Analysis of Basin Conditions Tahoe Valley South (6-5-01) Groundwater Basin, California

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Prepared for
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Respectfully submitted,
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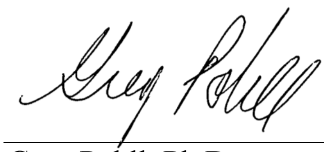

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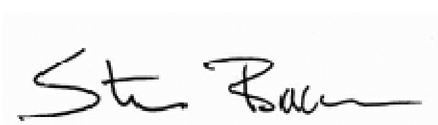

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EXECUTIVE SUMMARY

The Sustainable Groundwater Management Act (SGMA) was signed into law in September 2014 by Governor Jerry Brown to ensure that California's most at-risk groundwater basins are managed sustainably. SGMA defines "sustainable groundwater management" as "the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results" and entails curtailing seawater intrusion, subsidence, and long-term supply depletion by 2042 through local and regional management. (Wat. Code, § 10721(v).) Under SGMA, groundwater basins designated as medium- or high-priority must form groundwater sustainability agencies (GSA) by June 30, 2017 and adopt either a groundwater sustainability plan (GSP) or an alternative GSP (Alternative Plan) by January 31, 2022 or January 1, 2017, respectively.

One option under SGMA is an analysis of basin conditions that demonstrates that the basin has operated within its sustainable yield for at least a 10-year period (ABC Alternative) (Wat. Code ,§ 10733.6(b).). SGMA empowers local agencies to demonstrate sustainability through the creation of a GSA and submission to California Department of Water Resource (DWR) of either a GSP or, in appropriate circumstances, an Alternative Plan. As discussed in this report, the ABC Alternative is proper for the Tahoe Valley South (TVS) Basin (6-5-01) because the District has sustainably managed it for decades without any undesirable results.

The South Tahoe Public Utility District (District) was formed under the Public Utility District Act, which authorizes the District to manage local groundwater resources, including developing, adopting, and implementing a groundwater management plan. (Pub. Util. Code § 15501 et seq.) The District is a local agency within the meaning of both the Groundwater Management Plan laws and the Sustainable Groundwater Management Act (see Wat. Code §§ 10753(a), 10721(n).) In compliance with SGMA, the District has submitted two separate GSA formation notices to DWR to act as the GSA for the TVS Basin. The District is the largest water purveyor in the South Lake Tahoe area and utilizes only groundwater as its water source. The District has been sustainably managing the groundwater resources in the TVS Basin for decades. In 2014, the District adopted an amended Groundwater Management Plan (GWMP) Since its adoption, the 2014 GWMP has served as a successful planning tool enabling the District to maintain safe, sustainable, and high-quality groundwater resources in the long term. The 2014 GWMP includes both basin management objectives (BMOs) and a robust monitoring plan (Basin Monitoring Program). Based on the monitoring results, the District also prepares and presents an annual report (Annual Report) to the District's Board of Directors at a public meeting.

The TVS Basin is a highly productive sedimentary geologic basin located in the City of South Lake Tahoe and portions of El Dorado County, California. The basin-fill deposits that make up the main aquifer consist of sequences of sand and gravels which are inter-layered with silts and clays. On average 334,000 acre-feet per year (AFY) of precipitation falls within the TVS Basin and surrounding watersheds that contribute groundwater flow to the TVS Basin. Snowmelt is the primary source of groundwater recharge and sophisticated hydrologic models were used to calculate average annual recharge of 39,000 acre-feet. Groundwater recharge occurs primarily in the higher elevations and groundwater generally flows northward toward Lake Tahoe. Over the last few decades (1983 – 2015) average annual groundwater discharge to Lake Tahoe and local streams is 3,000 and 28,000 acre-feet, respectively. Groundwater extractions, which accounts for more than 95 percent of the potable water used in the TVS Basin, has averaged 8,000 AFY (1983 – 2015), though pumping rates have been declining recently and are expected to decrease to approximately 5,000 AFY by 2035.

SGMA defines sustainable yield as the "maximum quantity of water, calculated over a base period that is representative of long-term conditions in the basin and including any temporary surplus that can be withdrawn annually from a groundwater supply without causing an undesirable result." Therefore, to be operating sustainably, a basin's sustainable yield must be less than or equal to the amount of groundwater recharge. Groundwater recharge in the TVS Basin exceeds the sum of both groundwater allocations defined in the California-Nevada Interstate Compact (12,000 AFY) as well as historical groundwater extractions (8,000 AFY). Additionally, historical water demand has decreased and is expected to continue to decrease by close to 50 percent over the next twenty years. In conclusion, the TVS Basin is—and has been—operating within its sustainable yield.

SGMA identifies six undesirable results—chronic lowering of groundwater levels, reduction of groundwater storage, seawater intrusion, degraded water quality, land subsidence, and depletion of interconnected surface water—none of which are present in the TVS Basin. To ensure this trend is sustained, the ABC Alternative developed sustainability goals, identified sustainability indicators, and established minimum thresholds for four of the six undesirable results defined in SGMA. Seawater intrusion and land subsidence were found not to apply to the TVS Basin and, therefore, are not issues in the TVS Basin.

The ABC Alternative defines groundwater levels as triggering an undesirable result when regional water levels decline to such an extent that water demands can no longer be met. The total source capacity of community water supply wells within the TVS Basin is defined as the sustainability indicator. The minimum threshold for groundwater levels is defined as the maintenance of water levels above the screen intake at enough water supply wells for the total source capacity to meet or exceed the Maximum Daily Demand (MDD). The current source capacity for the TVS Basin is 28.8 million gallons per day (MGD) and the current MDD for the TVS Basin is 22.8 MGD, leaving a surplus of 6 MGD. Therefore, there is not an undesirable result since groundwater levels exceed the minimum threshold.

The sustainability goal for groundwater storage is to maintain adequate groundwater storage capacity to ensure a sustainable supply of groundwater. An undesirable result would occur under overdraft conditions. The sustainability indicator is defined as the net change in groundwater storage (positive or negative) as calculated from the TVS groundwater model. Based on this sustainability indicator, the District has set the minimum threshold for groundwater storage as a cumulative groundwater storage change of negative 450,000 acre-feet. Under even severe drought conditions groundwater recharge is nearly double total groundwater extractions. Additionally, modeling indicates that the average annual groundwater storage changes are negligible over the past 30 years. Therefore, groundwater conditions in the TVS Basin have not resulted in a reduction of storage and without an undesirable result.

This ABC Alternative identifies degradation of water quality, primarily from pollutants, as the District's main water supply concern. Due to the impact of degraded water quality on a water system's capacity to produce groundwater, the District defined the total source capacity of community water supply wells (28.8 MGD) as the indicator of water quality issues in the TVS Basin. The minimum threshold is defined as ensuring that water quality concerns do not threaten the ability of groundwater sources to meet the TVS Basin's MDD (22.8 MGD). Although source capacity has declined slightly since 2015 due to wells impaired by degraded water quality, these impairments have not resulted in an undesirable result.

Groundwater level declines caused by increasing water supply operations and climate variability are the two most likely causes of depletion of interconnected surface water bodies. To ensure that such depletions do not cause an undesirable result, this ABC Alternative identifies the reduction in baseflow as the sustainability indicator. The minimum threshold is defined as baseflow depletions in excess of 12,400 AFY—equivalent to 10 percent of the average annual runoff. Groundwater modeling, however, has shown that baseflow depletions have averaged only 2,500 AFY over the past 15 years, which is well below the threshold of 12,400 AFY. Therefore, despite climate variability and groundwater pumping, this undesirable result has not occurred in the TVS Basin.

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1,2-DCA	1,2-Dichloroethane
1,2-DCE	1,2 Dichloroethylene
1,4-DCB	1,4-Dichlorobenzene
ABC Alternative	Analysis of Basin Conditions Alternative
AF	Acre-feet
AFY	Acre-feet/year
AMCL	Alternative Maximum Contaminant Level
AMSL	Above Mean Sea Level
AS/SVE	Air-Sparge/Soil Vapor Extraction
BGS	Below Groundwater Surface
BMO	Basin Management Objective
BTEX	Benzene, Toluene, Ethylbenzene and total Xylenes
CASGEM	California Groundwater Elevation Monitoring
CSLT	City of South Lake Tahoe
District	South Tahoe Public Utility District
DDW	California Department of Drinking Water
DEM	Digital Elevation Model
DPE	Dual-Phase Extraction
DRI	Desert Research Institute
DWR	California Department of Water Resources
EDCWA	El Dorado County Water Agency
ft/yr	Feet per Year
g/cm3	Grams per Cubic Centimeter
GAMA	Groundwater Ambient Monitoring and Assessment
GCM	Global Climate Model
GFDL	Geophysical Fluid Dynamics Laboratory
GHG	Greenhouse Gas
GPM	Gallons per Minute
GSA	Groundwater Sustainability Agency

GSFLOW	Groundwater and Surface Water Flow Model
GSFRM	GSFLOW Regional Model
GSP	Groundwater Sustainability Plan
GWMP	Groundwater Management Plan
LBWC	Lukin's Brothers Water Company
LPA	Lakeside Park Association
LRWQCB	Lahontan Regional Water Quality Control Board
LULC	Land Use Land Cover
LUST	Leaking Underground Storage Tank
MCL	Maximum Contaminant Level
MDD	Maximum Daily Demand
mg/L	Milligrams per Liter
MGD	Million Gallons per Day
MtBE	Methyl tert- Butyl Ether
MODFLOW	Modular Groundwater Flow Model
NED	National Elevation Dataset
PCE	Tetrachloroethylene
pCi/L	Picocuries per Liter
PHD	Peak Hourly Demand
PRISM	Parameter-elevation Regressions on Independent Slopes Model
PRMS	Precipitation-Runoff Modeling System
PRV	Pressure Reducing Valve
SAG	Stakeholder Advisory Group
SCP	Site Cleanup Program
SEZ	Stream Environment Zone
SGMA	Sustainable Groundwater Management Act
SMCL	Secondary Maximum Contaminant Level
SNOTEL	Snow Telemetry
STATSGO	State Soil Geographic
SVE	Soil Vapor Extraction

SWRCB	State Water Resources Control Board
TAME	Tertiary-Amyl Methyl Ether
TBA	Tert-Butyl Alcohol
TCE	Trichloroethylene
TDS	Total Dissolved Solids
TKWC	Tahoe Keys Water Company
TRPA	Tahoe Regional Planning Agency
TVS	Tahoe Valley South
ug/L	Micrograms per Liter
UPW	Upstream Weighted
USFS	United States Forest Services
USFS-LTBMU	United States Forest Service – Lake Tahoe Basin Management Unit
USGS	United States Geological Survey
VC	Vinyl Chloride
WBZ	Water Bearing Zone
WY	Water Year

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1. INTRODUCTION

The Sustainable Groundwater Management Act (SGMA) was signed into law in September 2014 by Governor Jerry Brown to ensure that California's most at-risk groundwater basins are managed sustainably. SGMA defines "sustainable groundwater management" as "the management and use of groundwater in a manner that can be maintained during the planning and implementation horizon without causing undesirable results" and entails curtailing seawater intrusion, subsidence, and long-term supply depletion by 2042 through local and regional management. (Wat. Code, § 10721(v).) Under SGMA, groundwater basins designated as medium- or high-priority must form groundwater sustainability agencies (GSA) by June 30, 2017 and adopt either a groundwater sustainability plan (GSP) or an alternative GSP (Alternative Plan) by January 31, 2022 or January 1, 2017, respectively.

SGMA directed the California Department of Water Resources (DWR) to characterize each basin in the state as high, medium, low, or very low priority prior to January 31, 2015. DWR concluded that the basin prioritization that it finalized in June 2014 under the California Statewide Groundwater Elevation Monitoring (CASGEM) Program would serve as the initial prioritization under SGMA. The TVS Basin was designated as a medium priority basin.

1.1 ALTERNATIVE PLANS

Under SGMA, local agencies are authorized to submit an Alternative Plan, in lieu of a GSP, for review by DWR. SGMA identifies the following three Alternative Plans:

- A groundwater management plan (GWMP) developed pursuant to Part 2.75 of the Water Code (GWMP Alternative)
- Management pursuant to an adjudication action
- An analysis of basin conditions that demonstrates that the basin has operated within its sustainable yield for at least a 10-year period (ABC Alternative) (Wat. Code ,§ 10733.6(b).)

To be eligible to submit any of the above Alternative Plans, the local agency must be able to demonstrate that (1) the Alternative Plan applies to the entire basin (23 Cal. Code Regs., § 358.2(a)), and (2) the basin is in compliance with Part 2.11 of the Water Code. Additionally, the local agency must demonstrate that its Alternative Plan 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 [Plan] to achieve the objectives of [SGMA]." (23 Cal. Code Regs., § 358.2(d).)

1.2 ANALYSIS OF BASIN CONDITIONS ALTERNATIVE

To be considered as an Alternative Plan, the Analysis of Basin Conditions Alternative must demonstrate "that the basin has operated within its sustainable yield over a period of at least 10 years." (Wat. Code, § 10733.6(b)(3).) SGMA defines "sustainable yield" as "the maximum quantity of water, calculated over a base period representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result." An "undesirable result" is defined as:

"[O]ne or more of the following effects caused by groundwater conditions occurring throughout the basin:

1. Chronic lowering of groundwater levels indicating a significant and unreasonable depletion of supply if continued over the planning and implementation horizon. Overdraft during a period of drought is not sufficient to establish a chronic lowering of groundwater levels if extractions and groundwater recharge are managed as necessary to ensure that reductions in groundwater levels or storage during a period of drought are offset by increases in groundwater levels or storage during other periods.
2. Significant and unreasonable reduction of groundwater storage.
3. Significant and unreasonable seawater intrusion.
4. Significant and unreasonable degraded water quality, including the migration of contaminant plumes that impair water supplies.
5. Significant and unreasonable land subsidence that substantially interferes with surface land uses.
6. Depletions of interconnected surface water that have significant and unreasonable adverse impacts on beneficial uses of the surface water."

(Wat. Code, § 10721(x)(1)-(6).)

1.3 Introduction to District's Analysis of Basin Conditions Alternative for the TVS Basin

The South Tahoe Public Utility District (District) has developed this Analysis of Basin Conditions Alternative for the Tahoe Valley South Subbasin of the Tahoe Valley Groundwater Basin, designated as DWR Groundwater Basin 6-5.01 (TVS Basin). This ABC Alternative was prepared in accordance with both SGMA and the Emergency Groundwater Sustainability Plan Regulations (California Code of Regulations, Title 23, Division 2, Chapter 1 .5, Subchapter 2). As demonstrated in this report, the District's Analysis of Basin Conditions Alternative is functionally equivalent to a GSP.

The following ABC Alternative uses information from the 2014 GWMP (Kennedy-Jenks, 2014), information derived from hydrologic modeling analysis performed pursuant to the GWMP implementation plan (Carroll *et al.*, 2016a; Carrol *et al.*, 2016b), and new information developed from monitoring data collected under the basin monitoring program.

The District held a public meeting on December 15, 2016 at which it discussed the findings in this report and directed staff to submit the ABC Alternative to DWR as an Alternative Plan. (see Attachment A.) No comments were received at this meeting. Development of the ABC Alternative was also discussed at numerous stakeholder advisory group (SAG) meetings over the past several months.

1.3.1 Analysis Area

The TVS Basin 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 subbasins: Tahoe Valley South, Tahoe Valley West, and Tahoe Valley North (Figure 1-1). Of these three subbasins, the TVS Basin is the largest and most productive.

The ABC Analysis Alternative covers the entire TVS Basin, satisfying the Alternative Plan requirement that an Alternative Plan apply to an entire groundwater basin, as well as the surrounding watersheds that contributes groundwater flow to the TVS Basin (see Figure 1-2). (23 Cal. Code Regs., § 358.2(a).) From the TVS Basin's western boundary, the analysis area further extends to include the watersheds that flow into Emerald Bay and Fallen Leaf Lake, as well as the Camp Richardson Watershed abutting Lake Tahoe. In the southwest and southern regions, the Tallac Creek, Taylor Creek, and Upper Truckee Watersheds are included. In the east, Trout Creek, Bijou Creek, and Bijou Park Watersheds extend to the California/Nevada state line. The Edgewood Creek and Burke Creek watersheds in Nevada are also included because groundwater from these areas flows into the TVS Basin (Figures 1-1 and 1-2).

The TVS Basin has an area of approximately 23 square miles (14,814 acres) in El Dorado County, California (Figure 1-2). The TVS Basin is roughly triangular in aerial extent and is bounded on the southwest by the Sierra Nevada, on the southeast by the Carson Range, and on the north by the southern shore of Lake Tahoe. The Basin generally conforms to the valleys of the Upper Truckee River and Trout Creek. The TVS Basin does not share a boundary with any other DWR basin or subbasin. The City of South Lake Tahoe (CSLT) overlies the northern portion of the TVS Basin. The southern boundary extends about 3 miles south of the town of Meyers. The northeast boundary of the TVS Basin is defined by the California-Nevada state line.

Elevations within the TVS Basin range from 6,225 feet at lake level, rising to above 6,500 feet within the TVS Basin (Figure 1-3). Elevations extend above 10,000 feet within the analysis area along the Carson Range and Sierra Nevada. Portions of seven watersheds overlie the TVS Basin, the largest of which include the Upper Truckee River. The Upper Truckee River flows north across the entire length of the basin and drains into Lake Tahoe through the Upper Truckee Marsh. The Upper Truckee River is joined by Grass Lake and Big Meadow Creeks along the southern extent of its course, Angora Creek centrally, and Trout Creek near Lake Tahoe (Figure 1-3).

1.3.2 Jurisdictional Boundaries

The TVS Basin underlies several different jurisdictions as shown on Figure 1-4. These include CSLT, the unincorporated communities of Meyers, Angora Highlands and Christmas Valley, and portions of unincorporated eastern El Dorado County. Within the greater South Lake Tahoe area, the majority of the land use is classified as Conservation area, followed by Residential, Recreation, Commercial and Public Service, and Tourist areas. The majority of the Conservation areas are federal lands managed by the United States Forest Service - Lake Tahoe Basin Management Unit (USFS-LTBMU). Most of the USFS-LTBMU managed land is located outside of the TVS Basin, but does include large areas around the Camp Richardson/Fallen Leaf Lake area within the northwest portion of the TVS Basin and along the basin margins on the eastern side of the TVS Basin. Additional information related to local governmental agencies with jurisdiction overlying the TVS Basin is attached as Attachment B.

1.3.3 TVS Basin's Compliance with Part 2.11 of the Water Code

The District has prepared a CASGEM Monitoring Plan, which has been approved by DWR, and has been designated as the CASGEM monitoring entity for the TVS Basin. (see Attachments C and D.) In compliance with Part 2.11 of the Water Code, the District monitors and reports groundwater elevation data to DWR on a semiannual basis.

1.3.4 Groundwater Model

A groundwater flow model was developed by the Desert Research Institute (DRI) for the hydrologic analysis area (Carroll, *et al.*, 2016a). The model is referred to as the TVS groundwater model. The model is used to quantify the TVS Basin conditions and is based on the U.S. Geological Survey (USGS) MODFLOW-NWT (Niswonger *et al.,* 2011) software. MODFLOW-NWT is the latest installment of the USGS modular program and relies on the Newton solution method and an unstructured, asymmetric matrix solver to calculate groundwater head. MODFLOW-NWT is specifically designed to work with the upstream weighted (UPW) 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) resolution. Layer thicknesses are 40 meters (131 ft) for layer 1 and layer 2, and 100 meters (328 feet) for layer 3. Layer 4 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 groundwater model simulates two distinct time periods. The first represents steady-state conditions prior to any significant groundwater production in the basin. Hydraulic conductivity was calibrated using the steady-state model configuration. The transient model simulates the period 1983-2015 to calculate changes in groundwater levels and flux due to variations in climate and groundwater extractions.

A second model was developed to simulate surface and subsurface hydrologic processes for the entire Lake Tahoe Basin and was used to calculate groundwater recharge. This model was developed by the DRI as part of a U.S. Department of Interior study looking at the historical and future water supply in the Truckee River Basin. The DRI model uses the numeric code Groundwater and Surface water Flow (GSFLOW, Markstrom *et al.,* 2008) which combines the USGS Precipitation-Runoff Modeling System (PRMS, Leavesley *et al.,* 2005) with the USGS Modular Groundwater Flow model (MODFLOW, Harbaugh 2005; Niswonger *et al.,* 2011). GSFLOW estimates energy and water budget partitioning to account for flow within and between the plant canopy and soil zone, streams and the groundwater, and is used to understand effects of climate change on the hydrology of mountain catchments to Lake Tahoe. This model is generally referred to as the GSFLOW Regional Model (GSFRM).

For calculations of recharge, the GSFRM is parameterized from the National Elevation Dataset (NED), State Soil Geographic (STATSGO) soils database, and USGS land use land cover (LULC) dataset. The depth of the root or soil zone is determined by the LULC for each 300 meter grid. Five categories of LULC are used in each 300 meter grid-cell based on dominant vegetation category: bare soils, grasses, shrubs, trees, and water. The GSFRM simulates transient conditions from 1980 to 2015. A two-year warm-up period is used to remove the influence of initial conditions. Daily weather data from four Snow Telemetry (SNOTEL) sites (Echo Peak, Fallen Leaf Lake, Hagans Meadow and Heavenly Valley) are used to drive the model in the region of the TVS Basin. While stations give point climate, Parameter-elevation

Regressions on Independent Slopes Model (PRISM) (PRISM Climate Group, 2016) data are used to distribute precipitation spatially over the entire basin. The four climate stations within the basin capture the gradient in precipitation from the west to the east side of the basin. This gradient is especially visible in wet and dry years, when the east side receives far less precipitation compared to the west side in dry years.

1.3.5 ABC Alternative Implementation Costs

Costs for implementation of the ABC Alternative are estimated using actual costs for the first two years of implementation of the District's GWMP, adopted in 2014, and projected costs using the 2-year average of the actual GWMP implementation costs projected over a 50-year period. The projected costs assumed Year 3, 4 and 5 costs at 50%, 40% and 30% of the 2-year average implementation cost. Costs projected after Year 5 are assumed to be at 20% of the 2-year average for years of regular activity and at 40% of the 2-year average for years on a 5-year reporting cycle. Based on these projections, the 50-year cost for implementation of the GWMP along with regular reporting to DWR as an ABC Alternative is estimated at $3.794 million. The average cost for implementation over this period is estimated at approximately $76,000 per annum.

Costs for implementation of the 2014 GWMP are from the District's Water Enterprise Fund. Costs for development and implementation of the District's groundwater management activities have been supported by the El Dorado County Water Agency (EDCWA) under its Cost Share Grant program. Under this program, EDCWA 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. It is believed that implementation of the GWMP and reporting as an ABC Alternative would be funded in a like manner as used for the 2014 GWMP.

2. BACKGROUND

2.1 SOUTH TAHOE PUBLIC UTILITY DISTRICT

The District was formed under the Public Utility District Act, which authorizes the District to manage local groundwater resources, including developing, adopting, and implementing a groundwater management plan. (Pub. Util. Code § 15501 *et seq*.) The District is a local agency within the meaning of both the Groundwater Management Plan laws and the Sustainable Groundwater Management Act (see Wat. Code §§ 10753(a), 10721(n).) The District's organization and management structure is provided in Attachment E.

The District is the largest water purveyor in the South Lake Tahoe area and utilizes only groundwater as its water source. Groundwater production from the District's wells is estimated to account for 83 percent of the total volume of groundwater extracted from the TVS Basin on an annual basis.

The District's service area extends beyond portions of the boundaries of the TVS Basin (Figure 1-2). Because of the topography and relief across its service area, the water system includes fifteen pressure zones, which are inter-connected using either booster pump stations or pressure reducing valves (PRVs). The District's water system presently includes thirteen active supply wells, two emergency standby wells, sixteen booster pump stations, twenty-six PRVs, twenty-three water storage reservoirs, 320 miles of waterline pipe and four well-head treatment systems. There are five interconnections with three neighboring water systems: Tahoe Keys Water Company (TKWC), Lukin's Brothers Water Company (LBWC), and Lakeside Park Association (LPA).

2.2 District's Groundwater Management Plan

The District has been sustainably managing the groundwater resources in the TVS Basin for decades. In 2000, the District adopted its initial GWMP (The District, 2000) in the form of a groundwater ordinance. In 2014, the District adopted a GWMP (Kennedy-Jenks, 2014) in accordance with Assembly Bill 3030, also known as the Groundwater Management Act under Water Code section 10750 et seq. Since its adoption, the 2014 GWMP has served as a successful planning tool enabling the District to maintain safe, sustainable, and high-quality groundwater resources in the long term. The 2014 GWMP includes both basin management objectives (BMOs) and a robust monitoring plan (Basin Monitoring Program). Based on the monitoring results, the District also prepares and presents an annual report (Annual Report) to the District's Board of Directors at a public meeting.

2.2.1 Basin Management Objectives

The 2014 GWMP includes the following BMOs:

- Maintain a sustainable long-term groundwater supply
- Maintain and protect groundwater quality
- Build collaborative capacity with local agencies, businesses, private property owners and the public
- Integrate groundwater quality protection into local land use planning activities
- Assess the interaction of water supply activities with environmental conditions
- Convene an ongoing SAG as a forum for future groundwater issues
- Conduct studies to assess future groundwater needs and issues
- Identify and obtain funding for groundwater projects

Maintaining and protecting the TVS Basin's groundwater resources is the primary BMO for the TVS Basin. Implementation of this BMO includes, but is not limited to, the regular monitoring and review of groundwater quality data, and the continued implementation of well standards for well construction, abandonment and destruction. Improving the integration of groundwater management into existing regulatory and land use planning programs is another related BMO included in the District's 2014 GWMP.

Stakeholder involvement with regional groundwater management is a key aspect for implementing the 2014 GWMP. Therefore, one of the 2014 GWMP's BMOs focuses on building collaborative capacity with local agencies, businesses, private property owners and other beneficial users of the groundwater basin. Pursuant to this BMO, the District provides educational services to the public through public presentations of informational items on relevant groundwater issues affecting the community. The District also supports a Stakeholders Advisory Group (SAG) that advises the District on groundwater issues and continues to foster an overall spirit of collaboration.

Conducting technical studies to assess future groundwater needs and issues is another key BMO for the TVS Basin. Actions under this BMO include supporting future groundwater studies that may include improving groundwater cleanup activities to mitigate ongoing impairment of water supplies, further evaluation of potential pumping effects on groundwater–surface water interactions, refining the groundwater budget, further evaluating groundwater flow conditions in significant water-bearing zones used for drinking water supply, assessing areas of degraded water quality, updating the District's current groundwater flow model, expanding the District's monitoring well network, and assessing the potential future need and feasibility of groundwater replenishment facilities for the TVS Basin.

2.2.2 Basin Monitoring Program

Implementing the Monitoring Program, the District collects data on a regular basis to assess groundwater conditions within the TVS Basin. Groundwater level measurements are collected by the District at designated groundwater supply and monitoring wells as designated by the 2014 GWMP using identified protocols and other supporting documents. Samples for groundwater quality are collected by the District at all public water system wells in accordance with the requirements of the California Department of Drinking Water (DDW). Additional groundwater level and quality data are compiled from other agencies that collect data in the TVS Basin. The District coordinates the collection of groundwater pumping volumes in the TVS Basin by the District and other water systems.

The District reviews the collected data with respect to historical data for each sampling location to assess changes in trends. Groundwater quality data is compared to drinking water quality standards as defined by the DDW, and the water quality objectives for groundwater in the TVS Basin provided in the Lahontan Regional Water Quality Control Board (LRWQCB) Basin Plan. The Basin Monitoring Program is modified by adding/removing wells over time based on the ongoing assessment of basin conditions; modifications are addressed in Annual Reports. Additional information regarding the District's Basin Monitoring Program is provided in Attachments F and C.

2.2.3 Reporting

The District prepares an Annual Report on the implementation of the 2014 GMWP to assess the groundwater supplies and conditions in the TVS Basin, including progress on implementation of the BMOs. The results from the Basin Monitoring Program and data review are included in the Annual Report. Each Annual Report identifies and prioritizes any groundwater quality issues, including proposed actions or inter-governmental agency coordination. The reports may include such other information as the District determines applicable to groundwater supplies in the TVS Basin. The District presents each Annual Report at a public hearing at a regularly scheduled Board of Directors meeting.

2.2.4 Stakeholder Advisory Group

Within the Lake Tahoe area, there is an existing, on-going coordination and collaboration with water issues in the TVS Basin through the SAG. The SAG was originally convened to provide input for the development of the 2014 GWMP, from various stakeholders that represented the District, local water purveyors, governmental agencies, business interests, and ratepayers representing a broad spectrum of interests. The District intends to continue convening SAG meetings pursuant to the ABC Alternative to ensure that local stakeholders remained engaged in—and abreast of—groundwater management concerns impacting the TVS Basin. Additional information regarding the SAG is provided in Attachment G.

2.3 District GSA Formation

In compliance with SGMA, the District has submitted two separate GSA formation notices to DWR to act as the GSA for the TVS Basin. On November 17, 2015, the District was recognized by DWR as the exclusive GSA for the portion of the TVS Basin within its service area jurisdiction. On September

29, 2016, pursuant to a memorandum of understanding with EDCWA, the District submitted a supplemental formation notice to act as the GSA for the remainder of the TVS Basin. The District expects to be recognized by DWR as the non-exclusive GSA for these portions of the TVS Basin on December 28, 2016. The District's exclusive and non-exclusive GSA boundaries are depicted in Figure 1-4.

3. BASIN SETTING

3.1 CLIMATE

3.1.1 Climatology

In general, precipitation falls as a result of moisture that moves into the area as weather systems move east from the Pacific Ocean (Crippen and Pavelka, 1970; Thodal, 1997). These masses are forced upward when they encounter the Sierra Nevada; as a result, precipitation is higher in the Lake Tahoe Basin than it is either in the Central Valley to the west, which lies at a low elevation, or the Carson City area to the east, which is in the rain shadow of the Sierra Nevada.

Due to this rain shadow effect, precipitation is generally greater in the western portion of the Lake Tahoe Basin as compared to the eastern portion (Figure 3-1). Frontal systems typically come from the west from November through May and account for over 85 percent of precipitation in the Lake Tahoe Basin. In some years, summertime monsoon storms from the Great Basin bring intense rainfall, especially to high elevations, primarily affecting areas to the northeast of South Lake Tahoe. Mean annual precipitation ranges from a low of 20 inches near Lake Tahoe to a high of 40 inches in the southwest. In the higher elevations annual precipitation can exceed 75 inches in the western basin, 55 inches in the south, and only 35 inches along the eastern flank near Heavenly Valley Ski Resort. On average, 334,000 acre-feet per year (AFY) of precipitation falls within the hydrologic area being analyzed in this ABC Analysis.

Most annual precipitation is in the form of snow. In the Sierra Nevada, snow falls in great quantities from late November to early April. Winter snow pack in the mountains can exceed 20 feet. Figure 3-1 shows the locations of the climate stations (SNOTEL) in South Lake Tahoe. The Echo Peak station measures almost twice as much precipitation as the other three stations (Fallen Leaf, Heavenly Valley, and Hagan's Meadow) that are located at lower elevations or to the east.

Table 3-1. Classification system for Water Years (WY) based on observed WY accumulated precipitation (P) at Hagen Meadows SNOTEL site. Upper bound of z-statistic and ranges in P provided.

WY Type	z (upper)	P (in)		Count
		>	≤	
Critical	-1.5	0	16	1
Dry	-1	16	21	4
Below	-0.5	21	25	7
Normal	0.5	25	35	10
Above	1	35	40	4
Wet	1.5	40	45	5
Very Wet	> 1.5	45	-	2

The South Lake Tahoe area experiences considerable variability in annual precipitation as shown in Figure 3-2. Over the period from 1979 to 2016, annual precipitation ranged between just under 15 inches (1987) to over 52 inches (1982) at the Hagan's Meadow climate station. Although precipitation rates in the region are highly variable, the annual average precipitation (29.7 inches) over the last ten years (2006 – 2015) is similar to the longer-term average (31.2 inches) over the period of 1979 through 2015. Recently, the region has been experiencing a lower than average precipitation from 2012 through 2015.

3.1.2 Water Year Classification

Water Year (WY) Classification refers to the categories used to assess the amount of annual precipitation in a basin. DWR generally assigns water year type based on river flow indices or precipitation amounts. For example, in the Sacramento Valley the State Water Resources Control Board (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).

For the TVS Basin, water years 1979 – 2016 were categorically defined by assuming a normal distribution in precipitation and establishing ranges based on the z-statistics in Table 3-1. To allow more flexibility in water year type, seven categories were established: 1) critical, 2) dry, 3) below normal, 4), normal, 5) above normal, 6) wet, and 7) very wet. Choice of z-statistics to define water years was selected to allow at least one critical water year over the 33-year analysis. Hagan's Meadow was used as the climate station because hydrologic modeling showed it best represented precipitation within the TVS Basin. The extremely wet periods are indicated by a z-statistic > 1.5 and occur in WY 1982 and WY 2011. The 2011 very wet year was the precursor to several years of lower than average conditions and WY 2015 is at the tail end of this drier than normal period and while it is not the single driest recorded event over the period it represents a more moderate drought that has lasted several years and can be compared to the drought of the early 1990s.

3.1.3 Climate Change

Recent findings show significant shifts in the timing of snowmelt and observed streamflow in several watersheds in the Sierra Nevada (Coats, 2010), and vulnerability of groundwater to changing climate in the region (Singleton and Moran, 2010).

A hydrologic modeling study was conducted in a nearby Lake Tahoe watershed (Incline Creek, Third Creek, and Galena Creek) to gain insight into mechanisms behind these potential changes (Huntington and Niswonger, 2012). An integrated surface and groundwater model was used to simulate climate impacts on surface water/groundwater interactions using projections of temperature and precipitation from 2010 to 2100, and to evaluate the interplay between snowmelt timing and streamflow, groundwater recharge, storage, groundwater discharge, and evapotranspiration.

Global Climate Models (GCMs) indicate that increased carbon dioxide concentrations will lead to increased temperatures within the study area by 2°C (3.6°F) – 4°C (7.2°F) from 2010 to 2100 relative to the base period of 1950 through 2010 (Christensen *et al.*, 2007). Actual temperature increases are highly dependent on the carbon dioxide emission scenario which relies on assumptions of population growth and future reliance on fossil fuels.

The climate models do not agree on expected changes in precipitation. For Greenhouse Gas (GHG) scenario A2, which is one of the most aggressive emissions scenarios (4°C or 7.2°F increase in temperature by 2100), four GCMs predict a steady decrease in annual precipitation, while the other two predict a steady increase in precipitation. The Geophysical Fluid Dynamics Laboratory (GFDL) Climate Model Version 2.1 model predicts the largest declines in precipitation on the order of 20 percent by the end of this century.

Though changes in precipitation magnitude are highly uncertain, all models agree that the snowpack will decline significantly in the future due to precipitation falling mostly as rain instead of snow (Huntington and Niswonger, 2012). This result is seen clearly in Figure 3-3 which shows the predicted changes in various hydrologic variables for the emissions scenario A2. According to this scenario, the snow-water content, which is a measure of the amount of water contained within the snowpack, decreases by a factor of five between 2010 and 2100. Additionally, increasing temperatures will result in significant timing shifts of hydrologic response. In particular, the snowpack will begin to melt earlier and earlier, which will cause peak runoff to occur about six weeks earlier in 2100 than it did in 2010. The earlier runoff cascades through the hydrologic system and impacts the timing of all other important hydrologic processes, including groundwater recharge, which is expected to peak about one month earlier in 2100 as compared to 2010.

