folsom Lake. The seven projects are on track to receive a combined $2.7 billion in state funding from Proposition 1, the 2014 water bond, once they meet the requirements imposed in the bond law. Four of the projects involve groundwater storage and three involve creation of a new or expanded reservoir. Two of these seven projects are likely to begin construction next year, with the other five expected to begin construction in 2024 or 2025. Project proponents are working now to obtain permits, arrange financing, finalize environmental documents, and negotiate contracts with state agencies for the delivery of public benefits from the projects, including environmental flows.

Implementation Steps:

- To formalize, streamline and continue existing efforts, the California Natural Resources Agency and the California Environmental Protection Agency will establish an interagency strike team to facilitate state permitting and support completion of these projects.
- Water Commission staff will continue to monitor development of the seven Proposition 1 projects closely.
- Permit teams from the California Department of Fish and Wildlife (CDFW) and the State Water Board will continue working with applicants and with other state agencies inform and advance the development of contracts for administration of public benefits.
- Water Commission, DWR, CDFW, and State Water Board teams will continue robust coordination. and working with applicants to draft and execute contracts for administration of public benefits.

2.3 Expand San Luis Reservoir by 135,000 acre-feet.

The federal government is proposing to expand San Luis Reservoir in Merced County to capture more winter storm runoff. In extremely wet years like 2017, San Luis fills and

California misses an opportunity to capture and store even more water for use during subsequent dry years. The project would expand the capacity of the two-million acre-foot reservoir by 130,000 acre-feet -- enough to supply nearly 400,000 homes a year. DWR is working with the U.S. Bureau of Reclamation (Reclamation) on this proposed project and sees it as an important part of a set of inter-related joint projects to benefit the Central Valley Project and State Water Project, which include upgrading the San Luis Reservoir dam for earthquake safety, modernizing conveyance of water through the Sacramento-San Joaquin Delta, and restoring capacity lost due to subsidence at major Central Valley canals.

Implementation Steps:

- In December 2019, Reclamation and DWR announced a partnership to move forward on the seismic upgrade. Reclamation and DWR celebrated the groundbreaking of the project in June 2022. Construction is expected to finish in 2028. DWR will continue to work with Reclamation to complete the seismic upgrade and expansion.

2.4 Rehabilitate dams to regain storage capacity.

As of May, 112 California dams are rated "less than satisfactory" by State dam inspectors, and the reservoirs behind 41 of those dams cannot be filled beyond a certain level in order to protect public safety. The loss of storage is about 350,000 acre-feet per year. Accelerating dam safety repairs would help local water districts regain lost storage capacity and improve public safety. While this has historically been a federal or local obligation, the Legislature and Administration enacted additional funding to support dam owners faced with costly repairs.

Implementation Steps:

- DWR will administer the $100 million in the 2022-23 budget for local dam safety projects and flood management.

2.5 Support local stormwater capture projects in cities and towns with the goal to increase annual supply capacity by at least 250,000 acre-feet by 2030 and 500,000 acre-feet by 2040.

Over the last 30 years, an average of approximately 324,000 acre-feet of stormwater a year has been captured and recharged in communities in the South Coast alone. While this value varies from year to year, during the exceptionally wet winter of 2004-05 over 900,000 acre-feet of runoff was captured and infiltrated into the local groundwater basins.

The size, cost, and feasibility of stormwater capture projects vary greatly by location. It is extremely difficult for stormwater agencies to accurately measure stormwater capture volume and to predict potential due to uncertainties with annual precipitation.

Implementation Steps:

- Through permitting and funding, the State will incentivize local agencies to develop stormwater capture projects and help offset the cost of completing these projects, including through stormwater crediting systems to encourage public-private partnerships.

- The State Water Board will hire a contractor to provide an estimate of current stormwater capture and use statewide and then re-evaluate every five years progress towards the 2030 and 2040 goals.

3. Reduce Demand

3.1 Build upon the conservation achievements of the last two decades to reduce annual water demand in towns and cities by at least half a million acre-feet by 2030.

During the 2012-2016 drought, Californians did their part to conserve water, with many taking permanent actions that continue to yield benefits; per capita residential water use statewide declined 21 percent between the years 2013 and 2016 and has remained on average 16 percent below 2013 levels as of 2020. Californians are stepping up again in this current drought. The State set a target of 15 percent for statewide conservation. Californians have made progress toward that goal in the summer of 2022, but more is needed to cope with the intense drought at hand and for the long term.

California enacted laws in 2018 to set new efficiency standards for how people use water in homes and businesses in ways that make sense in each region. These standards will drive fully-efficient water use in communities and eliminate water waste, even as communities continue to grow. The 2018 legislation calls for these standards to be met by 2030. The State Water Board is on track to set those new standards, informed by extensive data collection and analysis and recommendations from DWR. The recommended standards for indoor and outdoor water use for residential, commercial, industrial, and institutional water use could save 450,000 acre-feet per year starting in 2030. This amount of water would support 1.35 million homes, and the savings would prevent urban water use from rising as much as it would otherwise as population grows and more housing is built. These new standards would not apply to individual Californians, but local water suppliers must ensure the standards are met.

Given the acute need to conserve water in a potentially fourth dry year, the State Water Board will develop emergency conservation measures that expedite implementation of conservation in a way that is already mandated through the 2018 laws. If drought conditions persist, the new short-term requirements could take effect no later than spring 2023. The new requirements would consider the relative efficiency of each supplier. These new efficiency targets would therefore work as a bridge to take California from voluntary measures to efficiency-based, water-use budgets that account for differences in climate zones, landscape area, population, and other factors.

In addition, the Administration sponsors a robust campaign to motivate urban Californians to save water and is working to accelerate the transition of turf to landscapes that use less water. To this end, the State will partner with local agencies to convert 500 million square feet of ornamental turf by 2030, with corresponding investments in programs and policies that incentivize turf conversion. Removal of 500 million square feet of turf could generate 66,000 acre-feet of water savings each year at an estimated cost of $1 billion.

Implementation Steps:

- The State Water Board will develop short-term efficiency-based conservation targets for every urban retail water supplier based on their unique characteristics like climate zone, water demand, residential landscape area, and population. The Board will compare water suppliers' actual use to their estimated efficient use target and assign them a percent reduction, with a higher reduction target for suppliers whose actual use is further from their efficient use target.
- DWR and the State Water Board will target grants to help local water districts achieve efficiency targets, using funding recently approved by the Legislature.
- The State-run Save Our Water campaign will continue to educate Californians about the severity of the current drought and the need to make water conservation a permanent, daily practice.
- DWR will establish a grant program to support local efforts to replace ornamental turf with drought-tolerant landscaping and—where schools and parks require turf—to make turf irrigation and maintenance more efficient, with a focus on disadvantaged communities.
- The State Water Board will advance adoption of new long-term water use efficiency standards, per existing statute (2018).
  - Once DWR provides its formal recommendations, the State Water Board will begin the process for enacting the regulation to ensure the rule will be in effect by January 1, 2024.

3.2 Help stabilize groundwater supplies for all groundwater users, including a more drought-resilient agricultural economy.

California irrigated agricultural acreage declined by 1 million acres between 2002 and 2017. The approximately eight million acres of irrigated farm and ranchland will shrink by at least an estimated additional 500,000 acres to one million acres between now and 2040 as local agencies transition to groundwater use that is sustainable over coming decades. The conserved water should support a more drought-resilient agricultural economy that retains its vitality.

Implementation Steps:

The State will:

- Continue to implement the Sustainable Groundwater Management Act (SGMA) to protect communities, agriculture, and the environment against prolonged dry periods and climate change, preserving water supplies for existing and potential beneficial use.
- Support local water demand management that includes changes to cropping patterns and fallowing by building upon this year's investment of $40 million in grants to regional organizations working to reduce groundwater reliance and create local environmental and economic opportunities through land-use changes.
- Continue to support conservation and water efficiency practices by agricultural producers.
- Support flexibility in local land use decisions to protect beneficial uses and users.

- Continue direct investment and technical assistance in drought relief for agriculture with dedicated funding to assist socially disadvantaged and underserved populations.

4. Improve Forecasting, Data, and Management, including Water Rights Modernization

Crucial to achieving the water supply actions described here is a common, readily-available set of facts about water supply and use, better forecasting, and integrated use of data and technology. Water rights modernization and reform is a critical component of ensuring we can efficiently and effectively adapt to a changing climate.

4.1 Improve data collection and modernize forecasts for a changed climate.

Sierra snowpack provides about a third of the water people use in California, yet the existing approach to forecasting snowmelt runoff dates to the 1950s.

To account for climate change, we must simulate the physics of interactions among the atmosphere, water as rain or snow, and the land surface – and we need to do this for individual watersheds, incorporating site-specific features like slope orientation and depth of soil. This requires timely data collection.

Implementation Steps:

The State will:

- Continue to invest in the human and technical resources needed to improve predictions and forecasting for water supply planning.
- Advance a multi-agency effort to install 430 new stream gages and upgrade or re-activate 200 more across the state. These gages provide real-time surface water data for enhanced drought management and flood response.
- Work with the U.S. Army Corps of Engineers leadership to accelerate the pace at which the manuals guiding reservoir operations are updated to reflect a changed climate.

4.2 Improve the flexibility of current water systems to move water throughout the state.

California depends upon aging, damaged, or increasingly risk-prone infrastructure to transport water between different areas of the state. Modern infrastructure and tighter coordination between the state's two major water projects would expand capacity to move water when it is available.

The state and federal water projects are fed by levee-lined channels in the Sacramento-San Joaquin Delta. This Delta infrastructure faces serious threat of failure due to storm surge, sea level rise, and earthquakes that could collapse levees. Loss of this water supply for any amount of time poses significant risk to farms, businesses, and most California homes. South of the Delta, major canals have been damaged by subsidence caused by the over-pumping of groundwater, restricting the capacity to move water when it is available.

DWR proposes to modernize State Water Project (SWP) conveyance in the Delta. Had the proposed project been operational in 2021, the project could have captured and moved an additional 236,000 acre-feet of water into San Luis Reservoir during that winter's few large storms.

Administrative hurdles also limit flexibility to move water. Every year for the last 10 years, the federal and state water projects have applied to the State Water Board for temporary flexibility in the locations where water diverted by either project may be used. These "consolidations of the authorized places of use" of the SWP and the Central Valley Project last only a year and require repetitive work by all parties involved. A permanent change to allow for consolidated place of use among the projects would make water transfers easier and lay the groundwork for discussions about future operation of the two projects.

Implementation Steps:

- DWR will advance the design of and the draft environmental impact report for the proposed Delta conveyance project, which would construct new intakes along the Sacramento River and a tunnel under the Delta to safeguard SWP deliveries and ensure that the SWP can make the most of big but infrequent storm events.
- DWR will disburse $100 million included in the 2022-23 state budget to support costs of repairing four major San Joaquin Valley canals damaged by subsidence.
- DWR and the State Water Board will chart a work plan to address the resources needed for preparation, submittal, and consideration of a joint place of use petition from the federal and state water projects.

4.3 Modernize water rights administration for equity, access, flexibility, and transparency.

The foundation of how California manages water rights dates to the Gold Rush and has not evolved in step with changing public values and management needs. The State Water Board is challenged to provide timely, useful, and meaningful information to guide state and local water management decisions, which are especially vital during periods of drought.

Other western states including Washington, Oregon, Nevada, and Idaho manage water diversions much more nimbly than California, which puts them in better position to adjust to what many call "aridification" – the transition to a drier climate. The ability to adjust diversions quickly also is crucial to protecting fish and wildlife, other water right holders, and public health. To make a century-old water right system work in this new era, the State Water Board needs accurate and timely data, modern data infrastructure, and increased capacity to halt water diversions when the flows in streams diminish. These improvements are a necessary predicate to modernize our water rights system in a manner that respects water right priorities and aligns with current public values and needs.

Implementation Steps:

The State Water Board will:

- Continue to build upon efforts started last summer with the investment of $30 million to digitize existing paper records and rebuild the state's water right data management system.

- Develop pilot projects in two or three watersheds over the next five years to collect real-time diversion data and integrate the data into the State Water Board's water rights data system, with lessons learned and outcomes used to inform statewide tools needed for administering an efficient and effective water rights system.
- Develop data and analytical tools for implementing the water right priority system for an estimated 10 to 15 watersheds.
- Support modeling staff to develop more robust supply/demand models for the Delta watershed.
- Consider adopting regulations that would allow for curtailments of water rights in years when there is not a declared drought emergency. The State currently lacks the authority in most years to implement the priority water rights system without a declared drought emergency.
- Support enforcement staff to help address illegal and unauthorized diversions during dry conditions.
- Consider regulations, legislation, and pursuing resources needed to streamline and modernize the water right system, clarify senior water rights, and establish more equitable fees.

Why target these actions?

The last three years of record-breaking drought made painfully real the hotter, drier pressures on water systems. These four major sets of actions would put to use water that would otherwise be unusable, stretch supplies with efficiency, and expand our capacity to bank water from big storms for dry times. They are designed, in other words, for a climate prone to weather whiplash.

These actions alone will not eliminate local water supply risk. The variability of rain and snow is too great, as is the uncertainty about which projects local agencies will implement. These actions aim to spur local agency adaptation to a new reality and change the way the State does business in order to better support local and regional water management efforts.

Who will carry out this strategy?

The state and federal governments each operate large water delivery systems in California, but local water districts and counties have primary responsibility for getting supplies to homes and businesses. Thousands of local and regional entities play a role in water management. Implementation of this strategy will require decisive state action. It will also require partnerships, as local agency leaders, federal partners, farmers, other business owners, and individual Californians are essential actors in carrying out this plan. To ensure successful implementation in such a decentralized system, the State must lead, set goals, provide incentives, and be prepared to exert greater authority when necessary.

The State will prioritize its funds and human resources to support local projects that satisfy state planning and permitting requirements to protect natural resources and help us collectively reach the targets outlined above. The State will invest in forecasting and data and water right administration – including real-time tracking of water use – to improve all water management actions by state, local, federal, and private entities. The State will also ensure that California's response advances equity and takes into account communities that are most at risk from climate change and that have experienced environmental injustices.

Water affordability is key to ensuring the human right to water – established in California law -- in the face of a hotter, drier state. The State has made strides in promoting affordability through provision of low-interest loans and grants to support infrastructure and planning for water systems, and by addressing pandemic-related water debt. However, the increased investments in infrastructure necessary to meet our future water supply needs will put additional pressure on affordability. The State will identify how best to support low-income households and address community affordability of water systems. Electric and communication utilities have programs to ease cost burdens on low-income members of the community, and it is important to address this in the water utility sector in a way that Is workable and sustainable from a state budget perspective.

Where local agencies fail to build water resilience, the State will exert greater regulatory authority or work with the Legislature to gain authority to do so.

Moving Smarter and Faster

Climate change uniquely affects California's regions. This document articulates statewide targets for certain water management strategies, but achieving those overarching goals requires solutions at the local level, where the opportunities and challenges of each watershed vary tremendously. To encourage collaboration across watersheds that leads to greater statewide water resilience, the State will work with stakeholders and the Legislature to create:

- A funding program that incentivizes water users to develop regional targets for recycling, desalination, storage, efficiency, and other water management strategies.
- An expedited permitting path for water projects that help regions achieve those targets.

In order to deliver the pace and scale of projects necessary to meet this unprecedented climate challenge, we must modernize regulatory structures and expand staff capacity so that State agencies can assess, permit, fund and implement projects at the pace this climate emergency warrants.

The Administration will work with the Legislature and stakeholders to pursue the following:

- A more expeditious process for completing, reviewing and finalizing California Environmental Quality Act (CEQA) reviews and Water Code proceedings for critical water infrastructure projects to build drought and flood resilience.
- A voluntary permitting process for water infrastructure projects administered by the Governor's Office of Planning and Research (OPR). State agencies would retain authority to review, identify, and address environmental impacts, but the OPR would expedite the collective permitting process. This proposed process would not be an

option for water projects already under environmental review. The Administration would work with the Legislature to determine eligibility criteria for this voluntary process.

- Legislation, where appropriate, and regulations that would allow for curtailments of water rights in years when there is not a declared drought emergency. The State currently lacks the authority in most years to implement the priority water rights system without a declared drought emergency.

The Administration will:

- Develop water availability analysis guidelines for water right applications that account for high-flow periods on fully appropriated streams and the way climate change is shifting the seasonality and intensity of runoff. Develop permanent State Water Board regulations that specify the data and methodologies to be used for conducting such analyses in order to remove the current ambiguity about regulatory requirements.
- Establish a State Water Board, DWR and the California Department of Food and Agriculture "Groundwater Recharge Coordinating Committee" to jointly implement the groundwater recharge initiatives.
- Establish programmatic permitting for projects of a similar nature (such as water recycling or habitat restoration) in order to lower costs, simplify process, and speed permit approval.
- Institutionalize early alignment and regular internal coordination across state agencies on the permitting of water supply adaptation projects.

Conclusion

The world is getting hotter. The increased heat will intensify the natural swings in California's climate and shrink water supplies. Targeted state funds and focus will support local efforts to conserve, capture, recycle, and de-salt enough water to allow California communities to prosper in a hotter, drier climate.

CLIMATOLOGY

Climate change is increasing the risk of a California megaflood

Xingying Huang[1]*† and Daniel L. Swain[2,3,4]*†

Despite the recent prevalence of severe drought, California faces a broadly underappreciated risk of severe floods. Here, we investigate the physical characteristics of "plausible worst case scenario" extreme storm sequences capable of giving rise to "megaflood" conditions using a combination of climate model data and high-resolution weather modeling. Using the data from the Community Earth System Model Large Ensemble, we find that climate change has already doubled the likelihood of an event capable of producing catastrophic flooding, but larger future increases are likely due to continued warming. We further find that runoff in the future extreme storm scenario is 200 to 400% greater than historical values in the Sierra Nevada because of increased precipitation rates and decreased snow fraction. These findings have direct implications for flood and emergency management, as well as broader implications for hazard mitigation and climate adaptation activities.

INTRODUCTION

California is a region more accustomed to water scarcity than overabundance in the modern era. Between 2012 and 2021, California experienced two historically severe droughts—at least one of which was likely the most intense in the past millennium (*1*, *2*)—resulting in widespread agricultural, ecological, and wildfire-related impacts (*3*, *4*) and ongoing drought-focused public policy conversations. Yet, historical and paleoclimate evidence shows that California is also a region subject to episodic pluvials that substantially exceed any in the meteorological instrumental era (*5*)—potentially leading to underestimation of the risks associated with extreme (but infrequent) floods. Observed extreme precipitation and severe subregional flood events during the 20th century—including those in 1969, 1986, and 1997—hint at this latent potential, but despite their substantial societal impacts, none have rivaled (from a geophysical perspective) the benchmark "Great Flood of 1861–1862" (henceforth, GF1862). This event, which was characterized by weeks-long sequences of winter storms, produced widespread catastrophic flooding across virtually all of California's lowlands—transforming the interior Sacramento and San Joaquin valleys into a temporary but vast inland sea nearly 300 miles in length (*6*) and inundating much of the now densely populated coastal plain in present-day Los Angeles and Orange counties (*7*). Recent estimates suggest that floods equal to or greater in magnitude to those in 1862 occur five to seven times per millennium [i.e., a 1.0 to 0.5% annual likelihood or 100- to 200-year recurrence interval (RI)] (*5*, *8*).

The extraordinary impacts resulting from GF1862 provided motivation for a 2010 California statewide disaster scenario—known as "ARkStorm" (ARkStorm 1.0)—led by the U.S. Geological Survey in conjunction with a large, interdisciplinary team (*9*). The meteorological scenario underpinning the ARkStorm 1.0 exercise involved the synthetic concatenation of two nonconsecutive extreme storm events from the 20th century (*10*). Subsequent analysis suggested that such an event would likely produce widespread, catastrophic flooding and subsequently lead to the displacement of millions of people, the long-term closure of critical transportation corridors (*9*), and ultimately to nearly $1 trillion in overall economic losses (2022 dollars) (*11*).

Meanwhile, a growing body of research suggests that climate change is likely increasing the risk of extreme precipitation events along the Pacific coast of North America (*12*, *13*), including California (*14*–*16*), and of subsequent severe flood events (*17*, *18*). The primary physical mechanism responsible for this projected regional intensification of extreme precipitation is an increase in the strength of cool-season atmospheric river (AR) events (*19*–*21*). Previous analyses have suggested that the thermodynamically driven increase in atmospheric water vapor with warming is directly responsible for most of this projected AR intensification [e.g., (*16*)], with the remainder contributed by shifts in regional atmospheric circulation. There is also evidence that increased radiative forcing may result in an eastward shifted expression of atmospheric circulation anomalies associated with both the Madden-Julian Oscillation (*22*) and the El Niño–Southern Oscillation (ENSO)–forced component of the Pacific North American pattern (*23*)—both of which would increase the subseasonal variability of cool season precipitation over and near California. Compounding the increase in extreme precipitation associated with AR events are warming temperatures themselves (*24*)—which raise the mean elevation of snow accumulation in mountainous areas (*25*), increase instantaneous runoff rates as rain falls at the expense of snow (*18*), and raise the risk of "rain on snow" events (*26*). Collectively, these previous research findings motivate the question of whether climate change may substantially affect the odds of "low probability but high consequence" flood events.

Here, we describe the overall design and implementation of, as well as results from, "ARkStorm 2.0"—a new severe storm and flood scenario reimagined for the climate change era. Leveraging recent advances in atmospheric modeling by coupling a high-resolution weather model to a climate model large ensemble, we assess the meteorological characteristics of extreme storm sequences (henceforth referred to as "megastorm" events) as well as the subsequent extreme runoff and adverse hydrologic outcomes such meteorological conditions (henceforth, "megaflood" events) would produce under both present-day and warmer future climate regimes. This work builds

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upon previous research by explicitly considering long-duration (30-day) storm sequences (rather than single-storm events) most relevant to flood hazard management and disaster preparedness, characterizing large-scale ocean and atmosphere conditions associated with such severe storm sequences, and assessing the likelihood of these events over a wide range of potential levels of global warming. We find that climate change has already increased the risk of a GF1862-like megaflood scenario in California, but that future climate warming will likely bring about even sharper risk increases.

RESULTS

Large-scale and regional climate conditions associated with megaflood scenarios

We design two separate megastorm scenarios capable of causing a megaflood in California—one drawn from the recent historical climate (circa 1996–2005; henceforth "ARkHist") and another from a hypothetical warmer future climate (2071–2080 in the "high warming" RCP8.5 emissions scenario; henceforth "ARkFuture"). Each scenario comprises a multiweek sequence of consecutive severe winter storm events similar to what is reported to have occurred during the peak of the GF1862 event. Specific events are selected by ranking the 30-day cumulative precipitation on a California statewide basis simulated by the 40-member Community Earth System Model Large Ensemble (CESM1-LENS) and subsequently choosing from among the top 3 ranked events in each climate era to dynamically downscale using a high-resolution weather model [the Weather Research and Forecasting (WRF) model v4.3]. Further details can be found in Materials and Methods.

We find that both ARkHist and ARkFuture events occur during simulated warm-phase ENSO (El Niño) years, although the El Niño event that co-occurs with ARkFuture is much stronger [Niño 3.4 sea surface temperature (SST) anomaly = +1.48 K] than that with ARkHist (+0.56 K). Both events have maximum SST anomalies located in the tropical central Pacific (Fig. 1, A and B), which would be consistent with so-called "central Pacific" or "Modoki" El Niño (*27*). Warm (positive)

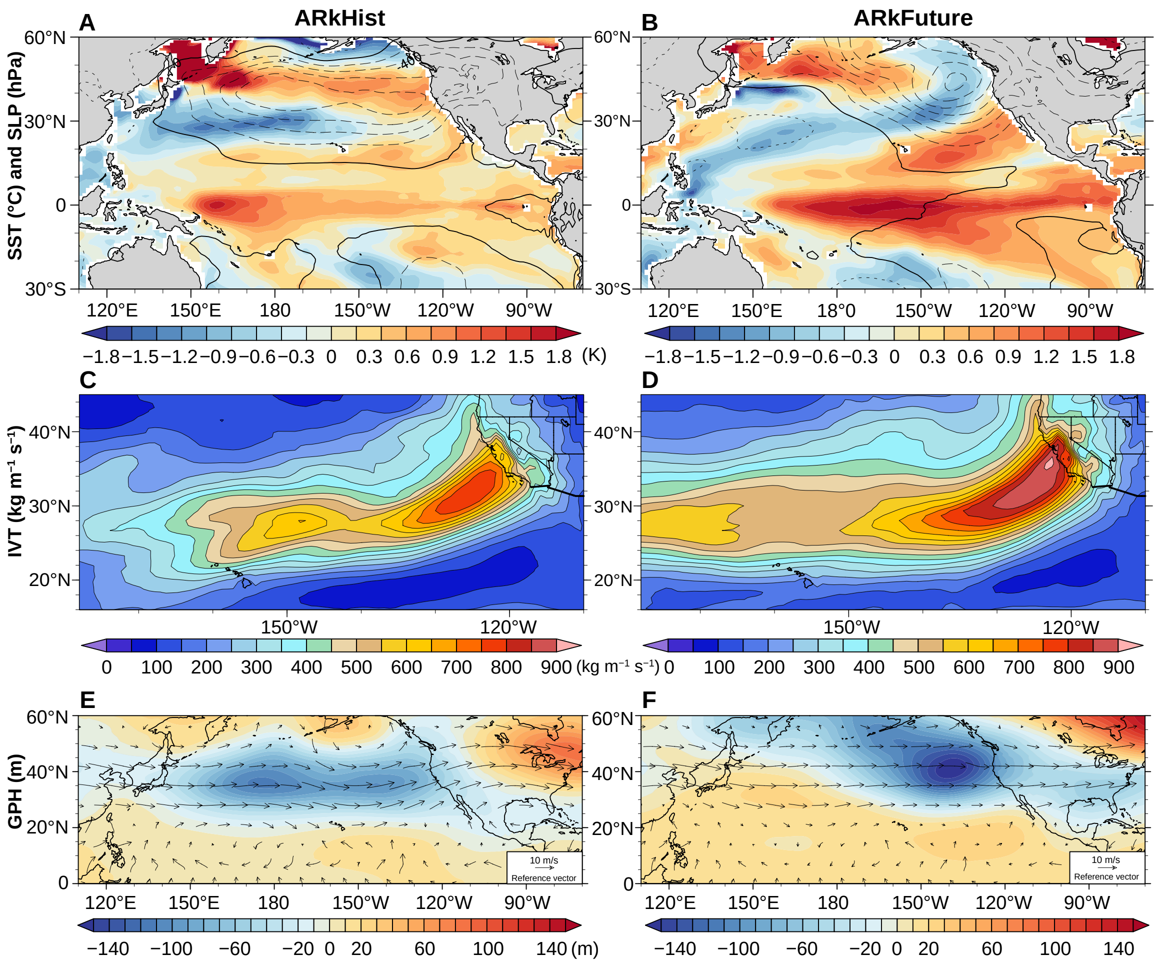

Fig. 1. Large-scale conditions during California megastorm scenarios. (**A** and **B**) Mean SST anomalies (color contours, K) and mean SLP (hPa) anomalies (dashed/solid contours) during ARkHist (A) and ARkFuture (B). SST and SLP are detrended before anomaly calculation using monthly data from each corresponding CESM1-LENS member (baseline period 1980 to 2005 for ARkHist; 2060–2090 for ARkFuture); solid (dashed) SLP contours denote positive (negative) anomalies in increments of 2 hPa. (**C** and **D**) Composite instantaneous vertically IVT (kg m^{-1} s^{-1}) for all hours in which California mean precipitation exceeds 1.5-mm ARkHist (C) and ARkFuture (D) using WRF 81-km simulations. Mean 30-day 500-hPa geopotential height (GPH, detrended) anomalies (color contours, m) and mean absolute 850-hPa wind vectors (m/s) (black arrows) during ARkHist (**E**) and ARkFuture (**F**).