Because of the large uncertainty in precipitation predictions, impacts to total groundwater recharge are difficult to predict. Four models suggest declining recharge while two suggest increasing trends (see Figure 3-3) (Huntington and Niswonger, 2012). Predicted declines for four of the models are approximately 10 percent by 2100.

3.2 Land Use

The Tahoe Regional Planning Agency (TRPA) developed a generalized depiction of the approved land uses for the Lake Tahoe Basin (TRPA, 2012). The land-use classifications are shown in Figure 3-4 for the Analysis of Basin Condition Alternative's hydrologic analysis area. The area and percent coverage is provided in Table 3-2. Land use within the TVS Basin is primarily designated as either backcountry (33,306 acres or 33.3 percent) or conservation (33,689 acres or 33.7 percent). To a lesser extent, wilderness (15,586 acres or 15.6 percent), residential (9,163 acres or 9.2 percent), recreation (5,844 acres or 5.9 percent), mixed-use (1,591 acres or 1.6 percent), tourist (395 acres or 0.4 percent), and resort recreation (306 acres or 0.3 percent) comprise the balance of land use categories overlying the TVS Basin. There are no agricultural or industrial land use types within the analysis area.

Land use classifications are defined by TRPA in the 2012 Regional Plan for Lake Tahoe (TRPA, 2012). Wilderness Areas are designated and defined by the U.S. Congress as part of the National Wilderness Preservation System. These lands offer outstanding opportunities for solitude and primitive, unconfined recreation experiences, and they contain ecological, geological, and other features of scientific, educational, scenic and historic value. Backcountry Areas are designated and defined by the U.S. Forest Service as part of their Resource Management Plans. These lands are roadless areas where natural ecological processes are primarily free from human influences. Conservation Areas are non-urban areas with value as primitive or natural areas, with strong environmental limitations on use, and with a potential for dispersed recreation or low intensity resource management. Recreation Areas are non-urban areas with

Table 3-2. Land use area and percent cover within the hydrologic study area.

Land Use	Area (acres)	Percent Cover
Backcountry	33,306	33.3%
Conservation	33,689	33.7%
Mixed-Use	1,591	1.6%
Recreation	5,844	5.9%
Residential	9,163	9.2%
Resort Recreation	306	0.3%
Tourist	395	0.4%
Wilderness	15,586	15.6%
Total:	99,878	

good potential for developed outdoor recreation, park use, or concentrated recreation. Resort Recreation Areas are the specific Edgewood and Heavenly parcels. Residential Areas are urban areas having potential to provide housing for the residents of the region. In addition, the purpose of the residential classification is to identify density patterns related to both the physical and manmade characteristics of the land and to allow accessory and non-residential uses that complement the residential neighborhood. Mixed-use Areas are urban areas that have been designated to provide a mix of commercial, public services, light industrial, office, and residential uses or have the potential to provide future commercial, public service, light industrial, office, and residential uses. Tourist Areas are urban areas that have the potential to provide intensive tourist accommodations and services or intensive recreation.

3.3 Soils

The TVS Basin consists of three soil types including alfisols, entisols, and inceptisols (NRCS, 2016). The spatial distribution of soil types is shown in Figure 3-5. Alfisols are primarily located in the eastern portion of the TVS Basin and develop from weathering processes that leach clay minerals out of the surface layer and into the subsoil. Alfisols tend to form under forest canopies and provide relatively high fertility to vegetation. The entisols occur within the eastern portion of the basin associated mountainous terrain. Entisols are weakly-developed soils that are unaltered from their parent material. Inceptisols are located along the western portion of the TVS Basin and along riparian corridors of Trout Creek and the Upper Truckee River. The inceptisols are better developed than entisols, but lack accumulation of clays which allows them to drain freely.

3.4 Geology

The regional geology for the Lake Tahoe Basin can be generalized as mountains composed mainly of granitic rocks and valleys filled with basin-fill sedimentary deposits. These basin-fill deposits in the valleys are the primary sources of groundwater in the Lake Tahoe Basin. The basin-fill deposits have been reworked by glacial activity, alluvial and fluvial processes, and by Lake Tahoe as the lake level fluctuates. Figure 3-6 shows the distribution of these deposits in the southern Lake Tahoe area (Saucedo, 2008). The surrounding mountains are primarily composed of granitic rock, but localized areas of volcanic rocks in the extreme headwaters of the Upper Truckee River to the south, as well as Jurassic-age marine sedimentary rocks near Fallen Leaf Lake. Furthermore, there are isolated outcrops of metamorphic rocks located on the northeast portion of the hydrologic analysis area in Nevada.

Lake Tahoe rests within a fault-bounded structural basin, or graben, bordered on the west by the Sierra Nevada and on the east by the Carson Range (U.S. Army Corps of Engineers, 2003). The Tahoe graben formed about two to three million years ago, leading to the large elevation difference between the Lake and the surrounding mountains (U.S. Army Corps of Engineers, 2003). The Tahoe-Sierra Frontal Fault Zone defines the west side of the Tahoe graben within the analysis area and is considered to be a Quaternary east-dipping normal fault, with east-side-down displacements (USGS, 2006). This western bounding fault zone is reflected as a northwest-southeast lineament along the mountain front of the Crystal Range from Emerald Bay toward Meyers, California. There are limited groundwater level and aquifer test data in the higher elevations where this fault is mapped so its effect on groundwater flow is not fully known. The East Tahoe Fault is inferred to form the eastern side of the Tahoe graben, and is poorly characterized as a Quaternary west- or east-dipping normal fault (USGS, 2006) This bounding fault strikes north-south along the mountain front of the Carson Range, from Stateline toward Meyers. The Tahoe Valley Fault Zone is a poorly characterized Quaternary fault that strikes southwest-northeast in the analysis area (USGS, 2006). There is limited evidence that this feature acts as a barrier to groundwater flow.

The depth and composition of the sediment-filled valleys was strongly affected by glaciation. At least four periods of major glaciation and one minor glacial advance took place during the Pleistocene Epoch (about 2 million to about 10,000 years) that greatly modified the landscape in the Lake Tahoe Basin. Large valley glaciers formed in most of the canyons around the lake, except along the eastern shore where glaciation was limited to the northern sides of the highest peaks (Burnett, 1971). One major result of the glaciations was the deposition of large quantities of sediment in the form of outwash, till, and moraine deposits, as well as discharge of considerable quantities of finer sediment into the lake. The deposits in Lake Tahoe and adjoining valleys can be greater than 1,000 feet thick in places (Hyne et al., 1972). Much of the glacially derived sediment is from decomposed granite that had been scoured away and reworked from the granitic slopes of the western and southern mountains.

The current outlet from Lake Tahoe, and the present-day Truckee River system, was formed between 10,000 - 75,000 years ago. Earlier, the elevation of the outlet was affected by the formation of ice dams. The lake level during these events is believed to have risen to as high as 6,800 feet (Birkeland, 1962) as a result of the formation of an ice dam at the natural outlet. The ice dam is believed to have been breached several times, resulting in periodic, catastrophic flooding down the valley and periodic lowering of the lake level. During the interglacial periods, the lake level would have been similar to today's level. Lava flows at the outlet of Lake Tahoe provide a minimum threshold for lake elevation at about 6,220 feet.

Within the TVS Basin, the geology consists of glacial, fluvial, and lacustrine basin fill deposits overlying the bedrock units. The distribution of these units at the surface is shown on the geologic map in Figure 3-6. Basin-fill deposits range in thickness from less than 100 feet along the basin margins to over 1,000 feet thick in the deeper portions of the TVS Basin. Gravity survey and well drilling information suggests that at least three areas of thick sediments occur within the TVS Basin. The largest of these underlies CSLT between the Tahoe Keys development and Bijou Creek. A second is located near the south shore of Lake Tahoe, north of Fallen Leaf Lake, underlying the present drainages of Baldwin and Taylor Creeks. A third underlies the Meyers area south of Twin Peaks. The areas where the basin-fill deposits are on the order of 600 feet to 1,000 feet thick generally correlate with the areas of the highest groundwater production.

Most of the basin-fill deposits consist of glacial outwash, which typically consists of fine silt to large boulders that have been sorted and stratified by the action of water sources from glaciers. Permeability of these deposits is typically moderate to high and these deposits are the primary groundwater producing zones in the analysis area.

During periods with high lake levels associated with the formation of glacial ice dams at the Lake Tahoe outlet, lake levels increased to several hundred feet above current lake level (about 6,225 feet above mean sea level (AMSL)). This resulted in extensive deposition of fine-grained lacustrine sediment at the bottom of Lake Tahoe, as well as in areas above and fringing the current lake level. These lacustrine deposits contain significant amounts of silts and clays having lower permeability. Changes in the elevation of the surface of Lake Tahoe over the geologic history of the lake have resulted in lacustrine deposits as high as 600 feet above the current lake. The more continuous and lower permeability fine-grained deposits form confining layers that affect groundwater flow through the basin.

In the TVS Basin, alluvial sediments are present around the streams (Figure 3-6). These sediments are primarily floodplain deposits composed of stratified silt and sand, stream channel deposits consisting of stratified sand and gravel with locally interbedded lacustrine deposits composed of bedded silt and clay (Harrill, 1977). The alluvium ranges from 10 to 20 feet thick near the basin margin and more than 500 feet thick near the south shore of Lake Tahoe. The alluvial deposits are restricted to stream margins and floodplains and consist mostly of decomposed granite from surrounding hillslopes and reworked glacial deposits. The alluvial sediments generally are very permeable.

Alluvial and fluvial sediment within stream and meadow depositional environments also are interbedded with layers of dark gray (nearly black) organic-rich sediment (buried soils) mixed with decomposing plant material and organic silt with stringers of coarse sand near the surface. These deposits are generally in the range from 5 to 8 feet thick, but may have local influence on the movement of shallow groundwater and interaction with surface water (Rowe and Allander, 2000).

Other sediment found in the TVS Basin include glacial deposits. The glacial deposits were formed as valley glaciers advanced north toward Lake Tahoe through the Upper Truckee River Valley during at least four episodes of glaciation during the Quaternary. As these glaciers advanced and receded, they formed ground, lateral, and terminal moraines. Ground moraine or glacial till in the analysis area consists of variable mixtures of silt and sand with cobble to boulders deposits that are poorly sorted and massive because these sediments were deposited from the underside of glaciers. Terminal and lateral moraine landforms form many of the ridges and other topographic features in the analysis area and are also composed of poorly sorted and massive deposits consisting of variable mixtures of silt and sand with gravel to boulder size sediment similar to glacial till. Due to their fine-grained matrix, the glacial till and moraine deposits typically have only moderate permeability. The Angora Ridge, located along the western side of the TVS Basin near Angora Creek, is a lateral moraine landform.

In addition to sediment directly deposited by glacial ice, sediment-laden melt-waters from the receding glaciers flowed downstream north toward Lake Tahoe. These streams dropped their sediment loads along their stream channels and in broad coalescing flood fans and outwash plains. These outwash fan and fluvial channel deposits are composed of layered beds of well sorted gravel, sand and silt size material, with moderate to high permeability. Where these glacial streams deposited sediment directly into Lake Tahoe, broad deltas were formed of interbedded sand with silt and clay. These delta sequences grade laterally with:

- lakeshore deposits consisting of moderately well sorted sand and gravel deposits with relatively high permeability;
- inter-fan and marsh deposits consisting of fine-grained sand, silt, and clay; and
- lake deposits, consisting of silt and clay.

Two representative cross sections (Figures 3-7 and 3-8) depict the interbedded nature and variability in thickness of the basin-fill within the TVS Basin that consist of coarse-grained glacial outwash, fluvial, and deltaic deposits and fine-grained lacustrine sediment. Figure 3-7 shows a north-south cross section extending north of Meyers across the area of thick basin fill to the south shore of Lake Tahoe. Figure 3-8 shows an east-west cross section along the south shore of Lake Tahoe from near Camp Richardson to near Bijou Creek on the east.

Most water wells drilled in the TVS Basin 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 basin, but thin toward the basin margins where they are underlain by shallow bedrock.

Permeability of these sediments differs considerably, both spatially within each unit and between the different units. In general, high permeability is found in glacial outwash and fluvial deposits, while glacial moraine and lacustrine deposits tend to have moderate and low permeability, respectively (Thodal, 1997; Fogg et al., 2007). Fogg *et al.* (2007) used lithologic and geophysical logs to construct a series of 10 regional cross-sections through the TVS Basin. They identified at least 26 water-bearing zones within the basin-fill aquifer using the 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.

The relatively high permeability glacial outwash and delta deposits form excellent groundwater aquifers. The best of these aquifers have been found in the north, primarily beneath the present day Truckee Marsh. Both the inter-fan, marsh and lake deposits are fine-grained and have relatively low permeability. These fine-grained deposits form at least four locally extensive aquitards that separate the reservoirs into a minimum of at least five distinct regional aquifers. Where the sediment types are layered, the aquifer can be characterized as different water-bearing zones (WBZ). Where the fine-grained confining layers are more discontinuous, the WBZs act as leaky or semi-confined aquifers. The shallowest intervals occur in the upper 200 feet. These WBZs are unconfined to semi-confined depending on the continuity and relative permeability of the overlying fine-grained layers. These shallow WBZs are the zones that interact most with surface waters.

Figure 3-9 shows a conceptual hydrogeological cross section across the northern portion of the TVS Basin to illustrate these WBZs. Up to five of these zones have been identified as being practical for groundwater management (Bergsohn, 2011). The different WBZ designations are informal and are based on local geographic area and the stratigraphic order is shown as a subscript showing the order in which they occur from deep to shallow depth (1 = lowermost zone; 5 = uppermost zone). The deepest zone

(WBZ1 on Figure 3-9) occurs in the deepest portions of the basin, generally at depths below 600 feet, and may act as a confined aquifer and may locally show artesian conditions. The middle two zones (WBZ2 and WBZ3 on Figure 3-9) represent the interval at depths between 200 to 600 feet and the shallowest two zones (WBZ4 and WBZ5 on Figure 3-9) represent depths to 200 feet.

3.5 Surface Water Features

There are eleven sub-watersheds that fall within the hydrologic study area (Figure 3-10). These include Emerald Bay, Cascade Creek, Tallac Creek, Taylor Creek, Camp Richardson, Upper Truckee River, Trout Creek, Bijou Creek, Bijou Park, Edgewood, and Burke Creek Watershed. The total watershed area is 99,900 acres, all of which flow into Lake Tahoe.

There are seven USGS stream gages within the hydrologic analysis area (Figure 3-10). For the Taylor Creek Watershed, the Taylor Creek gage (10336626) is located at the outlet of Fallen Leaf Lake and has daily discharge data available from 1968 – 1992. In the Upper Truckee River Watershed there are two gages. One gage is located at Highway 50 above Meyers, California (103366092) with a period of record from 1990 - 2016, and another downstream in CSLT (10336610) with data from 1971 - 2016. In the Trout Creek Watershed there are three gages. The upstream gage is at U.S. Forest Service Road 12N01 (10336770) with data from 1990 – 2011. Downstream there is a gage at Pioneer Trail (10336775) with data from 1997 – 2003 and again from 2007 – 2014. Further downstream the third gage is located near Tahoe Valley (10336780) with discharge data from 1960 – 2016. On the Nevada side of the analysis area, a gage exists on Edgewood Creek at Stateline, Nevada (10336760) with data from 1992 – 2012.

Discharge data from the downstream gages at Edgewood Creek (10336760), Trout Creek (10336780) and the Upper Truckee River (10336610) were used to develop a regression between watershed area and average annual runoff (Figure 3-11). The exponential relationship yielded an R^2 of 0.99. The regression equation was used to estimate average annual runoff for the eight remaining watersheds in the hydrologic analysis area (Table 3-3). Total average annual runoff from the analysis area to Lake Tahoe is estimated to be 124,000 AFY.

Numerous lakes occur within the hydrologic analysis area (Figure 3-10). Lake Tahoe is the principal hydrologic feature in the area. Lake Tahoe covers approximately 192 square miles in total area. In addition to Lake Tahoe, there are numerous other lakes and tributary streams in the South Lake Tahoe area. Some of the larger lakes in the area include Emerald Bay which is part of Lake Tahoe, Cascade Lake, Fallen Leaf Lake, and Echo Lake.

Over the last few decades the water surface elevation of Lake Tahoe ranged from 6,220 to 6,229 feet AMSL, and is controlled by the Lake Tahoe Dam, which regulates discharge into the Truckee River near Tahoe City. The natural sill (i.e., rim) of the basin is at 6,223 feet AMSL and once lake level drops below this elevation water is unable to be released to the Truckee River. Figure 3-12 provides a hydrograph for Lake Tahoe from 1980 to 2016. During this period, the Lake elevation has fallen below the natural rim eight times in response to drought periods.

Surface water features also help to filter water and provide critical habit in Lake Tahoe Basin. The most important of these features have been identified as Stream Environment Zones (SEZ). SEZ is a unique term developed by TRPA to denote perennial, intermittent and ephemeral streams and drainages, as well as marshes and meadows in the Lake Tahoe area. SEZs generally possess the characteristics of

Table 3-3. Estimates of average annual runoff for eleven sub-watersheds in the hydrologic analysis area.

Waterhsed	Area (acres)	Runoff (af)	Method
Burke Creek	3,179	2,936	Regression
Edgewood Creek	4,275	3,243	Measurements (2007-2012)
Emerald Bay	5,639	3,755	Regression
Bijou Park	1,974	2,603	Regression
Cascade Creek	3,019	2,889	Regression
Tallac Creek	2,932	2,864	Regression
Bijou Creek	1,807	2,560	Regression
Camp Richardson	2,651	2,785	Regression
Taylor Creek	11,787	6,943	Regression
Trout Creek	26,428	25,361	Measurements (1960-2016)
Upper Truckee	36,216	68,400	Measurements (2007-2016)
Total:	**99,907**	**124,339**	

riparian or hydric (wet site) vegetation, alluvial, hydric soils, and/or the presence of surface water or near-surface groundwater at least part of the year. As shown on Figure 3-13, the SEZs in the Lake Tahoe Basin include areas with seasonally high groundwater levels. The SEZs help protect water quality because as the surface water flows slow in these areas, natural processes of infiltration, nutrient uptake, denitrification, and sediment capture help to reduce sediment and nutrients in the surface water.

3.6 Groundwater Conditions

3.6.1 Groundwater Level History

Groundwater level data is measured semi-annually by the District in over fifty (50) wells that are located in the TVS Basin. The District well network includes thirty (30) observation wells and seventeen (17) municipal wells. All of the municipal wells are active and are used for public drinking water supply. Two 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 in the CASGEM program.

Construction details for selected wells in which hydrographs are provided are set forth in Table 3-4 and locations are shown on Figure 3-14. The groundwater zones, shown on Figure 3-14, are informal designations using geographically-based groundwater area designations (Christmas Valley, Meyers, Angora, South Lake Tahoe, Tahoe Keys and Bijou). Christmas Valley Zone is in the southernmost portion of the TVS Basin, south of Lake Valley and Highway 50. The Meyers Zone is located in the southern portion of Lake Valley from Highway 50 north to Twin Peaks. The Angora Zone is located in the southern portion of Lake Valley west of Twin Peaks. The South Lake Tahoe Zone is located north of Lake Valley

Table 3-4. Well screen intervals for selected groundwater elevation wells within the Tahoe Valley South Basin.

Well	Groundwater Zone	Ground Elevation (ft msl)	Top of Screen Depth (ft bgs)	Bottom of Screen Depth (ft bgs)
Mountain View	Angora	6313.14	95	164
			210	245
Blackrock Well #1	Bijou	6242.72	168	180
Henderson OW	Christmas Valley	6369.78	79	210
Bakersfield	Meyers	6310.50	180	240
			270	310
Elks Club Well #1	Meyers	6284.63	110	168
Washoan OW	Meyers	6307.84	102	275
CL-1	South Lake Tahoe	6278.37	104	115
CL-3	South Lake Tahoe	6278.49	39	50
Glenwood Well #3	Bijou	6261.68	112	192
Paloma	South Lake Tahoe	6267.10	188	248
			268	408
Sunset	South Lake Tahoe	6249.00	275	430
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
Valhalla	Tahoe Keys	6256.50	102	144

NOTES:

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

ft bgs: Depth in feet below ground surface.

from the Lake Tahoe Airport to the south shore of Lake Tahoe, west of the Tahoe Keys to Johnson Boulevard. The Tahoe Keys Zone is located north of Lake Valley from Camp Richardson east to the Tahoe Keys. The Bijou Zone is in the northeast portion of the TVS Basin from Johnson Boulevard east to Bijou Park.

The District collects semi-annual measurements timed to coincide with seasonal low (November) and high (May) groundwater elevations and continuous readings on a daily basis from selected wells using dedicated water-level monitoring equipment. Figures 3-15 to 3-20 present hydrographs for wells within each of these six groundwater zones for the period 2000 to 2016 based on semi-annual hand readings. The readings are collected over a two-day period to coordinate with water operations and allow production wells to be turned off for a minimum 12-hour recovery period prior to measurement. The descriptions below provide a brief interpretation of the water-level changes.

The District has one well in its basin monitoring network situated within the Tahoe Keys Zone. The Valhalla Well is an active water supply well constructed to a depth of 190 feet below ground surface (BGS) and produces water from the TKZ4 WBZ. Static water levels from this well are typically collected following a minimum 12-hour recovery time, with the exception of the May 2007 reading which shows a pumping water level (6,161.81 feet AMSL) recorded at a well pumping rate of 700 gallons per minute (GPM). With this pumping water level reading removed, groundwater elevations typically range from 6,210 to 6,235 feet AMSL (Figure 3-15). This well is located 1,600 feet from Lake Tahoe but does not show a significant correlation with the Lake Tahoe stage (Figure 3-15). This is consistent with the slow recovery behavior of this well following pumping. The static water levels collected from this well indicate that water levels in this area are stable.

Two types of groundwater level behavior are found in the Bijou Zone. The Blackrock Well #1 is a single observation well (converted from an inactive water supply well) constructed to a depth of 180 feet BGS and is screened through the BZ4 water-bearing zone. Static water levels in this well are stable, typically rising slightly above ground surface elevation (6,240 feet AMSL) as shown in Figure 3-16. The Glenwood Well #3 is a single observation well (converted from an inactive water supply well) constructed to a depth of 192 feet BGS and is also screened through the BZ4 water-bearing zone. This well is situated within 50 feet of the Glenwood Well # 5, an active water supply well producing water from the BZ3 and BZ4 water-bearing zones. The District uses the Glenwood Well #3 to monitor groundwater levels near the pumping well. In 2007, the District restricted pumping from the Glenwood Well #5 from late May through November in order to sustain production from the Bijou water-bearing zones. The water level response in the Glenwood Well #3 shows that this change in operation has been successful in allowing groundwater levels to recover to sustainable levels. Neither of the wells in the Bijou Groundwater Area responds to Lake Tahoe water levels. Regardless, these wells do not exhibit a long-term downward trend.

All three monitoring wells within the South Tahoe Zone exhibit relatively stable water levels (Figure 3-17). The CL-1 Well is a single observation well constructed to a depth of 115 feet BGS and is screened through the SLTZ5 WBZ. This well was constructed to monitor water levels in the neighboring Clement Well (offline since 1999). Water levels in the CL-1 Well generally range in elevation from 6,242 to 6,250 feet AMSL in response to seasonal changes in groundwater levels with no long-term trend. The Sunset Well is an active water supply well constructed to a depth of 440 feet BGS and produces water from the SLTZ2 and SLTZ3 WBZs. Static water levels from this well are typically collected following a minimum 12-hour recovery time. Water levels in the Sunset Well generally range in elevation from 6,219 to 6,234 feet AMSL in strong correlation with pumping rates (not shown Figure 3-17). The Paloma Well is an active water supply well constructed to a depth of 418 feet BGS and also produces water from the SLTZ2 and SLTZ3 WBZs. Likewise, the Paloma Well has water levels varying from 6,216 to 6,226 feet AMSL in concert with pumping rates. None of the wells exhibit a long-term downward trend.

The Mountain View Well within the Angora Zone is a single observation well (converted from an inactive artesian water supply well) constructed to a depth of 250 feet BGS and is screened through the AZ1 and AZ2 WBZs. Static water levels in this well are stable, typically rising slightly above ground surface elevation (6,313 feet AMSL) and flowing through an artesian overflow pipe to an adjoining meadow (Figure 3-18). In 2011, the Mountain View Well was removed from service and is currently used as an observation well. Manual discharge measurements indicate that artesian flow measured from the overflow pipe peaked in November 2011 at about 43 gallons per minute (GPM) and has steadily declined during the 2012-2015 drought to less than 10 GPM.

Groundwater levels within the Myers Zone are generally stable with short periods of declining water levels due to increased pumping rates (Figure 3-19). The Bakersfield Well is an active water supply well constructed to a depth of 330 feet BGS and produces water from the MZ3 and MZ4 WBZs. Static water levels from this well are typically collected following a minimum 12-hour recovery time with the exception of the May 2008 reading which is a pumping water level (6,239 feet AMSL) recorded at a well pumping rate of 1,500 GPM. With this pumping water level reading removed, groundwater elevations typically range between 6,278 to 6,289 feet AMSL. The Washoan Well is a single observation well constructed to a depth of 275 feet BGS and is screened through the SLTZ1, SLTZ2, SLTZ3 and SLTZ4 WBZs. Groundwater levels in this well are influenced by pumping of the Airport Well, which is evident in the initial static readings collected in 2001. The November 2015 water level measurement is believed to be an errant reading. With these anomalous readings removed, groundwater elevations typically range between 6,266 to 6,273 feet AMSL. The Elks Club Well #1 is a single observation well (converted from an inactive water supply well) constructed to a depth of 168 feet BGS and is screened through the MZ4 WBZ. This well is situated within 100 feet of the Elks Club Well # 2, an active water supply well producing water from the MZ3 and MZ4 WBZs. The District uses the Elks Club Well #1 to monitor groundwater levels near the pumping well (Elks Club Well #2). The Elks Club Well #2 replaced the Elks Club Well #1 as a production well in 2004. Using static water level readings collected after 2004, groundwater levels range from 6,265 to 6,275 feet AMSL (average of 6,271 feet AMSL). None of these wells exhibit a long-term downward trend.

The Henderson Well within the Christmas Valley Zone is a single observation well constructed to a depth of 210 feet BGS and is screened across the CVZ3 and CVZ4 WBZs. The CVZ3 and CVZ4 are used for water production at the South Upper Truckee Well #3. Water levels in the Henderson Well generally range in elevation from 6,242 to 6,252 feet AMSL with peaks in the spring when pumping is at a minimum and troughs in the fall following the peak summer pumping season (Figure 3-20). No long-term downward trend in water levels was observed in these groundwater zones.

3.6.2 Groundwater Flow Directions

Groundwater levels are shown in Figure 3-21 representing steady-state conditions (pre-1983) in the shallower (upper 300 feet) -- as simulated from the TVS Basin -- groundwater model. Figure 3-21 also shows generalized groundwater flow directions. Groundwater flows are generally directed from areas of high to low groundwater elevations. The relative rate of groundwater flow (i.e., velocity) is proportional to the hydraulic gradient and the hydraulic conductivity. The general groundwater level pattern observed in the TVS Basin is for higher groundwater levels to occur along the basin margins where a majority of recharge enters the groundwater system from higher elevations. Highest groundwater levels occur in the Christmas Valley Zone which also forms the topographically highest portion of the valley floor. From Christmas Valley, groundwater flows northward. Water from the Angora Zone flows southeast converging with flow from Christmas Valley and flow originating in the Carson Range to the east where groundwater flows around the lower permeable rocks in the Twin Peaks to the north along the Upper Truckee River riparian corridor. Ultimately groundwater discharges in local tributaries or to Lake Tahoe as underflow.

Groundwater elevation contour maps for May 2016 and November 2016 are presented in Figure 3-22 and represent a high and low groundwater level condition, respectively. The typical pattern is for the highest groundwater conditions to occur in the spring following the spring snowmelt and runoff. The lowest groundwater conditions typically occur in the late summer and early fall due to low recharge following the relatively dry summer months and increased groundwater pumping to meet seasonal demand.

Groundwater levels were contoured based on groundwater level measurements for all monitoring wells located in the TVS Basin. As indicated in Figure 3-7 and 3-8, the basin-fill deposits include a multitude of WBZs with inter-fingered clay lenses. To make maximum use of the available data, all wells are contoured together regardless of the WBZ where they are located. This is considered appropriate to illustrate the general pattern of groundwater flow in the TVS Basin.

Comparison of contours from the two measurement periods shows that the generalized pattern of groundwater flow remains similar between May 2016 and November 2016. This is consistent with the hydrograph data that shows the typical variation in groundwater levels is on the order of a few feet. In most of the TVS Basin, the November 2016 water level contours progress southward indicating a general lowering of water levels following the summer peak pumping months.

Vertical gradients were calculated for nested wells and adjacent well pairs located throughout TVS Basin (Figure 3-23). The nested piezometers SW-1, IW-1, and DW-1 are ideal for calculating vertical gradients as these are located approximately 50 feet from each other with average screen depths of 25, 130, and 240 feet BGS, respectively. Hydraulic heads measured in November 2016 were 6,319.24, 6,309.73, and 6,291.94 feet AMSL, for SW-1, IW-1, and DW-1, respectively. These data were used to calculate downward vertical gradients of 0.09 and 0.16 for the upper (SW-1 to IW-1) and lower (IW-1 to DW-1) sections, respectively.

Nested piezometers are not available in the northernmost part of the TVS Basin so nearby pairs with shallow and deep screen intervals were used to calculate a vertical gradient. The Sunset Well (average screen depth = 353 feet) is located approximately 2,200 feet west of the Chris Well (average screen depth = 121 feet), which is not ideal, but a general estimate of the vertical gradient can be made. In November 2016 the hydraulic head was measured at 6,225.87 and 6,222.93 feet AMSL for Sunset and Chris Wells, respectively. These data were used to calculate an upward vertical gradient of 0.01.

The USGS TCF Well is a nested well consisting of five observation wells completed in a single borehole that monitors groundwater levels at varying depths near Trout Creek in the South Lake Tahoe Groundwater Zone (Figure 3-23). Each of the WBZs monitored by this nested well are considered to be confined or semi-confined by the intervening clay and peat layers. Comparing the vertical difference in groundwater levels (see Figure 3-24) indicates upward flow from BZ1 and BZ3 toward BZ4 and downward vertical flow from BZ5 toward BZ4. The complex vertical flow directions observed in the nested well may result from the lowered potentiometric head in BZ4 induced by pumping of the Glenwood Well #5.

CL-1 and CL-3 are observation wells which were constructed as a well cluster at the Clement Well site. Both CL-1 and CL-3 monitor groundwater levels from the uppermost WBZ (TKZ5). Comparison of the vertical difference in groundwater levels (see Figure 3-25) shows higher groundwater levels in the shallow well indicating that vertical flow is directed downward through TKZ5 in this Groundwater Zone. Downward directed vertical flow through a WBZ is often a characteristic of recharge areas. These wells are located adjacent to Tahoe Mountain which is a known recharge area (see Figure 3-30).

These vertical gradients are consistent with the conceptual model of the TVS Basin in which recharge is generally occurring in the higher elevations, then flowing laterally and then moving up from depth to ultimately discharge in Lake Tahoe. Pumping effects may locally influence vertical hydraulic gradients between water-bearing zones.

3.6.3 Hydraulic Parameters

Aquifer tests were conducted at numerous wells providing estimates of hydraulic conductivity throughout the TVS Basin. Hydraulic conductivity is a measure of an aquifer's capacity to transmit water. A map of hydraulic conductivity values is shown in Figure 3-26.

The aquifer materials in the TVS Basin are very permeable. The hydraulic conductivity values range from 0.5 – 210 feet per day with a median of 27 feet per day and geometric mean of 20 feet per day. Aquifers with hydraulic conductivities greater than 1 foot per day are considered productive for groundwater extraction purposes.

The measured hydraulic conductivities were used to aid the groundwater model calibration process using the Pilot Point Methodology (Doherty, 2008). The hydraulic conductivity remains fixed at measured locations and an automated calibration procedure was used to adjust hydraulic conductivity values at unmeasured locations. Bedrock hydraulic conductivity values were assumed to be homogeneous. The resulting hydraulic conductivity field is shown in Figure 3-27. Highest permeability values are associated with the basin-fill deposits in the valley and along the riparian corridors. Bedrock hydraulic conductivity is 0.26 feet per day in the uppermost layer and decreases to 5.6×10^{-3} feet per day in deeper layers. Highest hydraulic conductivity values are located south of Twin Peaks near the Sioux A, Bakersfield, and Arrowhead 2 Wells in a region dominated by glacial deposits.

Storage parameters were determined through calibration of the transient groundwater flow model. A specific yield of 0.1 for bedrock and 0.3 for alluvium was used while specific storage was 3.0×10^{-7} ft^{-1} for all geologic units to achieve an agreement between simulated and measured water levels. Note that the average of storage coefficients derived from aquifer tests is 0.078, which is likely a measure of both confined and unconfined conditions.

3.6.4 Groundwater Storage

Groundwater storage within the TVS Basin has been calculated using a variety of techniques. In the 2015 Annual Report (Bergsohn, 2016), three storage values are presented ranging from 142,000 acre-feet (AF) to 2,400,000 AF. The lower value represents a storage volume calculated using lithological data from more than 110 water wells and pilot test holes drilled within the TVS Basin. The total depths of the borings used for this evaluation ranged from 30 to more than 850 feet (median = 442 feet); of which 30 percent were drilled to the bedrock contact. The larger value was calculated using the TVS Basin groundwater model but for all model cells that contained basin-fill deposits within the entire analysis area (i.e., beyond the TVS Basin). For this report another storage calculation was performed using the groundwater model, but limited to the TVS Basin and basin-fill sediments all the way to the bedrock contact. This second calculation yielded total storage of 2,700,000 AF. For the purposes of this report, the 2,700,000 AF of groundwater storage derived from groundwater that is limited to the TVS Basin, from the water table to the bedrock contact, is used for analysis of groundwater storage.

The smaller groundwater storage estimates calculated in the 2015 Annual Report relied on lithologic data to create a total sand isopach used to estimate the total reservoir volume of the water-bearing zones used for drinking water supply. The reservoir volume was tallied for coarse fractions (i.e. gravel; gravel and sand; coarse sand; and sand) exceeding forty feet in thickness for each well. The fine sand fraction was not included, as the amount of water pumped from this fraction for drinking water supply is believed to be minor. The storage coefficient was assumed to be 0.078 which is the average derived from 30 aquifer tests. Total storage estimates ranged between 142,000 – 196,000 AF depending on the interpolation method for the isopach map. Note that these estimates rely on analytically-derived storage coefficients which can be biased low. If specific yield storage coefficients are used (0.30), the total storage estimates range between 196,000 - 753,000 AF.

The value of total groundwater storage (2,700,000 AF) used for this analysis is derived from the groundwater model for the TVS Basin from the water table to the bedrock contact. Storage calculations were done using a Python script which reads simulated groundwater levels at every cell within the TVS Basin. For each cell, the code calculates storage by multiplying the difference in water table elevation and the cell bottom by the specific yield (0.3) and the cell's surface area (~ 2.5 acres). In other words, it multiplies the saturated volume of the cell by the specific yield. The storage for any cells below that cell was calculated in the same way, using the total volume of each cell as the saturated volume. Storage for all cells in a column was then summed, and the storage values for all columns were converted to a georeferenced raster image and clipped to the shape of the basin sediments. The raster cell values within this clipped shape were then summed to reach the final storage value.

3.6.5 Groundwater Quality

3.6.5.1 Data

The following analysis uses water quality data collected over the past 10 years to describe current groundwater quality conditions within the TVS Basin. These data consists of water quality records downloaded from the GeoTracker Groundwater Ambient Monitoring and Assessment (GAMA) database (last updated 11/09/2016) -- which include records from the GAMA-Department of Health Services dataset for water supply wells -- and records from the GAMA-Electronic Deliverable Format dataset for environmental monitoring wells (environmental wells). Environmental wells typically sample groundwater quality from the uppermost water-bearing zones, while the water supply wells typically sample groundwater quality in the deeper water-bearing zones used for drinking water production. For a detailed description of historical groundwater conditions, the reader is referred to Section 6.0 of the 2014 Groundwater Management Plan (Kennedy-Jenks, 2014).

3.6.5.2 General Groundwater Quality

Groundwater in the TVS Basin is generally of excellent chemical quality, suitable for the designated beneficial uses of municipal and industrial water use and for any other uses to which it might be put. Natural sources of salts are from the dissolution of minerals in the basin-fill deposits. Anthropogenic sources are from disposal of wastewater and infiltration of water containing fertilizers or other sources of salts, nitrates or phosphates. All sewage from within the Lake Tahoe Basin must be collected, treated and exported outside of the Lake Tahoe Basin. Spills and releases from the District's sewer collection system has the potential to contaminant surface water and groundwater quality. The District regularly performs inspections and maintenance on its sewer collection and recycled water export systems in order to prevent sewerage spills and releases.

A summary of the nutrient and general water quality data for water supply and environmental wells is provided in Table 3-5.

Table 3-5. General water quality for water supply and environmental wells within the Tahoe Valley South Basin (6-5.01) sampled over the past ten years.

Constituent	MCL	Units	WATER SUPPLY WELLS					ENVIRONMENTAL WELLS				
			Wells Sampled	**Average Conc.**	**Min. Conc.**	**Max. Conc.**	**Wells >MCL**	**Wells Sampled**	**Average Conc.**	**Min. Conc.**	**Max. Conc.**	**Wells >MCL**
Constituents with Primary MCLs								**Constituents with Primary MCLs**				
Nitrate (NO_3 as N)	45	mg/L	64	0.35	ND	4.5	0	17	0.03	ND	0.43	0
Nitrite (NO_2 as N)$_{usgs}$	1	mg/L	18	ND	ND	0.01	0	5	ND	ND	ND	0
Constituents with Secondary MCLs								**Constituents with Secondary MCLs**				
Chloride	250	mg/L	26	9.9	ND	64.3	0	1	45	45	45	0
Specific Conductance	900	µS/cm	38	199.9	64	549	0	0	-	-	-	-
Sulfate	250	mg/L	27	3.5	ND	10.1	0	18	22.7	ND	103	0
Total Dissolved Solids	500	mg/L	25	133	37	308	0	1	170	170	170	0

Note: Bold is for constituents with concentrations above the MCL.

Source: Geotracker GAMA Database for period from 2006 to 2016 for water supply wells and environmental wells within TVS Basin (last updated November 2016).

USGS: Water quality records for the water supply wells are from the GAMA-USGS dataset.

3.6.5.2.1 Water Supply Wells

Groundwater from water supply wells is relatively low in total dissolved solids (TDS) with typical values on the order of 100 milligrams per liter (mg/L). Average values for chloride and sulfate are very low at about 9.9 mg/L and 3.5 mg/L, respectively. Maximum nutrient concentrations for Nitrate (NO_3 as N) and Nitrite (NO_2 as N) are also low at 4.5 mg/L and 0.01 mg/L, respectively, well within maximum contaminant levels (MCLs) for these constituents.

3.6.5.2.2 Environmental Wells

General groundwater quality data for environmental wells is relatively limited for TDS and Chloride; but are within range of the water supply well values. Sulfate average (22.7 mg/L) and maximum concentrations (103 mg/L) are elevated compared to water supply well values. Nitrate concentrations are lower than water supply well values. Nitrite was not detected in the environmental well samples.

3.6.5.3 Inorganic Constituents

Inorganic constituents listed in drinking water standards generally include various metals, halogens and cyanide. Of these constituents, arsenic and chromium are the only constituents found at concentrations exceeding the primary MCLs; iron and manganese are the only constituents found at concentrations exceeding secondary MCLs (SMCLs).

3.6.5.3.1 Water Supply Wells

Table 3-6 presents a summary of the inorganic constituents detected in water samples collected from the water supply wells in the TVS Basin over the past 10 years. Of the wells sampled during this period, three had one or more instances of arsenic above the primary MCL of 10 micrograms per liter (µg/L) and three had one or more instances of iron above the SMCL (300 µg/L) (Figure 3-28).

Based on the incidences of arsenic in the water supply wells and the WBZs from which these wells produce, arsenic above MCLs is found in relatively deep confined WBZs found in the Meyers (MZ3, MZ4), Angora (AZ1, AZ2), South Lake Tahoe (SLTZ1, SLTZ2, SLTZ3), and Tahoe Keys (TKZ2, TKZ3) Groundwater Zones. Iron above MCLs is found in relatively shallow semi-confined and confined WBZs in the South Lake Tahoe (SLTZ4, SLTZ5) Groundwater Zone, and in relatively deep confined water-bearing zones in the Angora (AZ1, AZ2) Groundwater Zone. The sources of both the arsenic and iron is believed to be naturally-occurring derived from the weathering of exposed bedrock within and surrounding the groundwater basin and/or the dissolution of arsenic and/or iron-bearing materials within the basin-fill deposits. Iron in standby and offline wells may sometimes also be caused by the development of biofilms or corrosion of metal casings within the well.

3.6.5.3.2 Environmental Wells

Table 3-6 presents a summary of the inorganic constituents detected in water samples collected from the environmental wells in the TVS Basin over the past 10 years. Of the wells sampled during this period, four had one or more instances of chromium above the primary MCL (50 µg/L); 17 had one or more instances of iron above the SMCL (10 µg/L); and 11 had one or more instances of manganese above the SMCL (50 µg/L).

Incidences of chromium above MCLs are found in environmental wells at one site located within the Bijou Groundwater Zone, former Al's Ski Run Chevron site (T0601700100). Incidences of iron above

Table 3-6. Inorganic water quality for water supply and environmental wells within the Tahoe Valley South Basin (6-5.01) sampled over the past ten years.

Constituent	MCL	Units	WATER SUPPLY WELLS Wells Sampled	Average Conc.	Min. Conc.	Max. Conc.	Wells >MCL	ENVIRONMENTAL WELLS Wells Sampled	Average Conc.	Min. Conc.	Max. Conc.	Wells >MCL
Constituents with Primary MCLs								**Constituents with Primary MCLs**				
Aluminum	1	mg/L	26	0.05	ND	1.2	1	1	ND	ND	ND	0
Antimony	0.006	mg/L	26	ND	ND	ND	0	1	ND	ND	ND	0
Arsenic	**0.01**	**mg/L**	**32**	**0.006**	**ND**	**0.018**	**5**	1	ND	ND	ND	0
Barium	1	mg/L	26	ND	ND	0.02	0	1	0.04	0.04	0.04	0
Beryllium	0.004	mg/L	26	ND	ND	ND	0	1	ND	ND	ND	0
Cadmium	0.005	mg/L	26	ND	ND	ND	0	1	ND	ND	ND	0
Chromium	0.05	mg/L	26	ND	ND	ND	0	**12**	**0.008**	**ND**	**0.11**	**4**
Cyanide	0.15	mg/L	25	ND	ND	ND	0	0	-	-	-	-
Fluoride	2	mg/L	29	0.13	ND	0.308	0	1	ND	ND	ND	0
Hexavalent chromium	0.01	mg/L	18	ND	ND	0.001	0	11	ND	ND	0.003	0
Mercury	0.002	mg/L	26	ND	ND	ND	0	1	ND	ND	ND	0
Nickel	0.1	mg/L	26	ND	ND	ND	0	1	ND	ND	ND	0
Perchlorate	0.006	mg/L	22	ND	ND	ND	0	0	-	-	-	-
Selenium	0.05	mg/L	26	ND	ND	ND	0	0	-	-	-	-
Thallium	0.002	mg/L	26	ND	ND	ND	0	1	ND	ND	ND	0
Constituents with Secondary MCLs								**Constituents with Secondary MCLs**				
Copper	1	mg/L	26	ND	ND	0.16	0	1	ND	ND	ND	0
Iron	**0.3**	**mg/L**	**25**	**0.118**	**ND**	**6.7**	**3**	**17**	**20.6**	**0.025**	**550**	**17**
Manganese	0.05	mg/L	25	ND	ND	0.035	0	**11**	**2.78**	**0.013**	**17**	**11**
Silver	0.1	mg/L	25	ND	ND	ND	0	1	ND	ND	ND	0
Zinc	5	mg/L	25	0.002	ND	0.07	0	1	ND	ND	ND	0

Note: Bold is for constituents with concentration above the MCL.

Source: Geotracker GAMA Database for period from 2006 to 2016 for all DDW water supply wells and environmental wells within TVS Basin.

MCLs are found in environmental wells at one site located within the Bijou Groundwater Zone, former Al's Ski Run Chevron site (T0601700100), and at two other sites located within the South Lake Tahoe Groundwater Zone, former Muffler Place (T0601700122) and former USA Gas #7 (T0601700091) sites (Figure 3-28). Incidences of manganese above MCLs are found in environmental wells at one site located within the Bijou Groundwater Zone, former Al's Ski Run Chevron site (T0601700100). The current cleanup status for these sites are as follows: Al's Ski Run Chevron site is open – verification monitoring for Gasoline contaminants; former Muffler Place site is completed – case closed for Gasoline contaminants; and the former USA Gas #7 site is completed – case closed for Gasoline contaminants.

3.6.5.4 Radioactive Constituents

Radioactive constituents are present in groundwater found in the TVS Basin. Radiological substances include radium isotopes (Ra-226 and Ra-228), total soluble uranium, gross alpha activity and radon. Incidences of radiological substances exceeding the combined radium MCL of 5 picocuries per liter (pCi/L), the gross alpha MCL of 15 pCi/L and total uranium MCL of 20 pCi/L have been found in water supply wells within the TVS Basin (Figure 3-29).

Radioactive constituents in groundwater have not been sampled in the environmental wells.

3.6.5.4.1 Water Supply Wells

Table 3-7 presents a summary of the natural radioactivity detected in water samples collected from the water supply wells in the TVS Basin over the past 10 years. Of the wells sampled during this period, 1 had one or more instances of radium activity above the MCL, 11 had gross alpha activity above the MCL and 2 had uranium activities above the MCL.

Based on the incidences of radioactive constituents in the water supply wells and the water-bearing zones from which these wells produce, radium isotopes above MCLs is inferred to be found in a confined water-bearing zone found in the Bijou (BZ4) Groundwater Zone. Incidences of gross alphas activity above MCLs is found in relatively deep confined WBZs in the Meyers (MZ3), South Lake Tahoe (SLTZ1, SLTZ2, SLTZ3), and Tahoe Keys (TKZ2, TKZ3) Groundwater Zone, and in a confined WBZ in the Bijou (BZ4) Groundwater Zone. Incidences of uranium activity above MCLs is found in relatively deep confined water-bearing zones in the Bijou (BZ3) and South Lake Tahoe (TKZ2, TKZ4) Groundwater Zones (Figure 3-29). The source of the radioactivity is the naturally occurring radioactive isotopes found in granite and sediments derived from granite deposited in the basin-fill.

Radon is a radioactive gas formed by decay of small amounts of uranium and thorium naturally present in rock and soil and is found in groundwater throughout the TVS Basin. Investigation by the California Geological Survey shows that high radon potential is associated with granitic rock (certain granodiorite units), and lake terrace, glacial till and glacial outwash deposits. Moderate radon potential is associated with glacial till, outwash and lake terrace deposits derived from the granodiorite (Churchill, 2009). Radon gas derived from these materials can move into the groundwater system.

Table 3-7 shows radon levels in water samples collected from drinking water wells in the TVS Basin ranges from 47 pCi/L to greater than 4,000 pCi/L. The proposed MCL for radon was 300 pCi/L and the proposed Alternative MCL (AMCL) was 4,000 pCi/L. There has been no recent activity by the U.S. Environmental Protection Agency or SWRCB Division of Drinking Water towards adopting a radon MCL. Adoption of an MCL for radon by either U.S. Environmental Protection Agency or SWRCB Division of Drinking Water would affect water supplies in the TVS Basin.

Table 3-7. Radionuclide water quality in water supply wells within the Tahoe Valley South Basin (6-5.01) sampled over the past ten years.

			WATER SUPPLY WELLS					ENVIRONMENTAL WELLS				
Constituent	**MCL**	**Units**	**Wells Sampled**	**Average Conc.**	**Min. Conc.**	**Max. Conc.**	**Wells >MCL**	**Wells Sampled**	**Average Conc.**	**Min. Conc.**	**Max. Conc.**	**Wells >MCL**
Constituents with Primary MCLs								**Constituents with Primary MCLs**				
Radium-226	**5 (combined Ra-226,228)**	**pCi/L**	**17**	**0.62**	**ND**	**3.99**	**1**	0	-	-	-	-
Radium-228		**pCi/L**	**17**	**0.95**	**ND**	**3.97**		0	-	-	-	-
Gross Alpha particle activity	**15**	**pCi/L**	**27**	**9.6**	**ND**	**29.7**	**11**	0	-	-	-	-
Radon 222	n/a	pCi/L	20	1,258	47	33,194	n/a	0	-	-	-	-
Uranium	**20**	**pCi/L**	**27**	**6.33**	**ND**	**24.1**	**2**	0	-	-	-	-

Note: Bold is for constituents with concentrations above the MCL.

Source: Geotracker GAMA Database for period from 2006 to 2016 for all DDW water supply wells and environmental wells within TVS Basin

3.6.5.5 Regulated Chemicals

Man-made contaminants which occur most frequently in the TVS Basin include petroleum hydrocarbon and chlorinated hydrocarbon compounds. Petroleum hydrocarbon compounds are from spills and releases associated with the operation of gasoline storage and fueling facilities. Contaminants of concern from these releases often include the most soluble fraction of the gasoline released, including benzene, toluene, ethylbenzene and total xylenes (BTEX) and the gasoline additives used as fuel oxygenates and octane enhancers including Methyl tert- Butyl Ether (MtBE), Tert-Butyl Alcohol (TBA), Tertiary-Amyl Methyl Ether (TAME), and ethanol. Chlorinated hydrocarbon compounds are most often used as industrial agents used for degreasing metals, cleaning electronic parts and dry cleaning fabrics. They are also contained in many household products such as oil-based paints, drain cleaners, spot removers, engine degreasers and paint removers. Contaminants of concern from these releases often include: Tetrachloroethylene (PCE); Trichloroethylene (TCE); 1,2-Dichloroethane(1,2-DCA); 1,2 Dichloroethylene (1,2-DCE); Vinyl Chloride (VC); and 1,4-Dichlorobenzene (1,4-DCB).

3.6.5.5.1 Water Supply Wells

Table 3-8 presents a summary of the regulated chemicals detected in water samples collected from the water supply wells in the TVS Basin over the past 10 years. Of the wells sampled during this period, 1 had one or more instances of 1,2-DCA above the MCL (0.5 µg/L) and three had one or more instances of PCE above the MCL (5.0 µg/L) (Figure 3-30).

Based on the incidences of regulated chemicals in the water supply wells and the water-bearing zones from which these wells produce, chlorinated hydrocarbons above MCLs is inferred to be found in relatively shallow semi-confined and confined water-bearing zones along the northwest margin of the South Lake Tahoe (SLTZ4, SLTZ5) and in confined water-bearing zones along the northeast margin of the Tahoe Keys (TKZ2, TKZ4) Groundwater Zones, locally referred to as the South "Y" Area. The source of these contaminants is believed to be from the former Lake Tahoe Laundry Works site (SL0601754315) (LRWQCB, 2016).

3.6.5.5.1 Environmental Wells

Table 3-8 presents a summary of the regulated chemicals detected in water samples collected from the environmental wells in the TVS Basin over the past 10 years. Of the wells sampled during this period, 68 had one or more instances of Benzene above the MCL (1 µg/L); 37 had one or more instances of MtBE above the MCL (13 µg/L); 13 had one or more instances of toluene above the MCL (150 µg/L); 10 had one or more instances of ethylbenzene above the MCL (300 µg/L); 9 had one or more instances of PCE above the MCL (5.0 µg/L); and four had one or more instances of 1,2-DCE above the MCL (6.0 µg/L).

Incidences of Benzene above primary MCLs are found in environmental wells at 9 sites within the TVS Basin, situated within the South Lake Tahoe Groundwater Area: Berry Hinckley Bulk Fuel Plant (SL0601781518); former Terrible Herbst (T06017000090); former USA #7 (T060170091); former Al's Ski Run (T0601700100); former Jet Thru Car Wash (T0601700108); former Muffler Palace (T0601700122); Redwood Oil Company (T0601700139); Keys Marina and Yacht Club (T0601700142); and Moss Chevron (T0601700153). The current cleanup statuses for these sites are as follows: Berry Hinckley Bulk Fuel Plant - Case Closed for Diesel, Gasoline Contaminants; former Terrible Herbst – Open, eligible for closure, Diesel contaminants; former USA Gas #7 site is completed – case closed for

Table 3-8. Chemical water quality in water supply and environmental wells within the Tahoe Valley South Basin (6-5.01) sampled over the past ten years.

			WATER SUPPLY WELLS					ENVIRONMENTAL WELLS				
Constituent	**MCL**	**Units**	**Wells Sampled**	**Average Conc.**	**Min. Conc.**	**Max. Conc.**	**Wells >MCL**	**Wells Sampled**	**Average Conc.**	**Min. Conc.**	**Max. Conc.**	**Wells >MCL**
Constituents with Primary MCLs								**Constituents with Primary MCLs**				
Benzene	0.001	mg/L	29	ND	ND	ND	0	**181**	**0.03**	**ND**	**3**	**68**
Carbon Tetrachloride	0.0005	mg/L	29	ND	ND	ND	0	33	ND	ND	ND	0
1,2-Dichlorobenzene	0.6	mg/L	29	ND	ND	ND	0	33	ND	ND	ND	0
1,4-Dichlorobenzene (1,4 DCB)	0.005	mg/L	29	ND	ND	ND	0	33	ND	ND	ND	0
1,1-Dichloroethane	0.005	mg/L	29	ND	ND	ND	0	33	ND	ND	ND	0
1,2-Dichloroethane (1,2-DCA)	**0.0005**	**mg/L**	**22**	**ND**	**ND**	**0.001**	**1**	59	ND	ND	ND	0
1,1-Dichloroethylene	0.006	mg/L	28	ND	ND	ND	0	41	ND	ND	ND	0
cis-1,2-Dichloroethylene (1,2-DCE)	0.006	mg/L	28	ND	ND	ND	0	**8**	**0.008**	**ND**	**0.029**	**4**
trans-1,2-Dichloroethylene	0.01	mg/L	28	ND	ND	ND	0	33	ND	ND	0.006	0
Dichloromethane	0.005	mg/L	29	ND	ND	ND	0	4	ND	ND	ND	0
1,2-Dichloropropane	0.005	mg/L	29	ND	ND	ND	0	33	ND	ND	ND	0
1,3-Dichloropropene	0.0005	mg/L	28	ND	ND	ND	0	0	-	-	-	-
Ethylbenzene	0.3	mg/L	29	ND	ND	ND	0	**181**	**0.035**	**ND**	**1.7**	**10**
Methyl tert-butyl ether (MTBE)	0.013	mg/L	29	ND	ND	0.001	0	**226**	**0.253**	**ND**	**32**	**37**
Monochlorobenzene	0.07	mg/L	29	ND	ND	ND	0	33	ND	ND	ND	0
Styrene	0.1	mg/L	34	ND	ND	ND	0	27	ND	ND	ND	0
1,1,2,2-Tetrachloroethane	0.001	mg/L	34	ND	ND	ND	0	10	ND	ND	ND	0
Tetrachloroethylene (PCE)	**0.005**	**mg/L**	**28**	**0.001**	**ND**	**0.046**	**3**	**33**	**0.014**	**ND**	**0.120**	**9**

Table 3-8. Chemical water quality in water supply and environmental wells within the Tahoe Valley South Basin (6-5.01) sampled over the past ten years (continued).

Constituent	MCL	Units	WATER SUPPLY WELLS					ENVIRONMENTAL WELLS				
			Wells Sampled	Average Conc.	Min. Conc.	Max. Conc.	Wells >MCL	Wells Sampled	Average Conc.	Min. Conc.	Max. Conc.	Wells >MCL
Constituents with Primary MCLs								**Constituents with Primary MCLs**				
Toluene	0.15	mg/L	29	ND	ND	ND	0	**181**	**0.035**	**ND**	**1.000**	**13**
1,2,4-Trichlorobenzene	0.005	mg/L	29	ND	ND	ND	0	27	ND	ND	ND	0
1,1,1-Trichloroethane	0.2	mg/L	29	ND	ND	ND	0	33	ND	ND	ND	0
1,1,2-Trichloroethane	0.005	mg/L	29	ND	ND	ND	0	33	ND	ND	ND	0
Trichloroethylene (TCE)	0.005	mg/L	28	ND	ND	ND	0	33	ND	ND	ND	0
Trichlorofluoromethane	0.15	mg/L	29	ND	ND	ND	0	33	ND	ND	ND	0
Vinyl Chloride (VC)	0.0005	mg/L	29	ND	ND	ND	0	33	ND	ND	ND	0
Xylenes	1.75	mg/L	29	ND	ND	ND	0	**122**	**ND**	**ND**	**8.8**	**7**

Note: Bold is for constituents with concentrations above the MCL.

Source: Geotracker GAMA Database for period from 2006 to 2016 for all DDW water supply wells and environmental wells within TVS Basin.

Gasoline contaminants; the former Al's Ski Run Chevron site is open- verification monitoring for Gasoline contaminants; the former Jet Thru Car Wash is Completed – Case Closed for Gasoline contaminants; the former Muffler Place site is Completed – Case Closed for Gasoline contaminants; Redwood Oil Company – is Completed – Case Closed for Diesel, Gasoline contaminants; Keys Marina and Yacht Club is open-eligible for closure, Gasoline contaminants; and the Moss Chevron site is Completed – Case Closed for Gasoline contaminants.

Incidences of MtBE above primary MCLs are found in environmental wells at 6 sites within the TVS Basin, 5 of which are located within the South Lake Tahoe Groundwater Area: former USA #7 (T060170091); former Al's Ski Run (T0601700100); former Jet Thru Car Wash (T0601700108); former Muffler Palace (T0601700122);and Moss Chevron (T0601700153). The other site is located in the Meyers Groundwater Area: former Meyers Shell (T06017400147). The current cleanup statuses for these sites are as follows: former USA Gas #7 site is completed – case closed for Gasoline contaminants; the former Al's Ski Run Chevron site is open- verification monitoring for Gasoline contaminants; the former Jet Thru Car Wash is Completed – Case Closed for Gasoline contaminants; the former Muffler Place site is Completed – Case Closed for Gasoline contaminants; the Moss Chevron site is Completed – Case Closed for Gasoline contaminants; and the former Meyers Shell site is Completed – Case Closed for Gasoline contaminants.

Incidences of toluene above MCLs are found in environmental wells at five sites within the South Lake Tahoe Groundwater Area: Berry Hinckley Bulk Fuel Plant (SL0601781518); former Terrible Herbst (T0601700090); former USA #7 (T060170091); former Al's Ski Run (T0601700100); and former Muffler Palace (T0601700122) sites. The current cleanup statuses for these sites are as follows; Berry Hinckley Bulk Fuel Plant -Case Closed for Diesel contaminants; former Terrible Herbst – Open, eligible for closure, Diesel contaminants; former USA Gas #7 site is Completed – Case Closed for Gasoline contaminants; the former Al's Ski Run Chevron is Open- Verification Monitoring for Gasoline contaminants; and the former Muffler Place site is Completed – Case Closed for Gasoline contaminants.

Incidences of ethylbenzene above MCLs are found in environmental wells at eight sites within the South Lake Tahoe Groundwater Area: former USA #7 (T060170091); former Jet Thru Car Wash (T0601700108); Berry Hinckley Bulk Fuel Plant (SL0601781518); former Terrible Herbst (T0601700090); Mobil Lakeside Service (T0601700093); former Al's Ski Run (T0601700100); Redwood Oil Company (T0601700139); and former Midas Muffler (T100000063644) sites. The current cleanup statuses for these sites are as follows: former USA Gas #7 is Completed – Case Closed for Gasoline contaminants; former Jet Thru Car Wash is Completed – Case Closed for Gasoline contaminants; Berry Hinckley Bulk Fuel Plant - Case Closed for Diesel contaminants; former Terrible Herbst – Open, eligible for closure, Diesel contaminants; Mobil Lakeside Service - Case Closed for Gasoline contaminants; former Al's Ski Run is Open- Verification Monitoring for Gasoline contaminants; Redwood Oil Company is Completed – Case Closed for Diesel, Gasoline contaminants; and former Midas Muffler is Completed - Case Closed for Gasoline and Chlorinated Hydrocarbon contaminants.

Incidences of PCE and 1,2 DCE above MCLs are found in environmental wells at one site within the South Lake Tahoe Groundwater Area of the TVS Basin: Redwood Oil Company (T0601700139). The current cleanup statuses for this site is Completed – Case Closed for Diesel, Gasoline contaminants.

3.6.5.6 Groundwater Contamination

MtBE and PCE are the two most frequently detected contaminants of concern that have impaired groundwater supplies in the TVS Basin. MtBE has an extremely high aqueous solubility (48,000 mg/L @

20-25 degrees centigrade), is very weakly sorbed to soils (K_{OC} =1.15), has a very high mobility in water and density lower than water [0.7404 grams per cubic centimeter (g/cm^3)]. As a result, MtBE is easily leached from soil into groundwater. Once in the subsurface, it is resistant to biodegradation and can therefore, pose a long-term groundwater contamination problem (Fetter, 1999).

PCE has high aqueous solubility (150 mg/L @ 20-25 degrees centigrade), is also very weakly sorbed to soils (Koc =2.42), has moderate mobility in water and density greater than water (1.62 g/cm^3). As a result, PCE is also easily leached from soil into groundwater. Once in the subsurface PCE typically degrades by progressive dehalogenation. The time required for dehalogenation is variable and dependent on subsurface conditions (e.g., temperature, pH, dissolved oxygen content, presence of nutrients and microorganisms, etc.). Therefore, degradation may or may not occur (Fetter, 1999).

Because PCE is denser than water, it can be found in deeper portions of the groundwater system, concentrated along low permeability horizons at the bottom of water-bearing zones.

3.6.5.6.1 Groundwater Contamination Sites

The SWRCB maintains an extensive database of information used for managing sites that impact groundwater and requires groundwater cleanup, referred to as GeoTracker (http://geotracker.waterboards.ca.gov/). Site information contained in GeoTracker includes clean-up status, potential contaminants of concern, site history, environmental data and technical reports on completed activities. The reader is referred to GeoTracker for this detailed site information.

Figure 3-31 shows the locations of open and closed groundwater cleanup sites by cleanup program type in the TVS Basin (e.g., Leaking Underground Storage Tank (LUST) Cleanup site, Site Cleanup Program (SCP) site). The LUST Cleanup sites are typically gasoline stations but may also include other sites with petroleum hydrocarbon contamination. The SCP sites are typically commercial sites with chlorinated hydrocarbon contamination. Inspection of Figure 3-31 shows that the majority of these sites are located along the main commercial business district from the intersection of Highway 89 and Highway 50 (known as the "South Y") along Highway 50 to Stateline. In order to show areas of groundwater quality concerns with respect to water supply, brief descriptions of several of the most significant open sites are provided below.

Meyers Landfill Site

The Meyers Landfill site (SL601724846; T10000000216) is located in the Myers Groundwater Zone between Pioneer Trail and Saxon Creek. This was a municipal landfill operated by private parties from 1946 to 1955 and El Dorado County from approximately 1955 to 1971 under USFS Special Use Permits. Water leaching through the landfill has impacted groundwater beneath the site, resulting in a plume of contaminated groundwater extending approximately 2,000 feet in a north-northeast direction, down- gradient of the site. The contaminants of concern include both petroleum and chlorinated hydrocarbons, including VC, BTEX and naphthalene. VC has also been detected in surface water samples collected from Saxon Creek, down gradient of the former landfill (Weston, 2012). Contamination at the site is being remediated using an impermeable cover to prevent surface water from percolating through the landfill waste. Groundwater monitoring is currently being performed to evaluate the effects of the cover on groundwater flow and water quality underlying the site (USFS, 2013).

Terrible Herbst Gas Station Site

The Terrible Herbst Gas Station site (T0601700090) is located in the South Lake Tahoe Groundwater Zone along Highway 50 neighboring Trout Creek. This site has been under investigation since a District construction crew encountered petroleum contamination during excavation near the site in 1984. Releases of gasoline from the LUST system impacted groundwater beneath the site. In 1997, groundwater samples collected from this site were first analyzed for and then subsequently detected MtBE. Site investigations completed at the site showed a plume of MtBE contaminated groundwater, which at its maximum, extended more than 600 feet in a north-northwest direction, down-gradient of the site. Historical maximum MtBE concentrations within this plume exceeded 500 µg/L (Broadbent, 2003). The District was concerned that the down-gradient margin of this contaminant plume impinged on the capture zone of the Paloma Well. In January 2000, two sentinel wells were installed to monitor groundwater quality near the leading edge of this plume. Remediation activities for petroleum hydrocarbon contamination began in 1995 during replacement of the LUST system. At that time, remediation involved the over-excavation and removal of contaminated soils and the installation of an air-sparge/soil vapor extraction system (AS/SVE). In July 2001, the AS/SVE system was shut-down and later restarted in November 2003. During the interim, direct removal of gasoline "free product" from three monitoring wells was started (in August 2003). In 2005, a dual-phase extraction (DPE) system was installed to improve the groundwater cleanup. The DPE system was operated through August 2008. Free product has not been detected in any site monitoring wells since April 2008. By the end of 2008, contaminant concentrations had declined across most of the historical contaminant plume area, with high residual contaminant concentrations remaining in a "hotspot" centered around one well located within the Highway 50 right-of-way. During the first quarter of 2012, MtBE levels had decreased in all site monitoring wells below MCLs (Westmark, 2012). The contaminant plume that exceeds water quality objectives is believed to be less than 100 feet in length. This site is currently Open and is eligible for site closure.

South Y PCE Site

The South Y PCE site (SL0601794942) is located in the South Lake Tahoe Groundwater Zone neighboring the "Y." This site includes the water supply wells that have been impacted by PCE and is currently in the investigation stage. Other sites within the "Y" area in which PCE is the contaminant of concern include Big O Tires (SL0601729739), Lakeside Napa (SL0601756146) and Lake Tahoe Laundry Works (SL0601754315). Both the Big O Tires and Lakeside Napa sites are also in the investigation stage. The Lake Tahoe Laundry Works site is actively being remediated using a soil-vapor extraction/groundwater air sparging (pulsed ozone) system to remove PCE mass from the vadose zone. A workplan to perform Batch Pumping has been submitted to the LRWQCB for review and consideration as an alternative remediation technology to supplement the existing pulsed ozone system (E2C Remediation, 2016).

Tahoe Tom's Gas Station Site

The Tahoe Tom's Gas Station site (T0601700101) is located in the Bijou Groundwater Zone near Stateline. This site has been under investigation since the discovery of petroleum hydrocarbon contamination at the site in 1999. Releases of gasoline from the LUST system impacted groundwater beneath the site, resulting in a plume of MtBE contaminated groundwater which extends more than 400 feet in a northwest direction, down-gradient of the site. In 2014, this MtBE contaminant plume impaired a LBWC system well. Remediation activities at this site have relied on soil vapor extraction, dewatering and various methods to increase dissolved oxygen levels in the subsurface, including air sparing and in-situ chemical oxidation. On March 4, 2014, the LRWQCB issued an investigative order requiring the responsible party to submit a remediation plan to re-start the on-site remediation system or operate an alternate treatment system for the removal of soil and groundwater contamination from this site. On August 8, 2014, the LRWQCB issued a new cleanup and abatement order (CAO No. R6T-2014-0079) requiring the responsible party to monitor MtBE contaminant levels in the impaired well and/or provide an alternate source of drinking, conduct corrective actions to cleanup groundwater on- and off-site, and implement an expanded monitoring and reporting program. In December 2014, the LRWQCB issued an amended (CAO No. R6T-2014-0079-A1) requiring the responsible party to start operation of a remediation system to contain petroleum hydrocarbon contaminates from leaving the property. In order to satisfy the amended CAO, the responsible party is using a high-vacuum DPE and localized in-situ chemical oxidation injections to mitigate the site (LRM, 2016).

Private Residence site

The Private Residence site (SL0601714201) is located in the Bijou Groundwater Zone. This site includes the private water supply wells that have been impacted by PCE and MtBE within the Tahoe Meadows subdivision. This site is currently in the investigation stage. Results of recent investigation suggest that the lateral extent of PCE and MtBE contamination is generally delineated, while the vertical extent of delineation is incomplete. The source(s) of MtBE and PCE contamination has not been identified (Fugro, 2014). During 2016, LRWQCB sampled select domestic wells for the Private Residence site. In June 2016, PCE was detected above MCLs in 1 well and below MCLs in 4 other private wells.

3.6.5.6.2 Progress of Groundwater Cleanup – MtBE

On March 28, 2000 the El Dorado County Board of Supervisors adopted Ordinance No. 4553 prohibiting the sale of fuel containing MtBE within the El Dorado County portion of the Lake Tahoe Basin (EDC, 2000). This Ordinance 4553 significantly reduced the threat of MtBE contamination resulting from spills and releases of gasoline used in the TVS Basin. Therefore, nearly all of the closed LUST Cleanup sites involving MtBE employed remediation to address contamination from spills and releases that pre-date March 2000. In order to illustrate the progress of MtBE groundwater cleanup activities in the TVS Basin, brief descriptions of several of the most significant closed sites are provided below.

Figure 3-31 shows that all of the LUST Cleanup sites in the Meyers Groundwater Zone are closed. The most significant of these closed sites are the Beacon Meyers (T0601700137) and Meyers Shell Station (T0601700147) sites. Releases of gasoline from the Beacon Meyers site impacted groundwater resulting in a plume of MtBE contaminated groundwater extending approximately 1,150 feet in a north-northeast direction, down-gradient of the site (Secor, 1998). Upon the death of the property owner, the LRWQCB took on cleanup of the site using special state funds earmarked for emergency, abandoned, and recalcitrant sites. A contractor hired by the LRWQCB spent six years investigating the extent of groundwater contamination and conducting cleanup actions involving the over excavation and removal of contaminated soils, soil vapor extraction, and pump and treat groundwater remediation. In 2005, the LRWQCB closed the case after post-remediation monitoring showed that MtBE levels had decreased from a maximum concentration of 3,900 µg/L to less than the MCLs.