SST anomalies are also present in the western Bering Sea and Sea of Okhotsk, as well as along the immediate California coast, in both cases. In addition, a broad region of negative sea level pressure (SLP) anomalies is centered over the Gulf of Alaska and adjacent portions of western North America—consistent with traditional El Niño teleconnections—although the zone of negative SLP anomalies extends farther westward across the North Pacific in ARkHist.

We acknowledge, however, that these large-scale patterns and associations with ENSO are drawn from only two individual scenario instances, and we cannot determine from this analysis alone whether these relationships are robust across a wider range of potential megastorm events. To offer a more systematic assessment, we consider the top 4 ranked 30-day California precipitation events in the CESM1-LENS historical and warmer future snapshot periods (fig. S1). We find that all eight such events are associated with anomalously warm conditions in the tropical Pacific Ocean, and Niño 3.4 SST anomalies are uniformly positive (+0.33, +0.56, +2.28, and + 1.56 K for the top 4 historical events and + 1.17, +1.95, +1.48, and + 1.39 K for future events, respectively, using detrended SST). However, it has recently been demonstrated that dynamic ENSO indices can better capture the spatial diversity of ENSO events and their subsequent western U.S. hydroclimate teleconnections (*28*). We thus calculate the ENSO Longitude Index (ELI)—an ENSO metric that tracks the average longitudinal position of ENSO-associated deep convection and accounts for the nonlinear response of convective activity to SST (*29*). As with Nino 3.4 SST anomalies, all eight such events are again associated with anomalously warm conditions in the tropical Pacific Ocean, but ELI values more clearly illustrate a wider range of ENSO spatial variability and dynamical intensity (ELI = 169.9°E, 171.6°E, 185.1°E, and 181.5°E for the top 4 historical events and ELI = 174.2°E, 181.0°E, 176.8°E, and 179.1°E for future events, respectively, using detrended SST).

Using the ELI categorizations defined in (*29*), this suggests that two of four events each in the historical and future simulations occur under "strong El Niño" conditions (ELI ≥ 179°E), and one of four historical and two of four future events occur under "moderate El Niño" conditions (170°E ≤ ELI < 179°E), with the final historical event falling nominally under the "moderate" threshold. Collectively, seven of eight historical and future potential California megastorm events occur under moderate or strong El Niño conditions as defined by the ELI (eight of eight, if rounding to the nearest degree of longitude). These findings strongly suggest that there is a substantially elevated likelihood of month-long storm sequences capable of producing very large precipitation accumulations during moderate to strong El Niño conditions and that the conspicuous anomalous deepening of the Gulf of Alaska low present in most of these eight events (fig. S3) is plausibly linked to El Niño teleconnections [which would be consistent with (*28*)].

Much previous work has focused on the critical role AR storms ("ARs") play in California hydroclimate—both as beneficial bolsterers of water supply and as the cause of hazardous floods (*30*–*32*). Composite analysis of 30-day averaged vertically integrated water vapor transport (IVT) and animations of IVT over the 30-day scenarios (movies S1 and S2) confirm that ARs are the primary storm mode during both ARkHist and ARkFuture (Fig. 1, C and D) scenarios, with a well-defined moisture transport axis extending northeastward from just north of the Hawaiian Islands to central California. This alignment is suggestive of 30-day mean storm trajectories capable of entraining large quantities of subtropical moisture (i.e., a "Pineapple Express"–type pattern), although with considerable upstream longitudinal extension of the IVT corridor westward of Hawaii (particularly in the future scenario; Fig. 1, C and D). This overall zonal pattern (but with localized meridional flow near California) is consistent with that recently associated with "AR families" occurring during El Niño conditions (*33*), which tend to be characterized by a strengthened subtropical Pacific jet stream and a persistently anomalous Gulf of Alaska cyclone that together favor long-duration periods of successive AR activity across California. While the general spatial structure of IVT is similar for both scenarios, ARkFuture exhibits mean 30-day composite IVT values that are ~25% higher than ARkHist.

Both severe storm sequences are associated with strong westerly (zonal) winds throughout nearly the entire atmospheric column (fig. S4), with a pronounced vertical maximum of ~60 m/s located around jet stream level (200 to 250 hPa) between 30°N and 35°N. Zonal winds are stronger in ARkFuture, especially in the upper troposphere (by >10 m/s above ~400 hPa). Analysis of 500-hPa geopotential height fields (Fig. 1, E and F) indicates that both events are associated with a broad region of negative mid-tropospheric height anomalies over the North Pacific to the west of California, although the negative height anomaly is more localized to the northeastern Pacific in ARkFuture. This suggests that both ARkStorm scenarios are associated with a robust Pacific jet, which is dynamically consistent with the eastward extension of the wintertime Pacific jet associated with both El Niño (Fig. 1, A and B) [e.g., (*28*)] and climate change [e.g., (*34*)], although the 30-day mean low-level (850-hPa) flow pattern exhibits a slightly more zonal pattern (with less of a meridional component over the northeastern Pacific) in ARkFuture relative to ARkHist. Visual inspection of movies S1 and S2 further confirm that both 30-day scenario storm sequences are characterized by the occurrence of multiple deep extratropical cyclones just west of or over California, which is consistent with recent results in (*35*), which found that AR-associated precipitation in the San Francisco Bay Area increased more for ARs directly associated with extratropical cyclones than those without.

We also find that composite atmospheric instability is relatively high during both ARkStorm scenarios. A 30-day composite convective available potential energy (CAPE) exhibits a broad region of >300 J/kg west of the northern California coast during ARkHist, with an even wider region of CAPE (>300 J/kg) (and locally >400 J/kg) in ARkFuture (fig. S5). The values might be unremarkable in a different geographic context, but in coastal California, ARs are typically associated with primarily stratiform or dynamically forced precipitation, and California ARs tend to be characterized by moist-neutral (versus conditional unstable) vertical profiles (*36*). Modest increases in atmospheric instability have been associated with outsized impacts during certain historical California storm events, increasing the risk of flash flooding/debris flows (*37*) and severe wind gusts (*38*) (fig. S6).

Cumulative and extreme precipitation

In both ARkHist and ARkFuture, 30-day cumulative precipitation is extremely high. In ARkHist, we find broad regions exceeding 500 mm of cumulative precipitation, with widespread areas exceeding 1000 mm in the Sierra Nevada (SN) and more isolated pockets exceeding 1000 mm in the Coast Ranges, Transverse Ranges, and far southern end of the Cascade Range (domain maximum of ~2150 mm; Fig. 2A). In ARkFuture, spatial patterns of event total precipitation

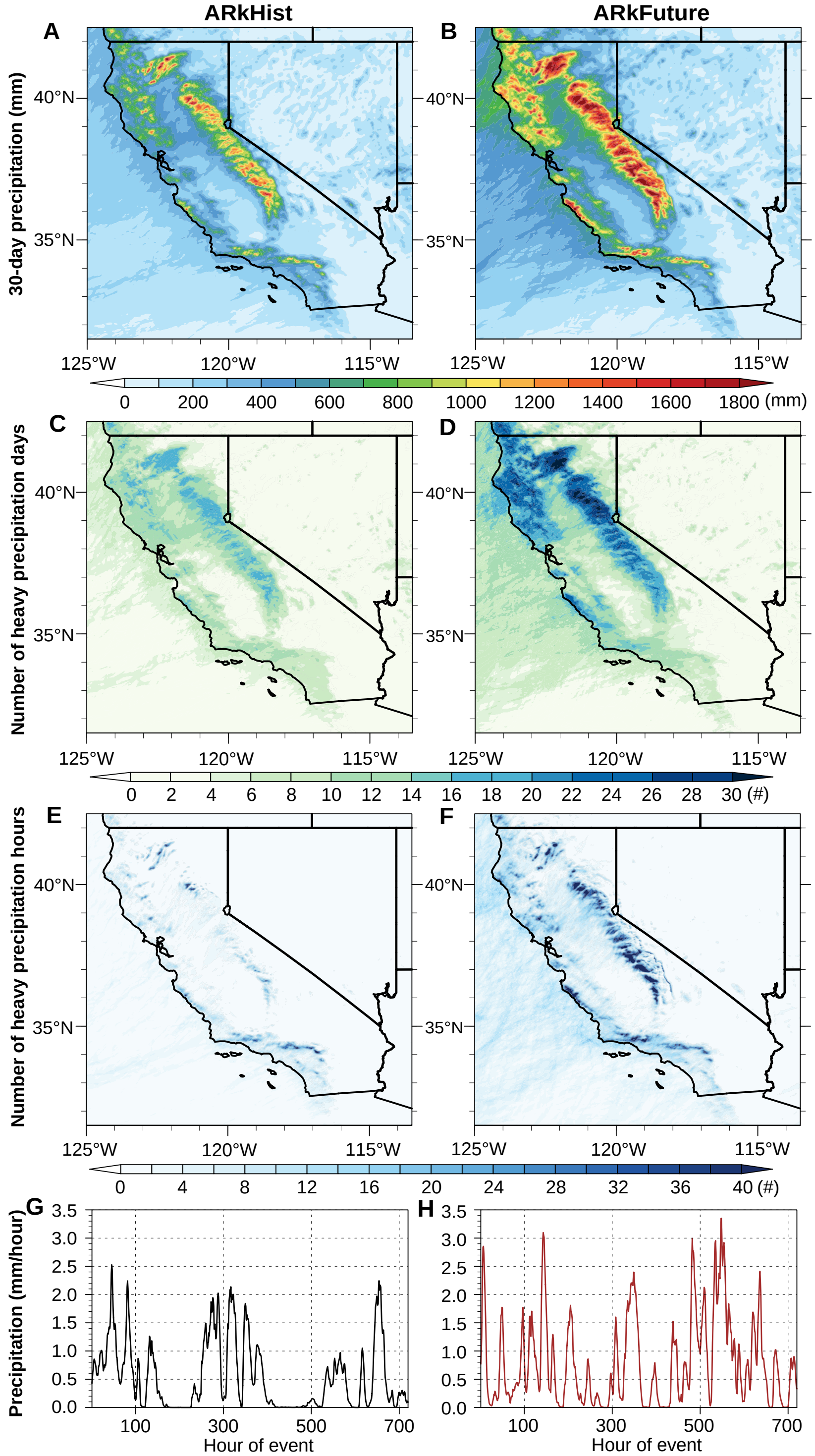

Fig. 2. Precipitation associated with California megastorm scenarios. (**A** and **B**) Cumulative 30-day precipitation (mm) during ARkHist (A) and ARkFuture (B). (**C** and **D**) Cumulative number of heavy precipitation days (days with precipitation > 20 mm/day) during ARkHist (C) and ARkFuture (D). (**E** and **F**) Cumulative number of heavy precipitation hours (hours with precipitation >10 mm/hour) during ARkHist (E) and ARkFuture (F). (**G** and **H**) Time series depicting hourly precipitation (mm/hour) on a cumulative California statewide basis during ARkHist (G) and ARkFuture (H). Data depicted in all panels are from the innermost 3-km WRF domain.

are similar but are uniformly characterized by heavier accumulations, with broad areas in both northern and southern California exceeding 700 mm and widespread areas in the abovementioned mountain areas above 1400 mm (domain maximum of ~3200 mm; Fig. 2B). We note that these values are comparable to maximum precipitation informally reported during the GF1862, which exceeded 2500 mm in at least two locations on the SN western slope over a slightly longer (~40-day) period (*6*). In general, cumulative precipitation in ARkFuture is between 35 and 60% higher than in ARkHist for northern and central California (although locally >80% higher), with lesser increases in far southern California (fig. S7, A and B). On a statewide average basis, 30-day precipitation is ~45% higher in ARkFuture.

Although absolute increases in cumulative precipitation are highest in mountainous areas (fig. S7A), relative increases in event total precipitation are greatest in areas that are not prone to orographic enhancement of precipitation during prevailing southwesterly winds (fig. S7B). Thus, some of the largest relative increases in precipitation (locally >80%) instead occur in regions that are less historically accustomed to receiving extreme precipitation during these events, such as inland valleys and otherwise wind-shadowed areas, which is consistent with earlier work (*16*).

Both ARkStorm scenarios are also notable for their very high precipitation intensities. We quantify this on several time scales, focusing on the frequency (over the 30-day scenario periods) with which precipitation intensity exceeds fixed daily and hourly thresholds [the number of days with precipitation > 20 mm/day and the number of hours with precipitation > 10 mm/hour, henceforth "heavy precipitation days" (HPDs) and "heavy precipitation hours" (HPHs)]. In ARkHist, we find that nearly all coastal areas experience at least 8 (of 30) days with precipitation exceeding 20 mm, and most mountain areas exceed 14 such days (except the Transverse Ranges in southern California, Fig. 2C). In ARkFuture, we find a sharp increase in the number of HPDs, especially in northern and central California, where most coastal areas exceed 16 (of 30) HPDs and most mountain areas exceed 20 such days (Fig. 2D and fig. S7, C and D). In some small pockets in the northern SN and far southern Cascades, all 30 days of the ARkFuture scenario are HPDs. HPD increases are substantially smaller in magnitude across southern California (mostly on the order of one to five additional days) but still nearly ubiquitous (fig. S7C).

Because of their particular relevance in the context of flash flood and debris flow risk (*39*), we specifically consider the occurrence of short-duration precipitation extremes in both ARkStorm scenarios. We find that the highest number of such hours occur in orographically favored areas, with the highest frequency of occurrence in the southern California Transverse Ranges and the Feather River watershed in the northern SN during ARkHist (Fig. 2, E and F). In ARkFuture, we report large and widespread increase in the occurrence of HPHs across essentially the entire domain. The largest increases [+25 to 40 cumulative hours (fig. S7, E and F)] occur broadly across the SN and (locally) in Santa Lucia Mountains—shifting the domain-wide maximum in HPH from southern to northern California. We find large relative increases (~200 to 300%) in the frequency of HPH and a large increase in the spatial extent of affected regions in ARkFuture. On a statewide average basis, we find that the frequency of HPH is ~220% higher in ARkFuture versus ARkHist (Fig. 2, G and H). Oakley *et al.* (*40*) conducted a literature review on published hourly rainfall rates in California and/or similar Mediterranean climate regions thought to be sufficient to trigger shallow landslides and debris flows in susceptible terrain, noting a range (5 to 20 mm/hour) that encompasses our HPH threshold (10 mm/hour) in the present study. These findings, therefore, likely have large implications from a flash flood and debris flow risk perspective.

California-wide average cumulative precipitation during the 30-day periods encompassing both extreme storm sequence scenarios represents a considerable fraction of the total annual [October-September water year (WY)] precipitation occurring during both ARkHist (~447 mm or 46% of the WY total) and ARkFuture (~586 mm, of 40% of the WY total). Compared to the climatological mean WY precipitation across all 40 ensemble members during the baseline periods (1996–2005 and 2071–2080, respectively); however, these events represent an even larger fraction of average annual precipitation—60% of WY precipitation in ARkHist and 71% of WY precipitation in ARkFuture. This also means that both the ARkHist and ARkFuture occur during anomalously wet WYs overall (32 and 77% wetter than the contemporaneous averages in ARkHist and ARkFuture, respectively). This would be dynamically consistent, from an ENSO teleconnection perspective, with the strong relationship between moderate to strong El Niño events (as characterized by the ELI) and anomalously wet cool-season conditions in California (*29*). It also has significant implications from a potential flood hazard perspective, as soil conditions are likely to be more saturated than average during anomalously wet WYs, likely amplifying runoff and further elevating the risk of flooding.

To systematically contextualize the precipitation-related results arising from these two specific downscaled extreme storm scenarios drawn from CESM1-LENS relative to all top-ranked 30-day precipitation events in multiple large ensembles—including the CanESM2, GFDL-CM3, and CSIRO-Mk3.6 ensembles [as described in (*41*)]. We conducted an intercomparison of these events during the historical and future study periods. We found that of the top 4 ranked megastorm events (as quantified by California-wide cumulative 30-day precipitation), all 16 events across the four single-model large ensembles have larger cumulative precipitation in the warmer future scenario versus their counterparts drawn from cooler historical climate snapshot period (fig. S1). We further show that hourly precipitation maxima are also higher in future versus historical megastorm events in all four large ensembles (fig. S2).

We also note that there are substantial differences across the large ensembles regarding the absolute magnitude of the 30-day precipitation associated with the top four ranked storm sequences, with CESM1-LENS exhibiting the largest precipitation accumulations (fig. S1). However, a direct comparison between these absolute precipitation values is not possible in this context because of the widely differing number of ensemble members and potential and biases in the representation of extreme precipitation in specific models. Nevertheless, we emphasize that the overall consistency of the response of both 30-day cumulative and hourly precipitation in the warmer future versus cooler historical megastorms, in relative terms within each respective large ensemble, suggests that many of the key conclusions drawn from the two synthetic case studies drawn from CESM1-LENS and emphasized in this analysis are likely to be generalizable.

Precipitation phase, freezing level height, and snow water equivalent

The heaviest precipitation during both ARkStorm scenarios occurs over mountainous terrain—particularly in the SN—and a substantial fraction of that high elevation accumulation falls in the form of snow. In ARkHist, a substantial fraction of the higher elevation portions of the SN receives more than 1000 mm (Fig. 3A) of snow water equivalent (SWE) over the 30-day event (yielding a domain maximum of 7.7 m of accumulated snowfall). Estimates of peak on-the-ground SWE range from around ~300 mm in the southern Sierra to 470 mm in the central Sierra (fig. S8), with even higher maxima over localized mountain peaks (Fig. 3). This extremely heavy snowfall would likely be highly disruptive to infrastructure and emergency response activities.

In ARkFuture, we find that the event-averaged precipitation phase changes from primarily snow to primarily rain at low to mid-elevations (~1200 to 2000 m) but remains primarily snow at very high elevations (≥2500 m) in the SN (Fig. 3, D and E). This results in a spatial dipole pattern of SWE changes, with large (>50%) SWE decreases at lower elevations but large SWE increases at the highest elevations (≥3000 m) of the SN and southern Cascades (locally >50%, yielding cumulative total SWE as high as 1800 mm and a domain maximum of 10.4 m of accumulated snowfall) (Fig. 3, B and C). Further, there is a stark contrast between the large SWE and snow-to-rain ratio decrease in the northern SN versus a substantial SWE increase and lesser snow-to-rain ratio decrease in the southern SN (Fig. 3F) (likely because of lower elevations in the northern Sierra). We report widespread increases in the mean atmospheric freezing level height during ARkFuture (statewide freezing level of ~2230 m for the 30-day window) versus ARkHist (freezing level of ~1940 m; Fig. 3, G and H)—supporting prior studies finding that warmer temperatures during future extreme storm events will fundamentally alter mountain hydrology and subsequent watershed response [e.g., (*18*) and (*25*)].

Very large increase in cumulative and peak runoff during ARkFuture

We find that both ARkStorm scenarios are likely to generate very high runoff across a wide range of watersheds and topographies. Projected increases in ARkFuture runoff, however, are widespread and extremely high in magnitude. On a statewide basis, peak runoff during ARkFuture is more than double that during ARkHist (Fig. 3, I and J). In certain key watersheds, however, the relative differences are even larger: In all three SN subregions, the peak runoff is 200 to 400% higher in ARkFuture (fig. S9). A ~100% increase in peak runoff is also observed in the South Coast and Cascade subregions, with a 60% increase along the North Coast.

Event total cumulative runoff increases are similarly large, with increases of 100% or more across most of the SN western slope, the southern Cascades, the Santa Lucias, and also in several major urban areas with a high impervious surface fraction (including the Los Angeles, Sacramento, and San Jose metropolitan areas; fig. S9B). Even greater fractional increases are found for extreme runoff periods (defined as hours with surface runoff of >10 mm/hour; fig. S9, C and D), which increase from being almost negligible in ARkHist (generally three or fewer total hours, except in the Los Angeles Basin) to being widespread across nearly all of California's major urban areas and mountain ranges (with many locations experiencing >10 such extreme runoff hours). In addition, we find that runoff efficiency during ARkFuture relative to ARkHist (measured as the ratio of total 30-day runoff to 30-day precipitation) increases by ~50% (from ~0.19 to ~0.29)—suggesting that a considerably higher fraction of precipitation is likely to immediately contribute to potential food risk in the warmer future scenario.

Given the geographic concentration of numerous critical pieces of water and flood management infrastructure on the western slopes of the SN Mountains and in California's Central Valley, we conduct additional analysis focused on the Sacramento and San Joaquin River watersheds that encompass these regions [as defined by their respective U.S. Geological Survey (USGS) Hydrologic Unit Code (HUC) footprints; fig. S10]. We find large and ubiquitous increases in the upper tail of the empirical distribution of both precipitation and surface runoff at both hourly and 24-hour temporal aggregations in ARkFuture relative to ARkHist, although the relative increases are larger for the San Joaquin basin than the Sacramento Basin (Fig. 4). Here, again, we find that the relative increases in the uppermost tail of the surface runoff distributions are much larger than that of the precipitation distributions. At the 24-hour aggregation level, the upper tail of the surface runoff distributions is largely nonoverlapping in both basins (Fig. 4, G and H)—with virtually no overlap at all in the San Joaquin basin during ARkFuture relative to ARkHist. This points to the potential for historically unprecedented surface runoff regimes during future extreme storms in a strong warming scenario—especially in the watersheds draining the western slopes of the central and southern SN, with major implications for operation of critical water infrastructure in these regions.

We attribute these notably high increases in runoff, which greatly exceed fractional increases in precipitation, to the nonlinear hydrologic effects of increasing both total precipitation (via increased AR intensity) and decreasing the snow-to-rain fraction (due to AR warming and the solid-to-liquid phase change of precipitation). This so-called "double whammy effect," whereby both the volume of precipitation falling on watersheds and the fraction of that precipitation that immediately becomes runoff at higher elevations increases substantially, can be responsible for unexpectedly large increases in runoff volume (*18*). We also suggest that there is arguably a "triple whammy" effect at play in the case of ARkFuture: In addition to the previous two factors, there is evidence for multiple intense "rain on snow" events (*26*) in both scenarios (Fig. 3, G and H) that correspond temporally with event-maximum runoff peaks (Fig. 3, I and J). However, we acknowledge that antecedent hydrologic conditions—particularly soil moisture and the extent/moisture content of snowpack leading up to the event—could potentially have large influences on simulated runoff and ultimately on potential flood risks. In this analysis, we only consider the specific antecedent conditions that were actually present in the respective large ensemble members leading up to the simulated events. Although a comprehensive assessment of the various antecedent hydrological contributors to surface runoff is beyond the scope of the present manuscript, more systematic assessments will be conducted in later stages of the ARkStorm 2.0 project.

Megaflood risk increases robustly as function of climate warming

We assess the cumulative and annual likelihood of a 30-day megastorm sequence capable of causing a California megaflood and find that both increase strongly as a function of climate warming. On a high warming emissions trajectory (RCP8.5), we find that the cumulative likelihood of an ARkHist level event begins to accelerate after the year ~2020 period, with corresponding accelerations becoming apparent earlier (~2000) for lesser (50-year RI) and later (~2030) for higher magnitude (200-year RI) events (Fig. 5A).

To accommodate the various Earth system and sociopolitical uncertainties that complicate future predictions of possible greenhouse gas emission trajectories and to facilitate direct comparison

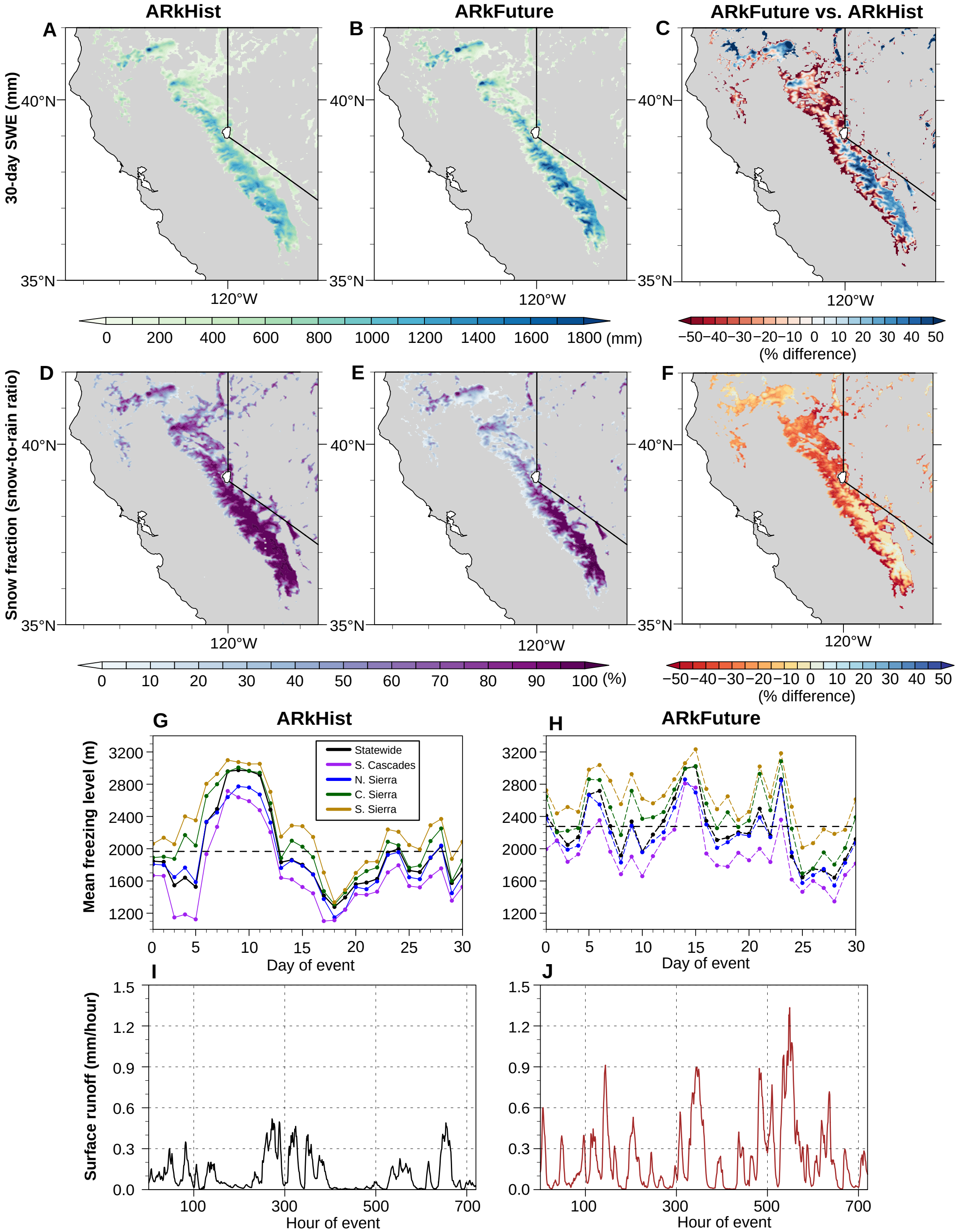

Fig. 3. Snowfall and surface runoff associated with California megastorm scenarios. (**A** and **B**) Cumulative 30-day gross SWE (mm) during ARkHist (A) and ARkFuture (B). (**C**) Difference in cumulative SWE (mm) between ARkFuture and ARkHist. (**D** and **E**) Mean snow fraction (snow-to-rain ratio, in percent) during ARkHist (D) and ARkFuture (E). (**F**) Difference (%) in mean snow fraction between ARkFuture and ARkHist. (**G** and **H**) Mean freezing level (m) during ARkHist (G) and ARkFuture (H). (**I** and **J**) Time series depicting hourly surface runoff (mm/hour) on a cumulative California statewide basis during ARkHist (I) and ARkFuture (J). Data depicted in all panels are from the innermost 3-km WRF domain.

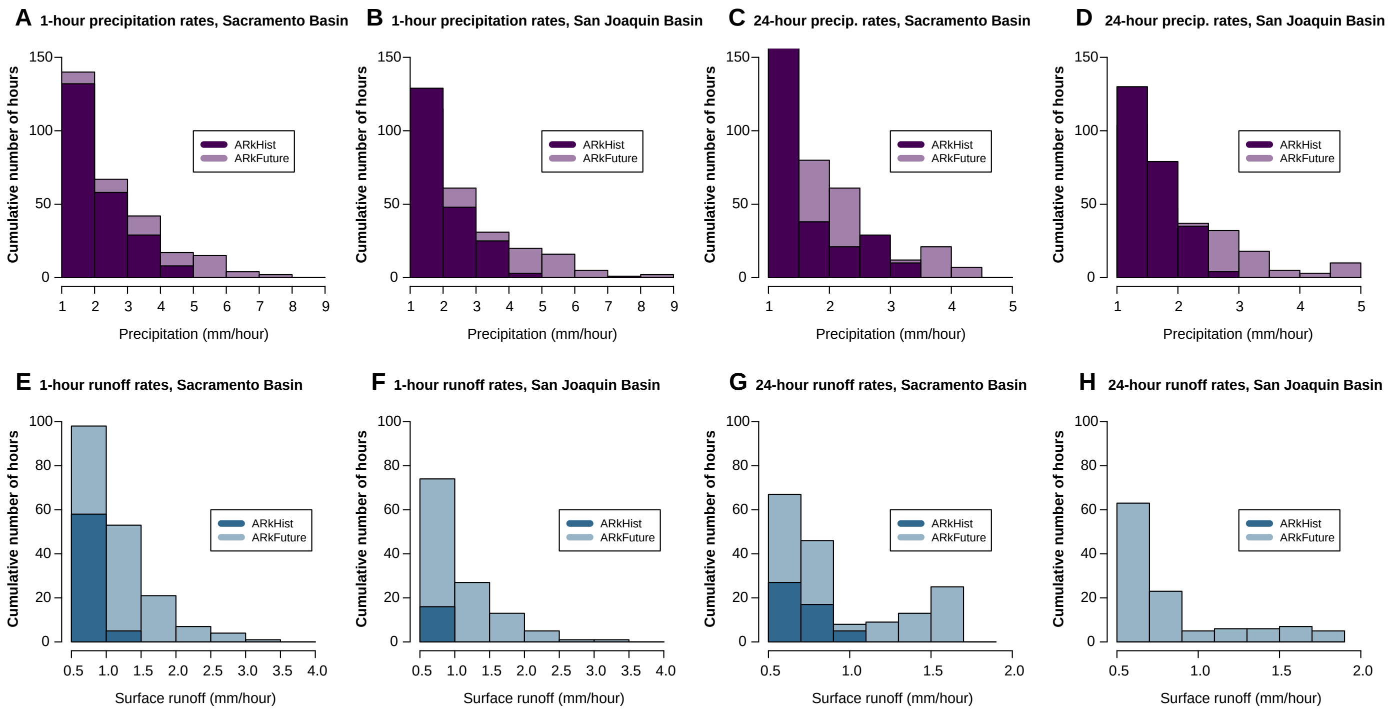

Fig. 4. Upper tail of precipitation and surface runoff distribution for Sacramento and San Joaquin River watersheds. Empirical histograms depicting the cumulative number of hours (over the 30-day scenarios) at or above specific precipitation [purple bars (**A** to **D**)] and surface runoff [blue bars (**E** to **H**)] thresholds (in units of mm/hour) at two levels of temporal aggregation (1 hour and 24 hours) for two key California watersheds as outlined by HUC Subregion 1802 (the Sacramento River watershed) and HUC subregion 1804 (the San Joaquin River watershed). Data are drawn from the WRF 3-km domain for ARkHist (darker bars) and ARkFuture (lighter bars) and are calculated as average values for each entire watershed. Values less than 1 mm/hour for precipitation and 0.5 mm/hour for surface runoff are excluded from this upper tail analysis.

with various proposed targets linked to specific planetary warming levels, we conduct further analysis to estimate changes in megastorm risk as a function of the warming itself. We find that the annual likelihood of an ARkHist level event increases rapidly for each 1°C of global warming [by ~0.012/year per degree C from a baseline of ~0.01/year]; Fig. 5B) and that this approximately linear relationship ($P < 0.001$) appears to hold even at very high levels of warming (~+4°C). We find that climate change to date (as of 2022) has already increased the annual likelihood of an ARkHist event by ~105% relative to 1920 in the CESM1-LENS ensemble and of an even higher magnitude (200-year RI) event by ~234%. This finding is consistent with prior work reporting progressively larger increases in projected extreme precipitation events for increasing event magnitudes [e.g., (*42*)]. We further find that by ~2060, on a high emissions trajectory, the annual likelihood of an ARkHist level event increases by ~374% and by ~683% for a formerly 200-year RI event. These statistics represent notably large increases in risk of California megastorm events due to climate change, as they transform an event that previously would have occurred once every two centuries into one that may occur approximately three times per century.

DISCUSSION

Our analyses suggest that the fundamental characteristics of the plausible worst-case California megafloods of the future will be familiar: Similar to their contemporary and historical counterparts, they will be characterized by a week-long sequences of recurrent, strong to extreme ARs during the cool season and coinciding with a persistently strong Pacific jet stream. Yet, we also find evidence of some critical differences: Future extreme storm sequences will bring more intense moisture transport and more overall precipitation, along with higher freezing levels and decreased snow-to-rain ratios that together yield runoff that is much higher than that during historical events. In addition, we find even larger increases in hourly rainfall rates during individual storm events, which have high potential to increase the severity of geophysical hazards such as flash flooding and debris flows. This is especially true in the vicinity of large or high-intensity wildfire burn areas, which are themselves increasing due to climate change (*39*) and yielding large increases in associated compound hazards (*43*).

An extensive body of existing research has linked climate change to increasingly extreme precipitation events [e.g., (*44–47*)], even in locations where changes in mean precipitation are nonrobust (*48*, *49*). There is further evidence that climate warming increases the intensity of ARs in many regions (*20*), including California (*16*, *19*). The strongest ARs are expected to strengthen considerably at the expense of the weakest—shifting the balance from "primarily beneficial" AR events to "primarily hazardous" ones (*21*)—an intensification brought about primarily via the direct thermodynamic effect of warming (*16*).

Our analysis goes beyond these prior works to demonstrate that climate change is robustly increasing both the frequency and magnitude of extremely severe storm sequences capable of causing megaflood events in California. Our analysis suggests that the present-day (circa 2022) likelihood of historically rare to unprecedented 30-day precipitation accumulations has already increased substantially and that even modest additional increments of global warming will

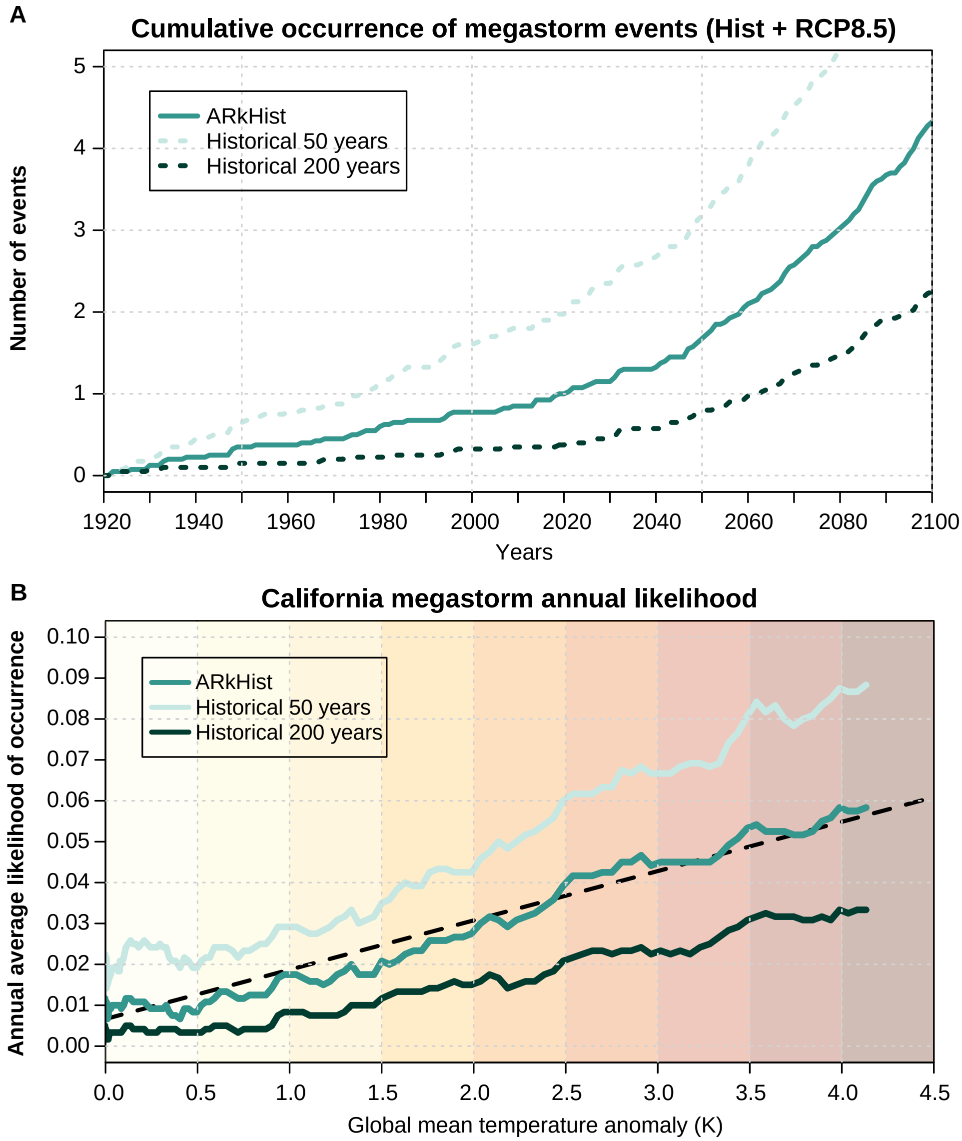

Fig. 5. Climate change and California megastorm risk. (**A**) Cumulative occurrence of extreme 30-day precipitation accumulations on a California statewide basis as simulated by the CESM1-LENS ensemble. The three blue-green curves denote cumulative occurrence of events equal or greater in magnitude to the ARkHist scenario, as well as for events with approximate RIs of 50 and 200 years. Data are drawn from the historical CESM1-LENS simulations for 1920–2005 and from the RCP8.5 scenario for 2006–2100. (**B**) Annual likelihood of extreme 30-day cumulative precipitation events as a function of projected global mean surface temperature (GMST; K) anomaly across the 40-member ensemble. Blue-green curves correspond to definitions in (A). GMST anomaly is defined relative to a baseline calculated from the CESM1-LENS preindustrial control run, and both annual likelihood and GMST are smoothed on a 30-year running mean basis.

bring about even larger increases in likelihood. Critically, this finding means that existing international emissions policies, which are estimated to yield cumulative warming of well over 2°C (*50*), will entail large further increases in the likelihood of a California megaflood event. We further find that all of the most intense 30-day megastorm events in the CESM1-LENS ensemble occur during moderate to strong ENSO warm phase (El Niño) conditions—both in the historical and warmer future scenarios—suggesting that these events may potentially exhibit some degree of predictability at seasonal scale. For these reasons, we emphasize that recognizing and mitigating the societal risks associated with this subtly but substantially escalating natural hazard is a critically important consideration from a climate adaptation perspective.

Recent evidence suggests that increases in western United States flood risk caused by anthropogenic warming may have been counteracted in recent decades by natural variability, but that further warming and shifts in natural variability will eventually "unmask" this accumulated increase in regional flood risk (*51*). Additional work suggests that the response of flood risk to climate change is likely to exhibit threshold behavior, at least in certain climatological and hydrological regimes (*52*), with a precipitation extremeness threshold dictating whether flood risk decreases (for smaller events, due to the antecedent soil aridification effect of warming temperatures) or increases (for the largest events, due to the overwhelming effect of large increases in precipitation intensity). Both of these considerations are especially germane to California—a region where most contemporary public policy and climate adaptation efforts emphasize drought and wildfire risk due to lack of recent experience with widespread severe floods. Collectively, the findings from previous work and this study illustrate the growing urgency of planning for and mitigating the hazards from potentially catastrophic floods in California in a warming climate.

The extreme storm scenario development and subsequent analyses described here represent the first phase of the broader ARkStorm 2.0 exercise, which is eventually expected to encompass a full suite of follow-on hydrologic and inundation modeling, hazard assessments, and tabletop disaster response exercises. We plan to work with local, regional, and federal stakeholders to integrate quantification of physical hazards resulting from an "ARkStorm"-level event in California within disaster resilience and climate adaptation frameworks. Our initial atmospheric modeling results presented here demonstrate that extremely severe winter storm sequences once thought to be exceptionally rare events are likely to become much more common under essentially all plausible future climate trajectories—suggesting that 20th century hazard mapping, emergency response plans, and even physical infrastructure design standards may already be out of date in a warmer 21st century climate. Still, region-wide and high-resolution runoff inundation modeling capable of accounting for the effects of various active and passive flood management infrastructure will be required to fully quantify the extent of flood-related hazards and associated societal impacts resulting from these two ARkStorm 2.0 scenarios, and these simulations are actively being planned for the project's future phases.

Yet, potential solutions to increasing flood risk do exist. Examples of climate-aware strategies that have the potential to mitigate harm during a 21st century California megaflood include floodplain restoration and levee setbacks, which would lessen flood risk in urban areas while offering environmental cobenefits (*53*); forecast-informed reservoir operations, which would afford reservoir operators greater flexibility in the face of uncertainty (*54*); and revised emergency evacuation and contingency plans that accommodate the possibility of inundation and transportation disruption extending far beyond that which has occurred in the past century. Some of these interventions—such as flood-managed aquifer recharge—even have the potential to reduce flood damages while simultaneously improving resilience to future regional droughts (*55*). Ultimately, our hope is that the analysis described here can serve as a geographically portable framework for scenario-based emergency response and regional adaptation endeavors in the climate change era, both within and beyond California.

MATERIALS AND METHODS

Overall ARkStorm 2.0 scenario design

ARkStorm 2.0 is a wide-reaching extreme storm and flood scenario for California that seeks to build upon previous disaster contingency and emergency response planning efforts. This endeavor is intended to build upon previous efforts in the original ARkStorm exercise (ARkStorm 1.0), which was completed in 2010 (*9*) and involved a broad consortium of local, state, and federal agencies. It was found that the hypothetical storm scenario used in ARkStorm 1.0 would have produced widespread, deep inundation of a large fraction of the Sacramento and San Joaquin valley floors, as well as widespread, life-threatening flooding in other highly populated parts of California. Total economic losses (the sum of direct damages and indirect losses due to business and economic disruption) were projected to exceed $750 billion [2010 dollars (*11*)]. This would be equivalent to approximately $1 trillion in 2022 dollars, making it the most expensive geophysical disaster in global history to date. Partly for this reason, this hypothetical event was informally dubbed California's "other Big One:" Such a flood event in modern California would likely exceed the damages from a large magnitude earthquake by a considerable margin.

In ARkStorm 1.0, the scenario design involved the artificial concatenation of two of the most intense individual storm sequences in the observed 20th century climate [from January 1969 to February 1986; (*9*)], with additional manual adjustments to the persistence of individual ARs to amplify cumulative precipitation totals. Historical atmospheric reanalysis data were used to obtain boundary conditions for simulating these concatenated events using the Weather Research and Forecasting Model (v3.0.1) at spatial resolution ranging from 2 to 6 km across California. Precipitation and other variables from this single simulation were then used to estimate flood and other related impacts.

In ARkStorm 2.0, we update and upgrade the methods used in ARkStorm 1.0 in several fundamental ways. First, we use a hypothetical extreme event selection method that is both systematic and internally consistent from an atmospheric dynamical perspective: Rather than artificially concatenating multiple historical events, we leverage the large sample size afforded by large ensemble climate model simulations to draw upon a much wider range of physically plausible event sequences that are available by considering the roughly century-long observational record alone (and we make no manual adjustments to storm sequencing). Second, we use a newer and more sophisticated weather model (WRF V4.3) with generally higher spatial resolution (3 km across all of California and adjacent regions). Last and most critically, we design and implement two separate scenarios—ARkHist and ARkFuture—with the combined aim of comparing a "lesser" present era severe storm sequence to a much more intense but physically plausible future sequence amplified by climate change. The overall approach of embedding a high-resolution weather model within existing climate model large ensemble simulations is similar to that described in (*16*) and has the dual advantage of not only expanding the statistical sample size of physically plausible but observationally rare or unprecedented precipitation events (in CESM1-LENS) but also attaining the high degree of physical realism afforded by simulating extreme ARs in a high-resolution setting (*38*).

Selection of specific extreme storm sequences

Both ARkHist and ARkFuture are intended to capture multiweek sequences of discrete severe storm events that produce extremely high cumulative precipitation over a 30-day period. The use of a 30-day accumulation period is motivated by the desire to conduct a realistic emergency management contingency exercise as part of ARkStorm 2.0 and the prior knowledge that multiple successive storm events often challenge infrastructure and response systems to a greater degree than shorter-duration events. We first calculate the cumulative 30-day precipitation for the state of California from all 40 ensemble members from the CESM1-LENS (*56*) from two decade long "snapshot" intervals during which high-frequency (6 hourly) data are available for dynamical downscaling: 1996–2005 (using the historical scenario, which aims to replicate real-world aerosol and greenhouse gas climate forcings) and 2071–2080 (using the RCP8.5 scenario, which assumes continued rapid growth of greenhouse gas emissions over the 21st century).

Among the available global climate model large ensemble datasets, CESM1-LENS stands out with its comprehensive suite of three-dimensional, high-frequency (6 hourly) atmospheric variables, which provide the forcing conditions required for dynamical downscaling simulations. We note that, while it might otherwise be desirable to sample from a wider time period than the two specific decades included in these snapshots, these are the only two such intervals for which a comprehensive suite of three-dimensional, high-temporal frequency (6 hourly) atmospheric conditions were retained in the original CESM1-LENS experiment, and so, it is not possible to conduct high-resolution WRF simulations during other intervals because of the unavailability of needed initial and boundary conditions. However, as the snapshot periods include data from 40 independent ensemble members initialized decades before the assessment period—each with their own sequences of internal variability—these snapshot periods nonetheless include a wide range of potentially relevant internal ocean-atmospheric oscillations.

We also note that although real-world greenhouse gas forcings are likely to be lower than assumed in the RCP8.5 scenario (*57*), this is the only scenario for which high-frequency data are available as part of the CESM1-LENS dataset (*56*). We further emphasize that although RCP8.5 is considered to be a high warming scenario, we explicitly intend to design a plausible "worst case scenario" storm and flood sequence in this analysis, and therefore, the use of a high-end emissions trajectory is appropriate.

We then rank all such 30-day cumulative precipitation events from each CESM1-LENS snapshot period, drawing from an effective sample size of 400-model years in each instance (10 years × 40 ensemble members). To ensure statistical independence of the dataset and that long-lasting events are not double counted, we require at least a 30-day separation between storm sequences. From among the top 3 ranked events in each period, we manually select a single 30-day storm sequence that exhibits large precipitation intensity peaks in both northern and southern California, as well as a pattern of 30-day cumulative precipitation that is spatially well distributed throughout both northern and southern portions of the state. This subjective aspect of the extreme event scenario selection process is critically important from the broader perspective of ARkStorm 2.0, which is designed to be a statewide exercise in which flood and emergency management capacity is severely tested. Therefore, we manually selected the respective ARkHist and ARkFuture events from among the top three ranked events such that each would bring a high level of impacts to the entire state rather than just a portion of the region. In so doing, we ultimately select the second ranked event for ARkHist (calendar date range: 2 September 2002 to 3 December 2002 in ensemble member #20) and the third ranked event for ARkFuture (calendar date range: 11 January 2072 to 11 February 2072 in ensemble member #2). Further analysis suggests that the selected ARkHist event has an approximate RI of ~85 years in the 1971–2020 era climate, and the ARkFuture event has an approximate RI of ~333 years in a 2051–2100 era high warming climate and is empirically unprecedented (i.e., a >400-year RI) in the 1971–2020 era climate (fig. S11).

LENS-WRF event-targeted downscaling approach

For each selected 30-day storm sequence, we use a high-resolution (3 km), nonhydrostatic regional weather model (WRF V4.3) embedded within initial and boundary conditions from CESM1 large ensemble (a framework known as "LENS-WRF") to perform dynamical downscaling as originally developed by (*16*). We use a full suite of three-dimensional atmospheric initial and boundary conditions from the high-frequency (6 hourly) temporal data available from the CESM1-LENS output files and conduct ~50-day long WRF simulations for each 30-day scenario event (allowing for ~1 week of model spin-up and ~1 week of event follow-up). Land surface initial and boundary conditions (including three-dimensional soil temperature, soil moisture, and snow depth) are drawn from the corresponding model member at monthly frequency (as this is the highest temporal resolution retained for three-dimensional land surface conditions in CESM1-LENS) such that they are spatiotemporally congruent with the atmospheric conditions.

In this analysis, we use a nonhydrostatic configuration of WRF-ARW (V4.3) including four nested domains with progressively finer spatial resolutions of 81, 27, 9, and 3 km (see fig. S12 for the detailed domain configuration). The outer three domains cover a large portion of the northeastern Pacific Ocean and the innermost 3-km domain also covers a broad oceanic region—as well as all of California and Nevada—to better represent near-coastal processes and sea-air interactions. WRF is configured using 44 vertical levels (with model top pressure at 50 hPa and vertical velocity damping turned on) and forced with time-varying SST (from CESM1-LENS). A higher density of vertical levels is prescribed near the surface to improve the representation of lower-level processes.

WRF physics parameterizations applied in these simulations include the Thompson graupel scheme (*58*), the Kain-Fritsch (new Eta) cumulus scheme (*59*) (for 81-, 27-, and 9-km domains only; cumulus parameterizations are turned off for the innermost 3-km domain), the Dudhia shortwave radiation scheme (*60*); the "rrtm" longwave radiation scheme (*61*), the Yonsei University (YSU) boundary layer scheme (*62*), the revised MM5 Monin-Obukhov surface layer scheme (*63*), and the Noah-multiple parameterization (MP) land surface model (*64*). The Noah-MP model includes a multilayer snowpack capable of liquid water storage and melt/refreeze cycles, direct representation of heat exchange due to phase changes, and a snow interception component allowing for canopy interception (*64*).

Model validation and fitness for purpose

The overall performance of both CESM (as implemented in CESM1-LENS) and WRF have been previously assessed and validated in the context of both mean and extreme cool season precipitation in California. Swain *et al.* (*14*) found that the simulated distribution of CESM1-LENS cool-season precipitation was statistically indistinguishable from observations during the recent historical period in both northern and southern California. In addition, Huang *et al.* (*38*) found that high-resolution (3 km), nonhydrostatic WRF simulations nested within boundary and initial conditions from atmospheric reanalysis (i.e., pseudo-observations) were capable of simulating real-world extreme AR events (including extreme IVT) and associated extreme precipitation—including spatial patterns of orographic enhancement. However, we acknowledge that this validation does not obviate the potential for parametric and/or structural uncertainties that could lead to model biases that are difficult to quantify (as it is not possible to directly validate large ensemble climate model representation of specific extreme events). Nonetheless, the LENS-WRF configuration used in the present analysis is capable of generating physically realistic extreme storm events and is an appropriate tool for use in the context of "plausible worst case" scenario development.