In 1998, a 640-gallon release of gasoline from a product line failure at the Meyers Shell Station (T0601700147) site impacted groundwater resulting in a plume of MtBE contaminated groundwater extending approximately 1,000 feet in a north-northwest direction, down-gradient of the site (Cambria, 1999). Cleanup actions at this site involved the over excavation and removal of contaminated soils, and approximately seven years of pump and treat groundwater remediation. In 2010, the LRWQCB closed the case after post-remediation monitoring showed that the extent of the MtBE contaminant plume had been reduced to 200 feet and MtBE levels had decreased from a maximum concentration of 25,800 µg/L to less than MCLs (LRWQCB, 2010a).

Figure 3-31 shows that several closed LUST Cleanup sites are located near the "Y". The most significant of these closed sites are the South Y Shell (T0601700150) and Swiss Mart (T0601700148) sites. Releases of gasoline from the South Y Shell site were first identified during improvements to the underground storage tank system in 1998. Releases from this site impacted groundwater resulting in a plume of MtBE contaminated groundwater extending approximately 600 feet in a north-northeast direction, down-gradient of the site. Cleanup actions at this site involved the over excavation and removal of contaminated soils, and approximately six years of pump and treat groundwater remediation. In 2006, the LRWQCB closed the case after post-remediation monitoring showed that the extent of the MtBE contaminant plume had been reduced to 30 feet and MtBE levels had decreased from a maximum concentration of 99,200 µg/L to less than MCLs (LRWQCB, 2006).

Releases of gasoline from the Swiss Mart site were first identified during improvements to the underground storage tank system in 1998. Releases from this site impacted groundwater resulting in a plume of MtBE contaminated groundwater extending approximately 500 feet in a north-northeast direction, down-gradient of the site, impairing a neighboring private well. Cleanup actions at this site involved the over excavation and removal of contaminated soils; soil vapor extraction and ozone air sparge treatment of contaminated groundwater. In 2010, the LRWQCB closed the case after post- remediation monitoring showed that the extent of the MtBE contaminant plume had been reduced and MtBE levels had decreased from a maximum concentration of 27,000 µg/L to less than MCLs (LRWQCB, 2010b).

2.6.5.6.3 Progress of Groundwater Cleanup – PCE

Along with the Meyers Landfill site, the Lake Tahoe Laundry Works site (SL0601754315) is the only other cleanup site that is actively remediating PCE contaminated groundwater in the TVS Basin. There are no closed PCE groundwater cleanup sites. Remediation activities at the Lake Tahoe Laundry Works site started in April 2010 with operation of a soil-vapor extraction (SVE) combined with a groundwater air-sparging treatment system. In October 2012, the SVE and air-sparging treatment system was shut-down and replaced using pulsed ozone air sparging.

After PCE concentrations in groundwater rebounded at the site (exceeding 50 µg/L), the SVE and air-sparging treatment system was restarted in November 2013, under a directive from the LRWQCB. Through January 2014, the total mass of volatile organic contaminants (including PCE) removed by the system has been estimated at approximately 860 pounds. The PCE mass remaining in shallow soils has been estimated at 4×10^{-3} pounds. The PCE mass remaining in shallow groundwater has been estimated at 1.8×10^{-1} pounds. Future activities at this site are planned to involve continued operation of the SVE and air-sparging treatment system, continued groundwater and shallow soil-vapor monitoring, and regular reporting of groundwater monitoring and status of cleanup activities to the LRWQCB (E2C Remediation, 2016). During the first quarter of 2014, PCE concentrations in groundwater at the site decreased to less than 10 µg/L. Based on these lower concentrations, the LRWQCB accepted the proposed shut-down of the treatment system as long as PCE concentrations did not rebound in groundwater or soil vapor by increasing an order of magnitude above concentrations detected in first quarter 2014 (LRWCB, 2014). In July 2016, the LRWQCB issued proposed revised cleanup and abatement order for this site (CAO No. R6T-2016-

PROP). Under this CAO, the LRWQCB indicated that recent data and investigation results support the contention that this site is the likely source of PCE detected in water supply wells in the South Y Area. Orders in the proposed CAO include new requirements for on-site plume containment, off-site investigation, completion of an off-site Corrective Action Plan, groundwater monitoring, and Chlorinated plume definition. The LRWQCB is currently reviewing public comments received in response to the proposed Corrective Action Plan.

The 2016 extent of the PCE plume is shown in Figure 3-32 (GEI Consultants, 2016). Concentrations are in excess of 1,000 ug/L at the southern tip of the plume and reduce to 50 ug/L in the central portion. Concentrations at TKWC #2 are 22 ug/L at the northern extent of the plume. PCE concentrations are below the MCL at TKWC #1 (3 ug/L) which is beyond the northern extent of the plume.

3.6.6 Groundwater Budget

3.6.6.1 Recharge

Recharge was extracted from the GSFRM and applied to the TVS domain. Recharge is defined as the model computed excess water leaving the unsaturated root or soil zone and entering the saturated zone after accounting for abstractions of interception, sublimation, surface runoff and evapotranspiration. GSFLOW simulated recharge for the TVS hydrologic basin varies from year to year based on annual cycles of precipitation. The spatial distribution of groundwater recharge for WY 2010, which represents average precipitation conditions, is shown in Figure 3-33. Most of the recharge occurs in the mountains of the Sierra Nevada and Carson Range. Annual recharge ranges from 9 inches in the valley to upwards of 34 inches in the higher elevations. This result is consistent with observations of stable isotope levels in stream baseflow and of groundwater from numerous shallow and deep-screened wells which indicate that a significant fraction of groundwater present within the TVS Basin is sourced from precipitation in high elevation areas that recharges at the mountain front and/or in the mountain block (Fogg, *et al.*, 2007). Fallen Leaf and Cascade Lakes are simulated as lakes and therefore receive constant recharge of approximately 30 inches per year.

Groundwater recharge is largely dependent on annual precipitation and it is important to understand how recharge changes over time. A regression equation was developed between annual precipitation at Hagan's Meadows climate station to groundwater recharge (Figure 3-34) with an R^2 of 0.92. Hagan's Meadow climate station was chosen because it resulted in the best correlation between precipitation at one station versus groundwater recharge. Annual groundwater recharge was derived from the groundwater flow model.

Groundwater recharge from WY 1983 – 2015 is shown in Figure 3-35. Average annual recharge over the last decade (2006 – 2015) is 36,400 AFY and the average over the entire simulation period (1983– 2015) is 39,000 AFY.

The ratio of recharge computed by the GSFLOW model to annual precipitation, which is termed as "recharge efficiency," can be used to describe the fraction (or percentage) of precipitation that is converted to recharge. Mean estimated precipitation by GSFLOW for the TVS domain is approximately 344,000 AFY over the hydrologic analysis area. Computed recharge efficiency for the TVS hydrologic basin varies annually but on average (1983 – 2015) is approximately 11 percent. The fraction of precipitation that becomes recharge is consistent with other studies in the region (Flint and Flint, 2007).

3.6.6.2 Groundwater Withdrawals

Groundwater is the primary source of drinking water and accounts for more than 95 percent of the potable water used throughout the area. Surface water as a drinking water source is relatively minor and is provided through a surface water intake to Lake Tahoe by LPA. Figure 3-36 shows the current service area boundaries for the water systems serving the greater South Lake Tahoe area. The region consists of four water purveyors including the District, TKWC, LBWC, and LPA. The location of the water supply wells for the three water purveyors (District, TKWC, LBWC) that primarily rely on groundwater is shown in Figure 3-37.

There are several small water systems that have wells which supply drinking water to schools, resorts, hotels, apartments and recreational areas located within the TVS Basin. There are also private wells situated within the TVS Basin. Many of these private wells are clustered through many of the older neighborhoods within the northeastern portion of the TVS Basin, near the south and east flanks of Tahoe Mountain, and at the south end of Christmas Valley. Groundwater production from small community water systems and private wells is believed to account for a little more than 5 percent of the total volume of groundwater extracted from the TVS Basin on an annual basis.

In total, there are approximately 509 active wells within the TVS Basin as shown in Figure 3-38. These include water supply wells for the District, TKWC, LBWC, and LMWC. In most of the TVS Basin, well densities are less than 10 wells per square mile. Higher well densities are located in the northeast portion of the TVS Basin with densities exceeding 100 wells per square mile near the Nevada border. Another high density area exists just south of the Y along the highway at the northwest end of the airport with well densities exceeding 50 wells per square mile. Higher well densities (10 to 50 wells per square mile) are also found at the southern tip of Twin Peaks and in Christmas Valley.

Figure 3-39 shows the historical water use from the four largest water purveyors which make up 93 percent of groundwater withdrawals in the TVS Basin. Groundwater withdrawals averaged 7,700 AFY and 8,000 AFY over the periods 1983 – 2015 and 2006 – 2015, respectively. Note that total demand has decreased from 9,700 AFY in 2007 to just over 6,000 AFY in 2015. Future demand projections from the 2010 Urban Water Management Plan (Winzler and Kelley, 2011) are expected to decrease to 4,700 AFY by 2035. These projections are based on the population and employment forecasts, plumbing code and planned water conservation measures.

The District's withdrawals are the largest of all four water systems, representing 83 percent of groundwater deliveries in the TVS Basin. Groundwater withdrawals from the three other water companies represent 9, 4, and 3 percent for TKWC, LBWC, and LPA, respectively.

The California-Nevada Interstate Compact Concerning Water of Lake Tahoe, Truckee River, Carson River, and Walker River Basins (Compact) approved in 1971 allocates a total annual surface water and groundwater diversion of 23,000 AFY within the California side of the Lake Tahoe Basin. In 1972 the SWRCB adopted a Policy for the Administration of Water Rights in the Lake Tahoe Basin establishing that all surface water and groundwater diversions shall not exceed the allocations defined in the Compact. In 1984 the SWRCB prepared a Draft Report titled, Policy for Water Allocation in the Lake Tahoe Basin (Policy). This Policy was termed Draft since both the States of California and Nevada were using the Compact for water allocations within the Lake Tahoe Basin (Baer, 1994; Kennedy-Jenks, 2007). The Policy has not been finalized. The Compact allocated a maximum of 23,000 AFY for use on the California side of the Lake Tahoe Basin; however, the Policy recommended that the allocation be split between public (State and Federal) and private lands. The Policy allocated a maximum of 12,493 AFY for use in the South Lake Tahoe area (California SWRCB, 1979). The District has a right to a total maximum allocation of 9,528 AFY, and this number has been used as a planning level assessment for the District's Urban Water Management Plan in order to represent the total available annual groundwater supply (Kennedy-Jenks, 2007; Winzler and Kelley, 2011).

3.6.6.3 Discharge to Streams and Lakes

The groundwater flow model was used to calculate groundwater discharge to local streams and Lake Tahoe. The annual discharge values are shown in Figure 3-40. Total groundwater flow to streams and Lake Tahoe averages 30,880 and 29,400 AFY for the periods 1983 – 2015 and 2006 – 2015, respectively. A majority of the discharge is to streams, representing approximately 83 percent of the total discharge.

Baseflow appears to oscillate in response to recharge but the year-to-year correlation indicates a weak, negative correlation (R2=0.06). A lag of 10-years induces a direct relationship to recharge but the correlation remains weak.

TVS estimated groundwater flux to Lake Tahoe averages 3,400 AFY from 1983 – 2015. Groundwater flux to Lake Tahoe shows a modest direct relationship to recharge (R2 = 0.17) and a significantly stronger indirect relationship to groundwater pumping (R2 = 0.39).

3.6.6.4 Changes in Groundwater Storage

The groundwater flow model was used to calculate changes in groundwater storage for WYs 1983 – 2015 (Figure 3-41). Annual change in groundwater storage magnitudes vary from -33,000 AFY (meaning water levels are falling) to 42,300 AFY (meaning groundwater levels are rising). On average, groundwater storage changes are near zero (-2,300 AFY), meaning groundwater storage changes tend to even out over periods of higher and lower recharge.

Changes in groundwater storage are generally associated with variations in climate and/or pumping. Given that groundwater recharge is well in excess of pumping, changes in groundwater storage are largely dependent on annual precipitation. A regression equation was developed between annual precipitation at Hagan's Meadow climate station and changes in groundwater storage as calculated by the TVS groundwater model (Figure 3-42). Hagan's Meadow climate station was chosen because it resulted in the best correlation between a single station's annual precipitation and changes in groundwater storage.

The zero point occurs at approximately 31 inches of annual precipitation at Hagan's Meadow, which is nearly equal to the long term (1983 – 2015) mean. The zero point represents the point at which groundwater storage does not change. Precipitation in excess of the 31 inches causes groundwater storage to increase (negative storage change) and vice versa.

3.6.6.5 Budget Summary

Table 3-9 shows the groundwater budget summary for three time periods: 1) prior to 1983, 2) 2006 – 2015, and 3) 2016 to 2035. The water budget for the period prior to 1983 and from 2006 to 2015 was calculated using the TVS groundwater model. For the future period the water budget was estimated based on the expectation that groundwater pumping would decrease to approximately 5,000 AFY.

Table 3-9. Groundwater budgets for pre-1983, 2006 – 2015, and 2016 – 2035 periods.

INPUTS			
	Pre-1983 (acre-ft/year)	**2006 - 2015 (acre-ft/year)**	**2016 - 2035 (acre-ft/year)**
Groundwater recharge	39,000	36,000	39,000
Groundwater storage	*minor*	2,000	minor
Total:	**39,000**	**38,000**	**39,000**

OUTPUTS			
	Pre-1983 (acre-ft/year)	**2006 - 2015 (acre-ft/year)**	**2016 - 2035 (acre-ft/year)**
Baseflow	31,000	28,000	29,000
Lake Tahoe	8,000	2,000	3,000
Groundwater pumping	*minor*	8,000	5,000
Groundwater storage	*minor*	*minor*	2,000
Total:	**39,000**	**38,000**	**39,000**

Notes: All values are rounded to the nearest 1,000 acre-ft/yr

Prior to 1983, average groundwater recharge most likely was similar to current conditions (39,000 AFY). Groundwater pumping was relatively small, probably less than 1,000 AFY. Under these conditions most groundwater discharged to Lake Tahoe (8,000 AFY) or as baseflow (31,000 AFY) to local streams.

As groundwater pumping increased through the 1980s, baseflow and groundwater flow to Lake Tahoe decreased. Over the last decade (2006 – 2015), baseflow rates decreased to approximately 28,000 AFY. Likewise, groundwater flow to Lake Tahoe decreased to 2,000 AFY. In response to pumping, water levels declined a few feet which allowed groundwater to be removed from storage (2,000 AFY). Short-term droughts caused groundwater recharge to decline slightly to 36,000 AFY, down 3,000 from the long-term average.

As a comparison the average rates of groundwater recharge, baseflow, groundwater pumping, groundwater flow to Lake Tahoe, and change in groundwater storage over the entire simulation period (1983 – 2015) is shown in Figure 3-43. The bars represent the mean over the simulation period and the bars represent the total range observed. Over the longer simulation period the system exhibits more variability, but the long-term averages are nearly the same as over the last decade (2006 – 2015).

Over the next few decades (2016 – 2035) groundwater recharge is expected to remain near the long-term average of 39,000 AFY. Groundwater withdrawals are expected to decline to approximately 5,000 AFY. As pumping declines water levels will rise in response, increasing storage changes on the order of 3,000 AFY. Over time, groundwater levels will equilibrate causing the storage term to approach zero. Under these conditions it is expected that groundwater flow to Lake Tahoe and baseflow rates will stabilize at 3,000 and 29,000 AFY, respectively.

3.7 DATA GAPS

The GWMP (Kennedy-Jenks, 2014) identified a number of data gaps that needed to be addressed to reduce conceptual model uncertainty. These include:

1) Improved understanding of source area protection zones and groundwater vulnerability to contamination and cleanup activities
2) Improved understanding of the impacts of detention basins on groundwater quality
3) Improved understanding of the impacts of groundwater pumping on surface water
4) Improved understanding of the potential impacts of climate change on groundwater conditions
5) Improved understanding of the groundwater budget and groundwater withdrawals
6) Update the existing groundwater flow model
7) Improved understanding of recharge areas and groundwater flow directions
8) Expansion of the monitoring well network to quantify variations in groundwater levels

Conducting technical studies to assess future groundwater needs and issues is another key BMO for the TVS Basin. DRI has been tasked with many of the items listed above and of those items, numbers 3, 4, 5, 6, 7 are either completed or near completion.

4. SUSTAINABLE YIELD

Under SGMA, sustainable yield is explicitly defined as "the maximum quantity of water calculated over a base period that is representative of long-term conditions in the basin and including any temporary surplus, that can be withdrawn annually from a groundwater supply without causing an undesirable result." The sustainable yield must be, at a minimum, less than or equal to the amount of groundwater recharge. As noted above, groundwater recharge varies in response to annual precipitation, but on average (1983 – 2015) groundwater recharge that flows to the TVS Basin is 39,000 AFY. Recharge is well in excess of the allocations (12,493 AFY) defined in the Compact for use in South Lake Tahoe (see section 3.6.6.1), which implies that the TVS Basin is operating well within its sustainable yield. Groundwater withdrawals over the last few years have been declining from 9,700 AFY in 2007 to just over 6,000 AFY in 2015. Additionally, future demand projections are expected to decrease to 4,700 AFY by 2035. In conclusion, the TVS Basin is operating well within its sustainable yield and it is expected to remain that way well into the future.

5. ANALYSIS OF UNDESIRABLE RESULTS

5.1 INTRODUCTION

Undesirable results occur when one or more significant and unreasonable effects are caused by groundwater conditions occurring throughout the basin: chronic lowering of groundwater levels, reduction of groundwater storage, seawater intrusion, degraded water quality, land subsidence, and depletion of interconnected surface water. For each of these groundwater conditions, the District has developed the following minimum thresholds which, if met, would trigger an undesirable result in the TVS Basin.

1. Chronic Lowering of Groundwater Levels - The minimum threshold for chronic lowering of groundwater levels shall be the groundwater elevation indicating a depletion of supply at a given location that may lead to undesirable results.
2. Reduction of Groundwater Storage - The minimum threshold for reduction of groundwater storage shall be a total volume of groundwater that can be withdrawn from the basin without causing conditions that may lead to undesirable results.
3. Seawater Intrusion - The minimum threshold for seawater intrusion shall be defined by a chloride concentration isocontour for each principal aquifer where seawater intrusion may lead to undesirable results.
4. Degraded Water Quality - The minimum threshold for degraded water quality shall be the degradation of water quality, including the migration of contaminant plumes that impair water supplies or other indicator of water quality as determined by the Agency, that may lead to undesirable results.
5. Land Subsidence - The minimum threshold for land subsidence shall be the rate and extent of subsidence that substantially interferes with surface land uses and may lead to undesirable results.
6. Depletion of Interconnected Surface Water - The minimum threshold for depletions of interconnected surface water shall be the rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results.

Minimum thresholds are defined as numeric values that, if exceeded, may cause an undesirable result. Two groundwater conditions—seawater intrusion and land subsidence related to groundwater extraction—were found to be not present and not likely to occur in the TVS Basin. Therefore, pursuant to section 354.28 of the GSP Regulations, a minimum threshold has not been developed. Justification for not developing minimum thresholds for these two groundwater conditions is provided in the corresponding sections below.

5.2 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).

5.2.1 Sustainability Goal

The first groundwater condition is the prevention of chronic lowering of groundwater levels in the TVS Basin. The goal 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 Basin. If long-term groundwater levels show a consistent declining trend that falls below the historical range, indicating a potential overdraft condition, then water supply wells are likely to fail and the needs of the beneficial users in the TVS Basin cannot be met.

The sustainability goal is to maintain a sustainable supply of groundwater by keeping groundwater water levels a safe distance above well screens.

5.2.2 Undesirable Result – Chronic Lowering of Groundwater Levels

The high reliance on groundwater necessitates that active wells have sufficient source capacity to meet water demands within the TVS Basin. In order to remain active, groundwater levels must be sustained adequately above the pump intake and the top of the uppermost screen interval of water supply wells to reduce the risk of corrosion and pump cavitation because of air entrainment in the water which would lead to a loss of production.

5.2.3 Sustainability Indicator

Because of the high reliance on groundwater to meet the drinking water needs of the beneficial users in the TVS Basin and the need to have water levels above screen intakes to reduce the risk of corrosion and pump cavitation because of air entrainment in the water, the total source capacity of community water supply wells is selected as the indicator of chronic lowering of groundwater levels in the TVS Basin.

The data requirements for this sustainability indicator are the source capacity of the active water supply wells operated by the District, TKWC and LBWC water systems. Source capacity values for current community water system wells operating in the TVS Basin are provided in Table 4-1.

Reasons for selection of this indicator for degraded water quality are as follows:

1. The data required for this indicator are readily available from each of the community water systems.
2. The source capacities of the community water system wells are sensitive to nearby groundwater levels that threaten the beneficial users of groundwater within the basin. As such, it is believed to be representative of groundwater levels conditions within the groundwater basin.
3. The source capacities of community water system wells are significantly changed by adjacent groundwater levels and the subsequent actions needed to address this undesirable result. The rate of these changes can be quantified and improvements detected over relatively short periods (less than five years).
4. The source capacities of the community water system wells are independent from the sustainable yield of the basin, but are dependent on changes in groundwater storage. However, the level of dependence on these other indicators is not critical and does not diminish its utility as an independent indicator of groundwater levels.
5. Trends in source capacities of community water system wells can inform policy decisions in evaluating the impacts of lowering groundwater levels. It can also be used as a performance measure to evaluate the effectiveness of management decisions to mitigate lowering groundwater levels effecting beneficial users within the basin.

5.2.4 Minimum Threshold

The minimum threshold is having water levels above the screen intake at enough water supply wells such that the total source capacity meets or exceeds the MDD. This threshold will be evaluated by monitoring static water levels in all active water supply wells semi-annually to ensure that levels are above the target levels in enough wells to meet the total MDD for the TVS Basin.

Table 4-1. Source capacity for active wells in the South Tahoe Public Utilities District, Tahoe Keys Water Company, and Lukins Brothers Water Company.

		SOURCE CAPACITY		
Well I.D.	**WATER SYSTEM**	**(gpm)**	**(mgd)**	**STATUS**
Al Tahoe Well #2	District	2500	3.6000	Active
Bakersfield Well	District	1500	2.1600	Active
Bayview Well	District	3600	5.1840	Active
Blackrock Well #2	District	90	0.1296	Active
Elks Club Well #2	District	300	0.4320	Active
GlenWood Well #5	District	1100	1.5840	Active
Helen Ave. Well #2	District	260	0.3744	Active
Paloma Well	District	2500	3.6000	Active
Sunset Well	District	600	0.8640	Active
SUT No. 3	District	1400	2.0160	Active
Valhalla Well	District	675	0.9720	Active
Arrowhead Well #3	District	1000	1.4400	Active - Treated
	DISTRICT SUB-TOTAL	**15,525**	**22.3560**	
TKWC No. 1	TKWC	1000	1.4400	Active
TKWC No. 3	TKWC	2000	2.8800	Active
TKWC No. 2	TKWC	550	0.7920	Active-Treated (LP GAC Limited)
	TKWC SUB-TOTAL	**3,550**	**5.1120**	
LBWC No. 1	LBWC	900	1.2960	Active
	LBWC SUB-TOTAL	**900**	**1.2960**	
	COMMUNITY WATER SYSTEMS TOTAL	**19,975**	**28.7640**	

There is no indication that groundwater levels are on a long-term downward trend in the TVS Basin and therefore should not fall to a level that threatens the ability of groundwater sources (public supply wells) to meet water system demands. Demand requirements for community water systems are calculated in accordance with methods described under Section 64554 of the California Waterworks Standards (Chapter 16, Title 22, Cal. Code Regs.). Under these standards, community water system's water sources shall have the capacity to meet the system's MDD calculated using the water system's daily, monthly or annual water use data, as available. These standards also include a water system's requirements for peak hourly demands (PHD), however these requirements are directed toward the adequacy of the water system's distribution system to provide sufficient flows. Therefore, only the MDD calculated for the community water systems reliant on groundwater will be used to establish a minimum threshold for chronic lowering of water levels in the TVS Basin.

The data requirements for the minimum threshold is the daily water production data for active wells in the District's water system; and the monthly water production data for the active wells in the TKWC and LBWC water systems. The LPA is primarily reliant on surface water to meet its water system demands. LPA has one active well (LPA Well #3). This well 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 Well #3 is not included in the minimum threshold calculations since it is rarely used.

The MDD for the District's water system is based on daily water use data. Therefore, the MDD for the District's water system is calculated using the day with the highest water usage (maximum day) over the preceding 10-years (WY 2005 – WY 2016).

The MDD for the TKWC and LBWC water systems is based on monthly water use data. The MDD for the TKWC and LBWC are calculated using the month with the highest water usage (maximum month) for each water system over the preceding 10-years (WY 2005 – WY 2016). 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. For the minimum threshold calculation, peaking factors for each water system were derived for each year and then averaged over the 10-year period. Average peaking factors over the 10-year period for the TKWC and LBWC water systems were 2.21 and 1.99, respectively. This is comparable to the 10-year average peaking factor derived for the District's water system (2.15) based on daily water usage data.

As indicated in Figure 5-1, about 93 percent of the total water demand is satisfied by the community water system wells operated by the District, TKWC and LBWC water systems. 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 Basin. Results of these calculations show that the current minimum threshold is a total source capacity of 22.8 million gallons per day (MGD) (Table 4-2).

Reasons for selection of this minimum threshold are as follows:

1. The data required for this minimum threshold is readily available from each of the community water systems.

Table 4-2. Maximum day demands calculated for community water systems operating within the TVS Basin (WY 2005 – WY 2016) and minimum threshold value for degraded water quality based on water demands. The minimum threshold for degraded water quality is the total maximum day demand (MDD), in million gallons per day (mgd), for community water systems reliant on groundwater operating within the TVS Basin.

Community Water System	Ca Water System No.	Active Wells	Connections[1,4]	Population Served[1,5]	Source Capacity (mgd)[2]	Maximum Day Demand (mgd)[3]
South Tahoe Public Utility District	910002	13	13,926	32,504	22.356	14.831
Tahoe Keys Water Company	910015	3	1,525	1,200	5.112	4.515
Lukins Brother Water Company	910007	1	952	3,000	1.296	1.358
TVS SUBBASIN (6-5.01) TOTALS		17	16,403	36,704	28.764	20.704
					Degraded Water Quality Minimum Threshold (110% of MDD)	**22.775**

NOTES;

1) Source: SWRCB Drinking Water Branch Drinking Water Watch (https://sdwis.waterboards.ca.gov/PDWW/).
2) Source capacity of active wells, in mgd (stand-by or offline sources not included).
3) 10 Year (WY 2005 - WY 2016) Water System Maximum Day Demand, in million gallons per day (mgd), as per CA Waterworks Standards (§ 64554).
4) Tahoe Key Water Company active connections.
5) Tahoe Key Water Company population increases to over 7,300 during the summer. Lukins Brothers Water Company population estimate.

2. The minimum threshold is calculated in a manner that is consistent with California Waterworks Standards and is representative of the volume of water needed to satisfy the water demands of the beneficial users of groundwater within the TVS Basin.
3. The minimum threshold is based on direct water use data which is sensitive to changes in population and water use in the TVS Basin. Therefore, it can be easily adjusted to reflect current beneficial user needs.
4. The volumes used for the sustainability indicator and accompanying minimum threshold are the same for ease of comparison.
5. The MDD is completely independent of the source capacity.
6. Groundwater levels do not fall in direct response to drought periods with the only exception being wells that are located a short distance from Lake Tahoe. Therefore, the minimum threshold defined above should be relatively insensitive to water year type.
7. The minimum threshold defined for groundwater levels would also be a useful indicator for groundwater storage, and to a lesser extent interconnected surface water. For example, if the minimum threshold for groundwater levels was violated this would also indicate that groundwater storage is declining at perhaps unsafe levels. If water level declines were such that the MDD could not be met, this would likely indicate increased loss from or reduced groundwater flow to surface water bodies but only for streams that are located near active production wells.

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. Table 4-3 shows the calculations used to derive the target water levels for the 16 production wells used in the TVS Basin. It is assumed that water levels must remain above the top of the screen to ensure proper well functioning. Depth to water is provided as measured in May 2016. Depth to water was not available during this period for four wells so they were estimated based on nearby wells. Recall that the semi-annual water level measurements represent static water levels (i.e., pumps are not running for 12 hours or more prior to taking the measurement). Specific capacity values represent either direct measurements at source capacity or calculations based on transmissivity estimates and source capacity rates (Cooper and Jacob, 1946). Transmissivity values were estimated using nearby wells for six of the production wells. The minimum water level target (Table 4-3) is calculated as the difference between depth from the top of screen and the additional drawdown expected at source capacity pumping rates.

The minimum threshold is defined as having enough wells meeting the water level target such that the MDD can be met for the entire TVS Basin. Currently the source capacity is 28.8 MGD and the MDD is 22.8 MGD, for a surplus of 6.0 MGD. Water levels would have to fall below the target level in enough wells for the source capacity to fall below the MDD.

5.2.5 Monitoring and Reporting

The sustainability indicator (source capacity) will be accounted on an annual basis for all of the community water system wells operating in the TVS Basin and provided in the Annual Report. Trends in source capacity will then be compared to the minimum threshold to determine whether any actions are required to prevent undesirable results from occurring within the TVS Basin. Based on the District's annual monitoring, the District will update and submit its analysis of basin conditions to the DWR every five years as required by SGMA.

Table 4-3. Minimum water level targets for active production wells within the TVS Basin.

Well I.D.	Water System	Top of Screen (ft bgs)	Bottom of Screen (ft bgs)	Depth to Water[1] (ft bgs)	Transmissivity (gpd/ft)	Expected Drawdown (ft)	Specific Capacity[2] (gpm/ft)	Water Level Min Target[3] (ft bgs)	Freeboard[4] (ft)
Al Tahoe Well #2	District	110	140	34	**67,649**	65	39	45	11
Bakersfield Well	District	130	170	26	55,569	52	29	78	53
Bayview Well	District	180	300	30	65,308	77	**47**	103	74
Blackrock Well #2	District	136	232	1	1,250	100	**1**	36	35
Elks Club Well #2	District	110	160	23	3,652	60	5	50	27
GlenWood Well #5	District	150	180	51	25,544	75	15	75	24
Helen Ave. Well #2	District	90	150	18	15,237	29	9	61	43
Paloma Well	District	188	248	43	39,996	112	22	76	33
Sunset Well	District	275	430	19	31,506	36	18	239	220
SUT No. 3	District	70	90	15	18,805	37	**38**	33	18
Valhalla Well	District	110	170	27	14,713	72	9	38	11
Arrowhead Well #3	District	250	280	44	**14,534**	92	9	158	114
TKWC No. 1	TKWC	125	312	**20**	**46,159**	39	26	86	66
TKWC No. 3	TKWC	175	300	**20**	**30,855**	100	18	75	55
TKWC No. 2	TKWC	138	188	**20**	**12,342**	74	7	64	44
LBWC No. 1	LBWC	132	182	**20**	**12,342**	97	7	35	15

Notes

1. Based on May, 2016 measurements. Bold values are estimates based on nearby wells.
2. Bold values represent directly measured specific capacity at well capacity. Other values are calculating using Cooper and Jacob (1946) equation.
3. Water level minimum threshold based on top of screen - expected drawdown at full well capacity.
4. Freeboard is defined as Water level target - depth to water.

There is no indication that groundwater levels are on a long-term downward trend in the TVS Basin and therefore should not fall to a level that threatens the ability of groundwater sources (public supply wells) to meet water system demands. The current source capacity is 6.0 MGD larger than the MDD which provides a relatively large buffer to allow water levels to fluctuate. In addition, under current conditions water supply wells have freeboard distances of 11 to 220 feet. It is important to note that only two wells (Al Tahoe Well #2 and Valhalla Well) have 11 foot freeboard distances.

5.3 Reduction of Groundwater Storage

- Sustainability Goal: To maintain groundwater 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 changes in groundwater storage.
- Minimum Threshold: Cumulative groundwater storage change of negative 450,000 AF, which indicates falling water levels.

5.3.1 Sustainability Goal

The sustainability goal for groundwater storage is to maintain groundwater storage reserves to ensure a sustainable supply of groundwater.

5.3.2 Undesirable Result – Reduction of Groundwater Storage

Long-term reductions in groundwater storage indicate an overdraft condition. When a groundwater basin is in an overdraft condition, water levels will trend downward making it more difficult to extract for water supply purposes.

Long-term reductions in groundwater storage are not occurring within the TVS Basin as evidenced by stable groundwater levels and average annual groundwater storage changes as calculated by the TVS groundwater model that are near zero. Minor groundwater storage changes do occur in response to climate variability and changes in groundwater extraction rates. Therefore, it is important to understand the magnitude of groundwater storage changes that occur due to climate variability versus more serious long-term declines.

5.3.3 Sustainability Indicator

The sustainability indicator will be cumulative changes in groundwater storage (either positive or negative) as calculated from the TVS groundwater model. The storage change calculations will be performed for the TVS Basin only, as opposed to the larger analysis area that makes up the groundwater model domain. Since groundwater storage can be calculated directly within the modeling framework, there is no need to specify a surrogate indicator.

5.3.4 Minimum Threshold

The minimum threshold for groundwater storage changes is a cumulative groundwater storage change of negative 450,000 AF, which indicates falling water levels. This value is based on expected groundwater level declines during a long-term drought that would not allow total source capacity to be met.

The TVS Basin is highly resilient to climate variations because average annual recharge is five times the amount of groundwater extracted. As shown in Figures 3-38 and 3-39, groundwater storage reductions occur during drought periods (Hagan's Meadow precipitation less than 31 inches), and is replenished during normal and above normal precipitation years.

Given that the TVS Basin is in a surplus state, undesirable results related to reductions in groundwater storage would occur if there were significant reductions in precipitation and drastic increases in groundwater pumping. As stated above, however, groundwater extraction rates are expected to decline in the future, thereby increasing resiliency. Though not all climate models are in agreement regarding future changes in precipitation, the worst case prediction is an approximately 20 percent reduction in precipitation by the end of this century (see Section 3.1.3). Using the regression equation developed in Figure 3-31 that relates annual precipitation at Hagan's Meadow to groundwater recharge, we can estimate the expected decrease in groundwater recharge. Because of the non-linear relationship, a 20 percent reduction in precipitation yields a 27 percent reduction in groundwater recharge or 27,100 AFY versus 37,500 AFY (regression derived). Regardless, groundwater recharge on the order of 27,000 AFY is still well in excess of historical groundwater extraction rates (7,700 AFY) and expected rates in 2035 of 4,700 AFY. In addition, groundwater recharge is in excess of the amount (12,493 AFY) allocated to South Lake Tahoe in the Compact.

Using the regression equation, groundwater recharge is approximately 15,000 AFY when annual precipitation at Hagan's Meadow is 16 inches, which is the threshold for the critical water year classification. Under the worst water year classification (critical), groundwater recharge is still nearly twice groundwater extractions in the TVS Basin.