Contextualization of CESM1-LENS relative to other large ensembles

We conduct additional analysis using daily precipitation data from several other large single-model ensembles [the 50-member CanESM2 (Canadian Earth System Model, Second Generation) at ~2.8° × 2.8° horizontal resolution, 20-member GFDL-CM3 (Geophysical Fluid Dynamics Laboratory Coupled Model, Version 3) at 2.0° × 2.5° horizontal resolution, and 30-member CSIRO-Mk3.6 (Commonwealth Scientific and Industrial Research Organisation Model, Version 3) at ~1.875° × 1.875° horizontal resolution] to aid in contextualization of the study's primary focus on results driven by CESM1-LENS (40 members at 1° × 1° horizontal resolution). We note that CESM1-LENS has the highest horizontal resolution, by a wide margin, as well as the second largest number of ensemble members of these four large ensembles. To conduct as systematic an intercomparison as possible, we extract precipitation data for each of the top 4 ranked events in each ensemble and during each ARkHist and ARkFuture snapshot period. The results of this analysis are discussed in Results and can be visualized in figs. S1 and S2.

HUC region precipitation and runoff analysis

We select two "four-digit/subregional" HUC regions, as defined by the USGS, for more detailed analysis of regional precipitation and surface runoff during ARkHist and ARkFuture scenarios: HUC 1802 (Sacramento subregion, which includes the Sacramento River basin and Goose Lake watershed) and HUC 1804 (San Joaquin subregion, which includes the San Joaquin River basin; see fig. S10 for geographic outlines). We select these HUC regions, particularly, because they encompass most or all of the major SN western slope water storage and flood control reservoirs, as well as broad swaths of land in California's Central Valley that are highly susceptible to large-scale flooding and are home to numerous flood control structures. We extract precipitation and runoff data from the WRF 3-km domain at 1 hour frequencies from geographic regions delineated by the respective HUC subregion shapefiles made available via the USGS (at https://apps.nationalmap.gov/downloader). We then plot empirical histograms of the upper tail of the precipitation (all values above 1 mm/hour) and runoff (all values above 0.5 mm/hour) distributions for each selected HUC region temporally aggregated at two different durations (1 and 24 hours) in both historical and future scenarios (Fig. 4).

Public availability of ARkStorm 2.0 atmospheric simulation data

Boundary and initial condition input files (derived from CESM1-LENS) and output files from the WRF simulations are archived on the DesignSafe web platform (*65*) via DOI: 10.17603/ds2-mzgn-cy51 (*66*).

SUPPLEMENTARY MATERIALS

Supplementary material for this article is available at https://science.org/doi/10.1126/sciadv.abq0995

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Science Advances

Climate change is increasing the risk of a California megaflood

Xingying HuangDaniel L. Swain

Sci. Adv., 8 (31), eabq0995. • DOI: 10.1126/sciadv.abq0995

Consultant Report

Groundwater Dependent Ecosystem Monitoring Plan

Mark Hausner and Susie Rybarski

Desert Research Institute

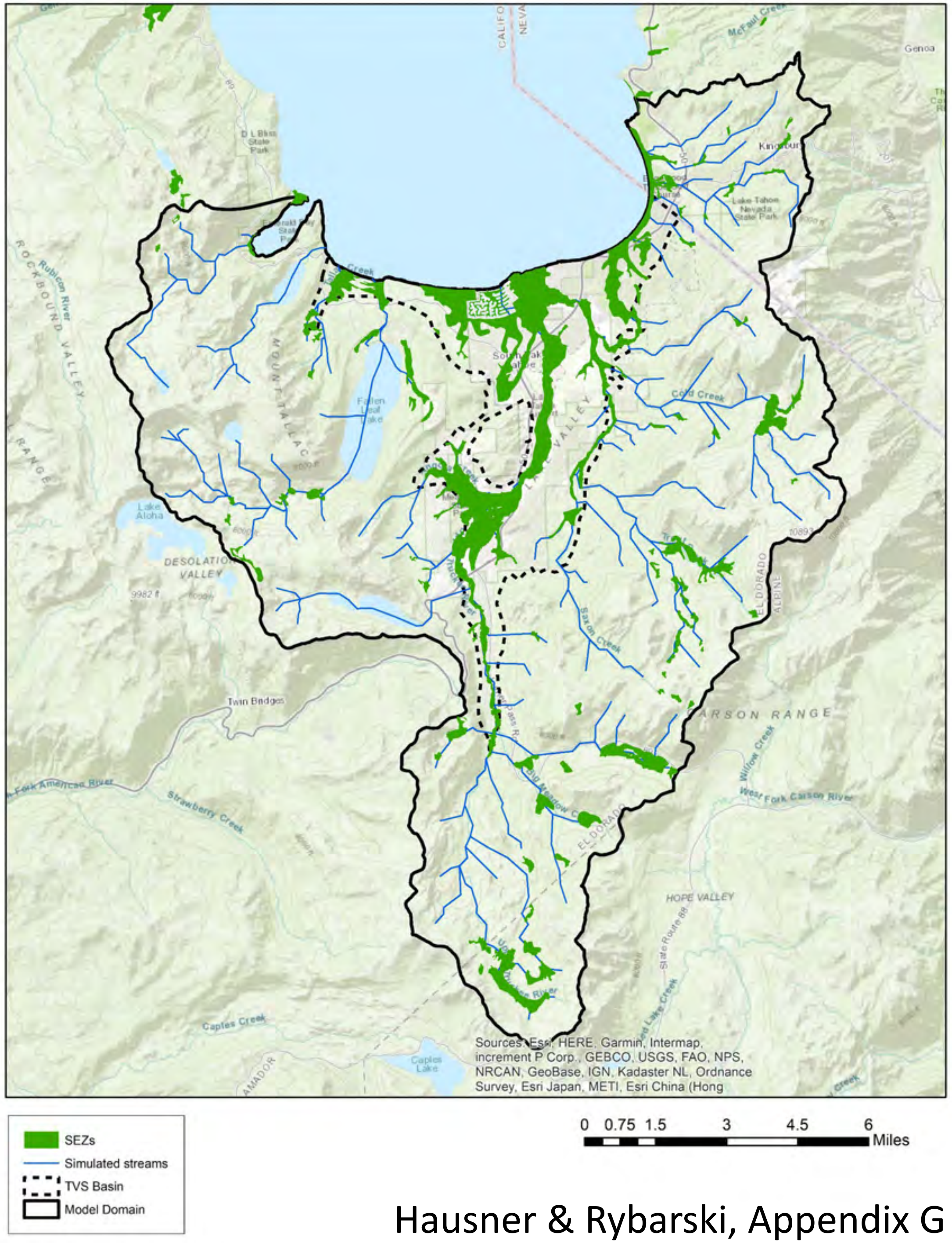
Plan Documents

- Alternative Plan for Tahoe Valley South Subbasin (6-005.01): First Five-Year Update, Volume I (Rybarski et al., 2022a). https://stpud.us/asset/9813
- Alternative Plan for Tahoe Valley South Subbasin (6-005.01): First Five-Year Update, Volume II: Appendices (Rybarski et al., 2022b). https://stpud.us/asset/9814
  - Appendix G: Assessment of Groundwater Dependent Ecosystems within the Tahoe Valley South Subbasin

8.3.2 Groundwater Dependent Ecosystems

- Sustainability Goal: To maintain a shallow water table that supports riparian vegetation in areas where riparian vegetation currently exists.
- Undesirable Result: Replacement of riparian vegetation by upland vegetation and loss of associated ecosystem services.
- Sustainability Indicator: Water table elevation.
- Minimum Threshold: Having average groundwater elevations within the interquartile range of historical variability.

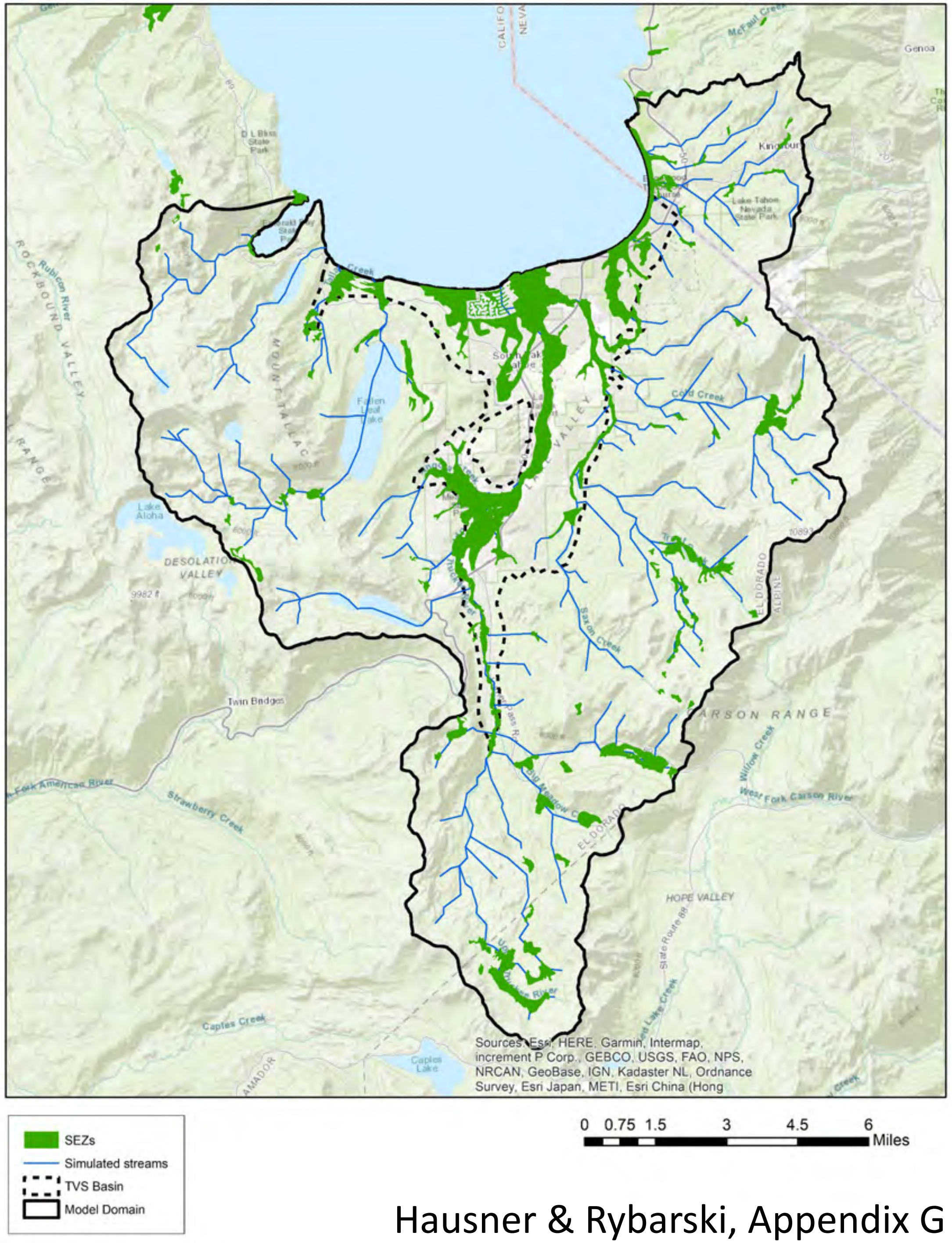
Rybarski et al., 2022a



Hausner & Rybarski, Appendix G

Groundwater Dependent Ecosystems

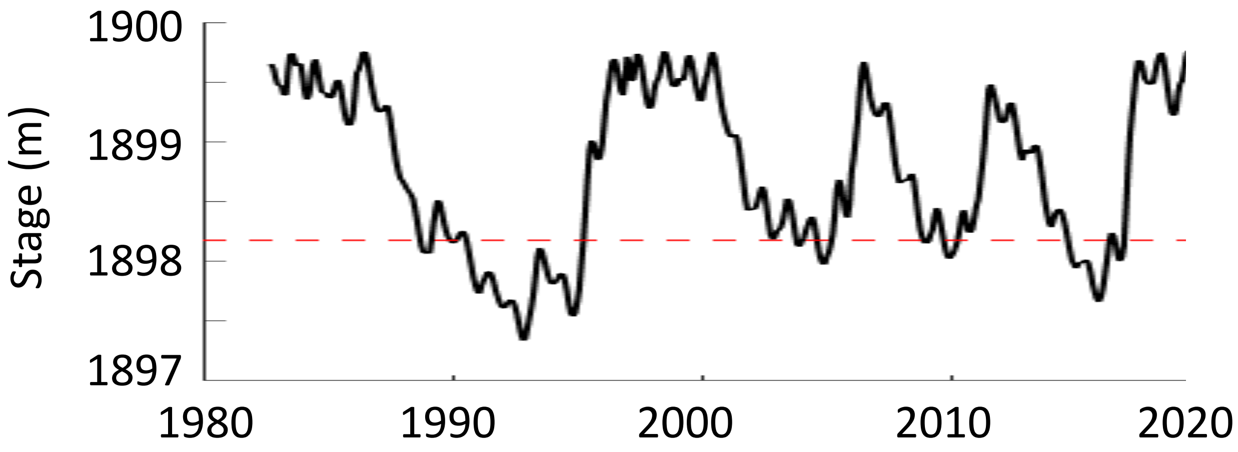
GDEs identified and mapped based on TRPA designated Stream Environment Zones (SEZs)

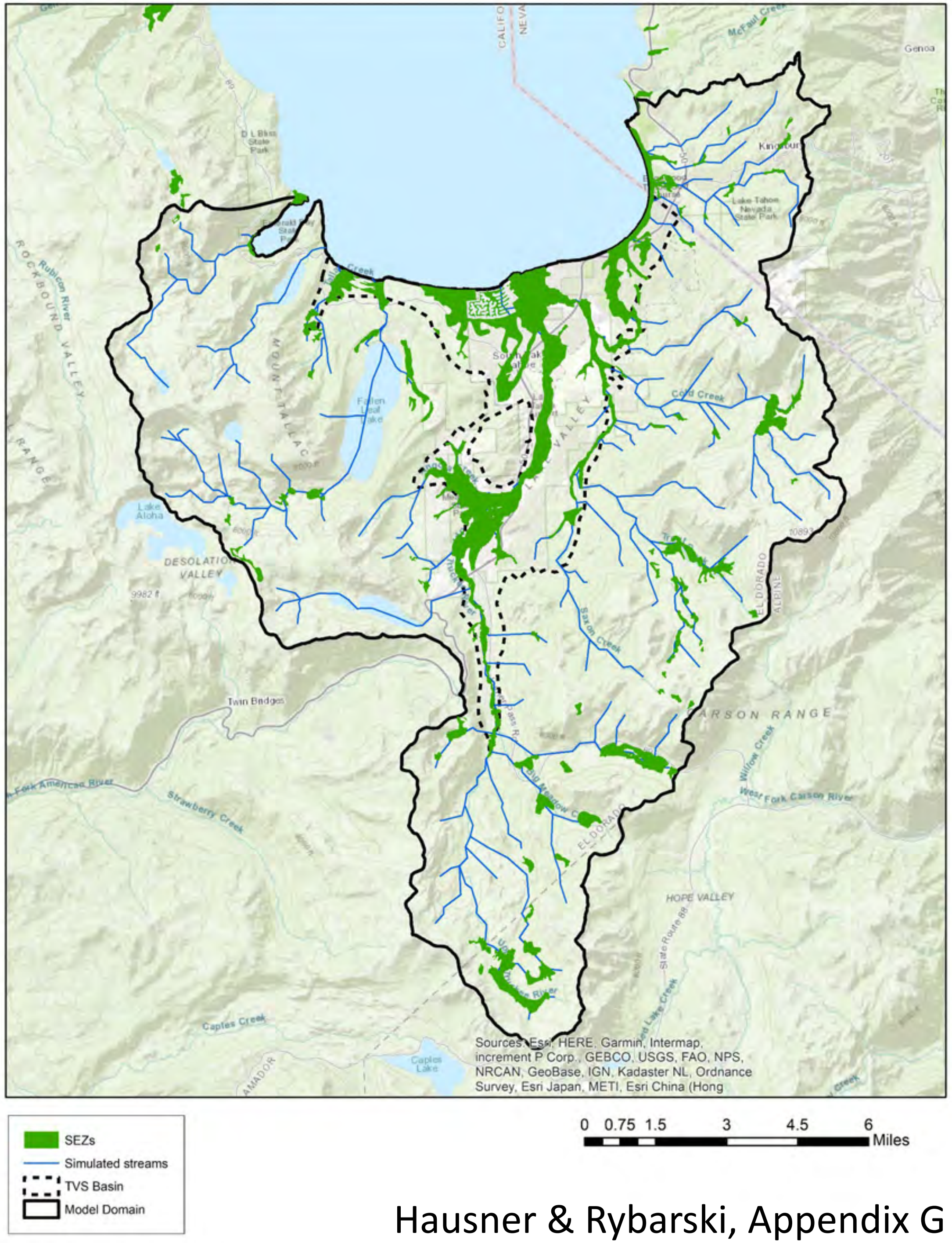


Hausner & Rybarski, Appendix G

Groundwater Dependent Ecosystems

Simulated groundwater levels from historical model were examined for declining water levels and none were found (30-year and 10-year trend tests)





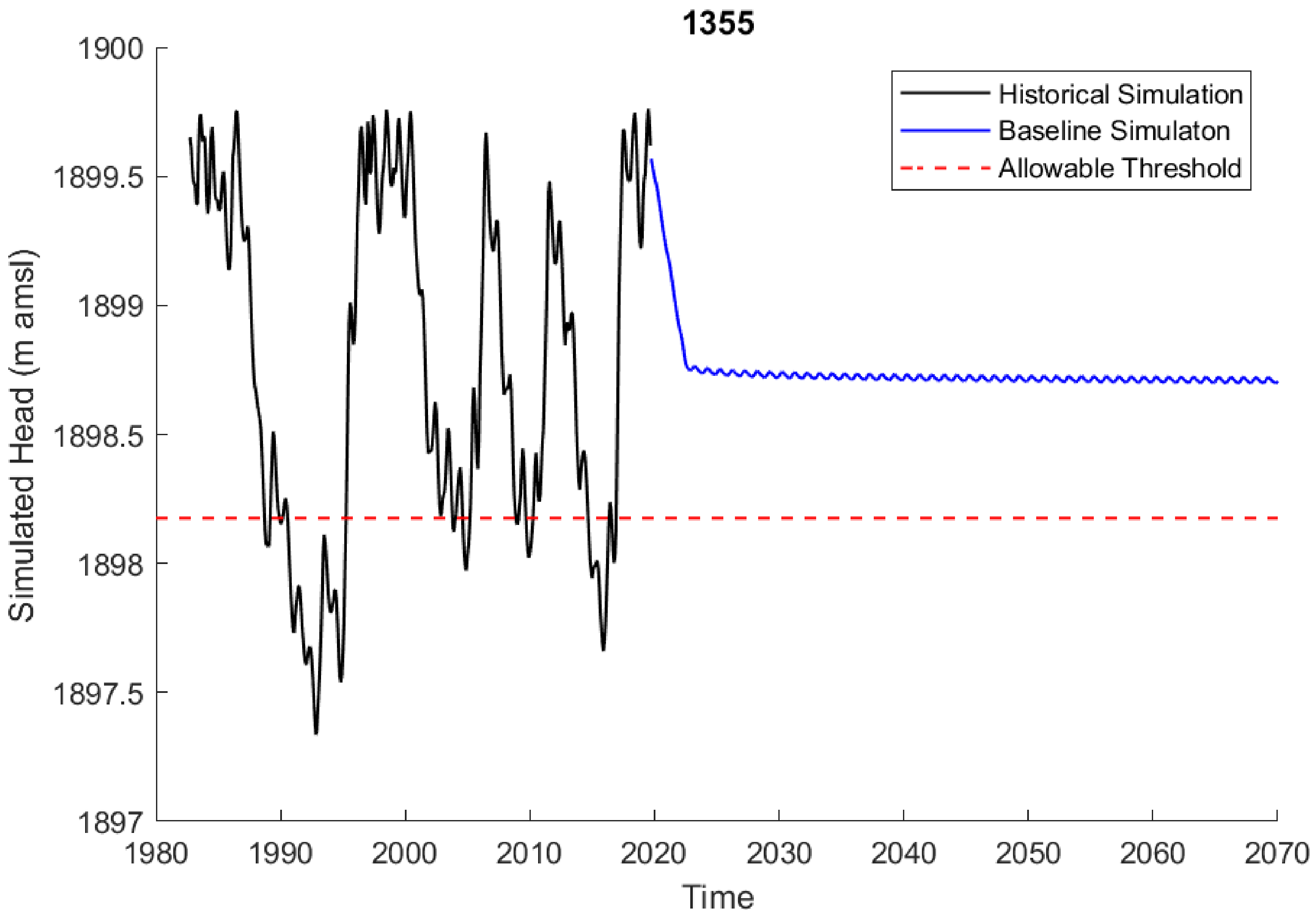
Hausner & Rybarski, Appendix G

Groundwater Dependent Ecosystems

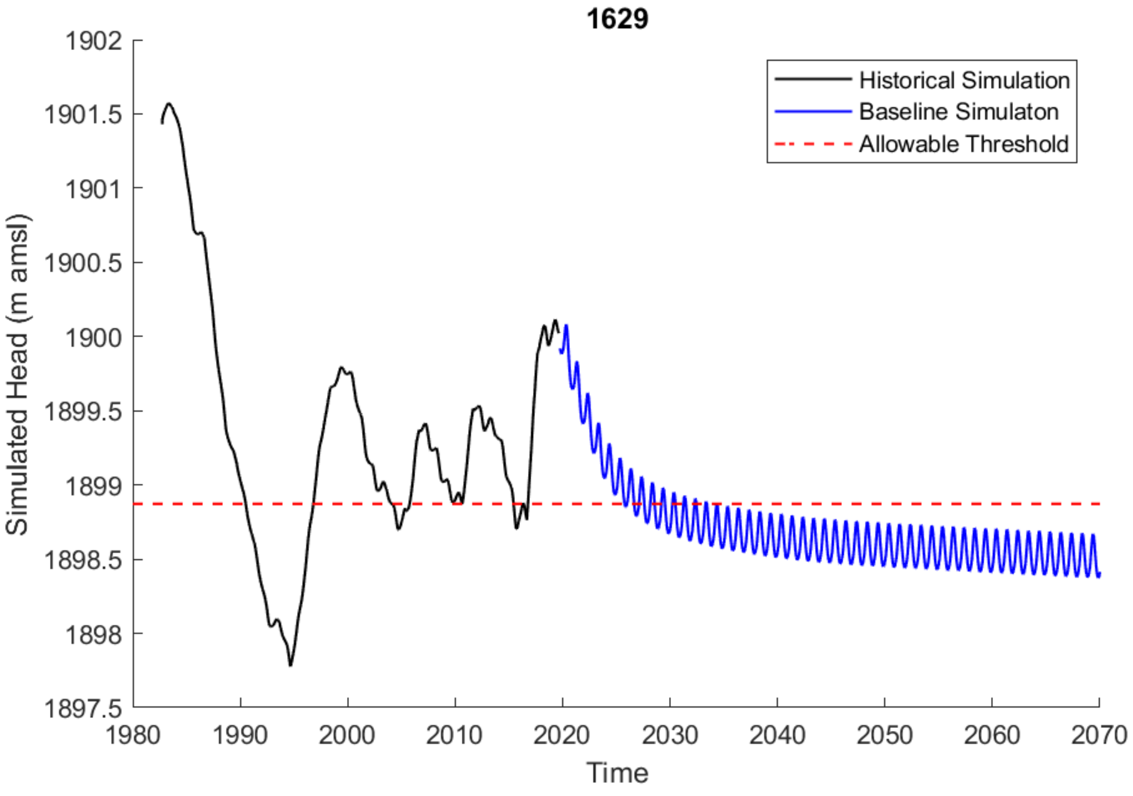
Baseline model simulation was used to identify GDEs that may be vulnerable in the future:

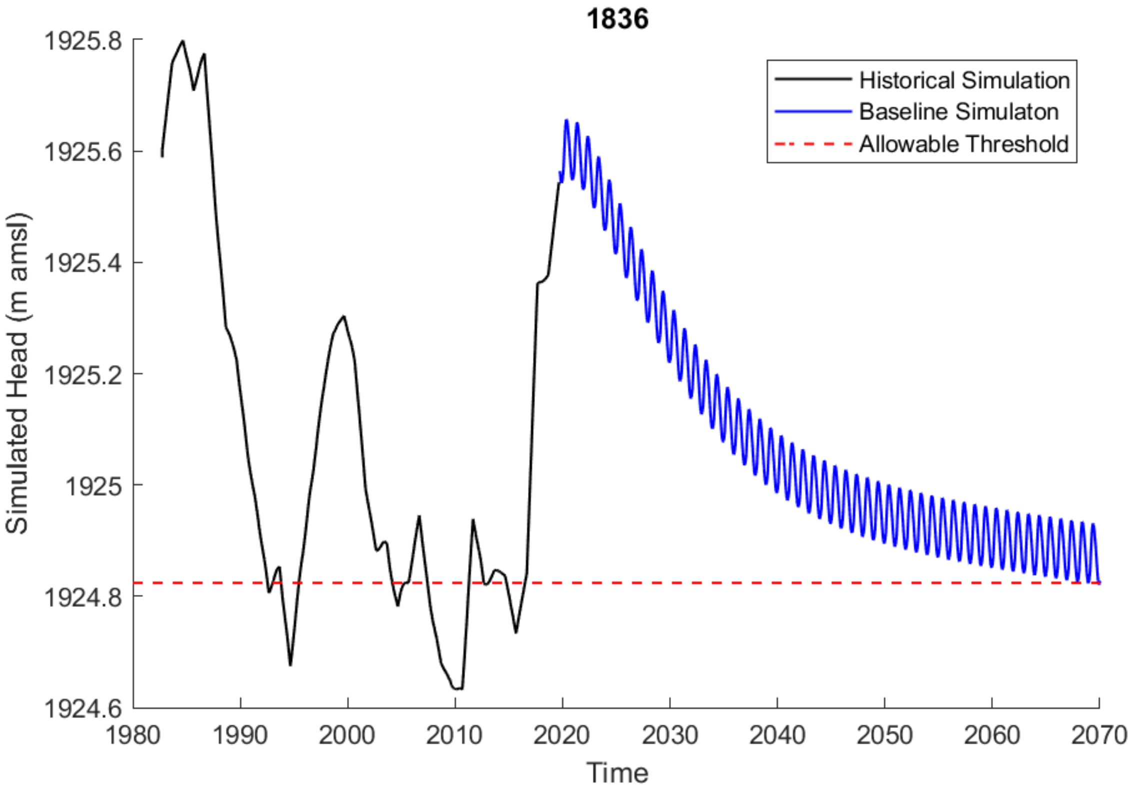
- Vulnerable vs. not vulnerable?
- Timeframe to threshold exceedance?

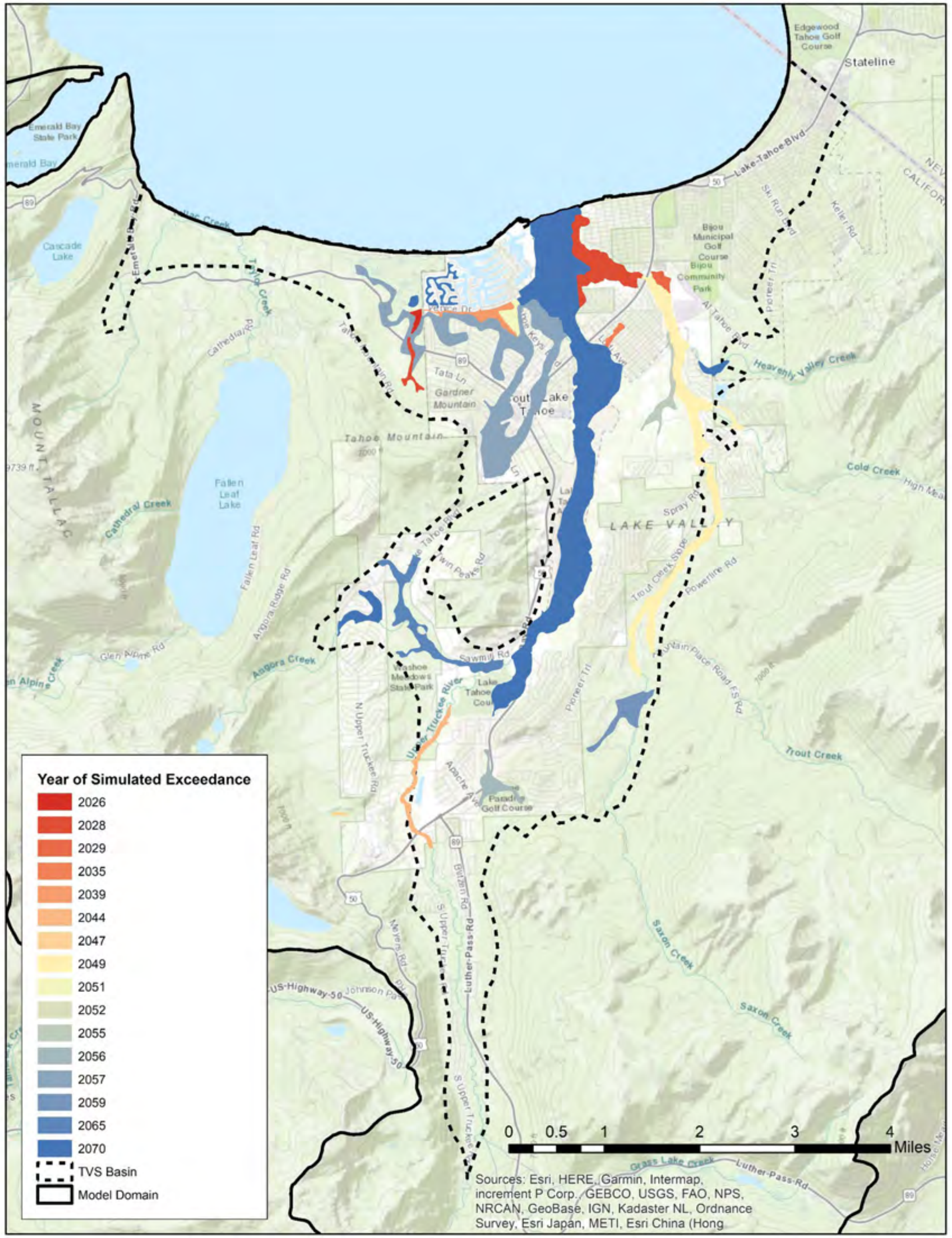
GDE classified as “Not Vulnerable



Vulnerable: Timeframe to Exceedance

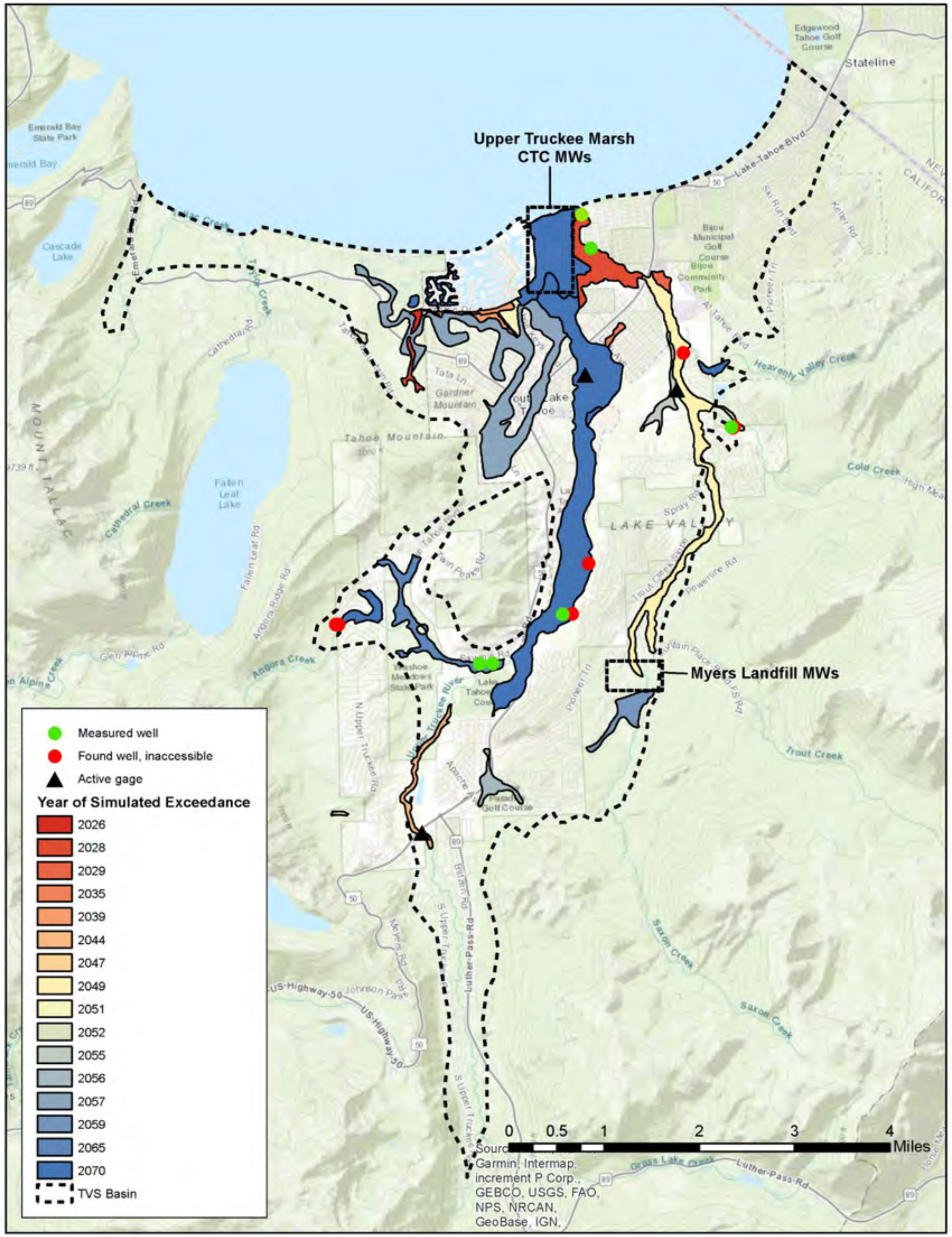






Groundwater Dependent Ecosystems

Prioritized based on simulated date of threshold exceedance, but SGMA monitoring needs to be based on ***measured*** water levels

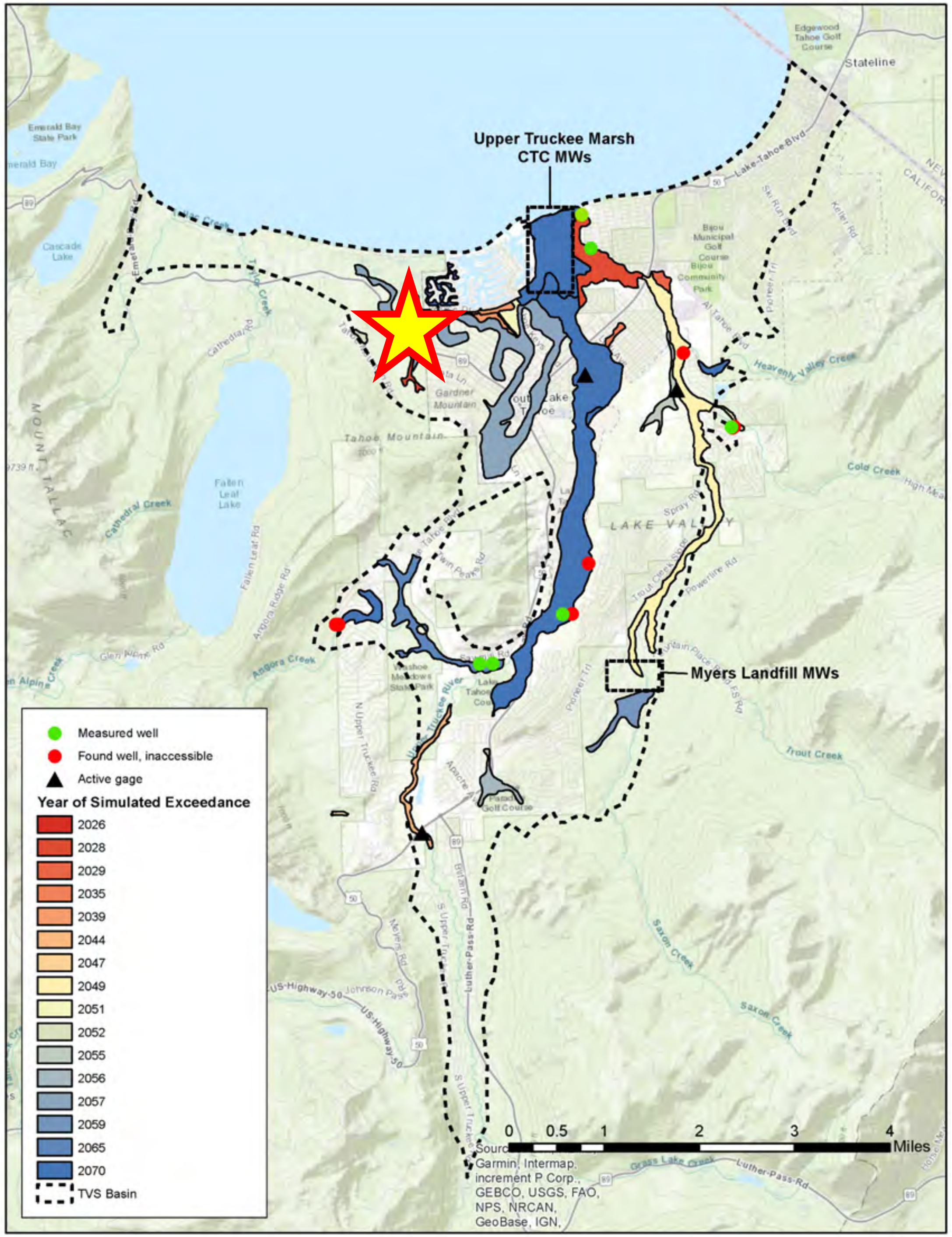


Visited existing monitoring locations in July

Some wells found and accessible to measurements (green dots)

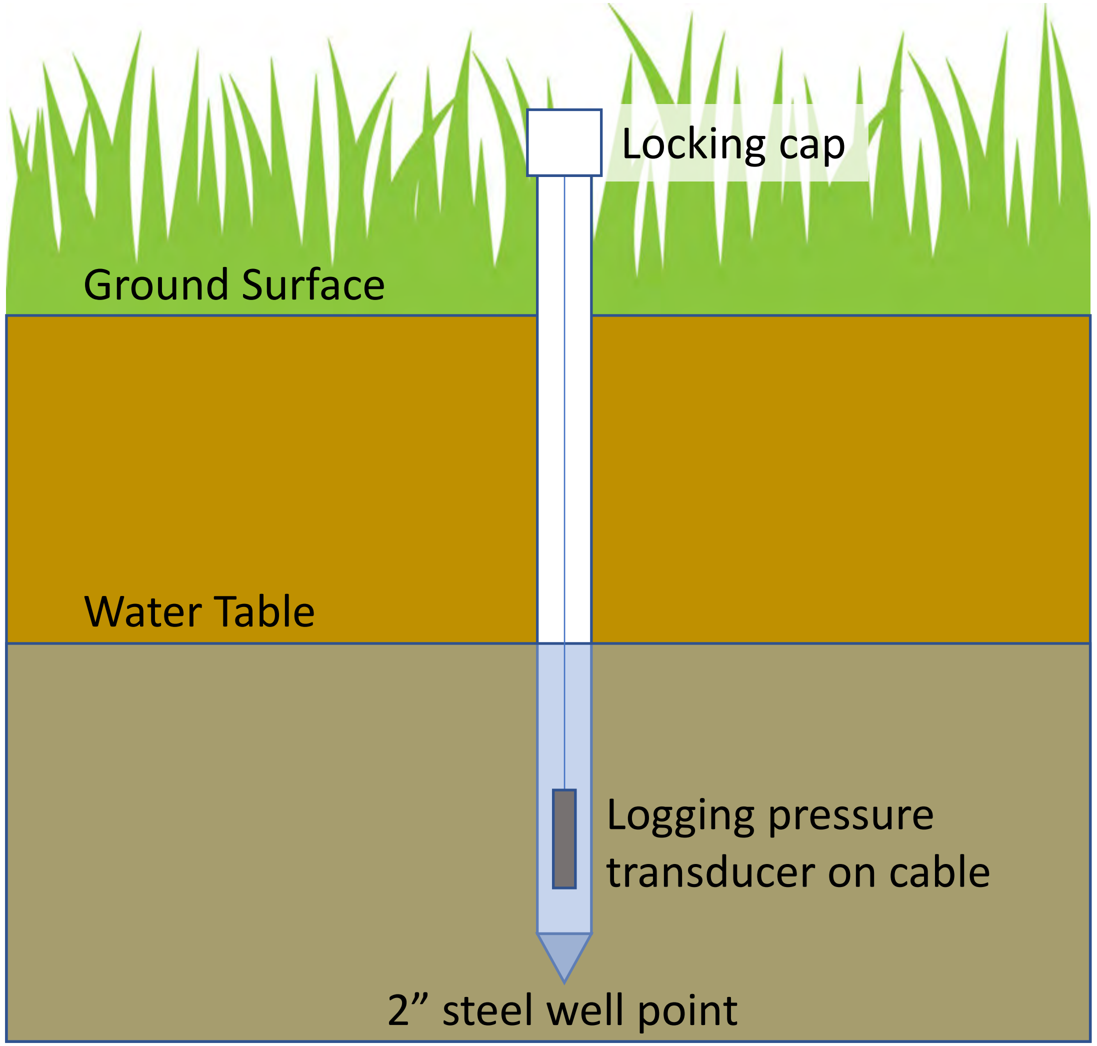
Some wells found but inaccessible (red dots)

Some wells operated by others (e.g. Myers landfill wells)



Proposing new monitoring wells near Pope Marsh

Monitoring Well Construction



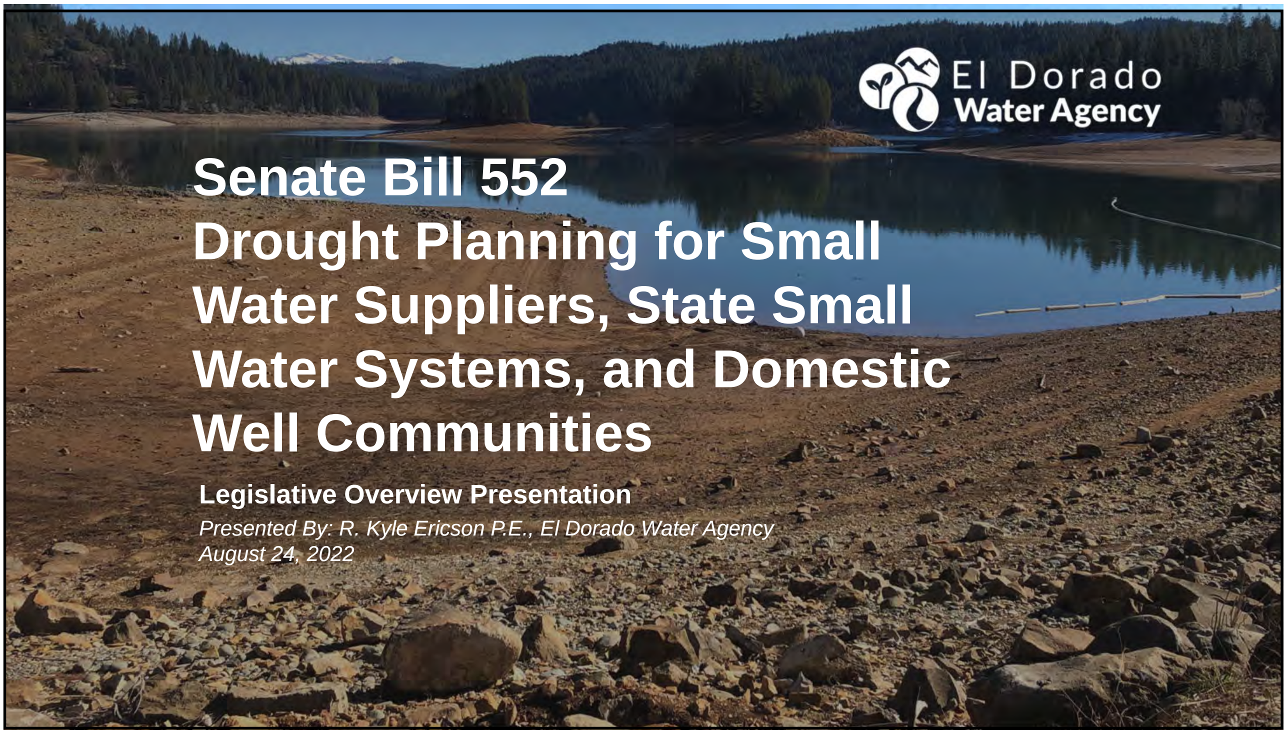
Proposed GDE Monitoring Program

- Instrumentation of existing wells and/or installation of new wells
- 5 years of monitoring
- Quarterly data collection and QA check
- Annual QC and threshold analysis
- Integrate with existing SEZ monitoring programs

Next Steps

- Invite stakeholders with appropriately sited monitoring wells to participate in the GDE monitoring program
- Identify sites and secure permission to install monitoring wells near priority GDEs
- Secure funding for Proposed GDE Monitoring Program

2022 Drought



Senate Bill 552 Drought Planning for Small Water Suppliers, State Small Water Systems, and Domestic Well Communities

El Dorado Water Agency

Legislative Overview Presentation

Presented By: R. Kyle Ericson P.E., El Dorado Water Agency
August 24, 2022

1

Background

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What is the Role of EDWA

- Created by State Legislation -1959 El Dorado County Water Agency Act
- Principally focused water supply from 1959 – 2018
- 2018 - Refocused as a Countywide Water Resource Planning Agency with the authorities defined in the 1959 El Dorado County Water Agency Act
- New focus is on all aspects of watershed health, long-term water supply planning, climate change adaptation, drought planning, stormwater resources planning, assistance to water purveyors, State and Federal legislative advocacy, etc.
- 2019 Water Resources Development and Management Plan
  - Identifies water resource issues through the county
  - Development of Resource Management Strategies(RMS)
  - Establishes programs too address water resource issues and implement RMS

3

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Preceding Legislation and Drought Planning

- **Assembly Bill 1668** and **Senate Bill (SB) 606** (passed in June 2018) outlined directives related to urban and agricultural water use efficiency and countywide drought resiliency
- The DWR **County Drought Advisory Group** (formed in November 2018)
  - Included El Dorado Water Agency (EDWA) and other members
  - Identified small water suppliers and rural communities at risk of drought and water shortage
  - Developed recommendations and guidance to address the needs of these communities
  - Informed SB 552

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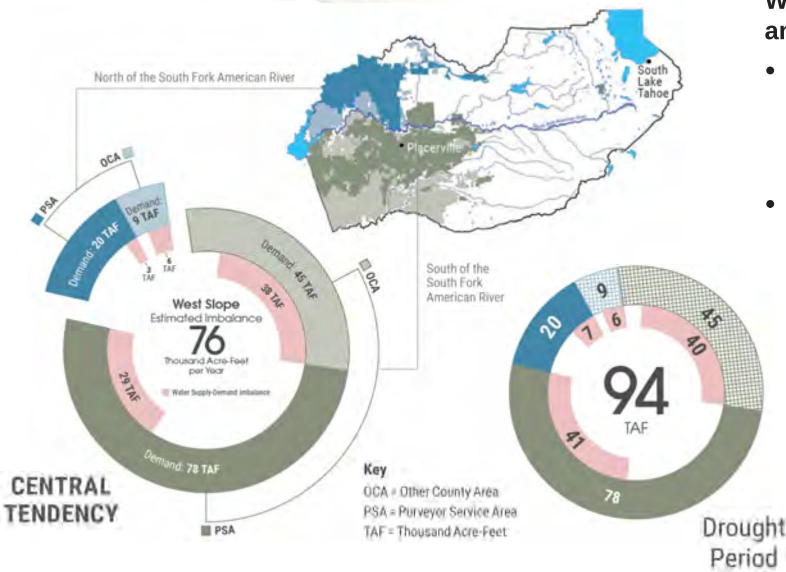
EDWA's Drought Planning Efforts



Water Resources Development and Management Plan (WRDMP)

- Forecasts a water supply-demand imbalance in the future, which will be exacerbated during drought periods
- Resource Management Strategies (RMS) identified water supply-related challenges.
  - *RMS 7*: Improve Drought and Water Shortage Preparedness
  - *RMS 8*: Ensure All Residents Have Water Accessibility and Affordable Water

5

5

EDWA's Drought Planning Efforts

Upper American River Basin Regional Drought Contingency Plan (UARB RDCP)

Developed to increase resiliency of water resources in the face of climate change and droughts.

- Unreliable water supply from low-yield fractured rock aquifers
- Limited ability for small water systems to share supplies
- Small water systems are particularly vulnerable due to lack of data and drought planning

- Consolidate and connect small water systems
- Complete drought planning for small water systems
- And more

6

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Senate Bill 552 Requirements

7

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Definitions

Community water system = public water system that serves at least 15 service connections used by yearlong residents or regularly serves at least 25 yearlong residents of the area

Small water suppliers = community water system serving 15-2,999 service connections and less than 3,000 AF annually

State small water systems = water system serving 5-14 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

Nontransient noncommunity water system = public water system that is not a community water system and that regularly serves at least 25 of the same persons over 6 months per year

Domestic well = groundwater well used to supply water or the domestic needs of an individual residence or a water system that is not a public water system and that has no more than 4 service connections

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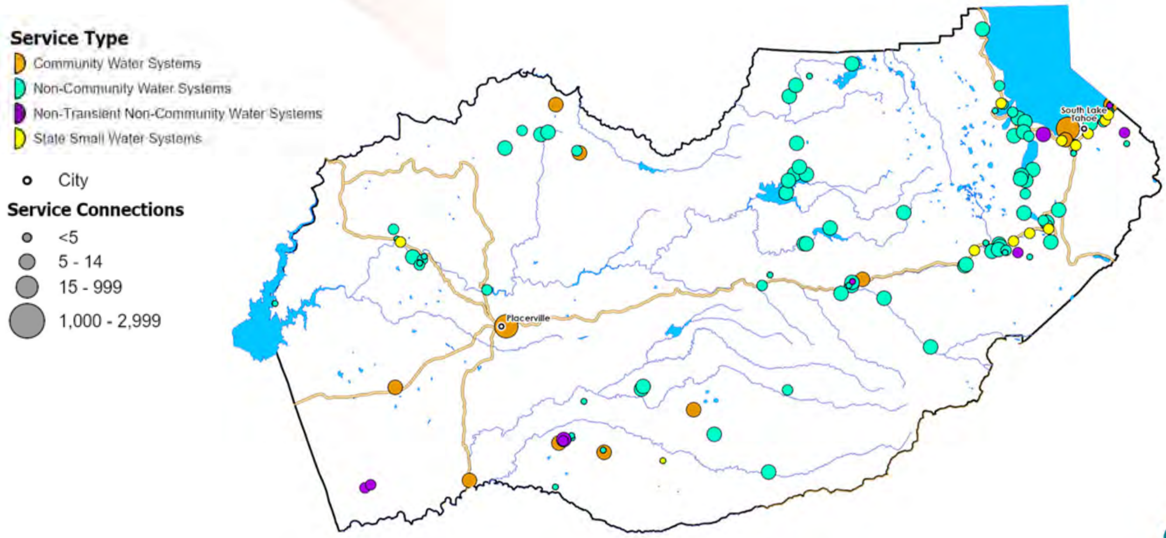
Small Water Systems in El Dorado County



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Small Water Systems in El Dorado County

Connections	Community Water Systems	Noncommunity Water Systems	Nontransient Noncommunity Water Systems	State Small Water System	Total
1,000-2,999 Service Connections	2	0	0	N/A	**2**
15-999 Service Connections	13	46	2	N/A	**61**
5-14 Service Connections	N/A	19	5 (5)	20	**44**
<5 Service Connections	N/A	32	2	N/A	**34**
Total	**15**	**97**	**9**	**20**	**141**

N/A = not applicable per definition

10

10

Requirements of SB 552

- Activities required by specific small water systems
- County Drought Task Force Requirements

11

11

1. Community water systems serving 1,000-2,999 service connections and nontransient noncommunity water systems that are schools

- Develop and maintain an abridged Water Shortage Contingency Plan (WSCP) with specific drought planning elements by July 1, 2023
  - Make WSCP available on their website or if no website is available, to persons upon request
  - DWR and State Water Board to provide template by December 31, 2022
- Report annually specified water supply condition information to the State Water Board
- Implement **certain resiliency measures** as early as January 2023

12

12

1. Community water systems serving 1,000-2,999 service connections and nontransient noncommunity water systems that are schools – *Required Resiliency Measures*

- By January 1, 2023, **implement monitoring systems** sufficient to detect production well groundwater levels.
- By January 1, 2023, **maintain membership** in the California Water/Wastewater Agency Response Network (CalWARN) or similar mutual aid organization.
- By January 1, 2024, to ensure continuous operations during power failures, **provide adequate backup electrical supply**.
- By January 1, 2027, **have at least one backup source of water supply, or a water system intertie**, that meets current water quality requirements and is sufficient to meet average daily demand.
- By January 1, 2032, **meter each service connection and monitor** for water loss due to leakages.
- By January 1, 2032, have source system capacity, treatment system capacity if necessary, and distribution system capacity to **meet fire flow requirements**.