The TVS Basin groundwater model was used to quantify undesirable results that may potentially result from reductions in groundwater storage. Specifically, the groundwater model was used to determine the rate of water level decline under long-term drought conditions. The model used 2010 as a starting condition because it represents average precipitation conditions (31 inches in 2010 versus a 1979 – 2015 average of 31 inches). The model simulated 10 years of 15,000 AFY of groundwater recharge which is equivalent to 16 inches (critical water year threshold) at Hagan's Meadows. The simulated water decline rates are shown in Figure 5-2.

Rates of water level declines under a critical water year are expected to range between 0.25 to 1 foot per year (ft/yr). The greatest water level declines are expected in the southeast and west-central portions of the TVS Basin. Both of these locations are located near the outer boundary of the TVS Basin, which is near the higher elevation regions where a majority of the recharge occurs and generally distant from active pumping wells.

Undesirable results will occur when groundwater storage reductions are in excess of 30,000 AFY for a 15-year period or longer. This is equivalent to the critical water year threshold of 16 inches at Hagan's Meadows for ten years or longer. Using a conservative assumption that water levels will decline 1 foot per year everywhere in the TVS Basin in critical water years, one can use the current freeboard in active water supply wells to determine when wells will not continue to operate properly. Table 4-4 shows the source capacity, cumulative source capacity reduction if wells were to fail due to long-term (15 years) drought conditions, and existing freeboard for the active water supply wells. Freeboard is defined as the distance between the current water level and the target static water level that will presumably lead to well failure. An undesirable result occurs when target water levels are reached in enough wells that MDD

Table 4-4. Source capacity and freeboard active water supply wells. Maximum Daily Demand for the Tahoe Valley South Basin is 22.77 MGD.

Well I.D.	Water System	Source Capacity (MGD)	Cum. Red. Source Cap. (MGD)	Freeboard[1] (ft)
Al Tahoe Well #2	District	3.60	24.80	11
Valhalla Well	District	0.97	23.83	11
LBWC No. 1	LBWC	1.30	22.53	15
SUT No. 3	District	2.02	20.52	18
GlenWood Well #5	District	1.58	18.93	24
Elks Club Well #2	District	0.43	18.50	27
Paloma Well	District	3.60	14.90	33
Blackrock Well #2	District	0.13	14.77	35
Helen Ave. Well #2	District	0.37	14.40	43
TKWC No. 2	TKWC	0.79	13.60	44
Bakersfield Well	District	2.16	11.44	53
TKWC No. 3	TKWC	2.88	8.56	55
TKWC No. 1	TKWC	1.44	7.12	66
Bayview Well	District	5.18	1.94	74
Arrowhead Well #3	District	1.44	0.50	114
Sunset Well	District	0.86	-	220
	Total:	**28.76**		

Notes
1. Freeboard is defined as Water level target - depth to water.

cannot be met. Annual precipitation of less than 16 inches per year (i.e., critical water year) would have to occur for at least 15 years before source capacity could not be met. Therefore, the minimum threshold is defined as a reduction of 30,000 AFY for 15 consecutive years, for a total reduction of 450,000 AF. In practice the threshold would be monitored on a cumulative basis to determine if the cumulative storage change falls below -450,000 AF.

The likelihood of experiencing a drought in the critical range (less than 16 inches at Hagan's Meadow) for 15 consecutive years is extremely low. However, if this were to occur, water level declines could lead to well failures and other undesirable results.

5.3.4 Monitoring and Reporting

Changes in groundwater storage will be accounted on an annual basis using the TVS groundwater model. Cumulative changes in groundwater storage will be compared to the minimum threshold to determine whether any actions are required to prevent undesirable results from occurring within the TVS

Basin. Based on the District's annual monitoring, the District will update and submit its analysis of basin conditions to the DWR every five years as required by SGMA.

The historical state of groundwater storage for the TVS Basin is shown in Figure 5-3. Figure 5-3 shows that groundwater storage varies according to pumping and climate variability, but is not near the specified threshold of negative 450,000 AF. The changes in groundwater storage have not reached the level of a significant and undesirable result, as indicated by its current level above the minimum threshold.

5.4 Seawater Intrusion

The TVS Basin sits at close to 6,250 feet above sea level in the Sierra Nevada Mountains. The closest source of saltwater is close to 200 miles away. Therefore, seawater intrusion is not an issue for the TVS Basin and as such a minimum threshold was not developed for this groundwater condition.

5.5 Water 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 Basin should not rise to a level that threatens the ability of groundwater sources to meet MDD.

5.5.1 Sustainability Goal

The sustainability goal for this groundwater condition is to maintain a sustainable long-term groundwater quality. The goal is to implement measures to manage the groundwater quality for long-term sustainability and reliability of the water supply for all users within the TVS Basin. If groundwater quality degrades over long periods, this is an indication of contamination. Though this is not the case in the TVS Basin, the goal will be to ensure that groundwater quality is maintained to support continued extraction for water supply purposes.

Current water use estimates indicate that more than 95 percent of drinking water used in the TVS Basin is from groundwater sources (District, 2016). Of this amount, more than 90 percent is produced from community water system wells, about 3 percent is produced from noncommunity water system wells, about 2 percent is produced from private wells, and about 1 percent is produced from State Small Water System and Nontransient Noncommunity Water System (Figure 5-1).

5.5.2 Undesirable Result - Degraded Water Quality

The high reliance on groundwater necessitates that active wells have sufficient source capacity to meet water demands within the TVS Basin. In order to remain active, groundwater sources must be able to produce water of acceptable water quality, in accordance with federal and state MCLs. Degraded water quality in the TVS Basin, primarily from pollutants, threatens the ability to produce groundwater of sufficient water quality and has resulted in impairment of some groundwater sources within the TVS Basin.

5.5.3 Sustainability Indicator

Because of the high reliance on groundwater to meet the drinking water needs of the beneficial users in the TVS Basin, the vulnerability of the groundwater basin to contamination and the impact of degraded water quality on a water system's capacity to produce groundwater, the total source capacity of community water supply wells is selected as the indicator of degraded water quality concerns in the TVS Basin.

The data requirements for this sustainability indicator are the source capacity of the active water supply wells operated by the District, TKWC and LBWC water systems. Source capacity values for current community water system wells operating in the TVS Basin are provided in Table 4-1. Current source capacity for all three water systems is 28.8 MGD.

Reasons for selection of this sustainability indicator for degraded water quality are as follows:

1. The data required for this sustainability indicator is readily available from each of the community water systems;
2. The source capacities of the community water system wells are sensitive to degraded water quality problems that threaten the beneficial users of groundwater within the basin. As such it is believed to be representative of degraded water quality conditions within the groundwater basin;
3. The source capacities of community water system wells are significantly changed by degraded water quality and the subsequent actions needed to address this undesirable result. The rate of these changes can be quantified and improvements detected over relatively short periods (less than 5 years);
4. The source capacities of the community water system wells are relatively independent from the sustainable yield of the basin, but are somewhat dependent on groundwater levels and changes in groundwater storage. However, the level of dependence on these other indicators is not significant within the TVS Basin and does not diminish its utility as an independent indicator of degraded water quality; and
5. Trends in source capacities of community water system wells can inform policy decisions in evaluating the impacts of degraded water quality on groundwater sources operating within the basin. It can also be used as a performance measure to evaluate the effectiveness of management decisions to mitigate degraded water quality concerns affecting beneficial users within the basin.

5.5.4 Minimum Threshold

In accordance with the sustainability goal advanced at the beginning of this section, degraded water quality concerns within the TVS Basin should not rise to a level that threatens the ability of groundwater sources (public supply wells) to meet water system demands. Demand requirements for community water systems are calculated in accordance with methods described under Section 64554 of the California Waterworks Standards. Under these standards, a community water system's water sources shall have the capacity to meet the system's MDD calculated using water system's daily, monthly or annual water use data, as available. These standards also include a water system's requirements PHD; however, these requirements are directed toward the adequacy of the water system's distribution system to provide sufficient flows. Therefore, only the MDD calculated for the community water systems reliant on groundwater will be used to establish a minimum threshold for degraded water quality in the TVS Basin.

The data requirements for the minimum threshold is the daily water production data for active wells in the District water system, and the monthly water production data for the active wells in the TKWC and LBWC water systems. LPA is primarily reliant on surface water to meet its water system demands. LPA has one active well (LPA Well #3). This well 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 Well #3 is not included in the minimum threshold calculations.

The MDD for the District's water system is based on daily water use data. Therefore, the MDD for the District's water system is calculated using the day with the highest water usage (maximum day) over the preceding 10 years (WY 2005 – WY 2016).

The MDD for the TKWC and LBWC water systems is based on monthly water use data. The MDD for the TKWC and LBWC are calculated using the month with the highest water usage (maximum month) for each water system over the preceding 10 years (WY 2005 – WY 2016). 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. For the minimum threshold calculation, peaking factors for each water system were derived for each year and then averaged over the 10-year period. Average peaking factors over the 10-year period for the TKWC and LBWC water systems were 2.21 and 1.99, respectively. This is comparable to the 10-year average peaking factor derived for the District water system (2.15) based on daily water usage data.

As indicated in Figure 5-1, approximately 93 percent of the total water demand is satisfied by the community water system wells operated by the District, TKWC and LBWC water systems. 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 Basin. Results of these calculations show that the current minimum threshold is 22.8 MGD (Table 4-2).

Reasons for selection of this minimum threshold for degraded water quality are as follows:

1. The data required for this minimum threshold is readily available from each of the community water systems;
2. The minimum threshold is calculated in a manner that is consistent with California Waterworks Standards and is representative of the volume of water needed to satisfy the water demands of the beneficial users of groundwater within the TVS Basin;
3. The minimum threshold is based on direct water use data which is sensitive to changes in population and water use in the TVS Basin. Therefore, it can be easily adjusted to reflect current beneficial user needs;
4. The volumes used for the degraded water quality sustainability indicator and accompanying minimum threshold are the same for ease of comparison; and
5. The water demand minimum threshold is completely independent of the source capacity sustainability indicator.

5.5.5 Monitoring and Reporting

The sustainability indicator (source capacity) will be accounted on an annual basis for all of the community water system wells operating in the TVS Basin and provided in the Annual Report. Trends in source capacity will then be compared to the minimum threshold for degraded water quality to determine whether any actions are required to prevent degraded water quality -- undesirable results -- from occurring within the TVS Basin. Based on the District's annual monitoring, the District will update and submit its analysis of basin conditions to the DWR every five years as required by SGMA.

The current state of the TVS Basin is indicated below in Figure 5-4. This figure shows that there is a sufficient supply of high quality water (source capacity) adequate to meet the drinking water needs of the beneficial users of groundwater in the TVS Basin. The trend in source capacity has declined since 2015, due to well impairments from degraded water quality. However, these impairments have not reached the level of an undesirable result, as indicated by its current level above the minimum threshold for degraded water quality.

5.6 LAND SUBSIDENCE

The TVS Basin consists mostly of coarse-grained glacial and alluvial/fluvial deposits and lesser fine-grained interbedded lacustrine layers. The coarse-grained deposits consist of variable mixtures of stratified and massive sand to boulders, which have sedimentologic characteristics that are less susceptible to compaction during deep declines in groundwater levels than the fine-grained lacustrine deposits composed of bedded silt and clay. The potential for land subsidence in the TVS Basin under current groundwater conditions is negligible because the fine-grained lacustrine deposits are relatively thin and discontinuous, and historical groundwater levels in the basin have been stable (e.g., Ireland et al., 1984). In addition, the analysis given below also demonstrates that the target water levels defined in Section 5.1., Chronic Lowering of Water Levels, are more restrictive than the thresholds defined for land subsidence and as such, a minimum threshold was not developed for this groundwater condition.

Land subsidence can be induced by deep declines in groundwater levels that allow for compaction, particularly of fine-grained layers. This compaction occurs as pumping of groundwater reduces the fluid pressure in pore spaces between grains, which would otherwise oppose the normal stress caused by the weight of overlying sediments. The stress borne by a porous medium can be expressed by Terzaghi's Law, such that

$$\sigma = \sigma' + p \quad (1)$$

where σ is the vertical normal stress, σ' is the effective stress, or 'grain-to-grain' stress, and p is the fluid pressure. Thus, with an unchanging vertical normal stress, a reduction in fluid pressure necessitates an increase in the effective stress, which can induce a shifting or elastic compression of grains to reduce porosity (i.e., compaction). The degree of compaction resulting from a given increase in effective stress– caused by an equivalent decrease in pore fluid pressure – is a function of the compressibility (α) of the aquifer rock or sediment, such that

$$-(dz) = \alpha z(d\sigma') = -\alpha z \rho_w g dh \quad (2)$$

where z is the saturated thickness, dz is the change in thickness (i.e., the compaction), $d\sigma'$ is the change in effective stress, and $\rho_W gdh$ is the drop in hydrostatic pressure due to a decrease in head (dh).

The compressibility of a dense, sandy gravel representative of the coarse glacial deposits making up much of the basin fill in the TVS Basin is 4 x 10^{-7} ft^2/lb (Domenico and Mifflin, 1965). Deeper wells (e.g. Sunset Well) access approximately 400 feet of saturated thickness. To generate land subsidence of 1 foot in these sediments, a sustained head drop of 100 feet would be required.

Assuming undesirable results would occur if subsidence would be in excess of 1 foot, the minimum threshold is defined as static water levels 100 feet less than current conditions. Table 4-5 shows the water level thresholds that would result to ensure subsidence magnitudes of less than 1 foot. In all but one case (Arrowhead Well #3), the target water levels defined in Section 5.1., Chronic Lowering of Water Levels, are more restrictive than the thresholds defined for land subsidence. Since the minimum water level thresholds defined in Section 5.1 (Chronic Lowering of Groundwater Levels) are more restrictive than those calculated in this section and the fact that the hydrogeologic setting is such that adverse subsidence is unlikely to occur, an explicit threshold will not be developed for this sustainability indicator.

5.7 INTERCONNECTED SURFACE WATER

- Sustainability Goal: To avoid depletions of interconnected surface water caused by groundwater use at a rate that has adverse impacts on beneficial uses of the surface water.
- Undesirable Result: Depletions to surface water systems can impact beneficial uses including water right holders and groundwater dependent ecosystems by degrading vegetation and species dependent on these sensitive environments.
- Sustainability Indicator: The reduction in baseflow to streams within the TVS Basin.
- Minimum Threshold: Baseflow depletions in excess of 12,400 AFY which represents 10 percent of the average annual runoff.

5.7.1 Sustainability Goal

The sustainability goal related to interconnected surface water to avoid depletions of interconnected surface water at rate or volume of surface water depletions caused by groundwater use that has adverse impacts on beneficial uses of the surface water and may lead to undesirable results.

The TVS Basin is located in a unique environmental setting. Water supply operations using groundwater may both affect environmental conditions or be affected by changes in the environment. Groundwater–surface water interactions with Lake Tahoe and the rivers and streams serve as both groundwater discharge and recharge locations depending on their location and the time of year.

SEZs are important ecological areas that are at least partially dependent on near-surface groundwater. The SEZs protect water quality because as the surface water flows slowly in these areas, natural processes of infiltration, nutrient uptake, denitrification, and sediment capture help to reduce sediment and nutrients in the surface water. Groundwater flow provides base flow to streams which maintains riparian habitat in summer months and provides streamflow for beneficial uses.

Protection of the linkage between groundwater and surface water is considered vital to the health of the lakes and rivers receiving the runoff. For these reasons, the goal will be to maintain a close connection of groundwater surface water bodies and to not significantly impair discharge for those SEZs receiving surface water for beneficial use.

Table 4-5. Water levels targets for land subsidence and chronic lowering of water levels.

Well I.D.	Water System	Depth to Water[1] (ft bgs)	Subsidence Water Level Threshold (ft bgs)	Water Level Min Target[2] (ft bgs)
Al Tahoe Well #2	District	34	134	45
Bakersfield Well	District	26	126	78
Bayview Well	District	30	130	103
Blackrock Well #2	District	1	101	36
Elks Club Well #2	District	23	123	50
GlenWood Well #5	District	51	151	75
Helen Ave. Well #2	District	18	118	61
Paloma Well	District	43	143	76
Sunset Well	District	19	119	239
SUT No. 3	District	15	115	33
Valhalla Well	District	27	127	38
Arrowhead Well #3	District	44	144	158
TKWC No. 1	TKWC	**20**	120	86
TKWC No. 3	TKWC	**20**	120	75
TKWC No. 2	TKWC	**20**	120	64
LBWC No. 1	LBWC	**20**	120	35

Notes
1. Based on May, 2016 measurements. Bold values are estiamtes based on nearby wells.
2. Water level minimum threshold based on top of screen - expected drawdown at full well capacity.

5.7.2 Undesirable Result

Groundwater level declines caused by increasing water supply operations and climate variability are the two most likely causes of depletion of interconnected surface water bodies. Understanding the relative impacts of groundwater pumping versus climate variability is important when developing thresholds that lead to undesirable results.

Lake Tahoe has a total capacity of 122,000,000 AF (USGS, 1997) and average groundwater flow is 5,600 AFY; therefore, fluctuations in groundwater flow to the lake are insignificant in terms of the lake's water balance. For this reason, potential undesirable results are focused on streams within the TVS Basin.

Undesirable effects to environmental conditions along the SEZs are likely to occur when groundwater pumping causes declines in base flow that are greater on the order 10 percent of the average annual runoff (12,400 AFY) for the reasons explained below. Much below this amount, the changes would be difficult to measure because measurement uncertainty ranges from 2 – 20 percent (Sauer and Meyer, 1992). If base flow amounts were to decrease beyond 10 percent, groundwater may begin to disconnect in areas thereby degrading vegetation and species dependent on these sensitive environments.

Surface water rights on streams within the TVS Basin total 8,500 AFY. This includes 0.8, 917.4, 8.1, 247.1, and 7,324.7 AFY on Benwood Creek, Cold Creek, Echo Creek, Sawmill Creek, and Upper Truckee River, respectively. Of these, the District holds permits for 7,115.7 AFY or 84 percent of the total water right within the TVS Basin but is currently not utilizing them. As discussed above, average annual runoff is 124,000 AFY and of this approximately 28,000 AFY, or 23 percent (per groundwater model 2000 – 2015), is derived as base flow from groundwater. Undesirable results to surface water right holders are not likely to occur since active water rights only makeup 7 percent of the average annual runoff of this amount and the District retains 84 percent of these rights.

5.7.3 Sustainability Indicator

To ensure that SEZs are not significantly affected by groundwater pumping, the reduction in baseflow is selected as the sustainability indicator. This term represents the baseflow depletion caused by anthropogenic impacts.

The primary reasons for selecting baseflow as a sustainability indicator for interconnected streams are as follows:

1. The calculations required for this indicator can be derived from the existing groundwater model that will be maintained and updated annually.
2. This indicator also provides a measure of how well groundwater is connected to streams.

5.7.4 Minimum Threshold

Impacts to baseflow can be quantified using the capture analysis techniques developed by Leake, *et al.*, 2010. The method relies on a groundwater model to calculate groundwater flux with and without groundwater pumping. The change in the flux to or from the stream can be attributed to groundwater pumping and this amount is referred to as baseflow depletion.

The baseflow depletion analysis was performed using the TVS groundwater model and the results are presented in Figure 5-4. As pumping increased in the 1980s, baseflow depletion rates began to steadily increase from a few hundred AFY in 1983 to an average of 2,500 AFY from 2000 – 2015. Following 2000, the baseflow reduction represents 2 percent of the average annual runoff (124,000 AFY).

The minimum threshold is defined as baseflow depletions in excess of 12,400 AFY, which represents 10 percent of the average annual runoff. From 2000 to 2015 baseflow depletions have averaged 2,500 AFY which is well below the 12,400 AFY threshold.

Though the minimum threshold is based on undesirable results that may form in SEZs, its application will also apply indirectly to other surface water right holders but in a highly conservative fashion.

5.7.5 Monitoring and Reporting

The sustainability indicator (annual baseflow depletion) will be accounted on an annual basis. The analysis will be performed in parallel with the Annual Report which also requires an annual update of the groundwater model to calculate changes in groundwater storage. Trends in annual baseflow depletion will then be compared to the minimum threshold to determine whether any actions are required to prevent degradation to interconnected streams.

6. CONCLUSIONS

SGMA's goal is to ensure sustainable groundwater management throughout the State. SGMA empowers local agencies to demonstrate sustainability through the creation of a GSA and submission to DWR of either a GSP or, in appropriate circumstances, an Alternative Plan. As discussed in this report, the ABC Alternative is proper for the TVS Basin because the District has sustainably managed it for decades without any undesirable results.

6.1 SUSTAINABLE YIELD

SGMA defines sustainable yield as the "maximum quantity of water, calculated over a base period that is representative of long-term conditions in the basin and including any temporary surplus that can be withdrawn annually from a groundwater supply without causing an undesirable result." Therefore, to be operating sustainably, a basin's sustainable yield must be less than or equal to the amount of groundwater recharge. The thirty-year average for groundwater recharge into the TVS Basin is 39,000 AFY, which exceeds the sum of both groundwater allocations defined in the Compact as well as historical groundwater extractions. Additionally, as previously discussed, historical water demand has decreased and is expected to continue to decrease by close to 50 percent over the next twenty years. In conclusion, the TVS Basin is—and has been—operating within its sustainable yield.

6.2 ANALYSIS OF UNDESIRABLE RESULTS

SGMA identifies six undesirable results—chronic lowering of groundwater levels, reduction of groundwater storage, seawater intrusion, degraded water quality, land subsidence, and depletion of interconnected surface water—none of which are present in the TVS Basin. To ensure this trend is sustained, the ABC Alternative developed sustainability goals, identified sustainability indicators, and established minimum thresholds for four of the six undesirable results defined in SGMA. Seawater intrusion and land subsidence were found not to apply to the TVS Basin and, therefore, are not issues in the TVS Basin.

6.2.1 Chronic Lowering of Groundwater Levels

The ABC Alternative defines groundwater levels as triggering an undesirable result when regional water levels decline to such an extent that water demands can no longer be met. The total source capacity of community water supply wells within the TVS Basin is defined as the sustainability indicator. The minimum threshold for groundwater levels is defined as the maintenance of water levels above the screen intake at enough water supply wells for the total source capacity to meet or exceed the MDD. As noted above, the current source capacity for the TVS Basin is 28.8 MGD and the current MDD for the TVS Basin is 22.8 MGD, leaving a surplus of 6 MGD. Therefore, there is not an undesirable result since groundwater levels exceed the minimum threshold.

6.2.2 Reduction of Groundwater Storage

The sustainability goal for groundwater storage is to maintain adequate groundwater storage capacity to ensure a sustainable supply of groundwater. An undesirable result would occur under overdraft conditions. The sustainability indicator is defined as the net change in groundwater storage (positive or negative) as calculated from the TVS groundwater model. Based on this sustainability indicator, the District has set the minimum threshold for groundwater storage as a cumulative groundwater storage change of negative 450,000 AF. As discussed above, however, under even critical water year classifications, groundwater recharge is nearly double total groundwater extractions. Additionally, modeling indicates that the average annual groundwater storage changes are negligible. Therefore, groundwater conditions in the TVS Basin have not resulted in a reduction of storage and without an undesirable result.

6.2.3 Degraded Water Quality

This ABC Alternative identifies degradation of water quality, primarily from pollutants, as the District's main water supply concern. Due to the impact of degraded water quality on a water system's capacity to produce groundwater, the District defined the total source capacity of community water supply wells (28.8 MGD) as the indicator of water quality issues in the TVS Basin. The minimum threshold is defined as ensuring that water quality concerns do not threaten the ability of groundwater sources to meet the TVS Basin's MDD (22.8 MGD). Although source capacity has declined slightly since 2015 due to wells impaired by degraded water quality, these impairments have not resulted in an undesirable result.

6.2.4 Depletion of Interconnected Surface Water

Groundwater level declines caused by increasing water supply operations and climate variability are the two most likely causes of depletion of interconnected surface water bodies. To ensure that such depletions do not cause an undesirable result, this report identifies the reduction in baseflow as the sustainability indicator. The minimum threshold is defined as baseflow depletions in excess of 12,400 AFY—equivalent to 10 percent of the average annual runoff. Groundwater modeling, however, has shown that baseflow depletions have averaged only 2,500 AFY over the past 15 years, which is well below the threshold of 12,400 AFY. Therefore, despite climate variability and groundwater pumping, this undesirable result has not occurred in the TVS Basin.

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8. FIGURES

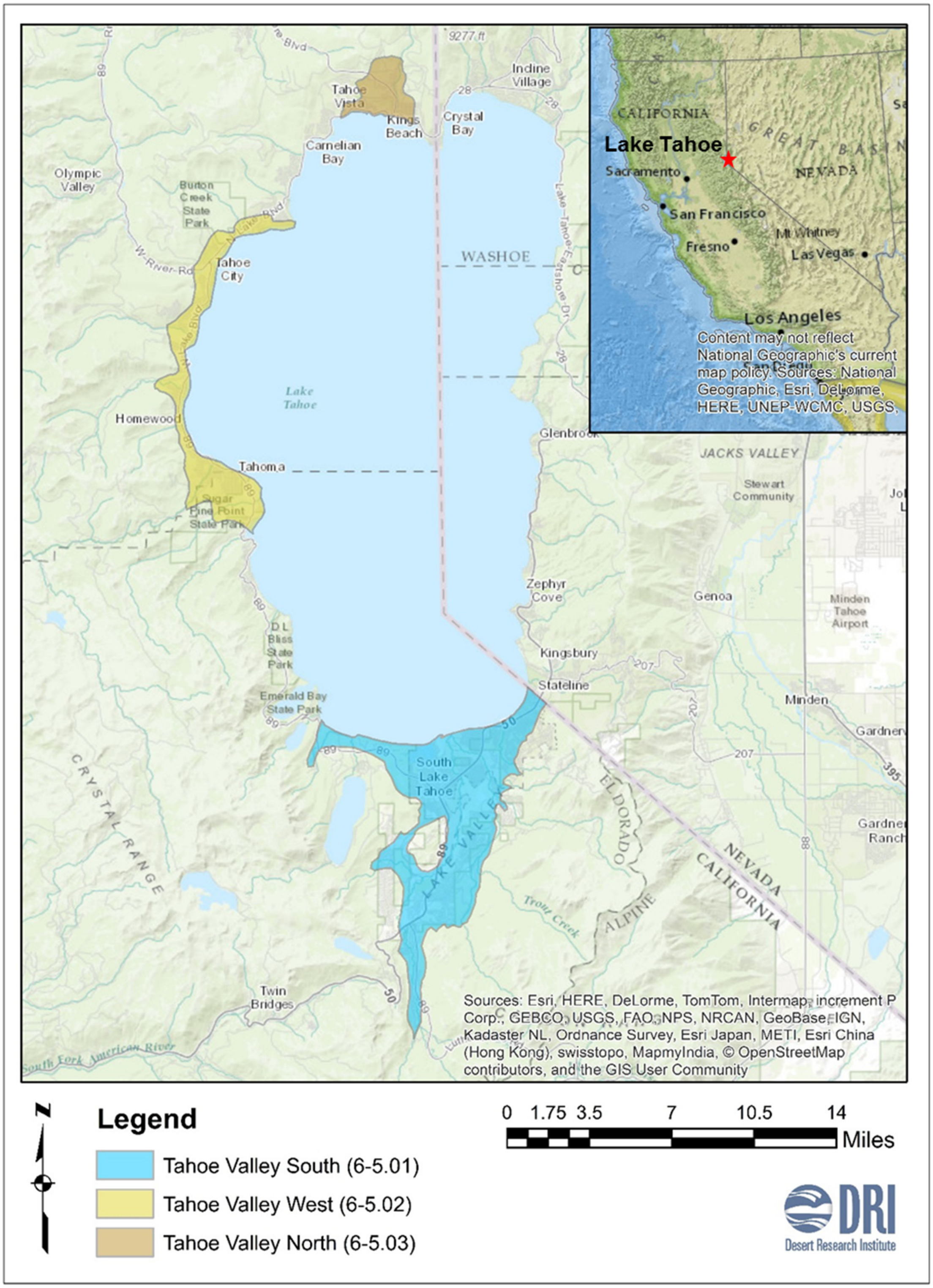


Figure 1-1. Lake Tahoe area regional map with California Department of Water Resources groundwater basins.

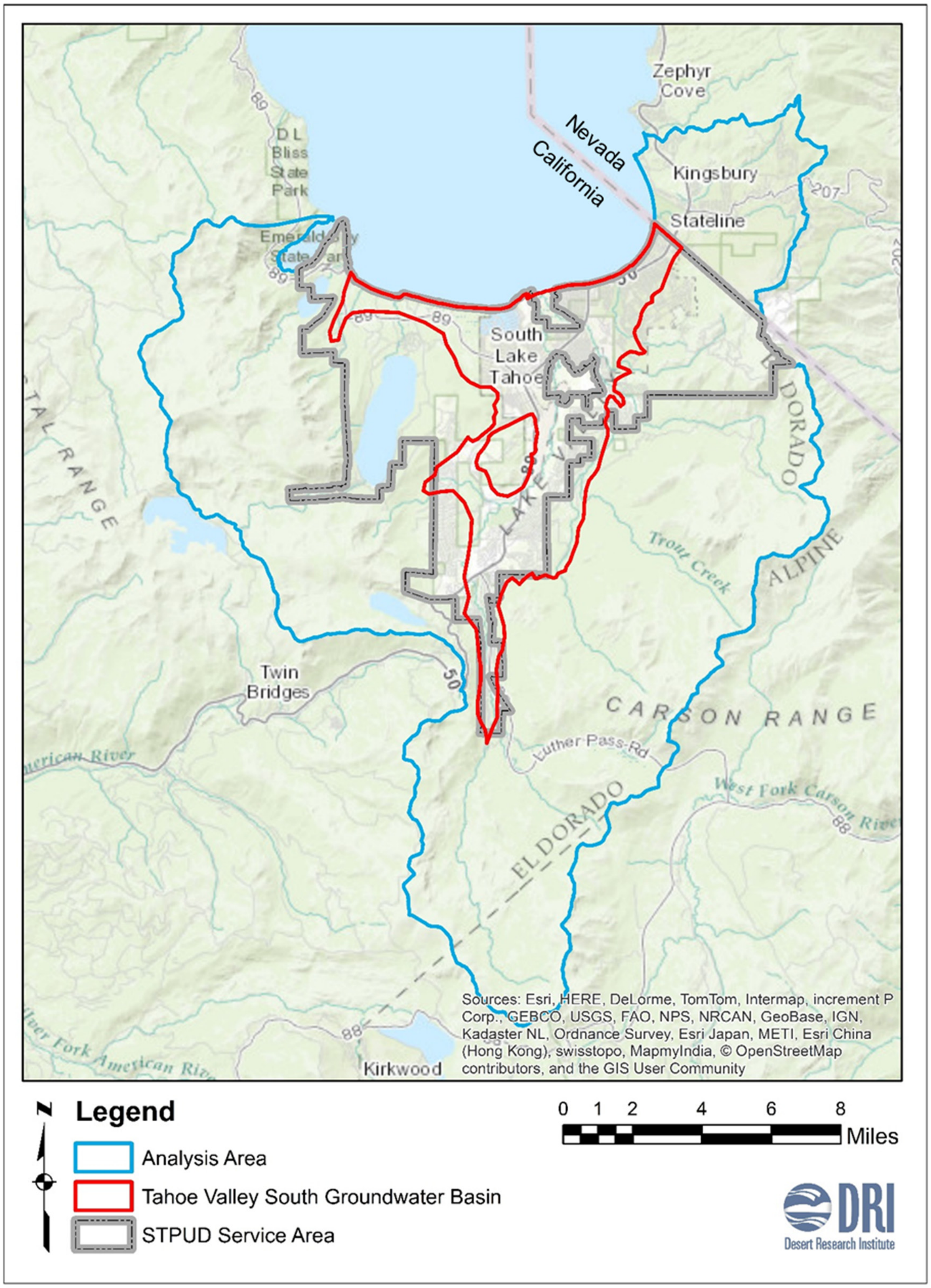


Figure 1-2. Tahoe Valley South groundwater basin showing the South Tahoe Public Utility District (District) service area and hydrologic analysis area.

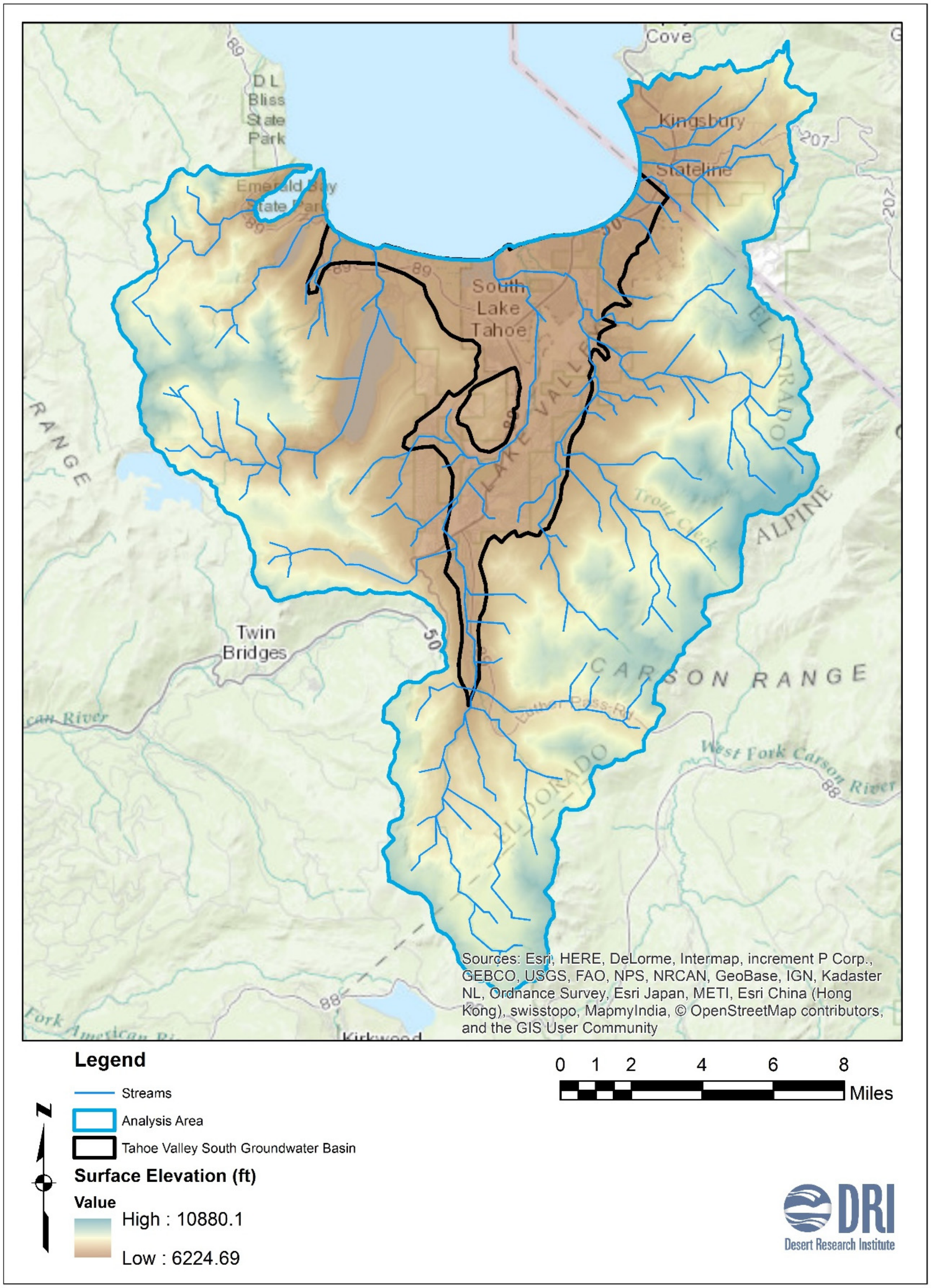


Figure 1-3. Topography and drainage network within the analysis area.