13

13

2. Community water systems serving 15-999 service connections

- Add drought planning elements to their Emergency Notification or Response Plans
- Plan should be updated every 5 years or after significant changes
- Report annually specified water supply condition information to the State Water Board

14

14

3. State Small Water Systems and domestic wells within County's jurisdiction

- County to **develop a plan** that includes potential drought and water shortage risk and proposed interim and long-term solutions
  - May be a stand-alone document or included to an existing county plan
- County to establish a **standing county drought and water shortage task force** to facilitate drought and water shortage preparedness

15

15

County Drought Plan Elements

- Plan elements must include:
  - Potential drought and water shortage risk
  - Proposed interim and long-term solutions for state small water systems and domestic wells
- Consider at a minimum:
  - **Consolidations** for existing water systems and domestic wells
  - Domestic well drinking water **mitigation programs**
  - Provision of **emergency and interim drinking water solutions**
  - An analysis of the **steps necessary to implement** the plan
  - An analysis of **funding sources** available to implement the plan

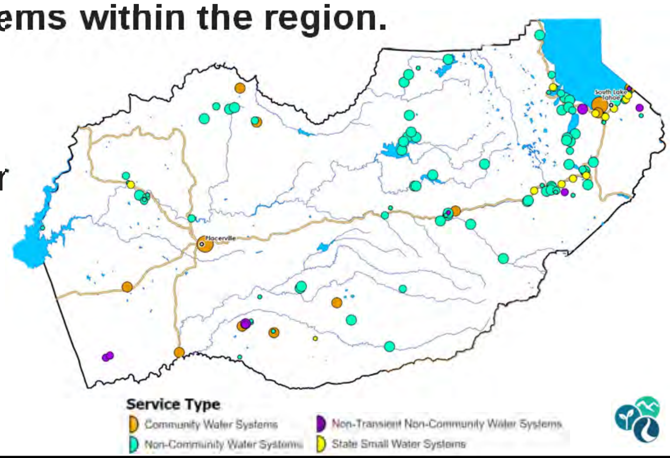
16

16

El Dorado County Drought Plan

To address the concerns discussed in the WRDMP and UARB RDCP, **El Dorado County's Drought Plan will address all small water systems within the region.**

This goes beyond what is required by SB 552, which only requires addressing water shortage preparedness for state small water systems and domestic wells.



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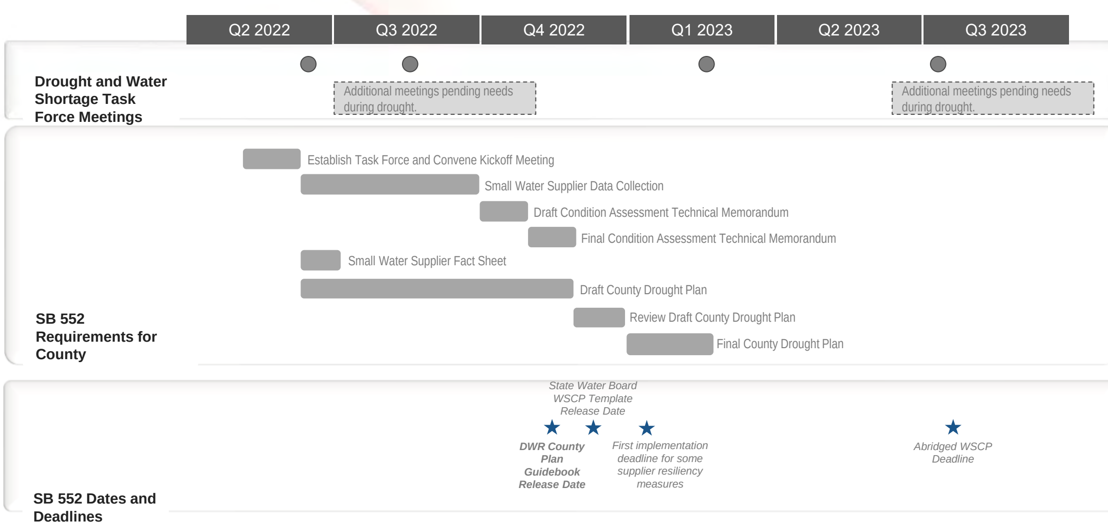
SB 552 Implementation Schedule



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18

Task Force Roles and Responsibilities

19

19

Drought and Water Shortage Task Force Roles

- Pursuant to Health and Safety Code Part 12, Chapter 4, § 116330, the **Local Primary Agency (i.e., County of El Dorado, Environmental Management Department) is responsible for public water systems.**
- Pursuant to California Code of Regulations Title 22, Chapter 14, § 64211 to 64217, **the local health officer or agency (i.e., County of El Dorado, Public Health Office) is responsible for state small water systems**
  - State small water systems are not public water systems because they have less than 15 service connections

20

20

Drought and Water Shortage Task Force Responsibilities

Provide current water supply conditions, data, and feedback → Review drought conditions, identify problems, and develop actionable solutions → Support SB 552 implementation and County Plan development → Disseminate Task Force findings and recommendations

21

21

Drought and Water Shortage Task Force Membership and Schedule

Core Members

El Dorado Water Agency

El Dorado County California

Supplemental Members

Small Water Supplier Representatives

State Small Water System and Domestic Well Representatives

Public Water Agency Representatives

Groundwater Sustainability Agency Representative

Meeting Frequency

- 2-3 times a year
- More frequently during drought or other water shortage events as needed

22

22

Moving Forward

23

23

Phased Approach to SB 552 Compliance

1. Prioritization and early planning

- Identify gaps & needs
- Identify priorities for grant funding
- Identify actionable next steps

2. Continued planning and information gathering

- Data collection
- Small water systems evaluation
- DWR workshops

3. Implementation of plans and strategies

Currently here

24

24

Questions?

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25

TVS SUBBASIN (6-005.01)
2022 SAG Workshop II
August 24, 2022

WY 2022

Water Supply and Demand Assessment

I.Bergsohn, PG, CHg

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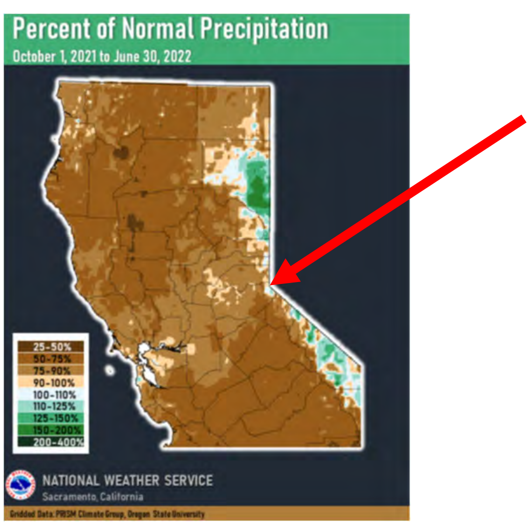
NWS Spring 2022 Climate & Drought Summary (NOAA, July 28, 2022)



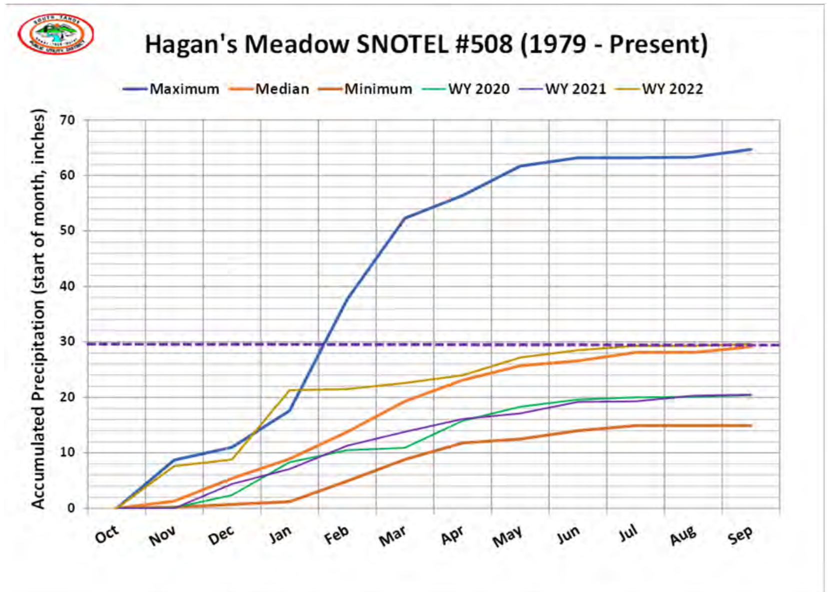
Water Supply and Demand Assessment (CWC § 10632 (a) (2))

- (i) Current year unconstrained demand, considering weather, growth, and other influencing factors, such as policies to manage current supplies to meet demand objectives in future years, as applicable.
- (ii) Current year available supply, considering hydrological and regulatory conditions in the current year and one dry year. The annual supply and demand assessment may consider more than one dry year solely at the discretion of the urban water supplier.
- (iii) Existing infrastructure capabilities and plausible constraints.
- (iv) A defined set of locally applicable evaluation criteria that are consistently relied upon for each annual water supply and demand assessment.
- (v) A description and quantification of each source of water supply

2

Precipitation

- Maximum = 67.5 " (WY 2017)
- Minimum = 14.9" (WY 1987)
- Median = 29.10" (WY 1979 – 2021)
- WY 2020 = 20.4" (Dry)
- WY 2021 = 20.6" (Below Normal)
- WY 2022 = 29.6" (Normal, Projected thru Aug 18, 2022)



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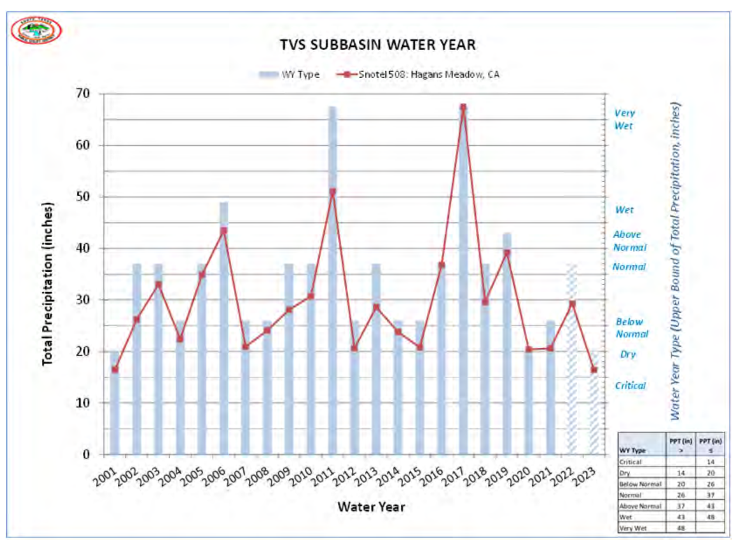
Water Year Type

- WY 2021 = 20.6" (Below Normal)
- WY 2022 = 29.3" (Normal, Projected thru June 20, 2022)
- WY 2023 = 16.4" (Dry, WY 2001)

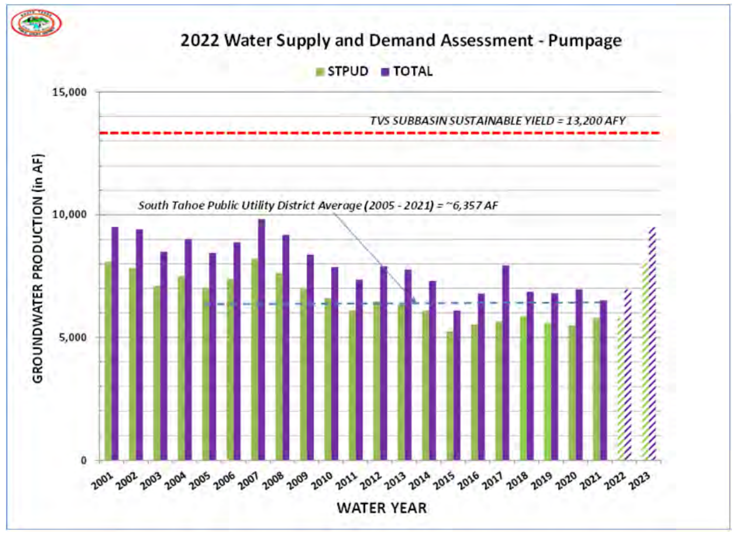


WY Type	PPT (in) >	PPT (in) ≤
Critical		14
Dry	14	20
Below Normal	20	26
Normal	26	37
Above Normal	37	43
Wet	43	48
Very Wet	48	

4

Water Demand

- Water Demand (AF):
  - STPUD: TOTAL
- WY 2021 (AF):
  - 5802: 6516
- WY 2022 (AF)
  - Projected, 5796: 6955
- WY 2023(AF)
  - 8037: 9500 (WY 2001)



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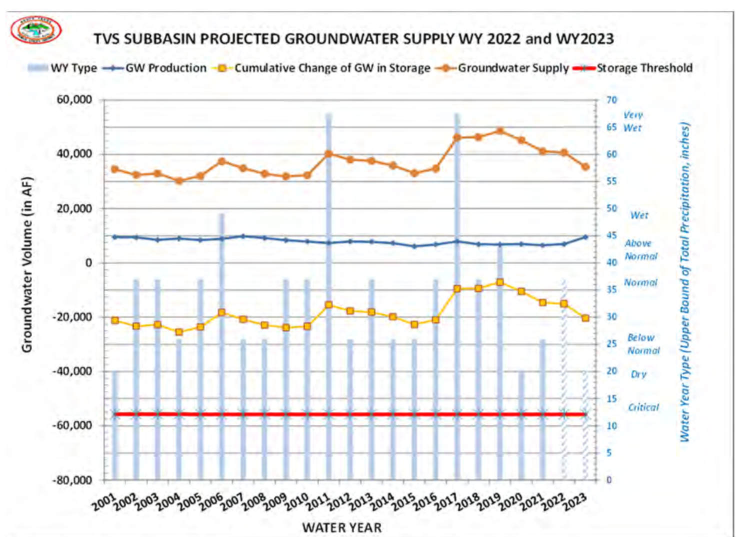
Water Supply

Storage Threshold [(-55,687 AF) – (GW in Storage AF)]

- WY 2021 = 41,082 AF
- WY 2022 = 40,627 AF (projected)
- WY 2023 = 35,368 AF (projected)



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South “Y” PCE Plume

Tahoe Valley South Subbasin Groundwater Management Plan Stakeholder Advisory Group Workshop August 24, 2022

Site Cleanup Subaccount Program (SCAP) Regional PCE Plume Investigation Update

Ed Tarter, PE
AECOM

Agenda

- Overview of Site Cleanup Subaccount Program (SCAP) Regional PCE Plume Investigation Task Objectives
- Key Observations from Regional PCE Plume Groundwater Investigation
- Summary of Current and Future SCAP Activities
- Recommended Future Actions

Regional PCE Plume Investigation Tasks

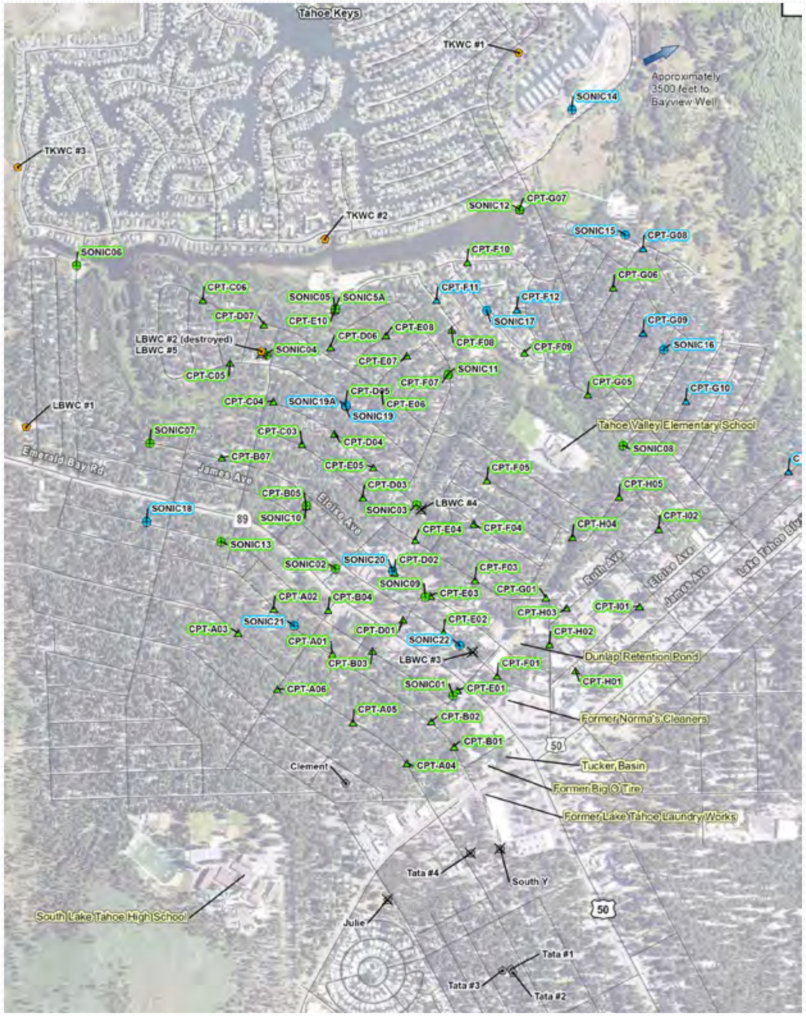
- Records Review and Inventory Development
- Regional PCE Plume Investigation
- Vertical Conduit Evaluation and Destruction
- Non-Municipal Water Supply Well Sampling
- Soil Gas Sampling
- Sentry Well Network Installation and Monitoring

Regional PCE Plume Investigation Objectives

- Define lateral and vertical extent of Regional PCE Plume
- Develop understanding of regional subsurface lithology
- Estimate horizontal and vertical groundwater gradients
- Monitor plume migration upgradient from key municipal supply wells
- Identify preferential pathways contributing to contaminant transport of PCE
- Evaluate potential threat to human health from vapor intrusion
- Evaluate feasibility of potential remedial and receptor protection options

Summary of Regional PCE Plume Investigation

- Fieldwork performed in 2019 and 2020
- 22 Sonic borings advanced to 300 feet bgs
- 57 Cone Penetration Test (CPT) borings advanced to 100 feet
- 6 - 8 groundwater samples collected per location



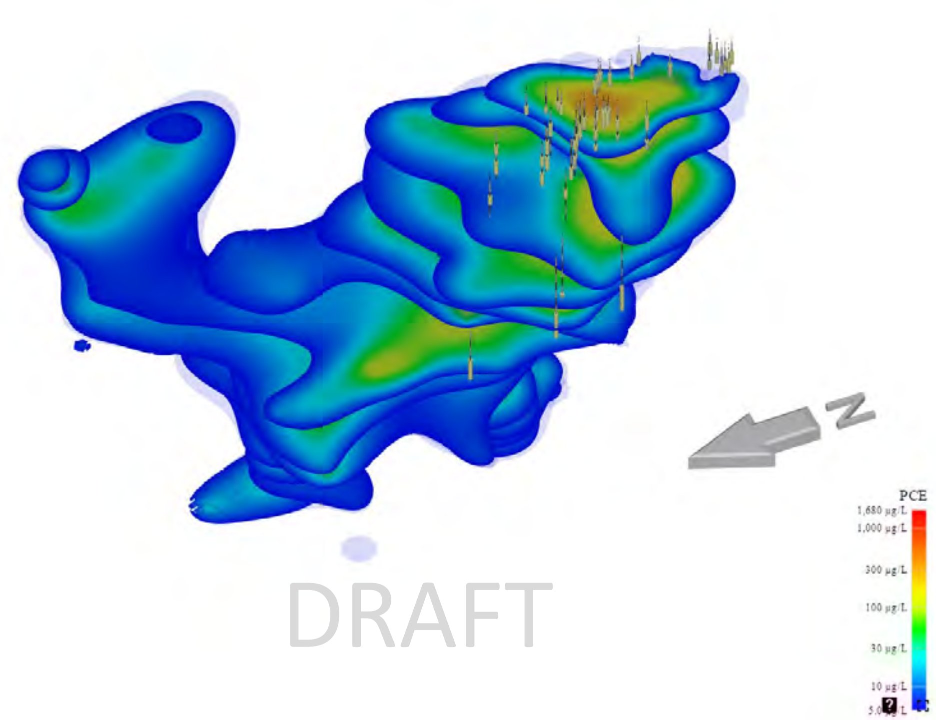
Key Observations from Regional PCE Plume Groundwater Investigation

Improved Understanding of the Conceptual Site Model

- Nature and Extent
- Regional Geology/Lithology
- Fate and Transport

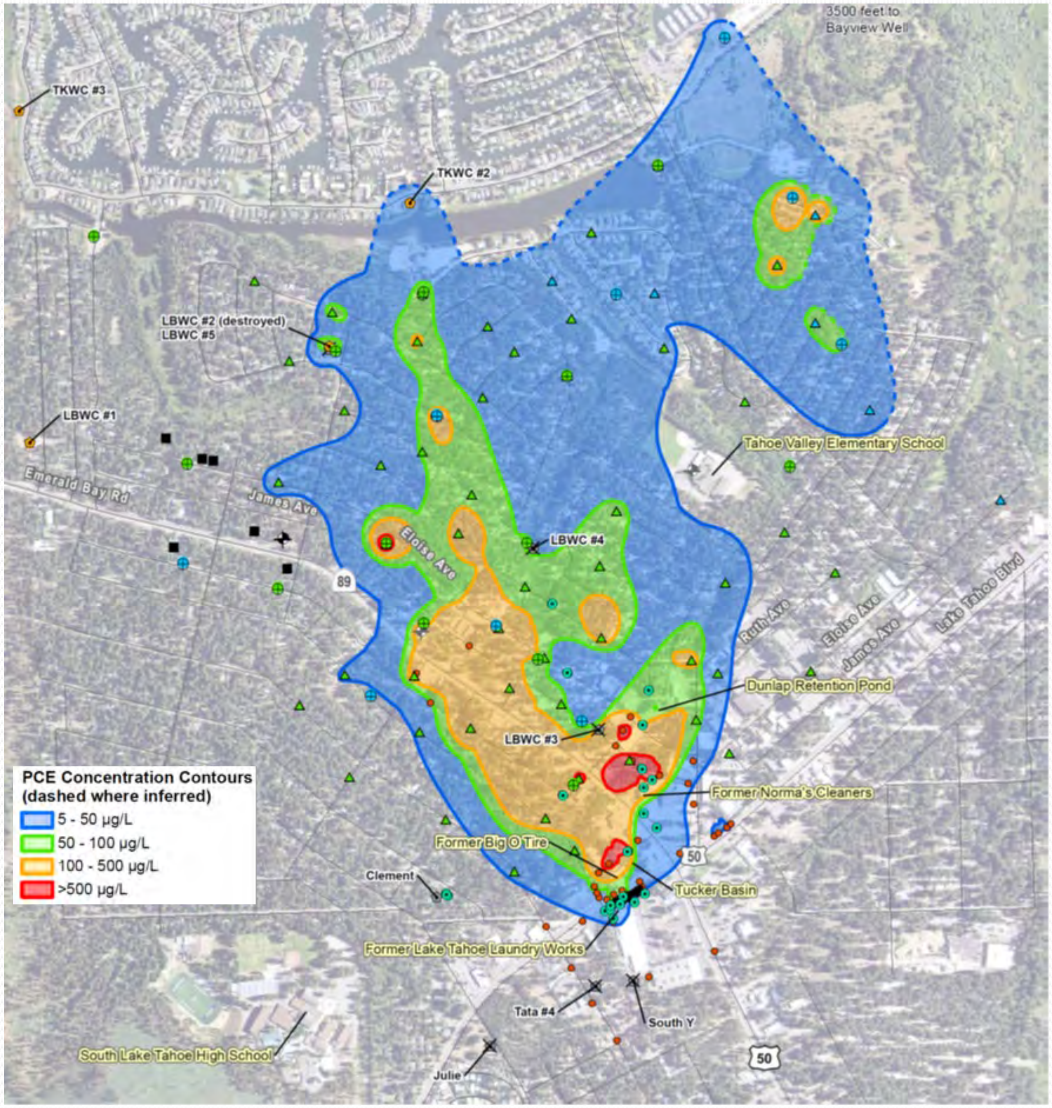
Earth Volumetric Studio™ (EVS) 3-D Model

- Developed Site specific model to estimate nature and extent of plume
- Model inputs:
  - PCE groundwater data collected by AECOM and various parties (LTLW, water purveyors, etc.)
  - Lithologic data during CPT sounding and Sonic drilling
- Model outputs:
  - Isocontour maps
  - 2D cross sections
  - 3D visualization tool



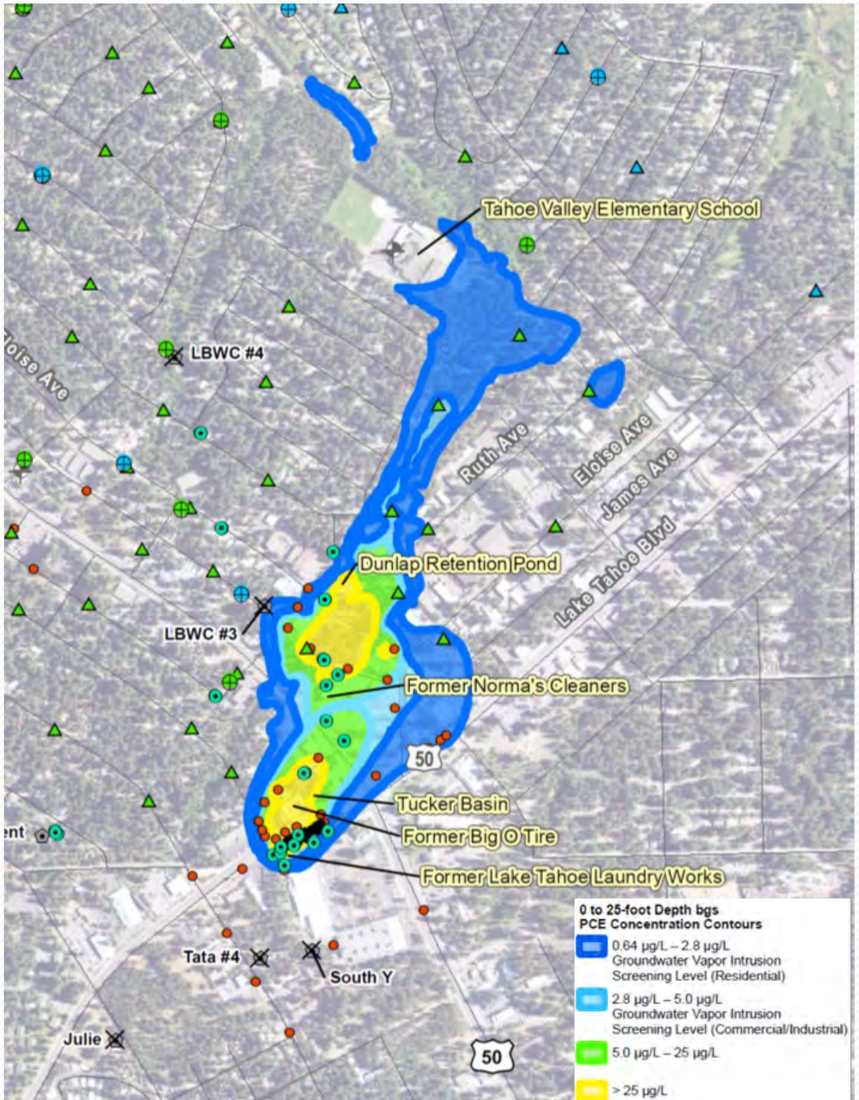
*EVS – Earth Volumetric Studio. EVS uses geostatistical mathematical methods (kriging), also known as gaussian process regression, to predict geological and PCE concentrations from sparse data samples spatially across a set model domain

Lateral Extent of PCE in Groundwater



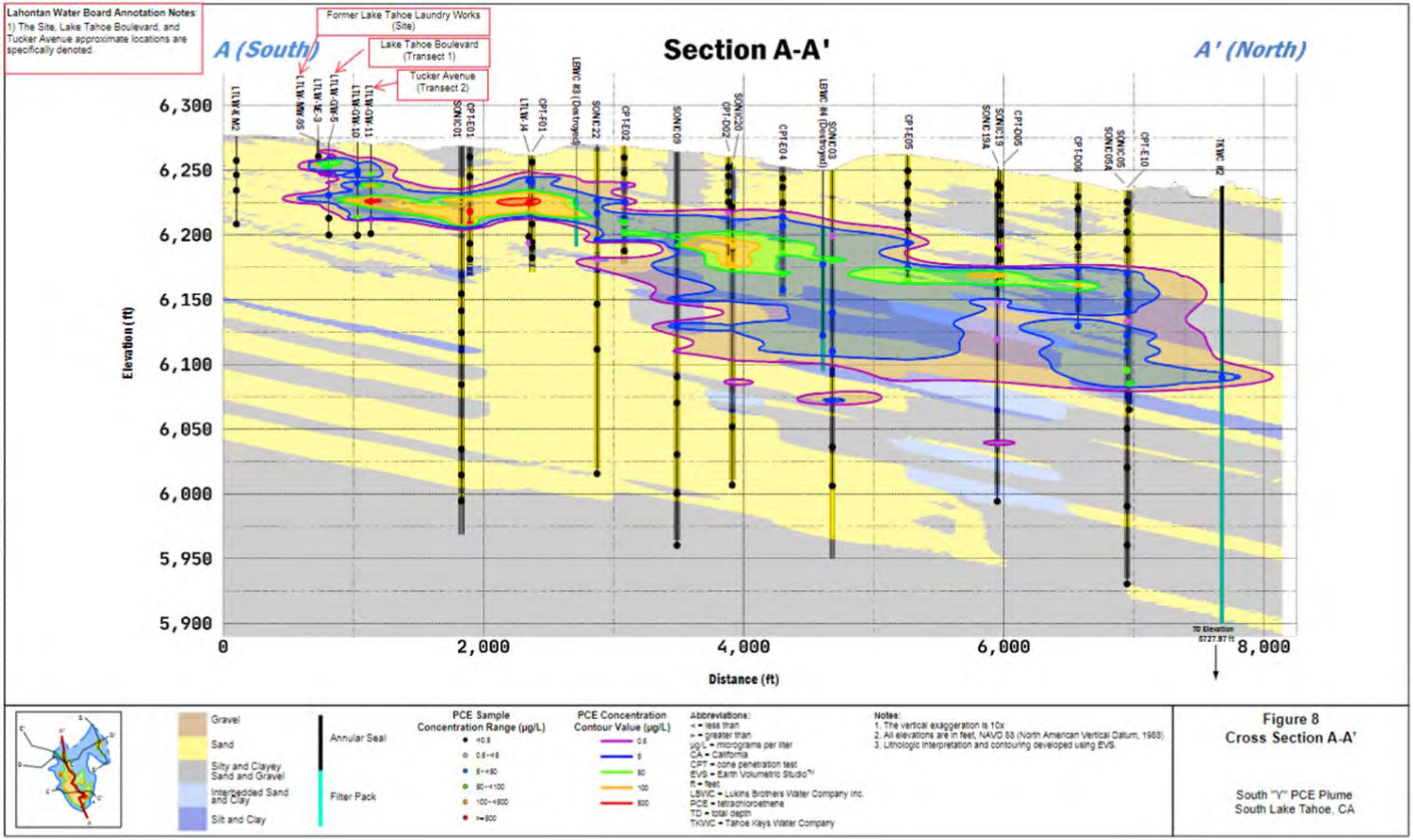
- PCE plume extends 8,000 feet longitudinally (south to north) towards Lake Tahoe.
- PCE plume extends 5,000 feet in the (east to west)
- Vertically down 50 feet to over 150 feet in depth.
- PCE detected above 5 µg/L from depths down to 185 feet bgs
  - 34 µg/L at Sonic 2 at a depth of 183-185 feet, bgs.
- PCE ranged from below the detection limit of 0.5 µg/L to 570 µg/L.

Lateral Extent of PCE in Shallow Groundwater



- PCE exceeds residential and commercial/industrial vapor intrusion Environmental Screening Levels (ESLs)
- PCE in shallow groundwater exceeds the residential vapor intrusion ESL (**0.64 µg/L**) from the South "Y" Area to the northeast towards Tahoe Valley Elementary School along the City of South Lake Tahoe's stormwater conveyance, then towards Tahoe Keys
- Max PCE detected 170 µg/L at location LTLW-MW-9S (screened from 10 to 25 feet bgs).

Vertical Extent of PCE in Groundwater and Regional Lithology



Vertical Extent of PCE in Groundwater and Regional Lithology - Notes

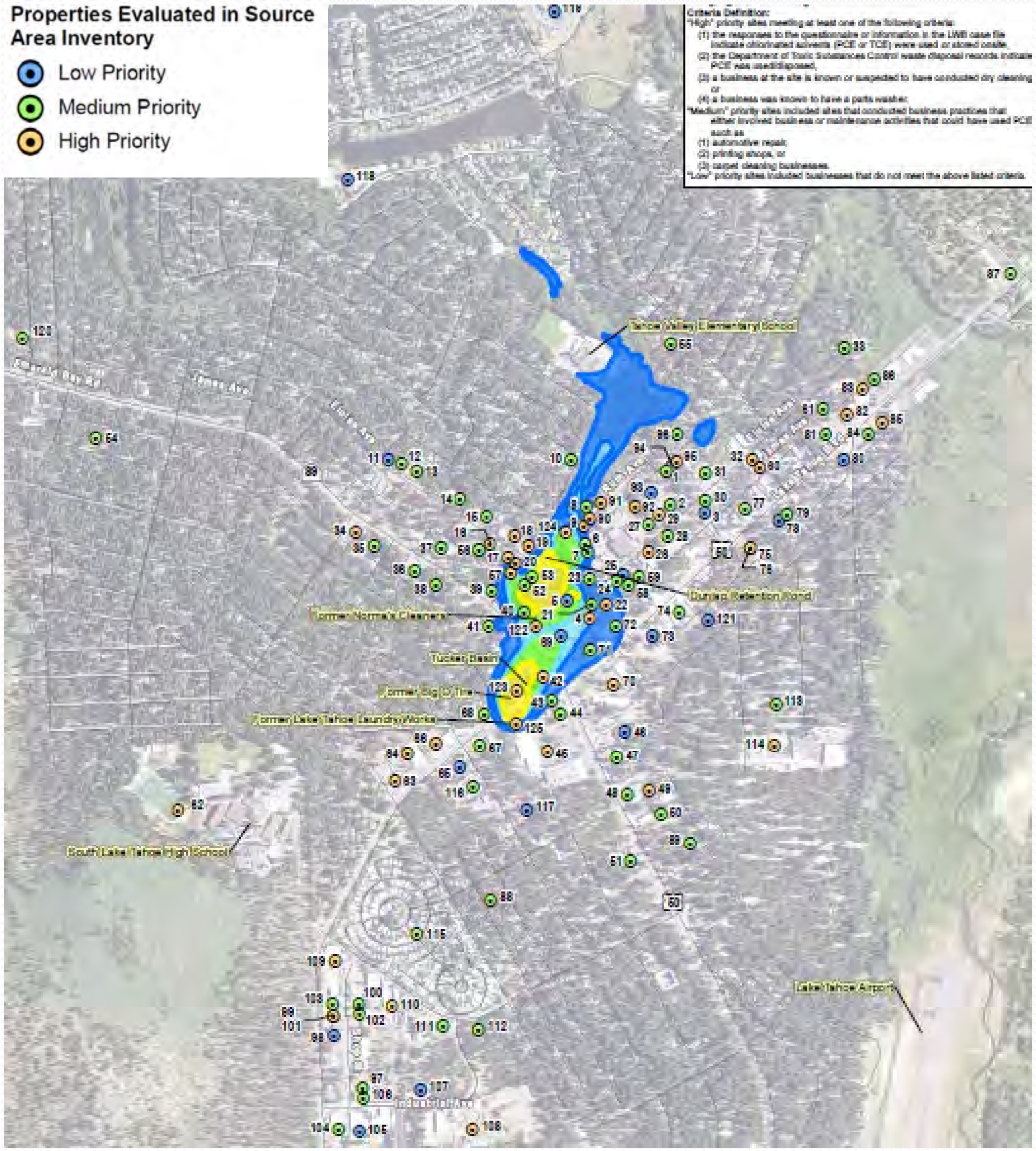
Nature and Extent

- Estimated extent PCE plume across the South "Y" Area from the south (A) near the former LTLW Site at historical multi-depth sampling location LTLW-KM2 to the north (A') near municipal supply well TKWC #2.
- From the far south near the former LTLW Site, historical multi-depth sampling locations with maximum concentrations near 50 feet bgs include LTLW-GW-12 (42 to 46 feet bgs) at a concentration of 10.9 µg/L, LTLW-J4 (35 to 39 feet bgs) at a concentration of 718 µg/L, and LTLW-GW-11 (42 to 46 feet bgs) at a concentration of 1,680 µg/L.
- In general, PCE concentrations are greater than 500 µg/L at a depth of approximately 50 feet bgs or 6,225 feet elevation above mean sea level (MSL).

Lithology

- In the southern portion of the regional PCE plume, cross section A-A' shows deposits of predominantly fine-grained sand underlain by silty and clayey sand and gravel.
- Progressing north, cross section A-A' shows interlayered silty/clayey coarser-grained sand and gravel deposits with lenses of ML and CL deposits becoming more common.
- These silt and clay deposits generally form aquitards or low permeability units that impede the vertical flux of groundwater and PCE.
- The general fining of sediments lakeward (north) is consistent with lower-energy deltaic and lake sedimentation near the lake versus higher energy glacial outwash and alluvial sedimentation near the uplands/mountains.

Potential Source Area Inventory



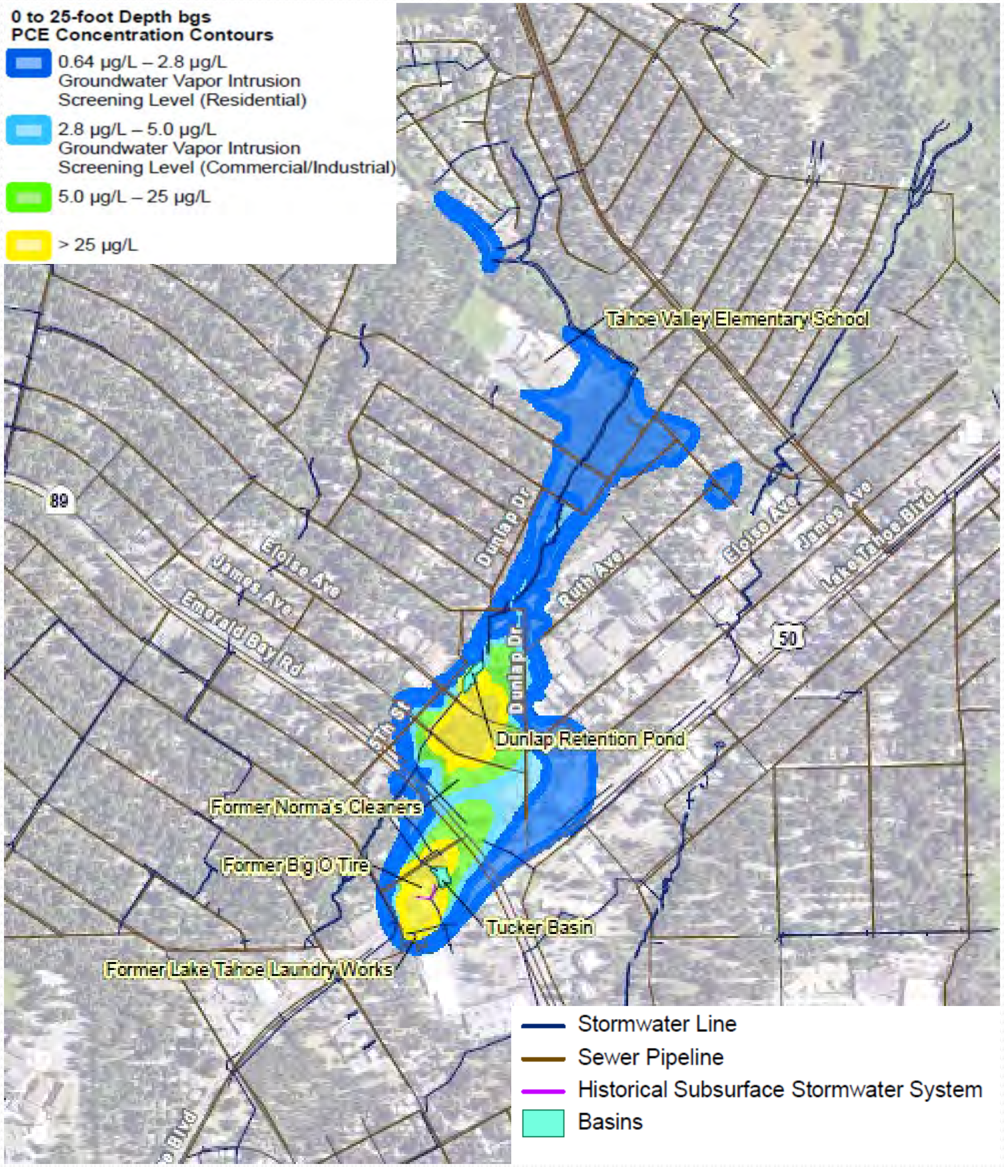
Identified Properties

- Properties with known or suspected use, storage, or disposal of PCE

Priorities

- "High" meet at least one of the following conditions:
  1) Records indicate that PCE or TCE onsite,
  2) DTSC records indicate PCE was used/disposed,
  3) Business at the site is known or suspected to have conducted dry cleaning, or
  4) Business was known to have a parts washer.
- "Medium" conducted business practices that either involved business or maintenance activities that could have used PCE, such as (1) automotive repair, (2) printing shops, or (3) carpet cleaning businesses.
- "Low" priority sites included businesses that did not fit into any of the criteria.

Preferential Pathway Inventory

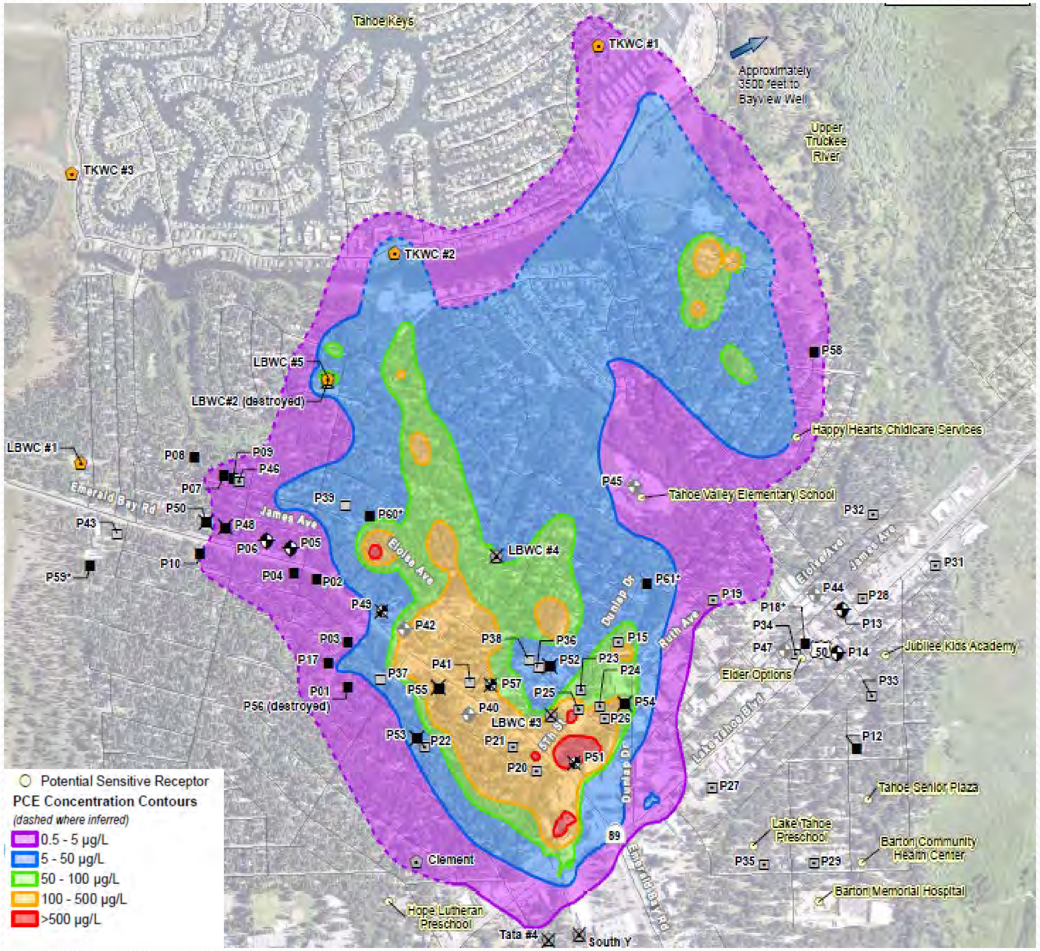


Inventory includes:

- stormwater conveyance systems,
- sewer conveyance systems,
- associated subsurface utility trench backfill materials

- Evaluate the potential role of potential pathways played in the distribution of contamination

Receptor Inventory

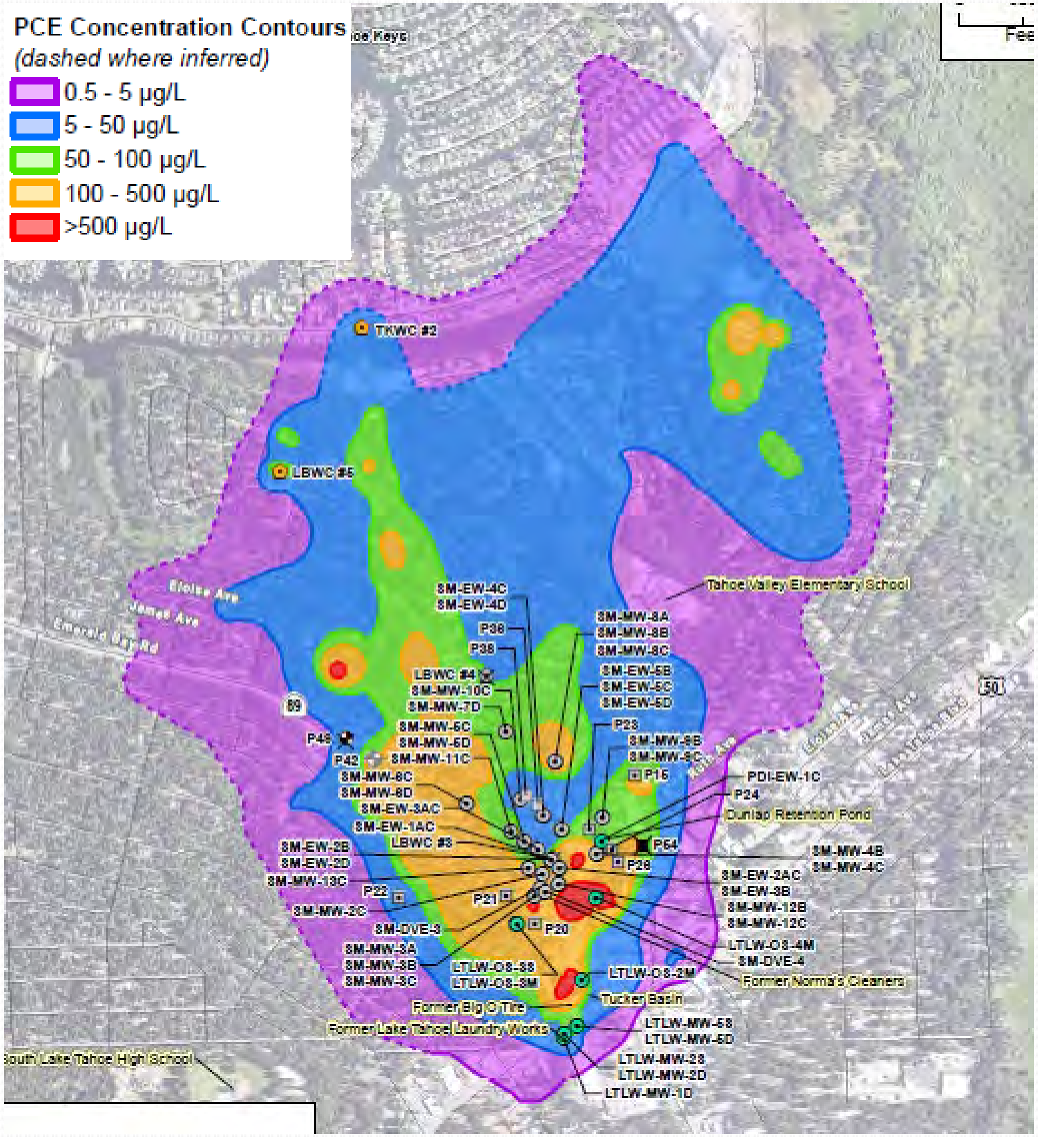


<u>Types of Receptors</u>

- Municipal wells
- Private Supply Wells
- Small Community Wells

Further evaluation and monitoring of wells described later.