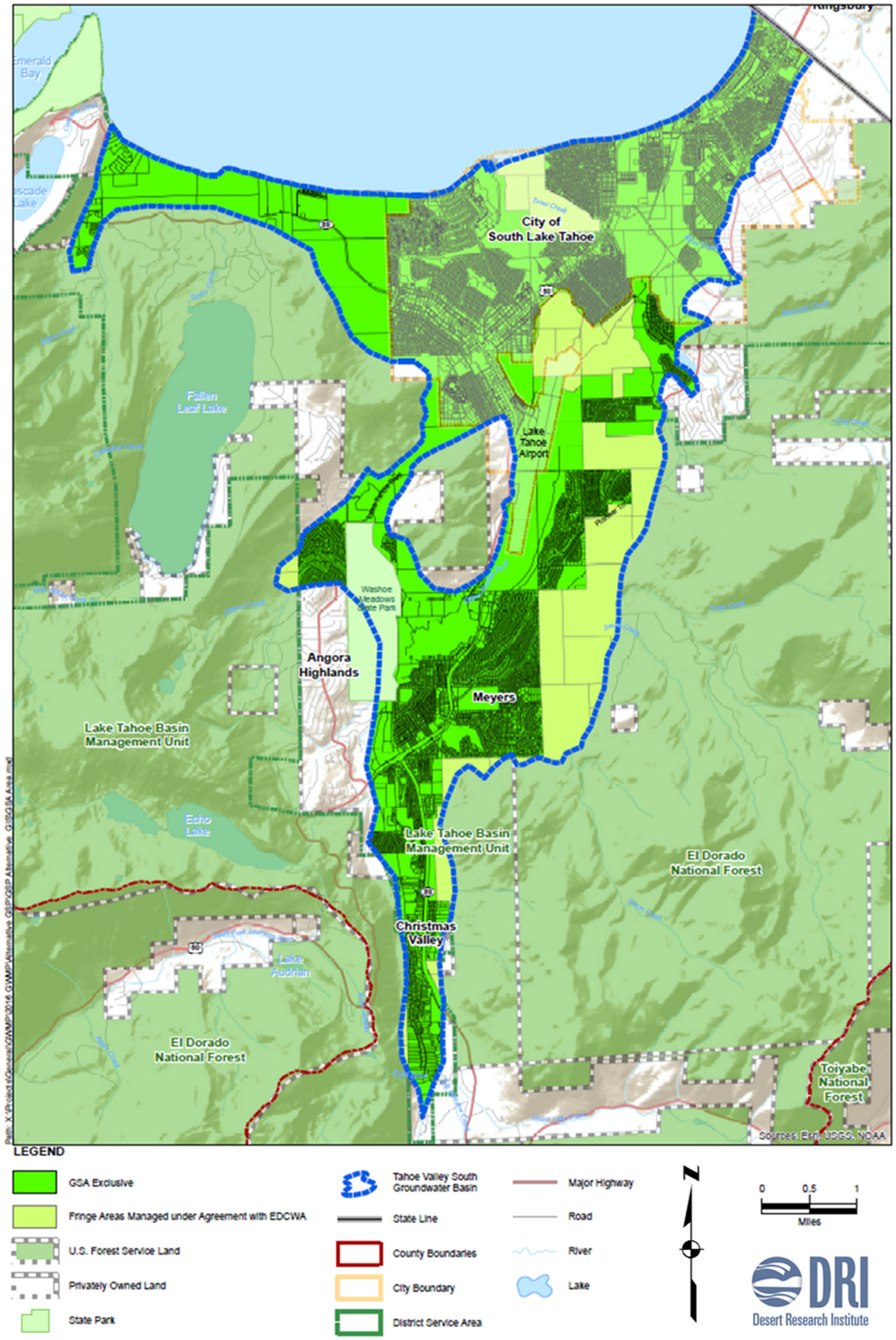


Figure 1-4. Tahoe Valley South Groundwater Subbasin (6-5-01), Groundwater Sustainability Agency (GSA) and other jurisdictional boundaries.

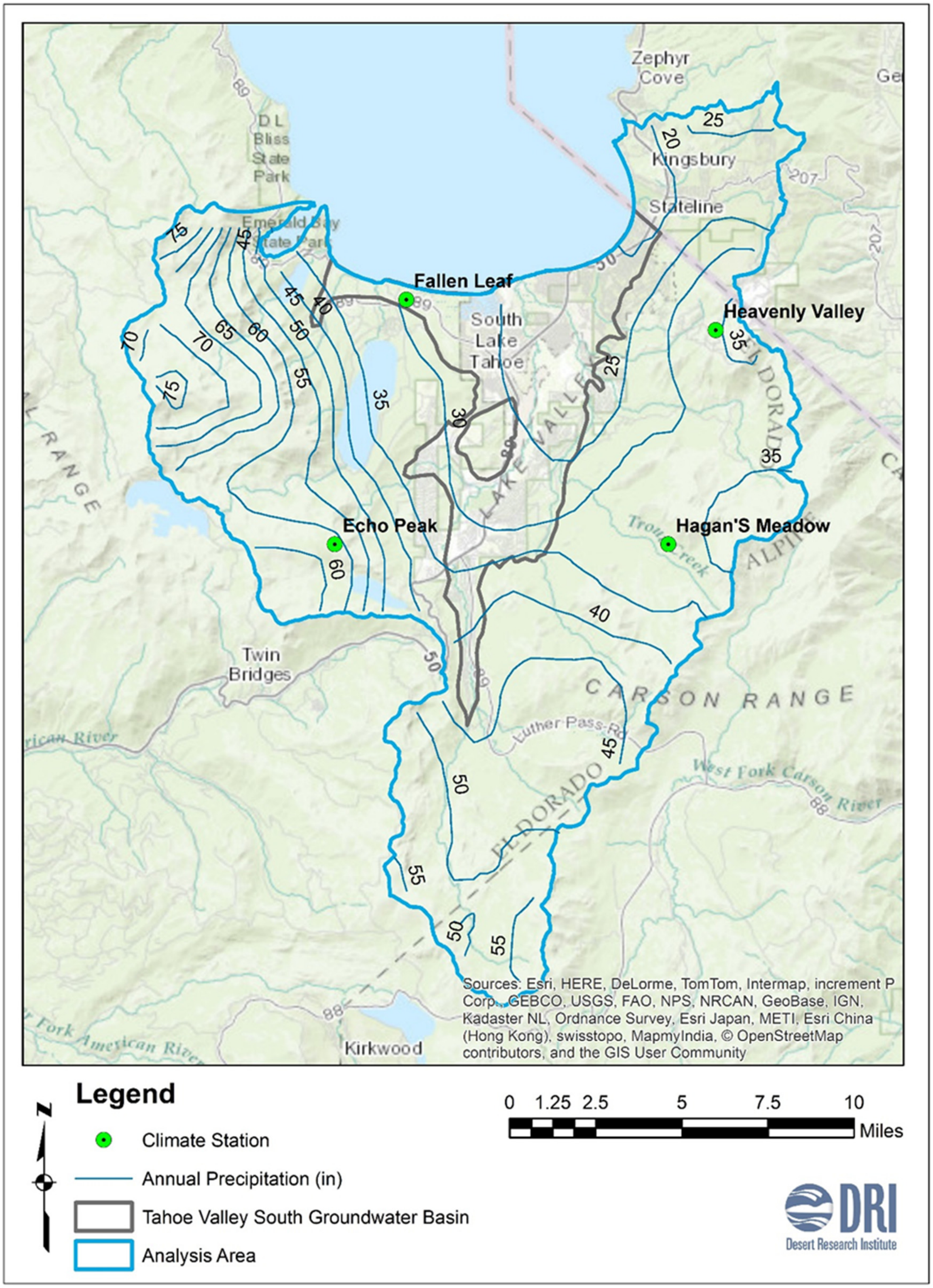


Figure 3-1. Average annual precipitation (in) isohyets and location of climate stations within the analysis area. Annual precipitation data (1981-2010) derived from PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu, Copyright © 2016.

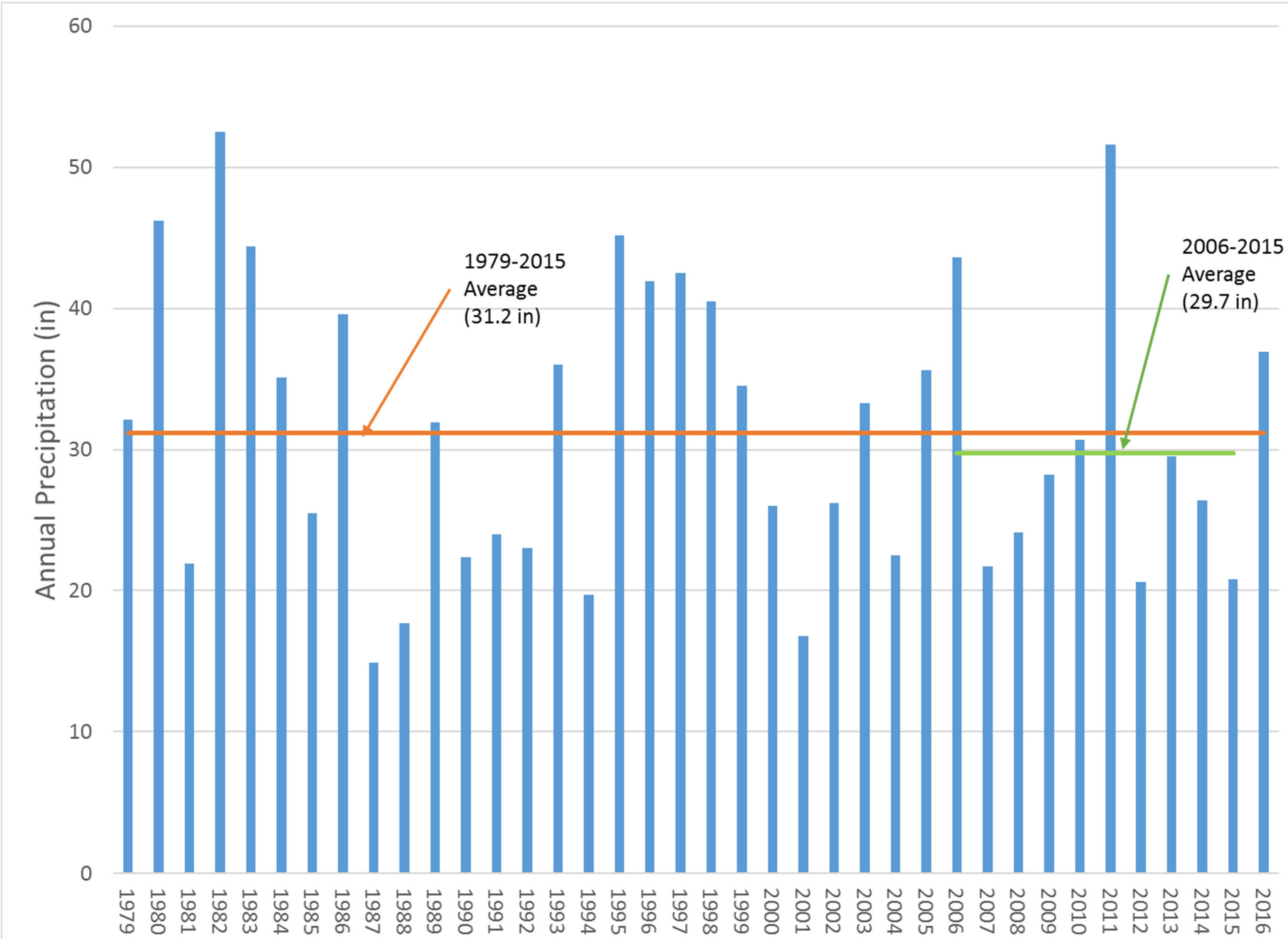


Figure 3-2. Annual water year precipitation at Hagan's Meadow climate station. Averages are presented for 1979 - 2015 and 2006 – 2015 periods.

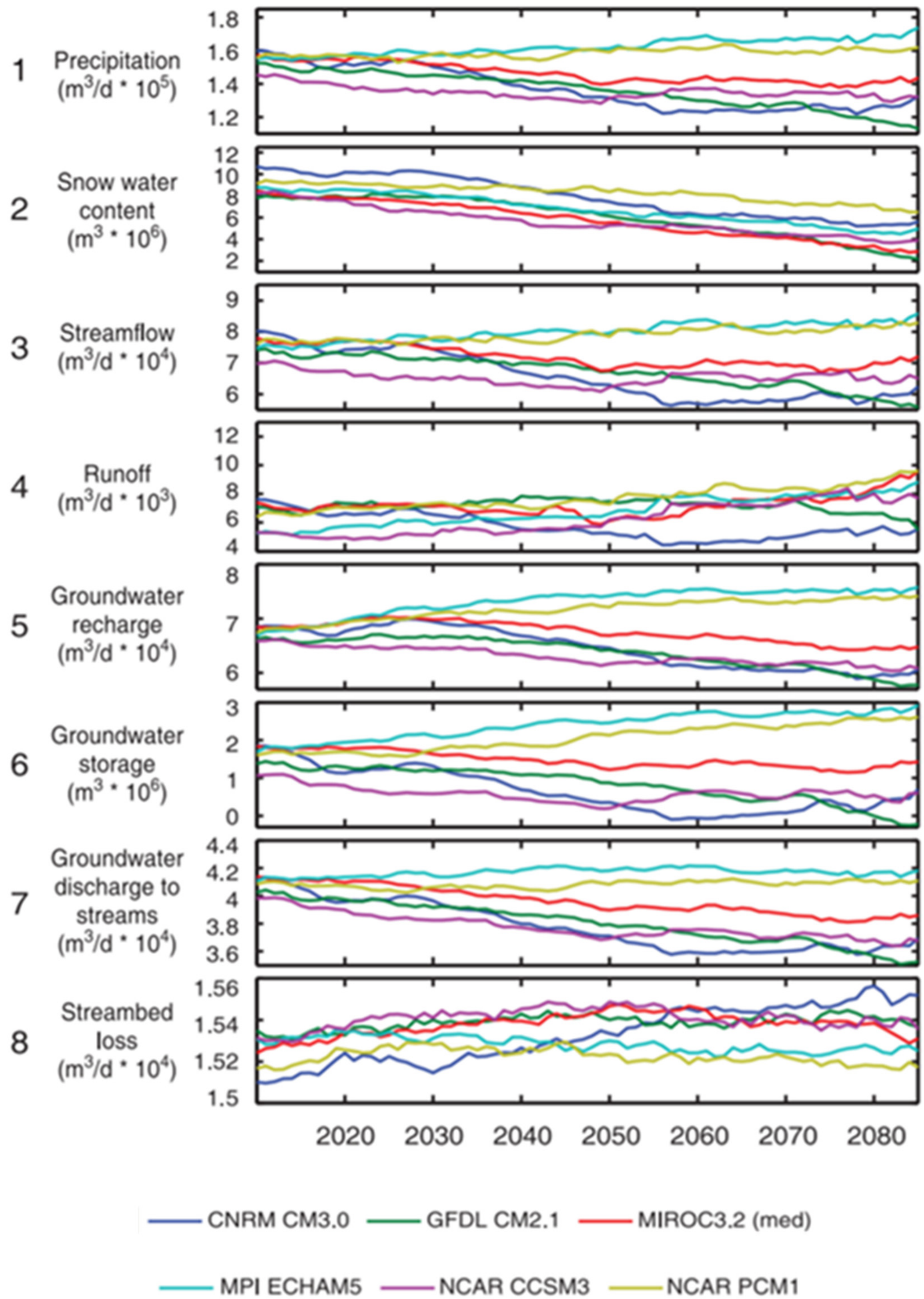


Figure 3-3. Time series of simulated yearly average hydrologic variables for Incline Creek, Third Creek, and Galena Creek watersheds from Huntington and Niswonger (2012). Simulated hydrologic variables for different GCMs (colored lines) and for greenhouse gas emission scenarios A2.

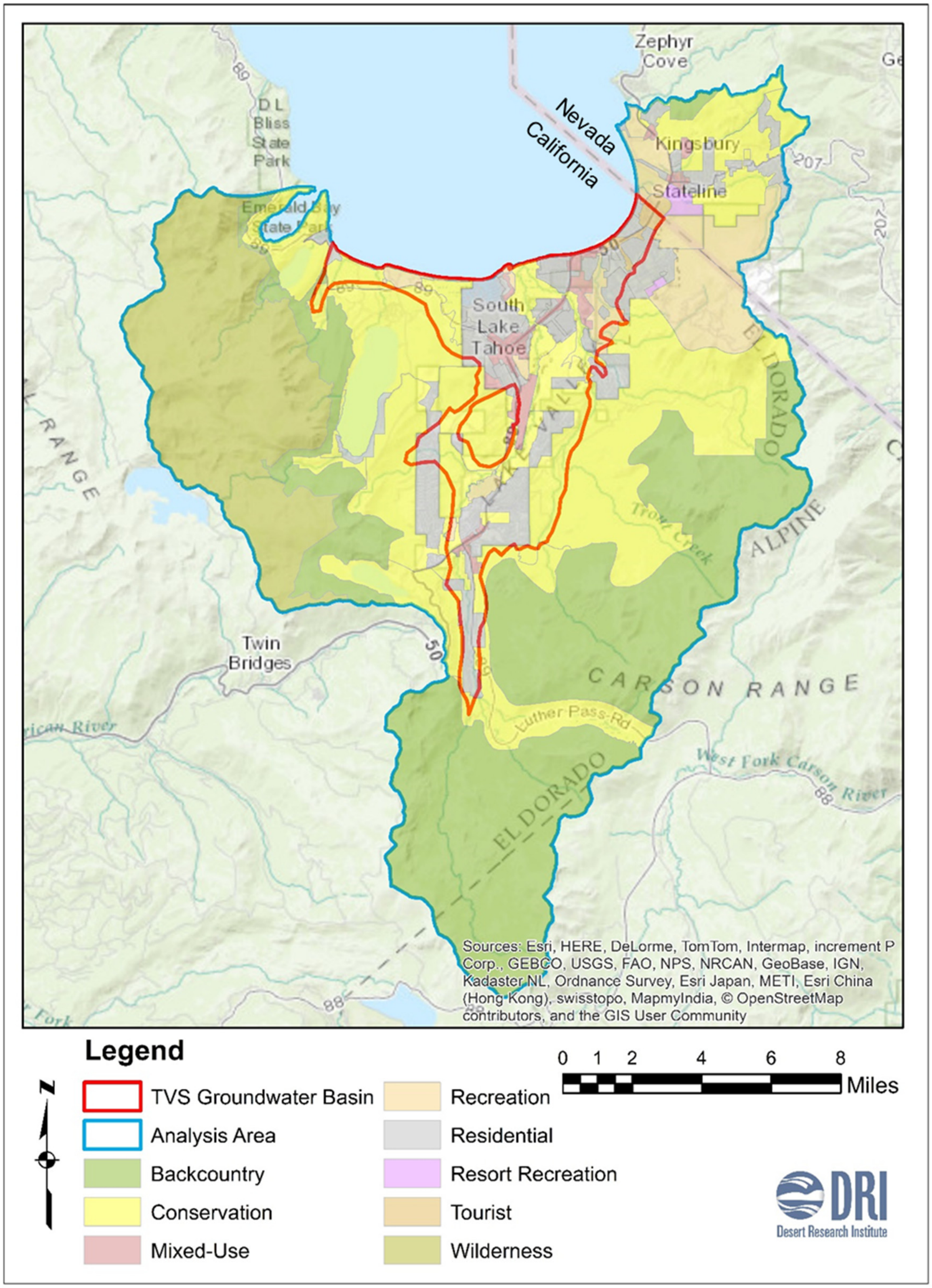


Figure 3-4. Land use types within the hydrologic analysis area (adapted from TRPA, 2012).

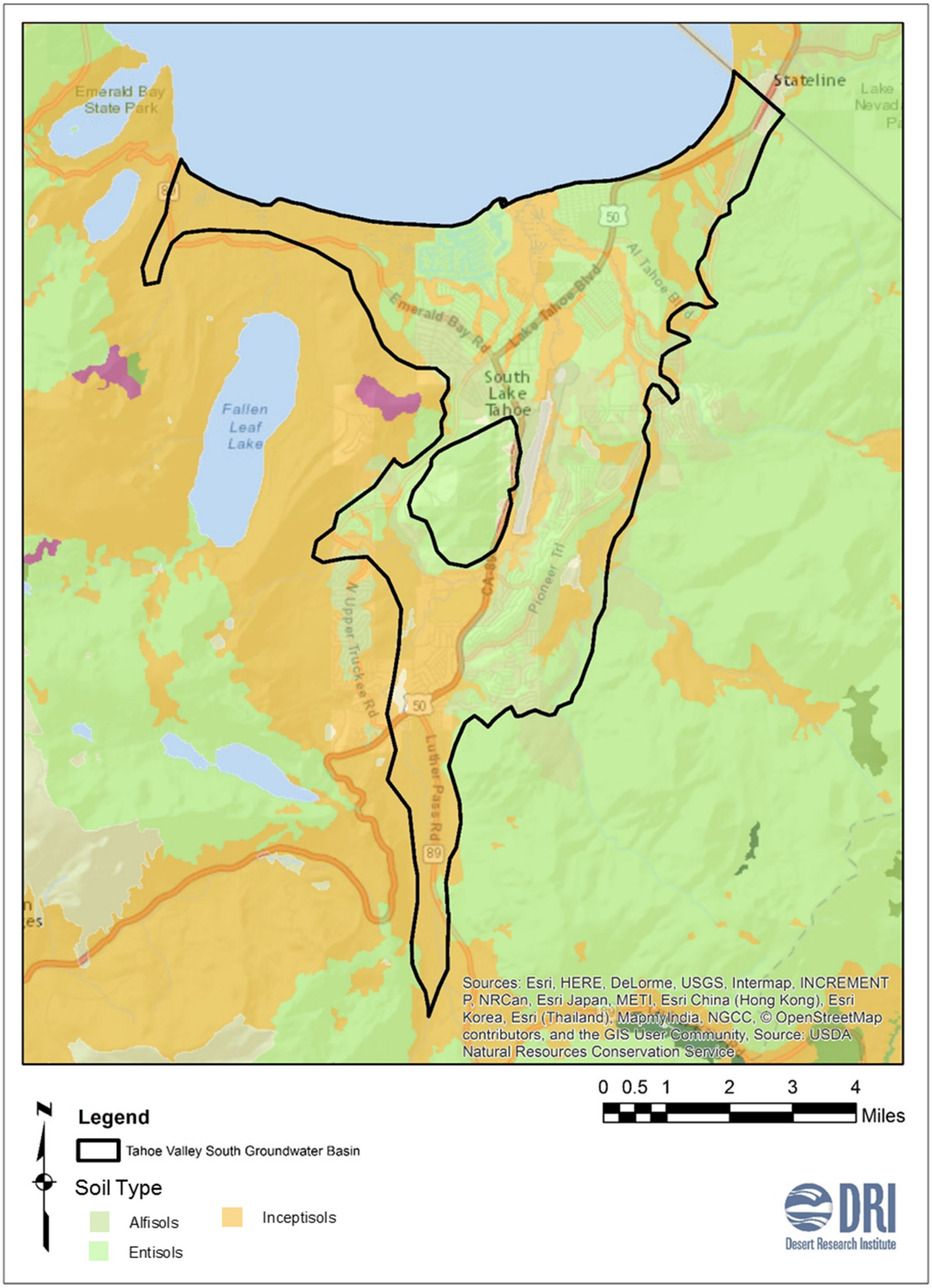


Figure 3-5. Soil types within and surrounding the Tahoe Valley South Groundwater Basin (NRCS, 2016).

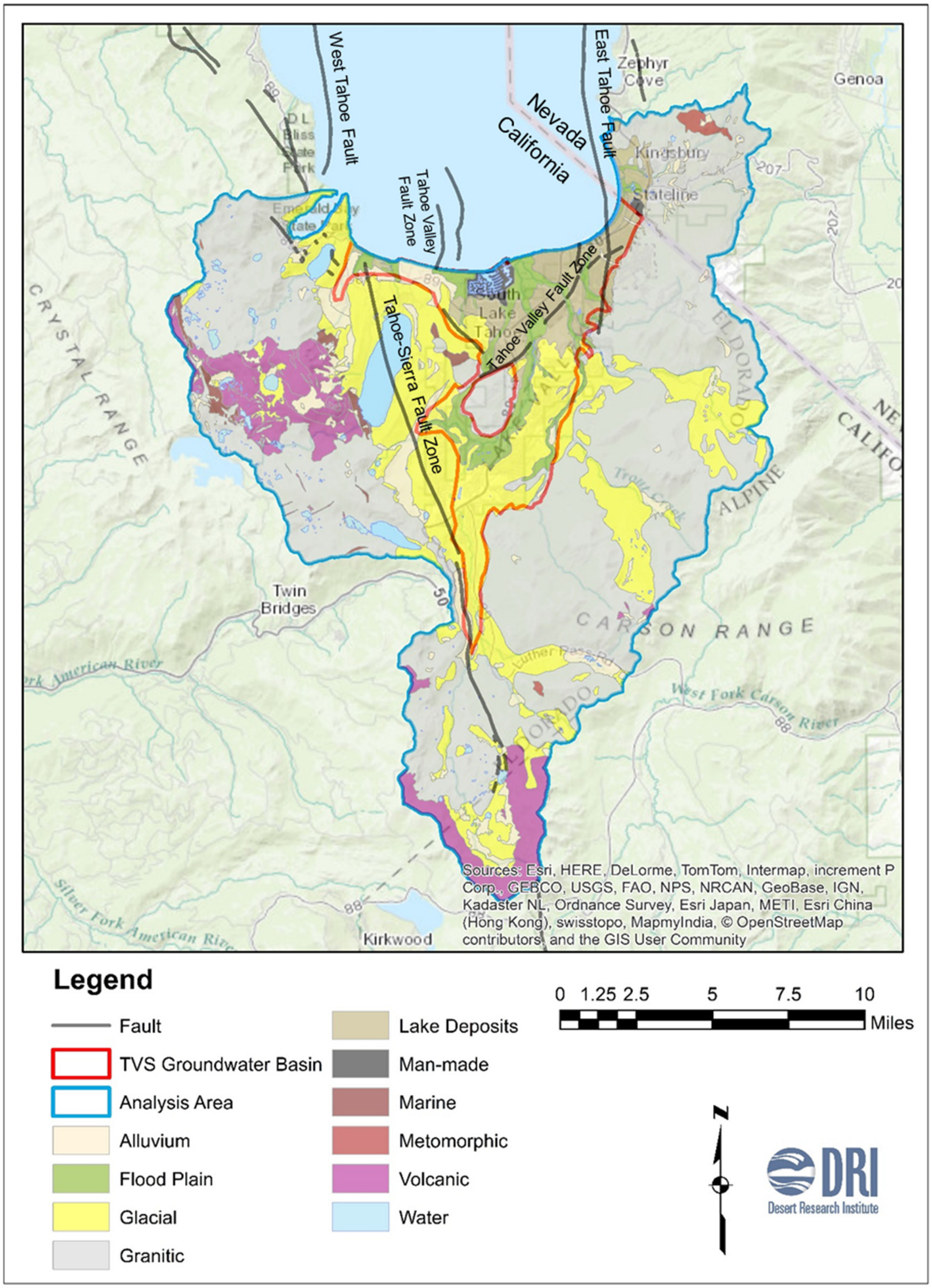


Figure 3-6. Generalized geologic map of the hydrologic analysis area. Source of geologic map is from Saucedo, 2008.

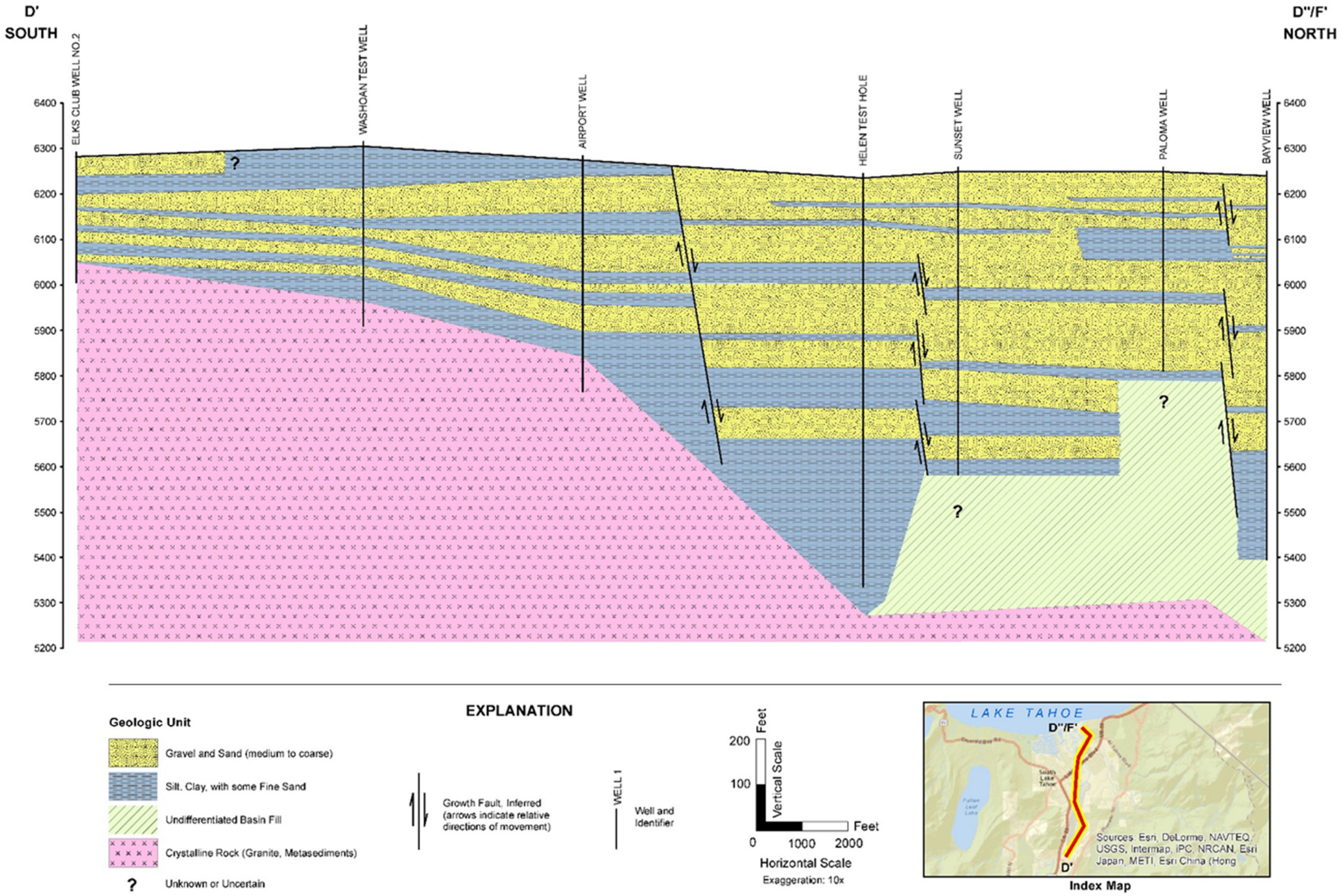


Figure 3-7. North-south geologic cross-section through Tahoe Valley South groundwater basin. Adapted from Kennedy-Jenks (2014).

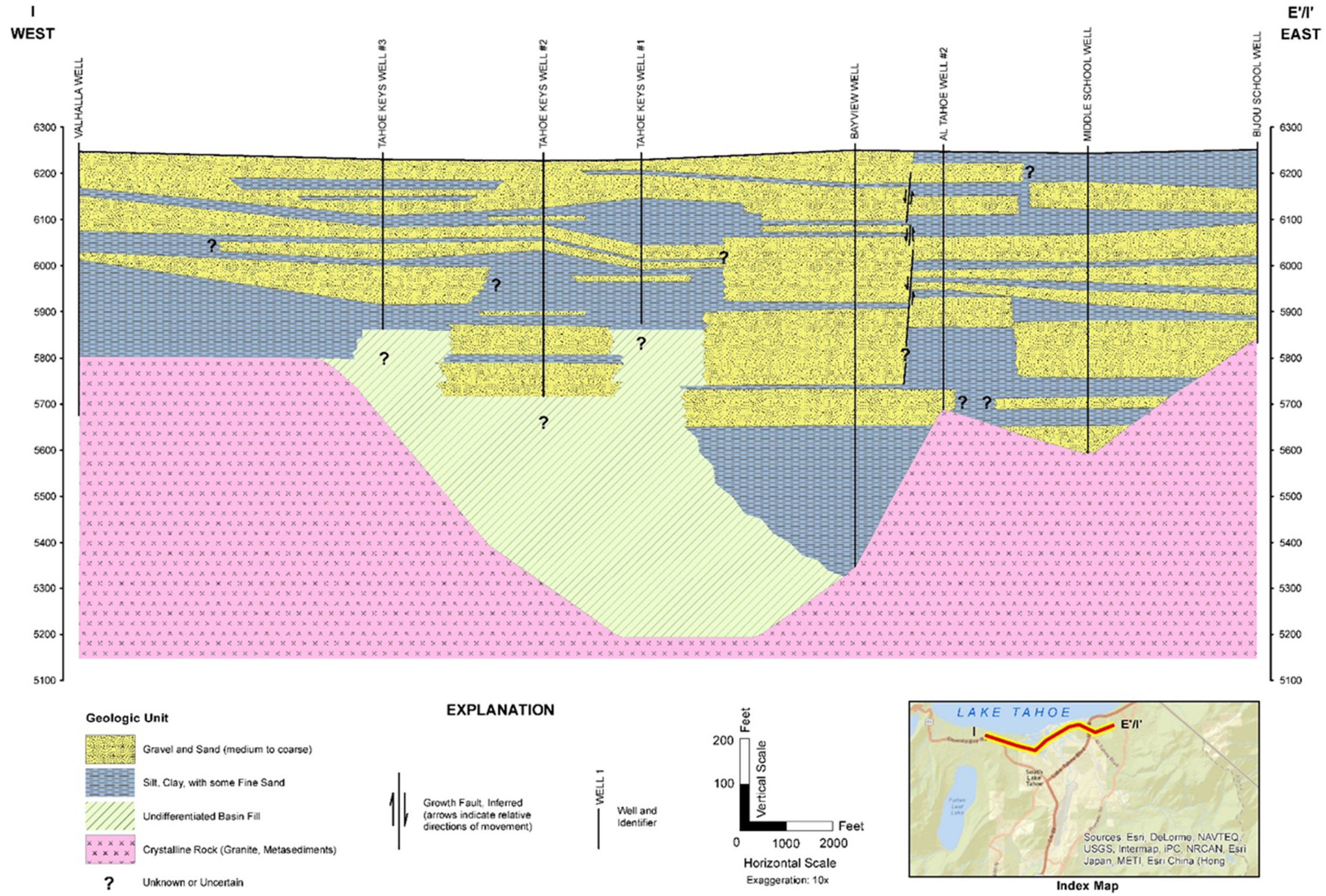


Figure 3-8. East-west geologic cross-section through Tahoe Valley South groundwater basin. Adapted from Kennedy-Jenks (2014).