Vertical Conduit Inventory



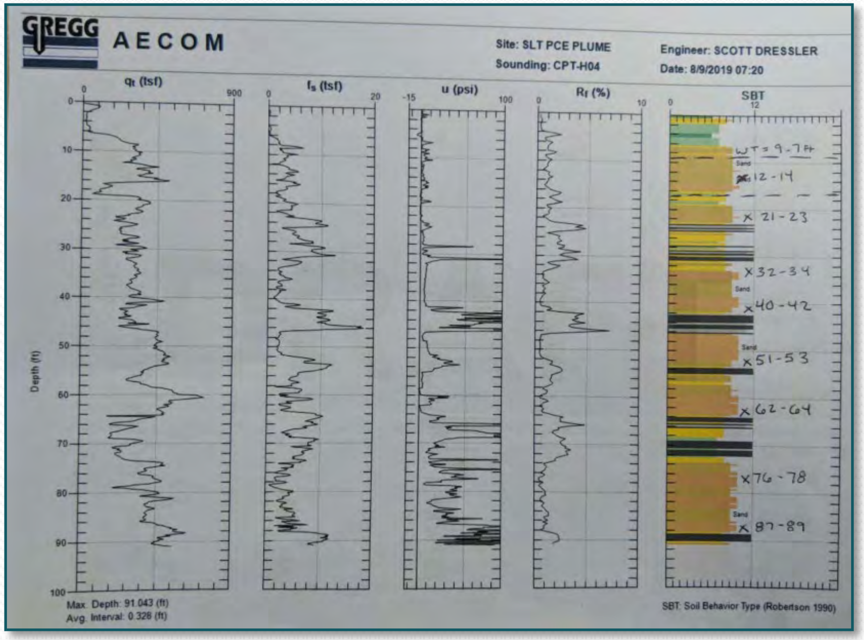
- Wells that act as a conduit for downward migration of PCE
- Further evaluation is currently ongoing

Nature and Extent Conclusions

- Improved understanding of lithology and lateral/vertical extents of Regional PCE Plume
- Plume appears to originate in the vicinity of the former LTLW Site
  - No PCE detected upgradient during previous sampling activities
- EVS model suggests an eastern lobe may be present east of Tahoe Valley Elementary School
- PCE in shallow groundwater appears to coincide with the alignment of portions of stormwater conveyance system
- PCE in shallow groundwater exceeds the residential vapor intrusion ESL (potential threat to human health)

Fate and Transport Conclusions – How PCE has migrated

- Regional and local lithology variability
- Physiochemical and geochemical conditions of the aquifer
- Regional groundwater flow direction towards Lake Tahoe



Fate and Transport Conclusions – (cont'd)

- Expected migration pathways
  - Infiltration of surface run-off containing dissolved PCE through the vadose zone
  - DNAPL migrated directly to the vadose zone and into the saturated zone/water table
  - Vapor-phase contamination/migration through the unsaturated zone via vapor transport

Fate and Transport Conclusions – (cont'd)

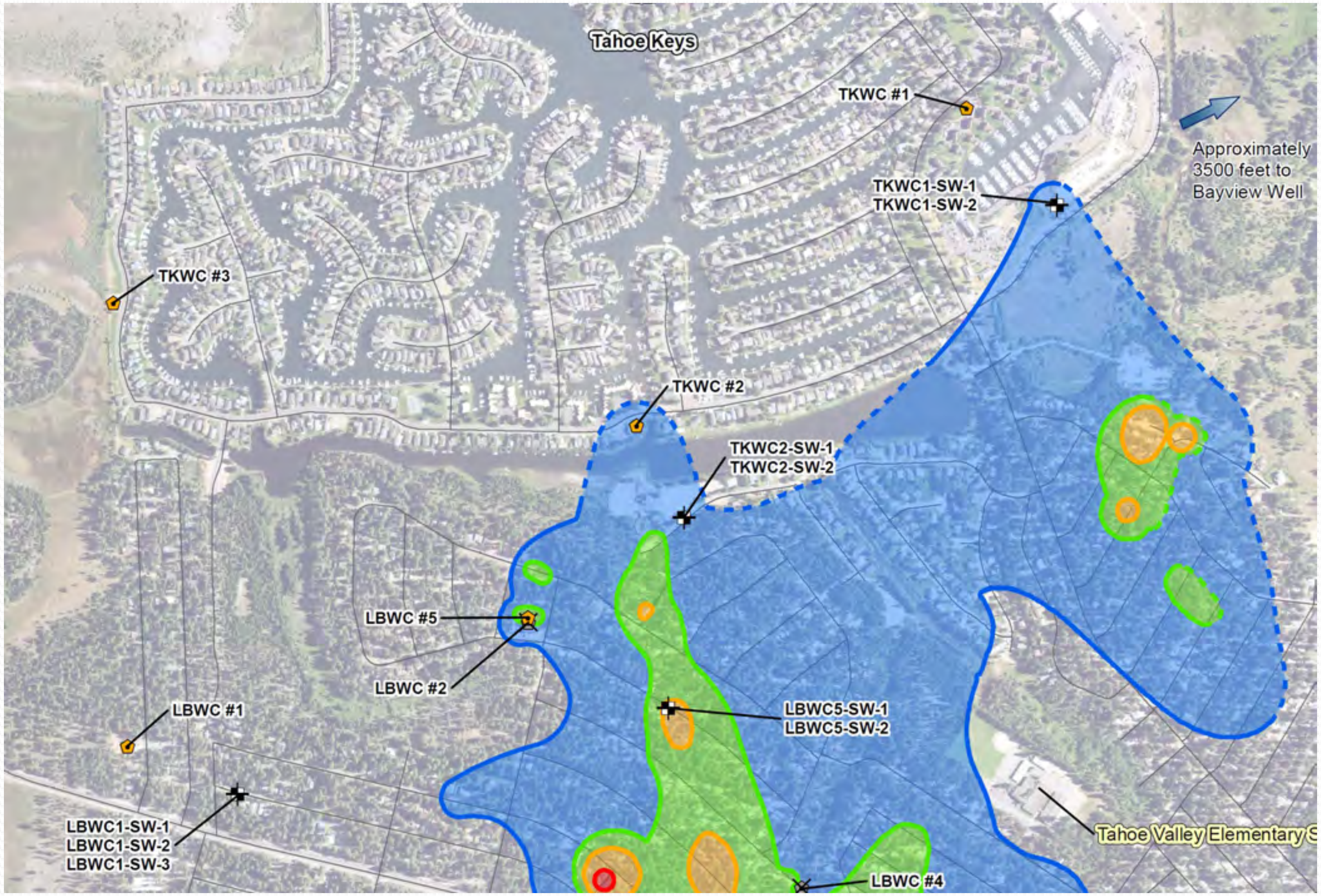
- Along preferential pathways (i.e., stormwater, sanitary sewer, and/or other subsurface utility corridors)
- Natural vertical recharge gradients along with intersecting capture zones from pumping wells (sinks)
- Potential vertical conduits (wells)

Summary of Current and Future SCAP Activities

- **Sentry Well Sampling**
  - 2 sample events completed (Oct 2021 and Apr 2022)
  - 2 more event scheduled (4Q22 and 2Q23)
- **Soil Gas Sampling –** July/August 2022
- **Non-Municipal Well Sampling –** July 2022
- **Vertical Conduit Evaluation and Destruction** - Summer/Fall 2022

Sentry Well Monitoring - Update

- Task Objective: Install and monitor sentry wells upgradient from threatened/impacted receptors



Results from Sentry Well Monitoring

PCE Concentrations for Event 1 (Oct 2021) and Event 2 (Apr 2022)			
Sentry Well ID	Sample Depth (feet bgs)	Sample Date	PCE (mg/L)
LBWC1-SW-1	106.1-108.9	4/26/2022	< 0.30
LBWC1-SW-1	106.1-108.9	10/19/2021	< 0.30
LBWC1-SW-2	141.6-144.4	4/26/2022	< 0.30
LBWC1-SW-2	141.6-144.4	10/19/2021	< 0.30
LBWC1-SW-3	163.6-166.4	4/26/2022	0.41 J
LBWC1-SW-3	163.6-166.4	10/19/2021	< 0.30
LBWC5-SW-1	76.1-78.9	4/27/2022	< 0.30
LBWC5-SW-1	76.1-78.9	10/19/2021	< 0.30
LBWC5-SW-2	148.6-151.4	4/27/2022	**160**
LBWC5-SW-2	148.6-151.4	10/19/2021	**130**
TKWC1-SW-1	115.6-118.4	4/26/2022	**120**
TKWC1-SW-1	115.6-118.4	10/20/2021	**99**
TKWC1-SW-2	157.6-160.4	4/26/2022	< 0.30
TKWC1-SW-2	157.6-160.4	10/20/2021	< 0.30
TKWC2-SW-1	145.6-148.4	4/26/2022	**40**
TKWC2-SW-1	145.6-148.4	10/19/2021	**43 J**
TKWC2-SW-2	175.6-178.4	4/26/2022	**34**
TKWC2-SW-2	175.6-178.4	10/20/2021	**21**

Note: TKWC1-SW-1 PCE detected greater than during the investigation

Calculated Vertical Flow Gradients (4Q21 and 2Q22)			
		Vertical Gradients	
Location	Sentry Well	Oct-21	Apr-22
Venice Drive	TKWC1-SW-1	0.0219	0.0060
	TKWC1-SW-2		
Texas Avenue	TKWC2-SW-1	0.0122	-0.0073
	TKWC2-SW-2		
James Avenue	LBWC1-SW-1	0.0341	0.1116
	LBWC1-SW-2		
	LBWC1-SW-3	0.0208	-0.1146
Anita Drive	LBWC5-SW-1	0.0097	0.0122
	LBWC5-SW-2		

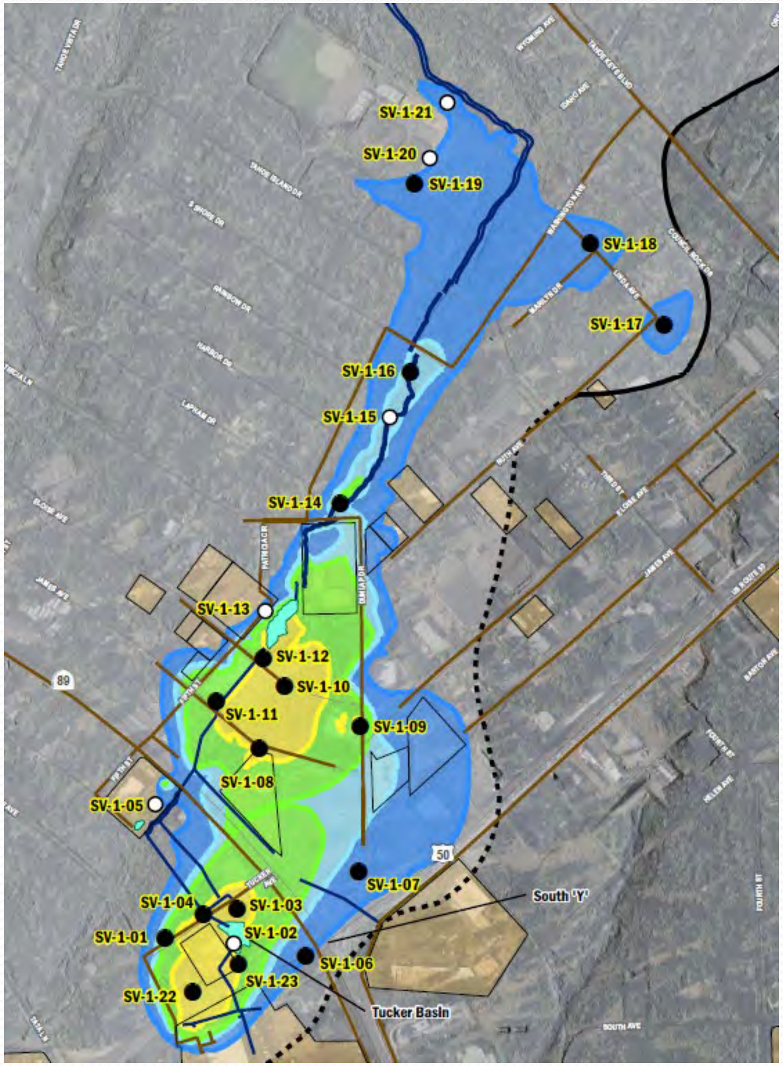
Note: Negative value show upward gradient

Groundwater vertical gradients can vary spatially due to:

- Permeability differences
- Fluctuate due to seasonal conditions
- Highly influenced by pumping wells

Soil Gas Sampling

- Task Objective: Evaluate potential threat to human health from vapor intrusion
- Completed soil gas sampling
  - Installed samplers at 25 locations (7/19 – 7/21)
  - Only shallow soil gas intervals sampled (~ 5 ft bgs)
    - Water encountered at 5 ft bgs
  - Retrieved samplers 8/4 - 8/5
  - Results will be presented in an investigation summary report (end of Sept)



Non-Municipal Water Supply Well Sampling

- Task Objective: Evaluate potential PCE exposure risk from well water consumption
- Completed well sampling
  - Wells that met the following criteria were sampled
    - Active wells
    - Have access from property owners
  - Sampled 7 non-municipal wells in July 2022

Recommended Future Actions

- Conduct investigations of utility-related preferential pathways
- Evaluate vertical gradients (install nested wells)
- Install perimeter wells to monitor plume stability
- Routinely sample active non-municipal supply wells
- Conduct GW investigations to address data gaps
  - Near Tahoe Valley Elementary (limited boring coverage)
  - Eastern lobe's connectivity to the main portion of the plume originating near the South "Y" Area

Recommended Future Actions (cont'd)

- Continue investigations of known and potential PCE source area(s)
- Conduct investigation(s) along the stormwater conveyance system
- Determine if shallow PCE plume poses a threat to human health
- Properly destroy identified potential vertical conduits
- Conduct a groundwater source protection analysis
  - Capture zone modeling or ROI determinations
- Evaluate feasibility of potential alternatives to protect receptors

Questions?

Tahoe Valley South Subbasin Groundwater Management Plan Stakeholder Advisory Group August 24, 2022

Proposed Cleanup and Abatement Orders

Lake Tahoe Laundry Works

Former Norma's Cleaners

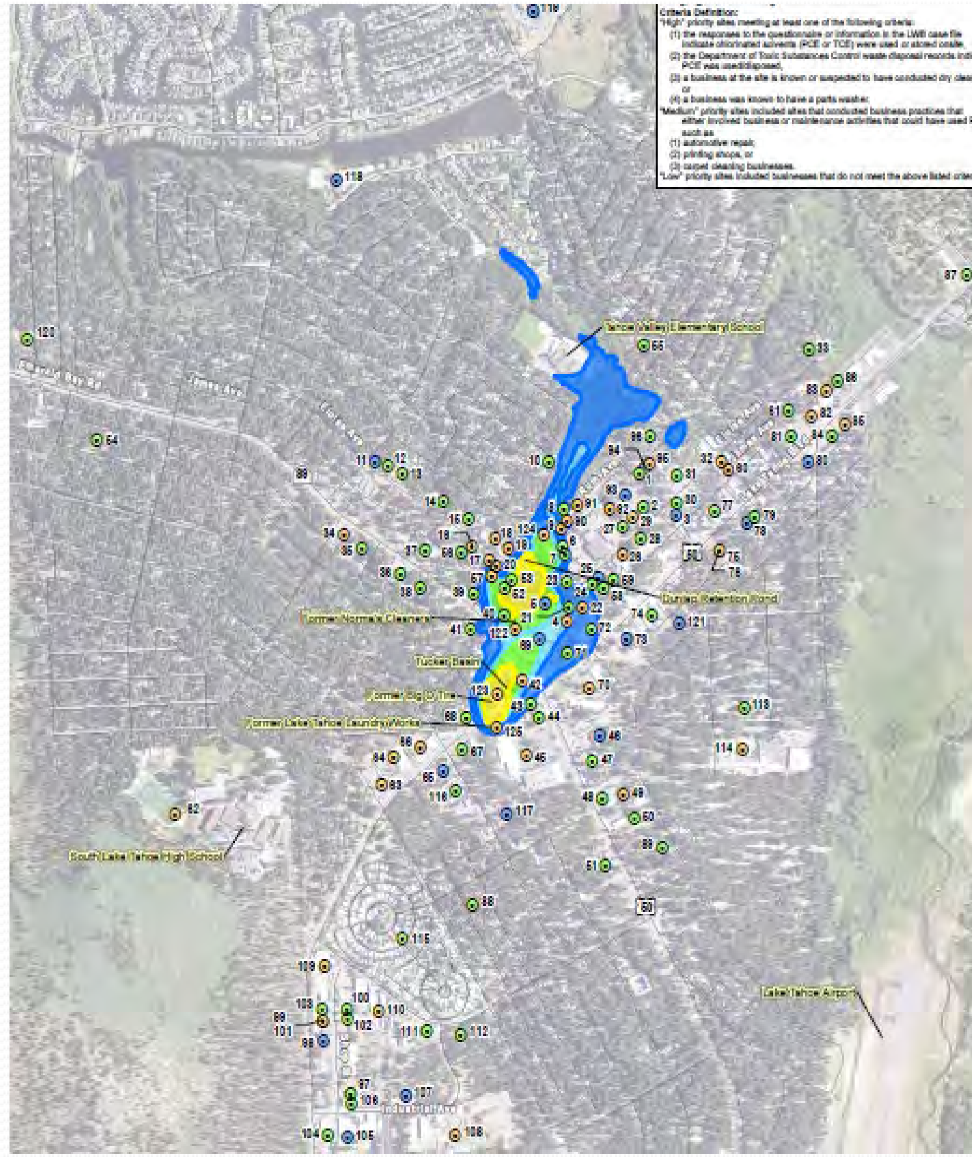
Big O Tires

Brian Grey, PG
Lahontan Water Board

Introduction

Proposed CAOs

- Lake Tahoe Laundry Works
- Former Norma's Cleaners
- Big O Tires



Proposed Cleanup and Abatement Orders– Lake Tahoe Laundry Works

Brief Background

Discharge source: Coin operated dry cleaning unit (1972-1979)

Municipal Supply Well Impacts Discovered: 1989

Case Opened: 2003

Investigations: 2003, 2004, 2005, 2008, 2015, 2017, 2018, 2019

Remediation: Soil vapor extraction/air sparge (2010-present)

Quarterly monitoring and reporting: (2009-present)

Current Enforcement Directive: CAO R6T-2017-0022

Property Ownership: No change

Proposed Cleanup and Abatement Orders– Lake Tahoe Laundry Works

Slice of Enforcement History

2014 Municipal Supply Well Impairment: Lukins #2 and #5

2015 Proposed CAO: Included requirements associated with regional PCE plume

- Public comments received: Connection to receptors is uncertain.
- Never issued.

Cleanup and Abatement Order R6T-2017-0022: Required delineation of lateral and vertical extent of contamination originating from the Site (i.e., evaluate potential contribution to regional PCE plume) and cleanup and abate of its effects.

Proposed Cleanup and Abatement Orders – Lake Tahoe Laundry Works

<u>CAO R6T-2017-0022 Petitions</u>

State Water Board

State Water Board did not hear petitions; dismissed

EL Dorado County Superior Court

El Dorado County Superior Court 2020 rulings:

<u>Fox (June 2020):</u> Petition granted. Vacated 2017 CAO as it relates to Fox and remanded it to Lahontan Water Board to apply the law provided by United Artists vs. Regional WQCB (2019)

<u>Seven Springs (November 2020):</u> Petition granted in part and denied in part. The Lahontan Water Board must set forth findings to bridge the analytical gap between the raw evidence and ultimate decision that the burden including costs, bear a reasonable relationship to the need for the reports. All other parts of the petition were denied.

Proposed Cleanup and Abatement Orders – Lake Tahoe Laundry Works

<u>**2022 Proposed CAO**</u>

- Considers data collected since 2017 CAO
  - Discharger
  - SCAP Investigation
- Requires delineation and cleanup of regional PCE plume
- Includes provisions for replacement water
- Addresses El Dorado County Superior Court rulings
  - Applies law provided in United Artist decision
  - Contains findings to support the Water Code section 13267 cost burden analysis

Proposed Cleanup and Abatement Orders – Big O Tires

Brief Background

Discharge source: Automotive Repair (1975-2006)

Municipal Supply Well Impacts Discovered: 1989

Case Opened: 2001

Investigations: 2001, 2006, 2020

Remediation: None

Quarterly monitoring and reporting: None

Current Enforcement Directive: Water Code Section 13267 letter (May 2019)

Property Ownership: No change

Proposed Cleanup and Abatement Orders – Big O Tires

2022 Proposed CAO Contents

- Like May 2019 Water Code 13267 directive
- Considers data collected since 2019
  - Discharger
  - SCAP Investigation
- Requires delineation and cleanup of known unauthorized releases originating from property
- SCAP Application

Proposed Cleanup and Abatement Orders – Former Norma's Cleaners

Brief Background

Discharge source: Coin operated dry cleaning unit (1969-1977)

Municipal Supply Well Impacts Discovered: 1989

Case Opened: 2001; Closed 2009; Re-opened 2019

Investigations: 2001, 2003, 2007, 2020

Remediation: Excavation (2008)

Quarterly Monitoring and Reporting: None

Current Enforcement Directive: Water Code Section 13267 letter (May 2019)

Property Ownership: 2014 (new)

Proposed Cleanup and Abatement Orders – Former Norma's Cleaners

2022 Proposed CAO Contents

- Like May 2019 Water Code 13267 directive
- Considers data collected since 2019
  - o Discharger
  - o SCAP Investigation
- Requires delineation and cleanup of known unauthorized releases originating from property
- SCAP Application

What's Next?

Public Comment Review and Response

- Comment Period Extended to September 19
- Review and Respond to Comments Received:
  - Seven Springs
  - Fox Capital
  - South Tahoe Public Utility District
  - Lukin Brothers Water Company
  - Tahoe Keys Water Company
  - Other interested parties
- Modify CAO(s) as needed
- Provide Opportunity for Additional Public Comment (if necessary)

Questions?

SGM Grant Program

ID	BMO	Project/Management Action (PMA)	Description	Benefit(s)	Indicator(s)	Reference(s)	SGM Project Type	RANK
2022-1	1	Expand TVS Subbasin Monitoring Network	Monitor groundwater levels for a five-year period in selected sentinel wells north of the South Y within the South Lake Tahoe subarea and in selected monitoring wells associated with the Meyers Landfill within the Meyers subarea.	Two (2) areas of the TVS Subbasin have been identified as needing additional groundwater monitoring. Monitoring north of the South Y would provide data on vertical gradients and localized drawdown effects. Monitoring within the Meyers subarea would improve regional water level and groundwater flow definition; and help identify potential groundwater level changes due to climate change.	Groundwater Levels	DRI, 2018	Data Gap	
2022-2	2	Targeted Groundwater Quality Monitoring	Identify existing wells that could be used for limited monitoring of	The South Y PCE contaminant plume impairs groundwater and threatens drinking	Water Quality	Kennedy Jenks, 2019; DRI, 2019; Rybarski et al, 2022	Data Gap	

ID	BMO	Project/Management Action (PMA)	Description	Benefit(s)	Indicator(s)	Reference(s)	SGM Project Type	RANK
			groundwater quality for specific contaminants of concern.	water wells within the TVS Subbasin. New sentry wells were installed in 2021 to provide water purveyors advanced warning of potential PCE migration upgradient from water supply wells. Funding for monitoring of these wells will end in 2023 (?). Targeted Groundwater Quality Monitoring would be used to extended monitoring in selected sentry wells. Many active community water supply wells within the TVS Subbasin are located near dry wells and detention basins used to infiltrate				

ID	BMO	Project/Management Action (PMA)	Description	Benefit(s)	Indicator(s)	Reference(s)	SGM Project Type	RANK
				stormwater. Dry wells and detention basins are susceptible to contamination from illicit discharges or dissolved contaminates in stormwater. Targeted Groundwater Quality Monitoring could also be used to assess the local occurrence of PFAS in stormwater.				
2022-3	2	TVS Subbasin WQ Database	Develop and maintain a comprehensive surface water and groundwater quality database for the TVS Subbasin.	Groundwater quality is evaluated based on available data. Land and water management agencies within the TVS Subbasin collect water quality data which is not regularly reported. A dedicated	Water Quality	Rybarski et al, 2022	Annual Reporting	

ID	BMO	Project/Management Action (PMA)	Description	Benefit(s)	Indicator(s)	Reference(s)	SGM Project Type	RANK
				database used to manage this data would improve future evaluation of groundwater conditions, data sharing and collaboration on water quality issues within the subbasin.				
2022-4	3	GSA Webpage Development	Use information from the Alternative Plan to improve public outreach through the District and EDWA websites.	Development of the first five-year update of the Alternative Plan has produced a plethora of new local groundwater information. Review and update of existing webpages would allow for improved understanding and engagement of well owners through dissemination of this information related to groundwater		Rybarski et al, 2022	Engagement and Outreach	

ID	BMO	Project/Management Action (PMA)	Description	Benefit(s)	Indicator(s)	Reference(s)	SGM Project Type	RANK
				management, private well ownership, contaminated groundwater, wellhead protection and local changes in groundwater levels.				
2022-5	3	Survey of Private Well Owners – Phase III	Complete the survey of private well owners in a safe, efficient, and cost-effective manner.	The District received 509 responses from private well owners during surveys of private well owners in 2017 (PWOS-I) and 2020 (PWOS-II). These surveys were successful in initiating contact with private well owners; notifying private well owners of the GSA; providing information to confirm the locations and use of private wells;			Engagement and Outreach	

ID	BMO	Project/Management Action (PMA)	Description	Benefit(s)	Indicator(s)	Reference(s)	SGM Project Type	RANK
				and inform the GSA on private well owner groundwater quality and groundwater supply concerns. Approximately 100 well owners remain to be contacted. A Phase III survey would endeavor to complete these surveys.				
2022-6	5	GDE/SEZ Monitoring	Develop and implement plans to monitor the potential impact of groundwater withdrawals on interconnected surface waters (ISWs).	Addresses the need for shallow groundwater monitoring within or near GDEs. Establishes groundwater level record to define a minimum threshold for GDEs in potentially vulnerable SEZs. Provides data to consider the need for establishment of a provisional	GDEs; Groundwater Levels	Rybarski et al, 2022	Data Gap	

ID	BMO	Project/Management Action (PMA)	Description	Benefit(s)	Indicator(s)	Reference(s)	SGM Project Type	RANK
				groundwater management area. Allows for evaluating measurable benefit to groundwater recharge from stream restoration EIPs.				
2202-7	2	Update South Y PCE Model	Incorporate new lithologic and groundwater quality data to update the South Y PCE Model	The South Y PCE Model is a three-dimensional fate and transport model used to evaluate various remedial alternatives for management of the South Y Regional PCE Contaminant Plume. The South Y PCE Model was developed in 2018 prior to the Regional Plume Characterization Investigation of the South Y Plume	Water Quality	DRI, 2019;	Technical assistance; Evaluation of groundwater management needs; groundwater contamination remediation.	

ID	BMO	Project/Management Action (PMA)	Description	Benefit(s)	Indicator(s)	Reference(s)	SGM Project Type	RANK
				(RPC). The RPC included the collection of lithologic and groundwater quality data from a total of 57 cone penetrometer test (CPT) and 31 sonic borings. In corporation of these data into the South Y PCE Model would improve the utility of this model as a tool for evaluating remedial alternatives and clean-up of this plume for impacted water purveyors, private well owners and enforcement agencies.				
2022-8	8	South Tahoe Groundwater Model (STGM)	Support inter-agency efforts to develop a revised GSFLOW model for the Lake	The STGM is the primary tool used to simulate future groundwater conditions in the	Groundwater Levels; Groundwater Storage;	Rybarski et al, 2022	Data Gap	

ID	BMO	Project/Management Action (PMA)	Description	Benefit(s)	Indicator(s)	Reference(s)	SGM Project Type	RANK
			Tahoe Hydrologic Basin including applying updated climate models to refine recharge estimates for the STGMl.	TVS Subbasin. This model relies on an existing GSFLOW model that uses boundary conditions from climate projections using best available global climate models (CMIP5). Since inception of the STGM, updated climate models (CMIP6) and emission scenarios have been developed which are being used to update climate-change projections for the Lake Tahoe Hydrologic Basin. A revised GSFLOW model of the Lake Tahoe Hydrologic basin would allow for the reassessment of groundwater	Interconnected Surface Waters			

ID	BMO	Project/Management Action (PMA)	Description	Benefit(s)	Indicator(s)	Reference(s)	SGM Project Type	RANK
				recharge based on the latest climate science using improved climate scenarios.				