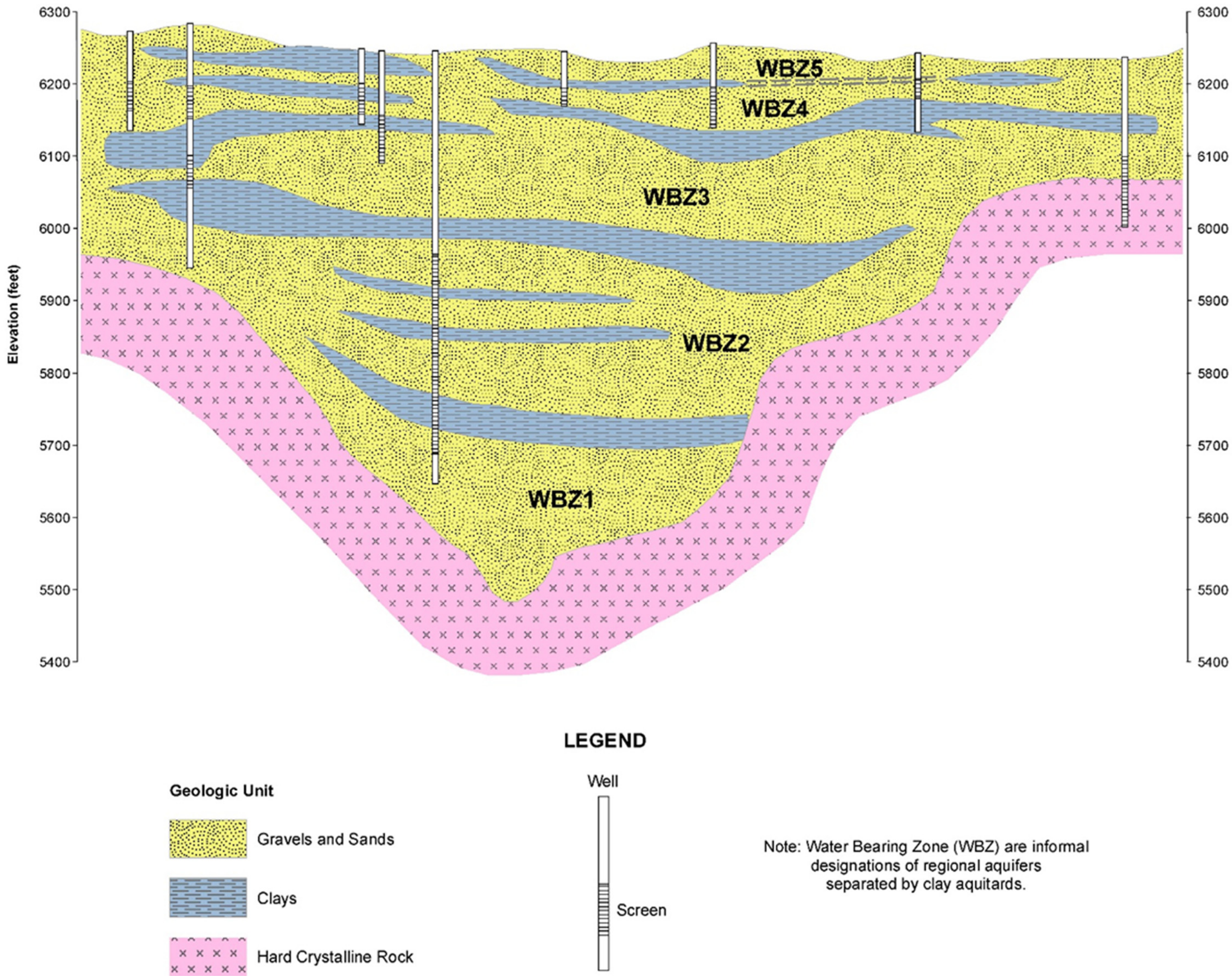


Figure 3-9. Conceptual geologic cross-section oriented east-west showing typical water bearing zones. Adapted from Kennedy-Jenks (2014).

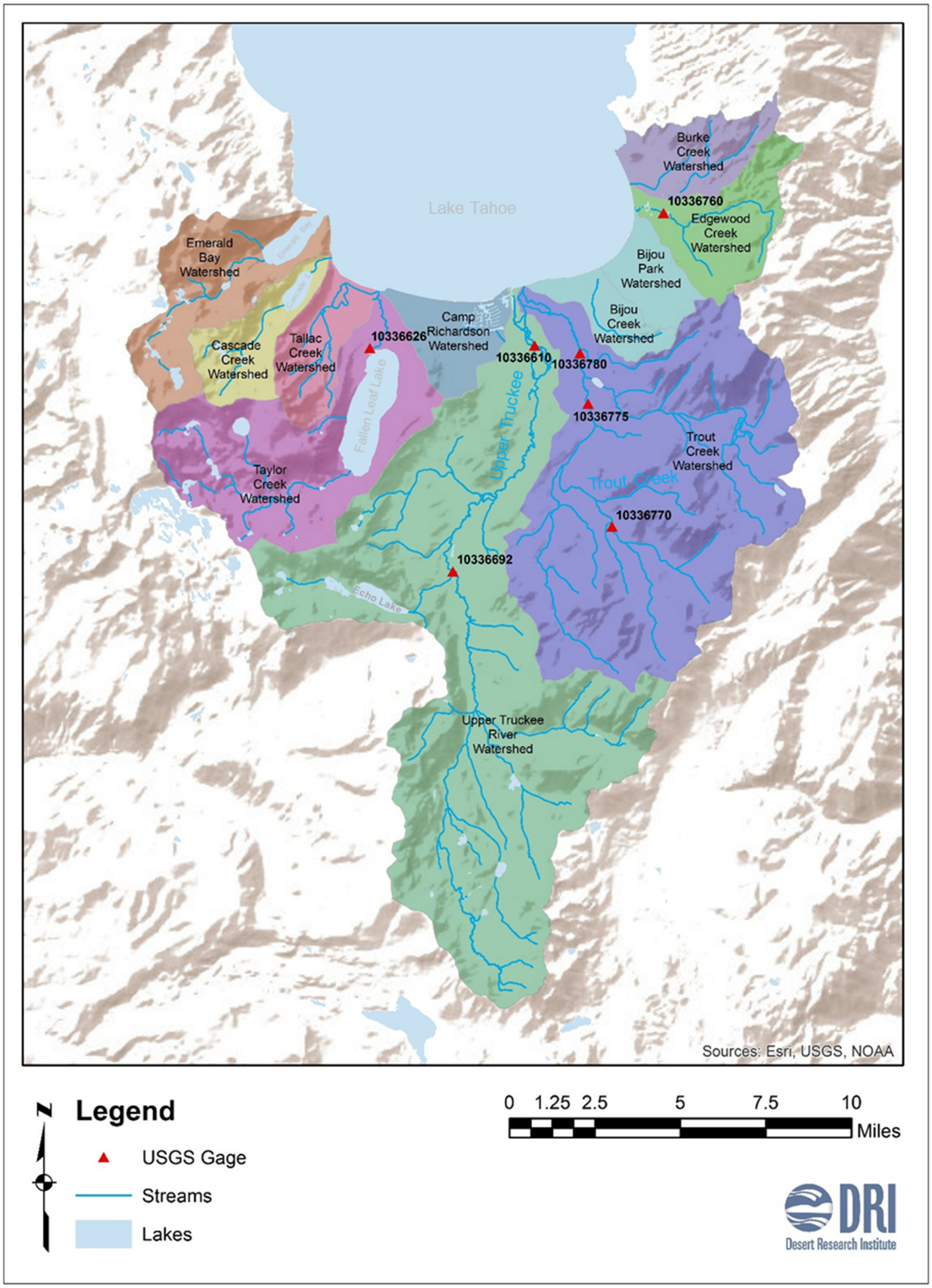
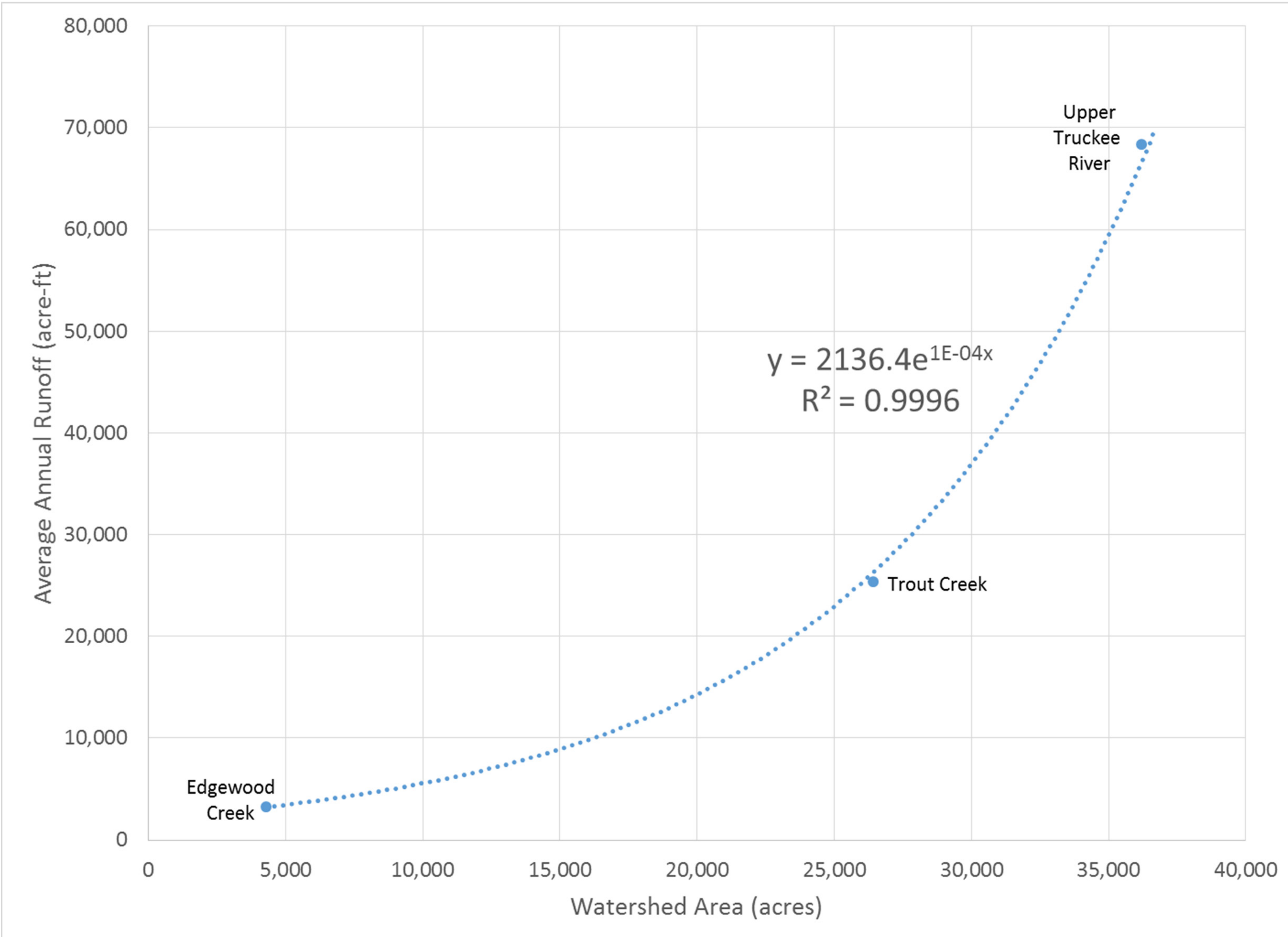


Figure 3-10. Watersheds, lakes, streams, and USGS gaging stations within the analysis area.



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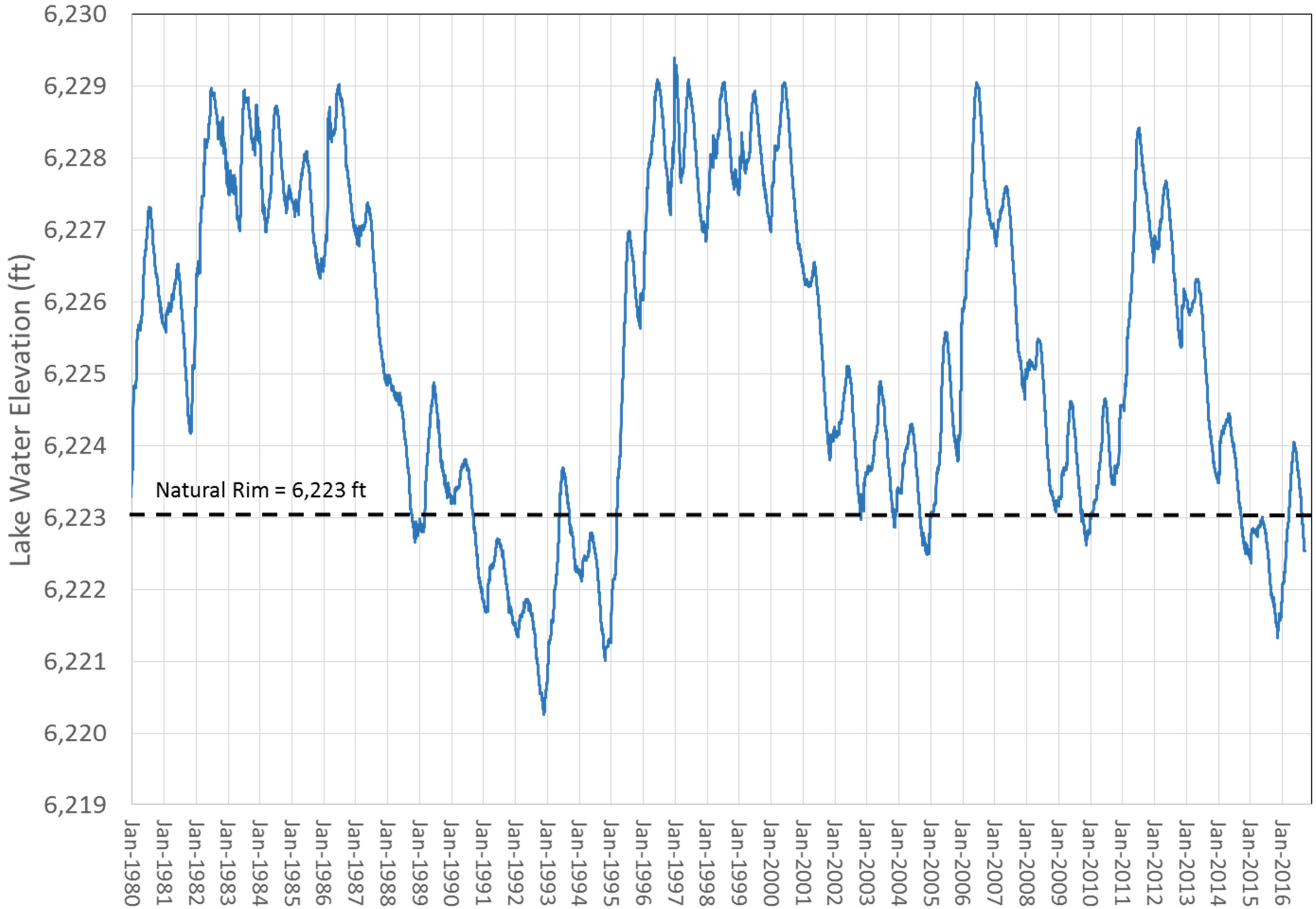

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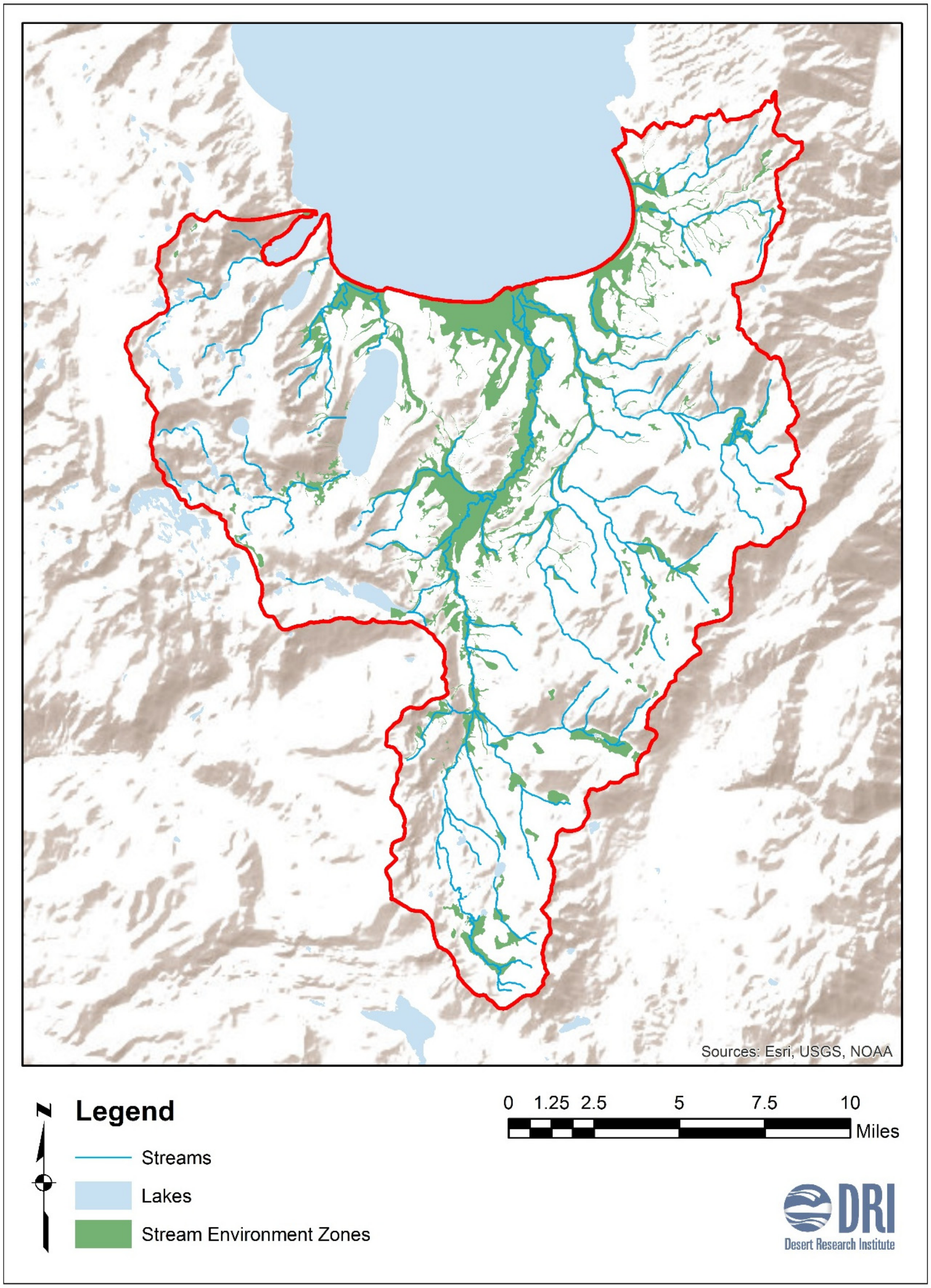


Figure 3-13. Tahoe Regional Planning Agency Stream Environment Zone map.

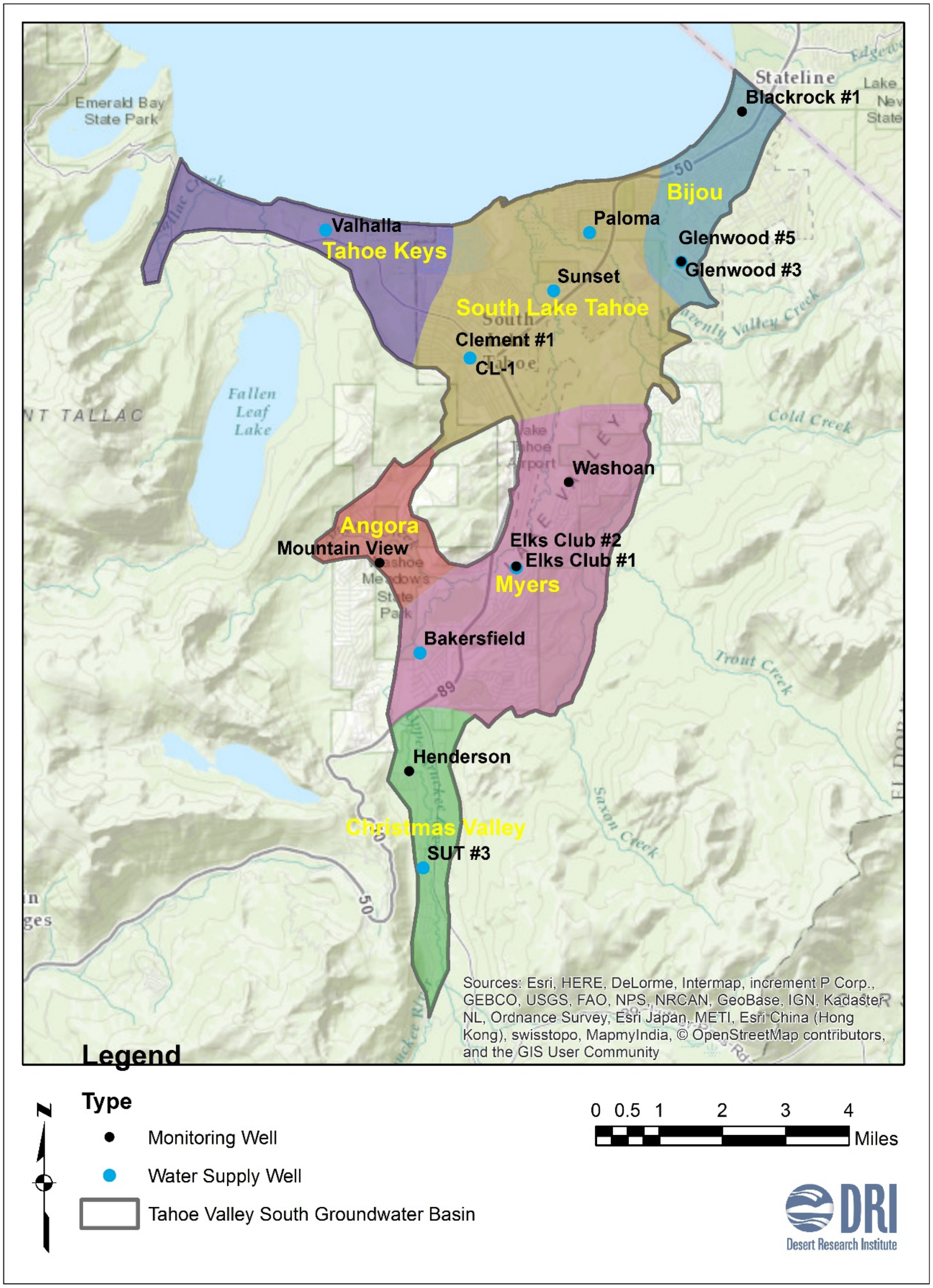


Figure 3-14. Selected monitoring well locations and groundwater zones.

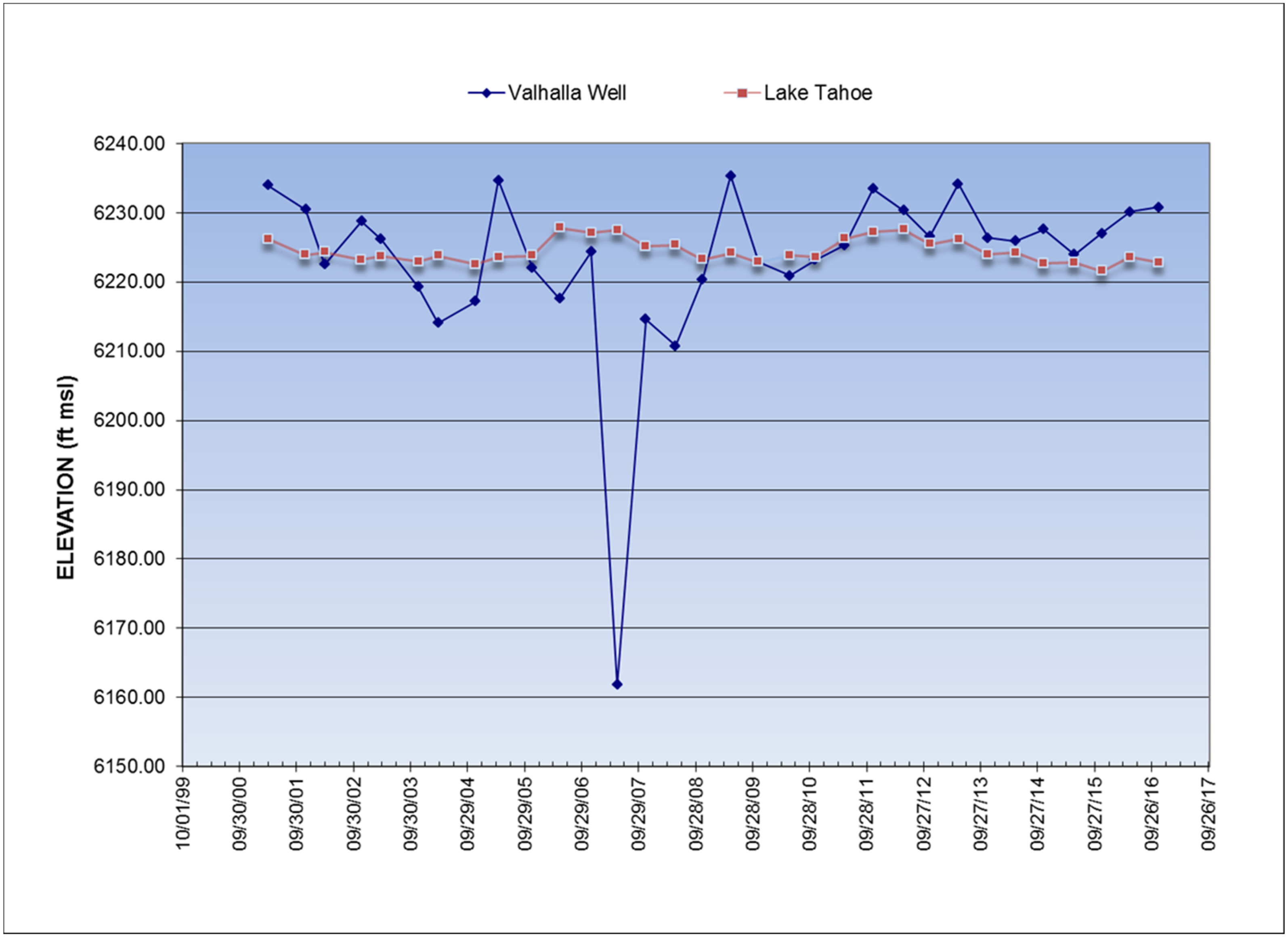


Figure 3-15. Groundwater hydrograph for the Valhalla well within the Tahoe Keys Groundwater Zone. Also shown is the water level (stage) of Lake Tahoe over the period of record for groundwater levels.

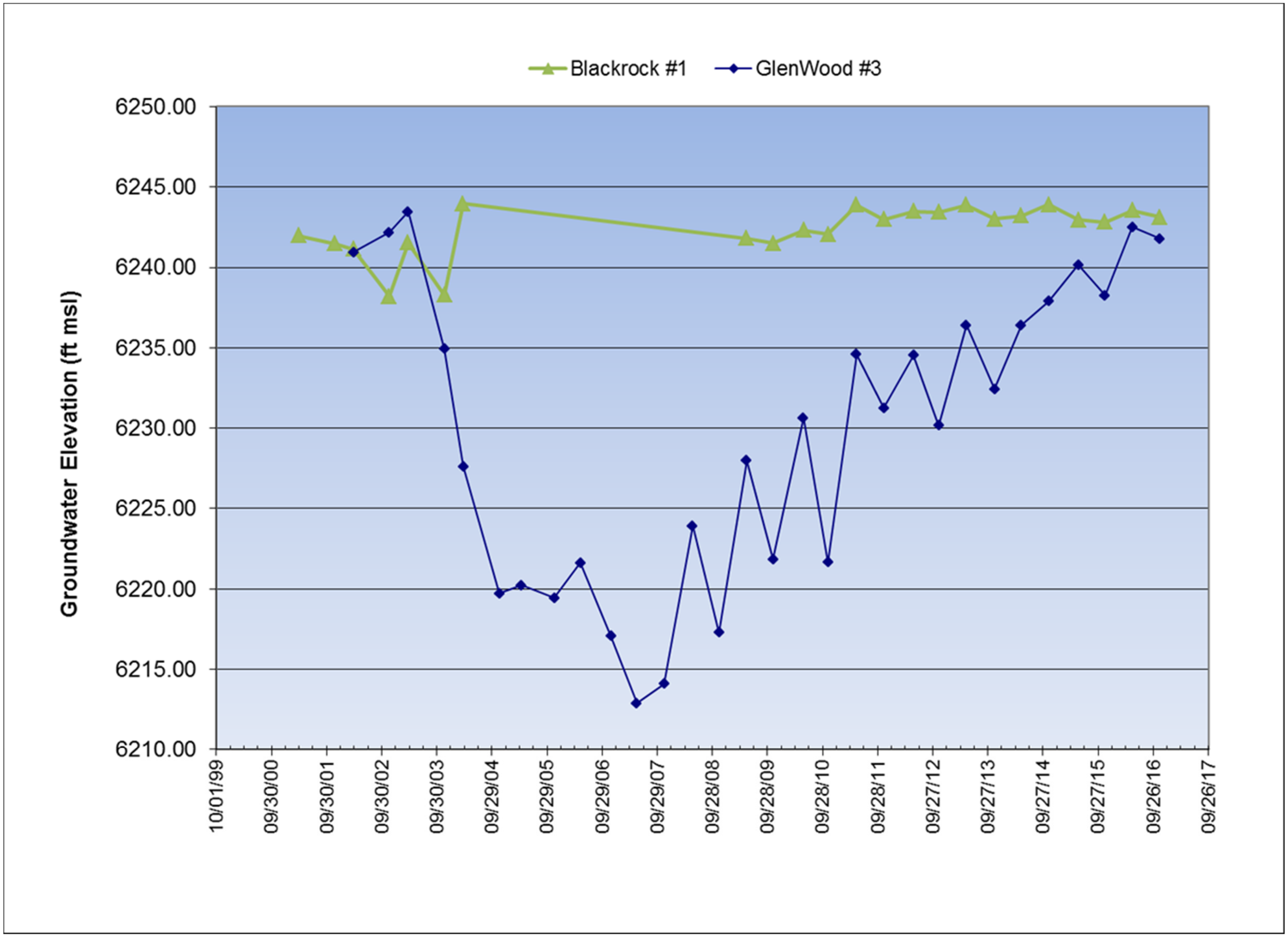
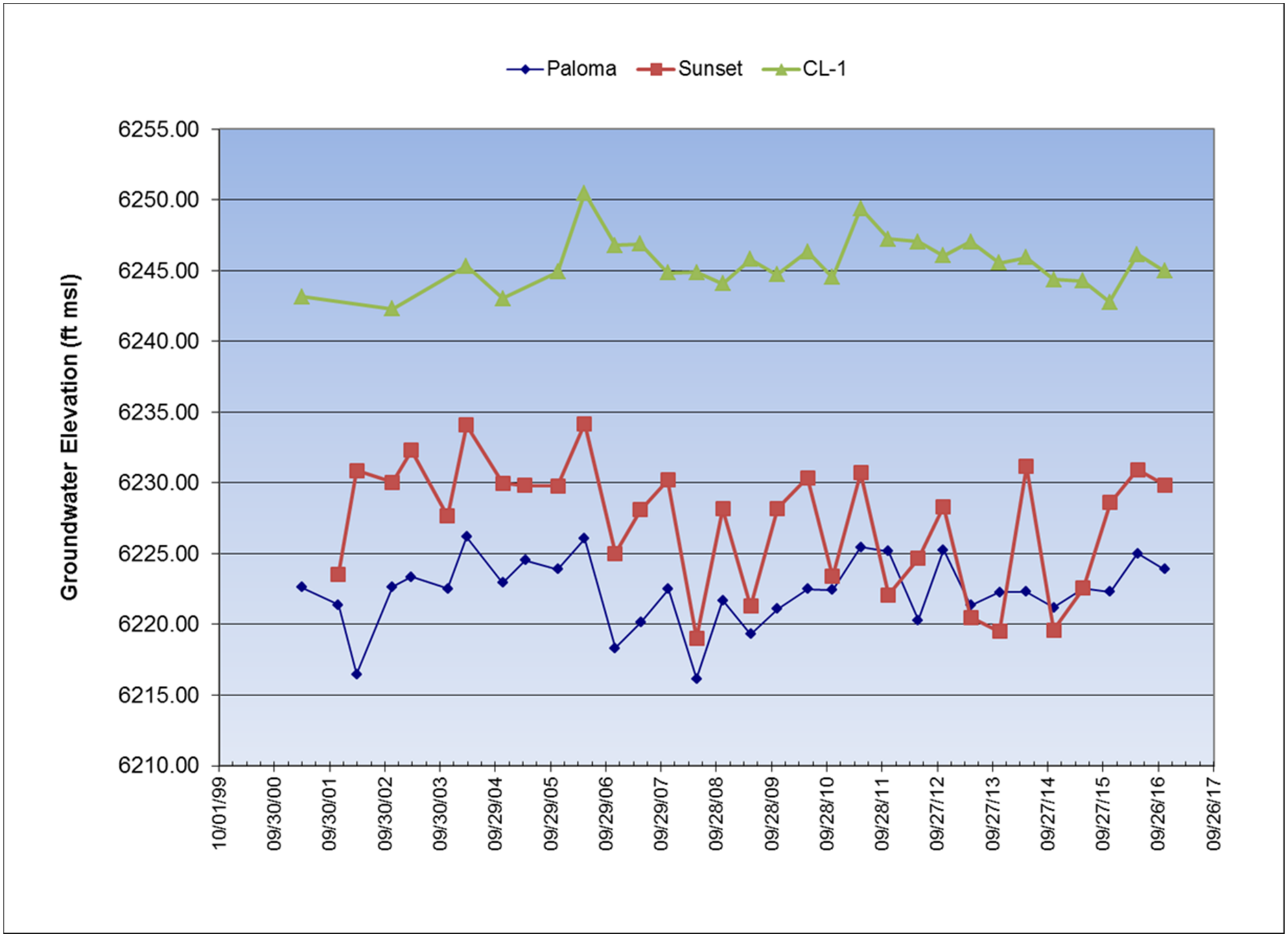


Figure 3-16. Groundwater hydrographs for the Blackrock #1 and Glenwood #3 wells within the Bijou Groundwater Zone.



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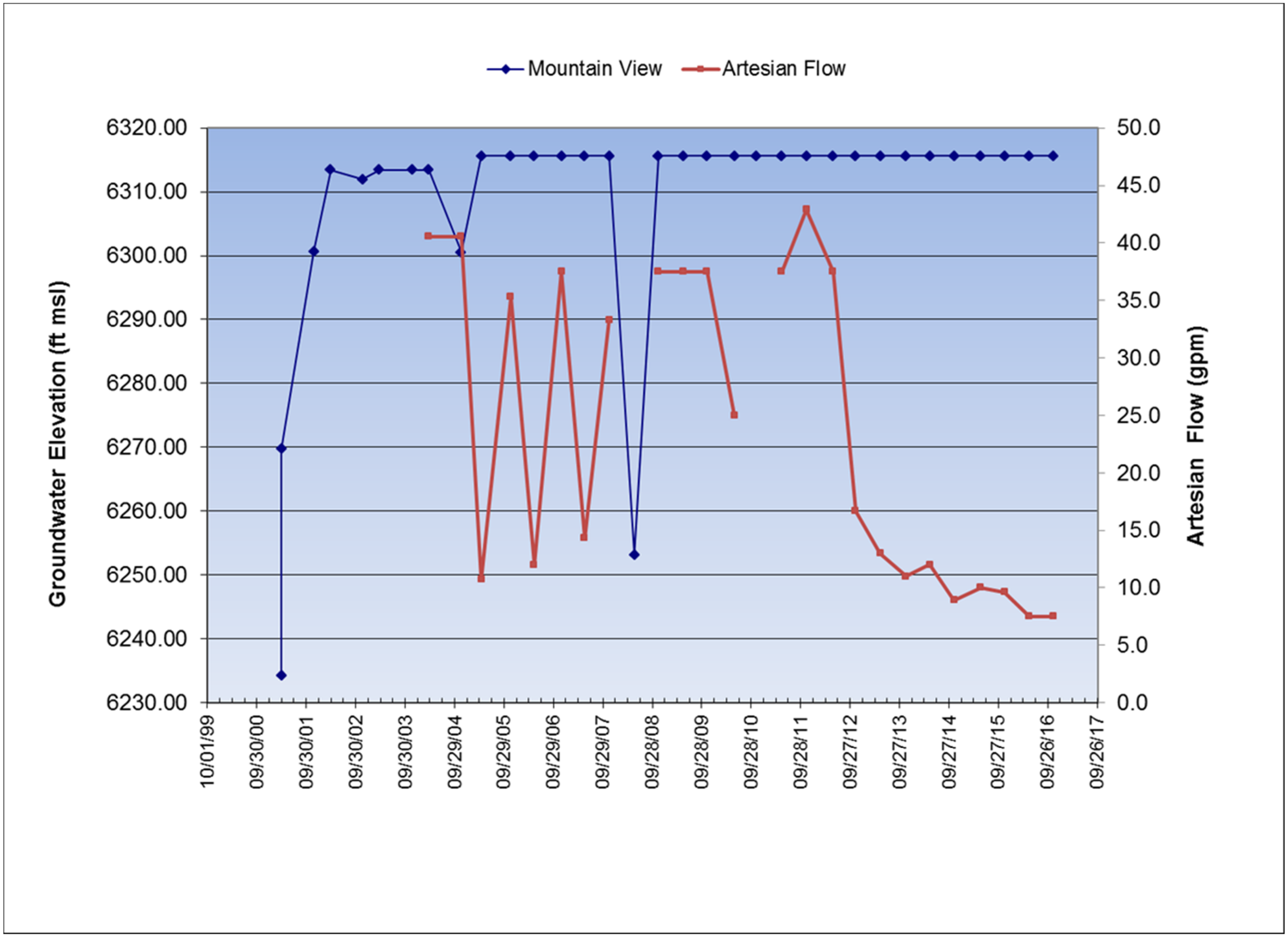

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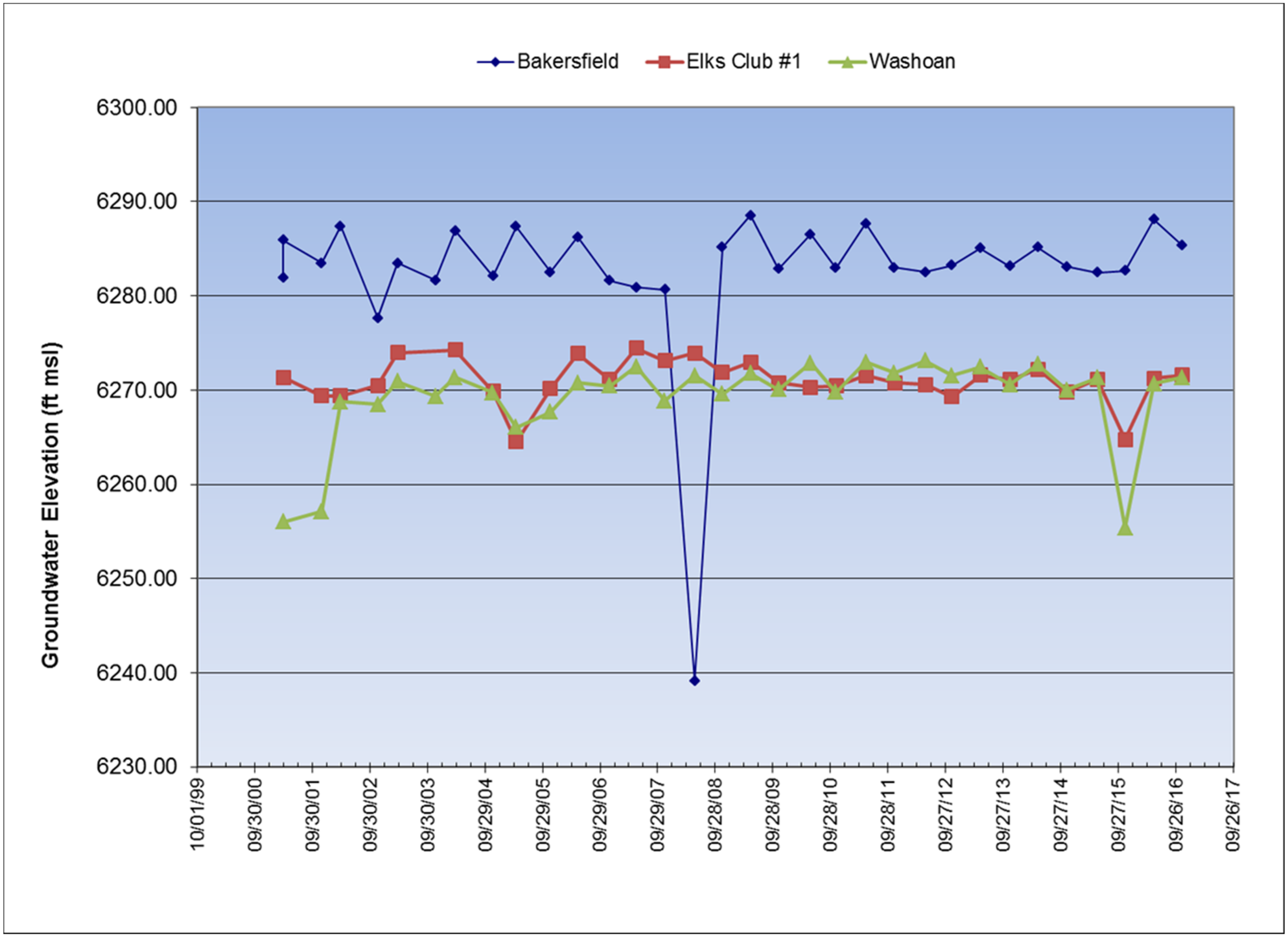

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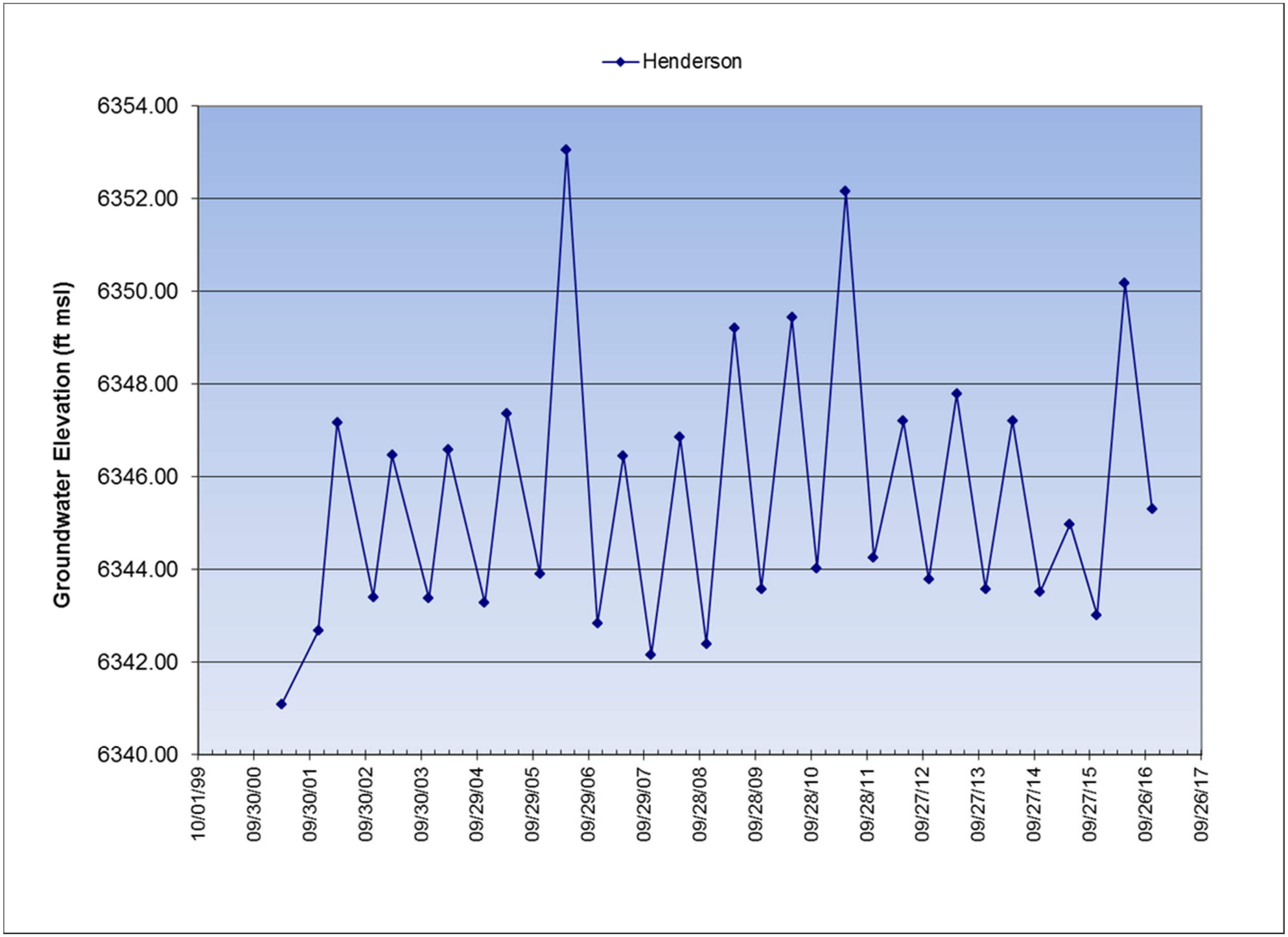


Figure 3-20. Groundwater hydrographs for the Henderson well within the Christmas Groundwater Zone.

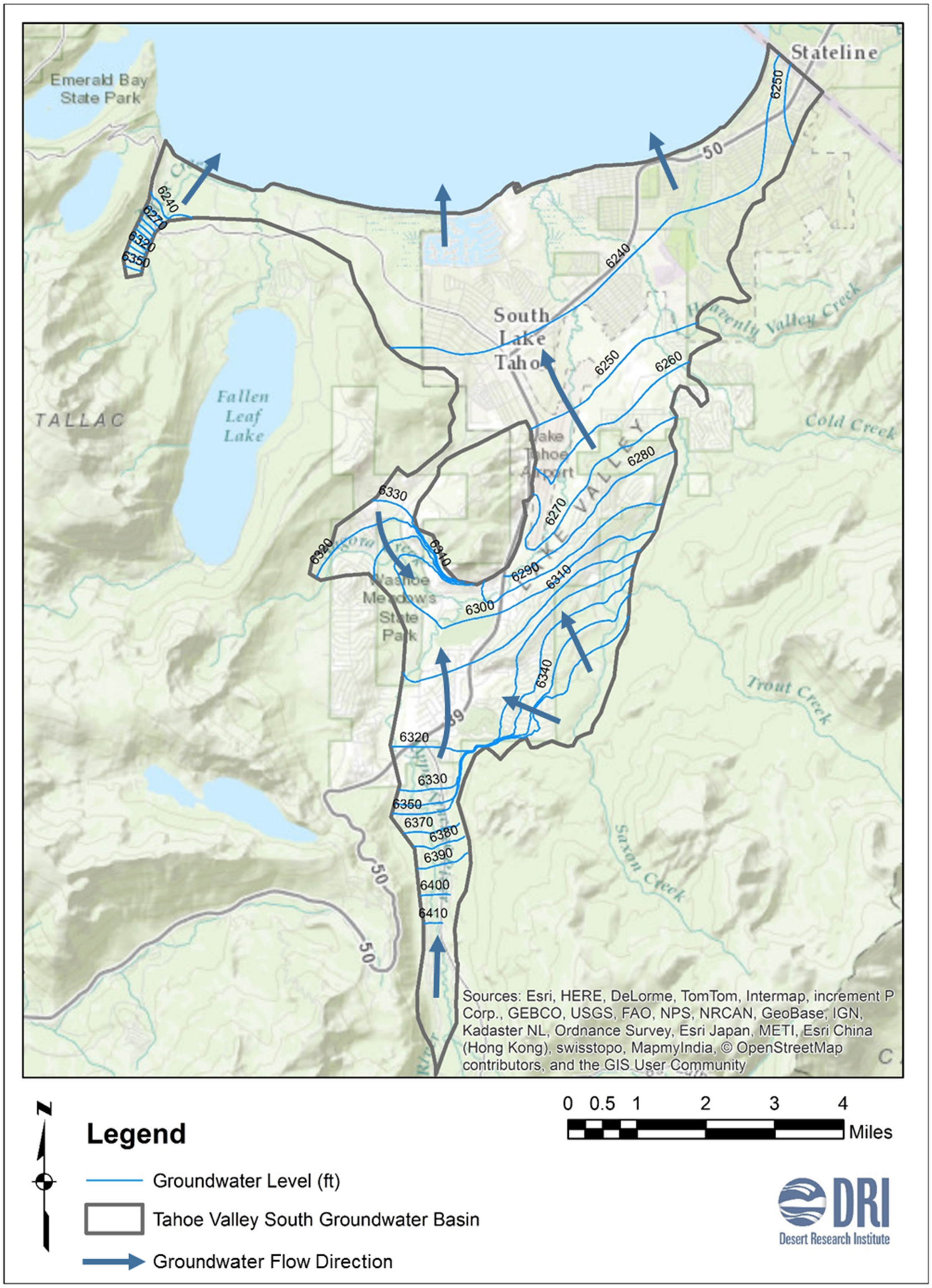


Figure 3-21. Shallow aquifer (upper 300 ft) water levels and flow directions (based on steady-state MODFLOW model). Contour interval is 10 ft.

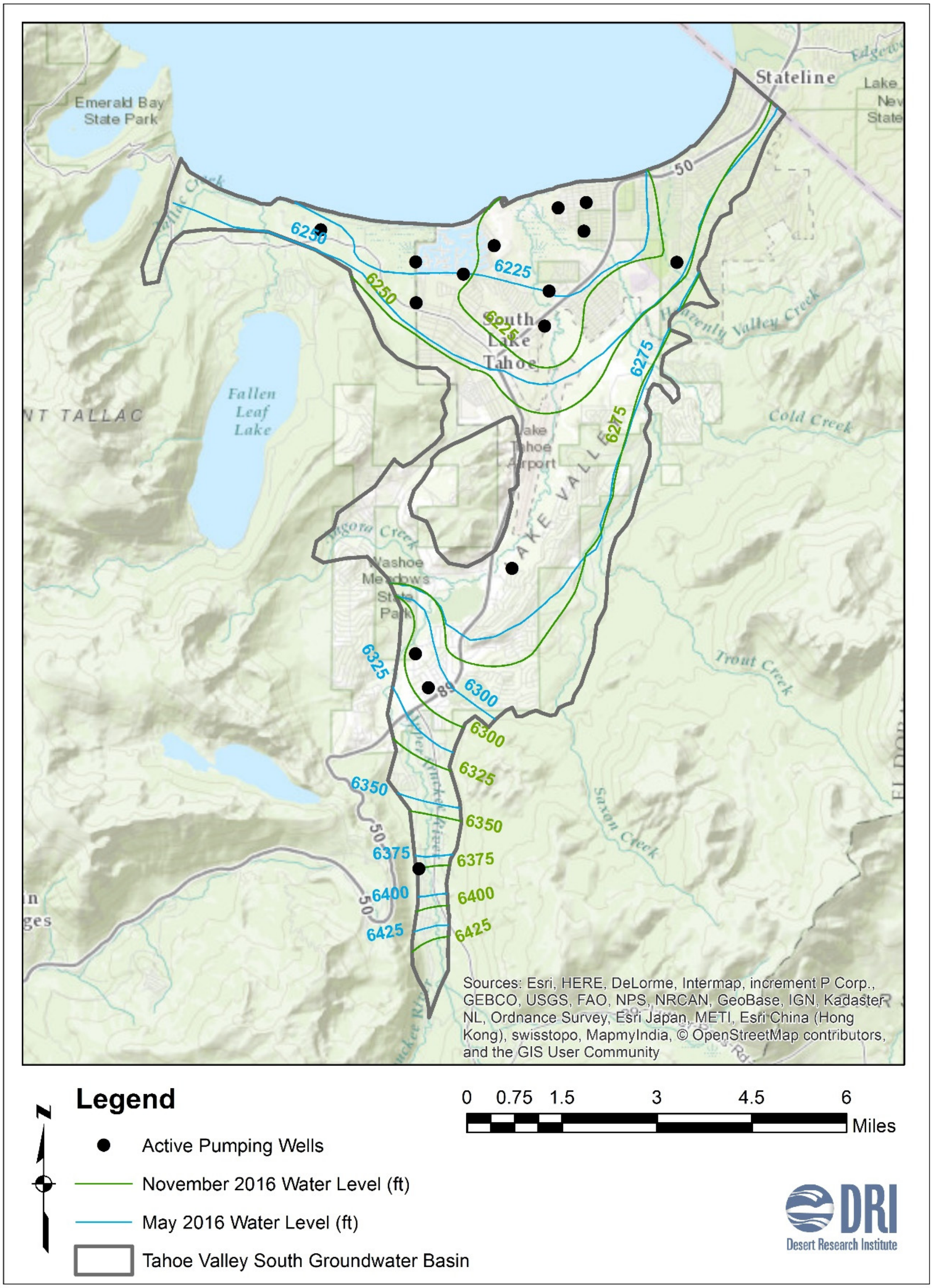


Figure 3-22. Shallow aquifer (upper 300 ft) water levels as measured in May 2016 and November 2016. Contour interval is 25 ft.

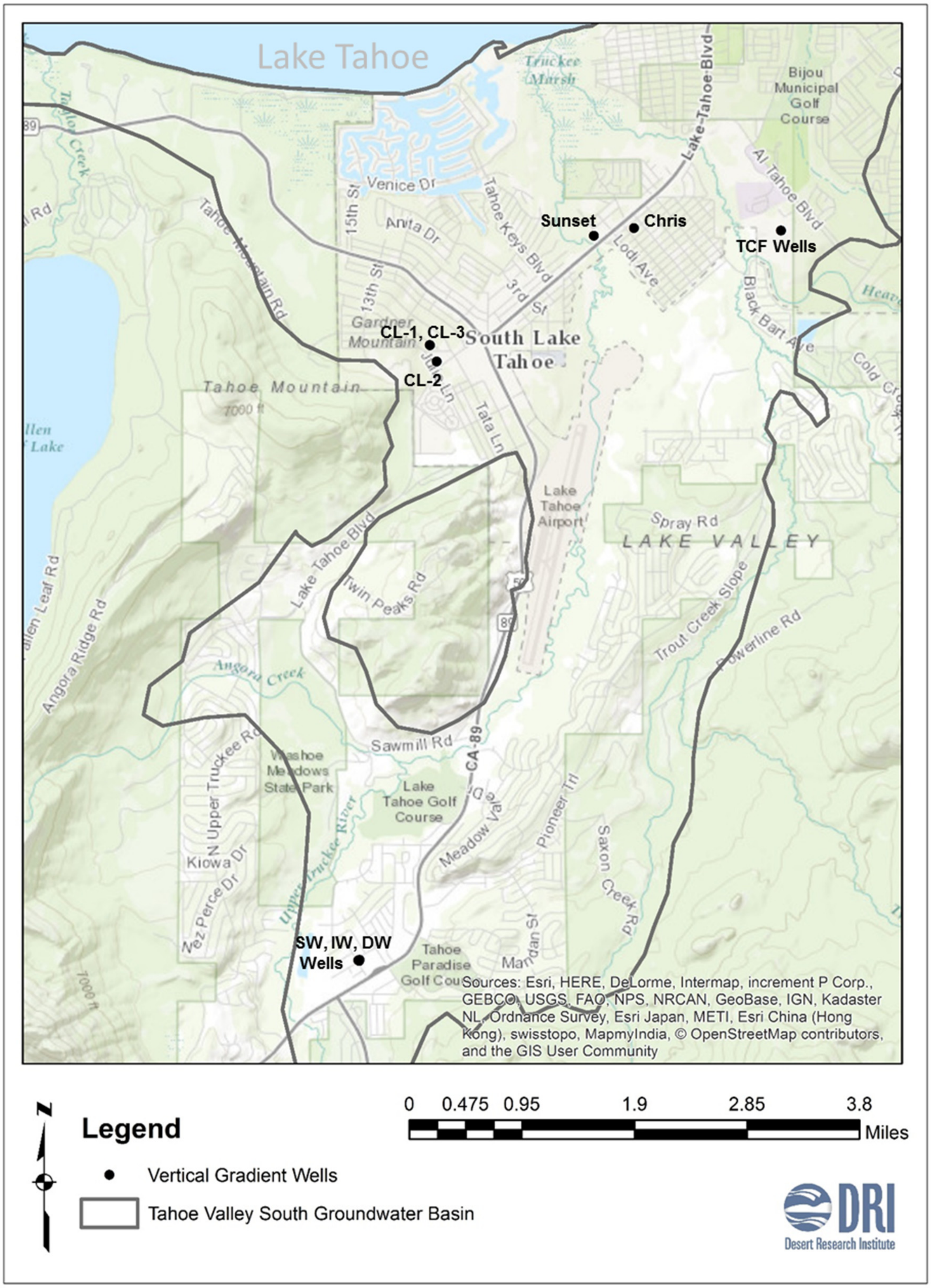


Figure 3-23. Location of wells used to calculate vertical hydraulic head gradients.

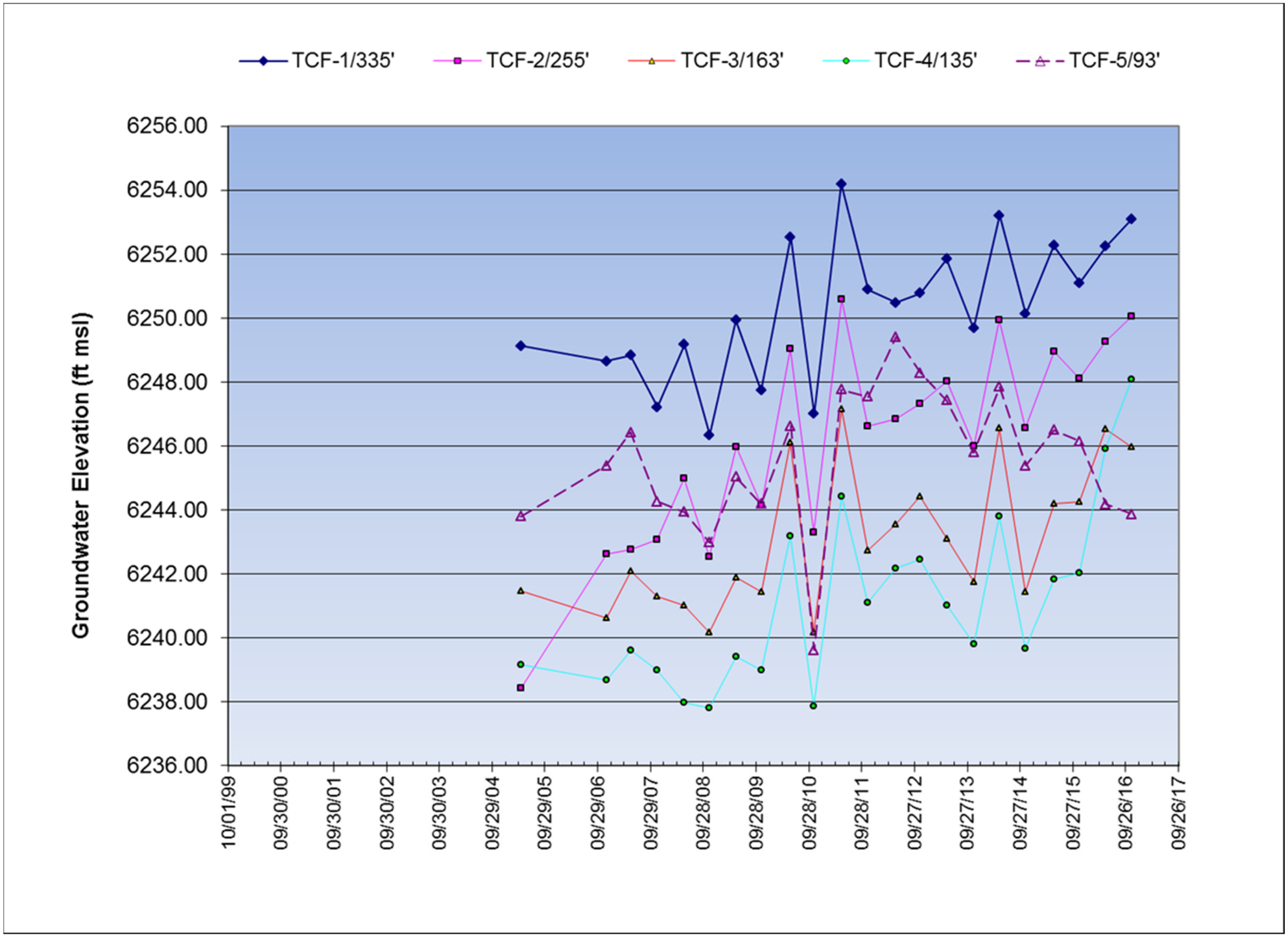


Figure 3-24. Groundwater hydrograph for wells in the South Lake Tahoe Groundwater Zone: USGS TCF nested well (6,296 feet msl). Total well depths for the observation wells completed within the common borehole are as indicated.

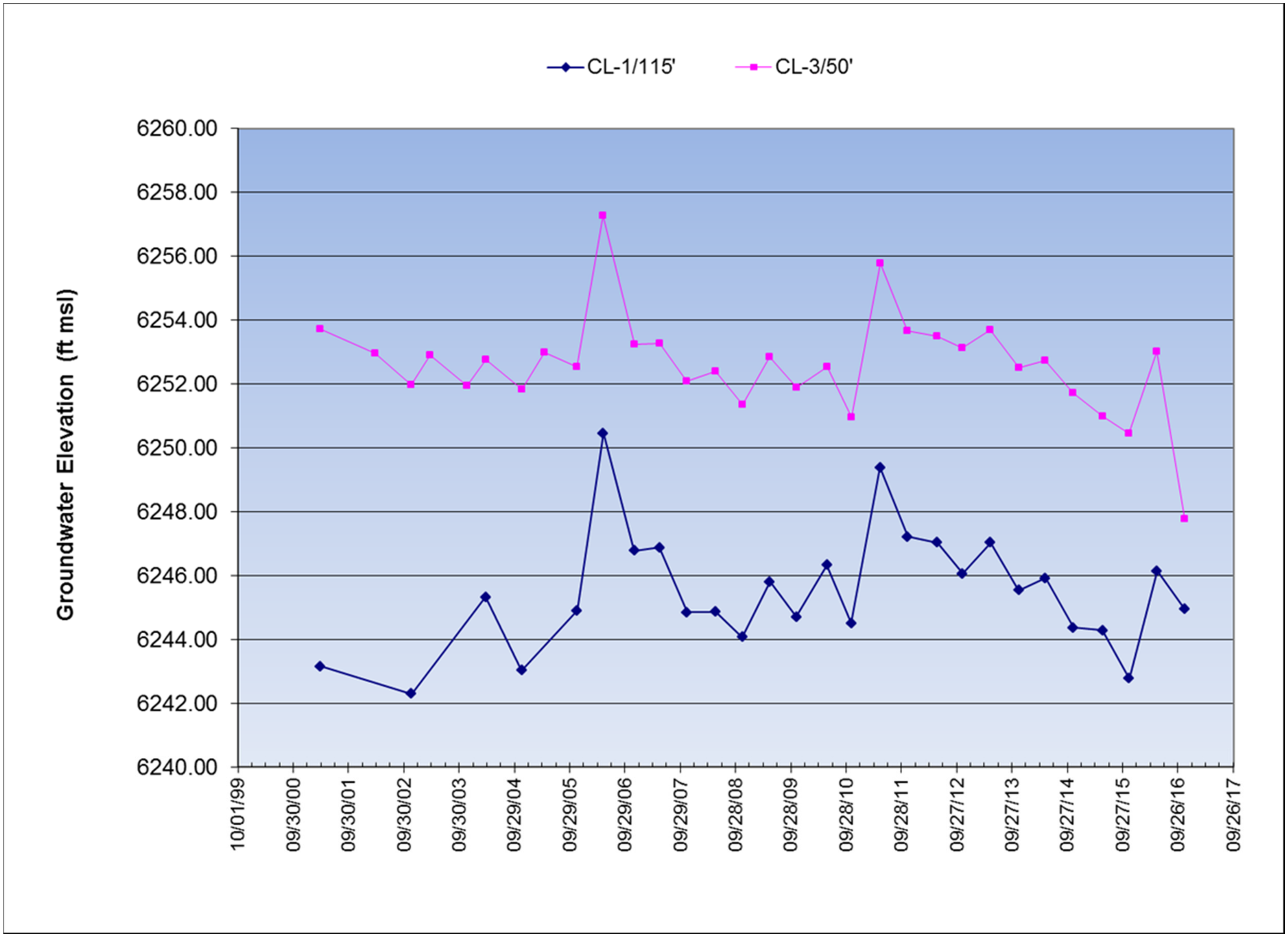


Figure 3-25. Groundwater hydrograph for wells in the South Lake Tahoe Groundwater Zone: Clement well cluster (6,279 feet msl). Total well depths for the observation wells comprising the well cluster are as indicated.

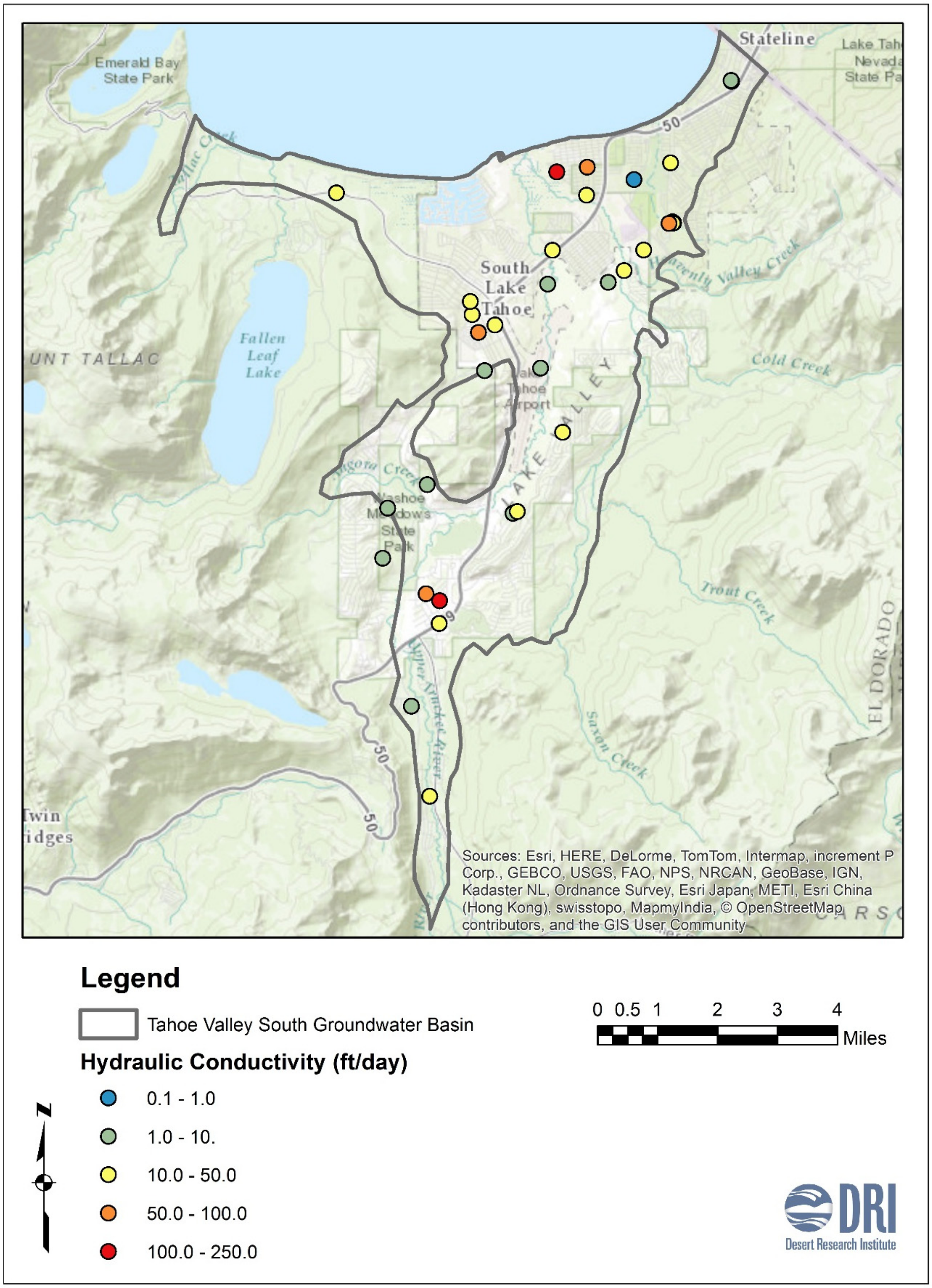


Figure 3-26. Hydraulic conductivity (ft/day) within the Tahoe Valley South groundwater basin.

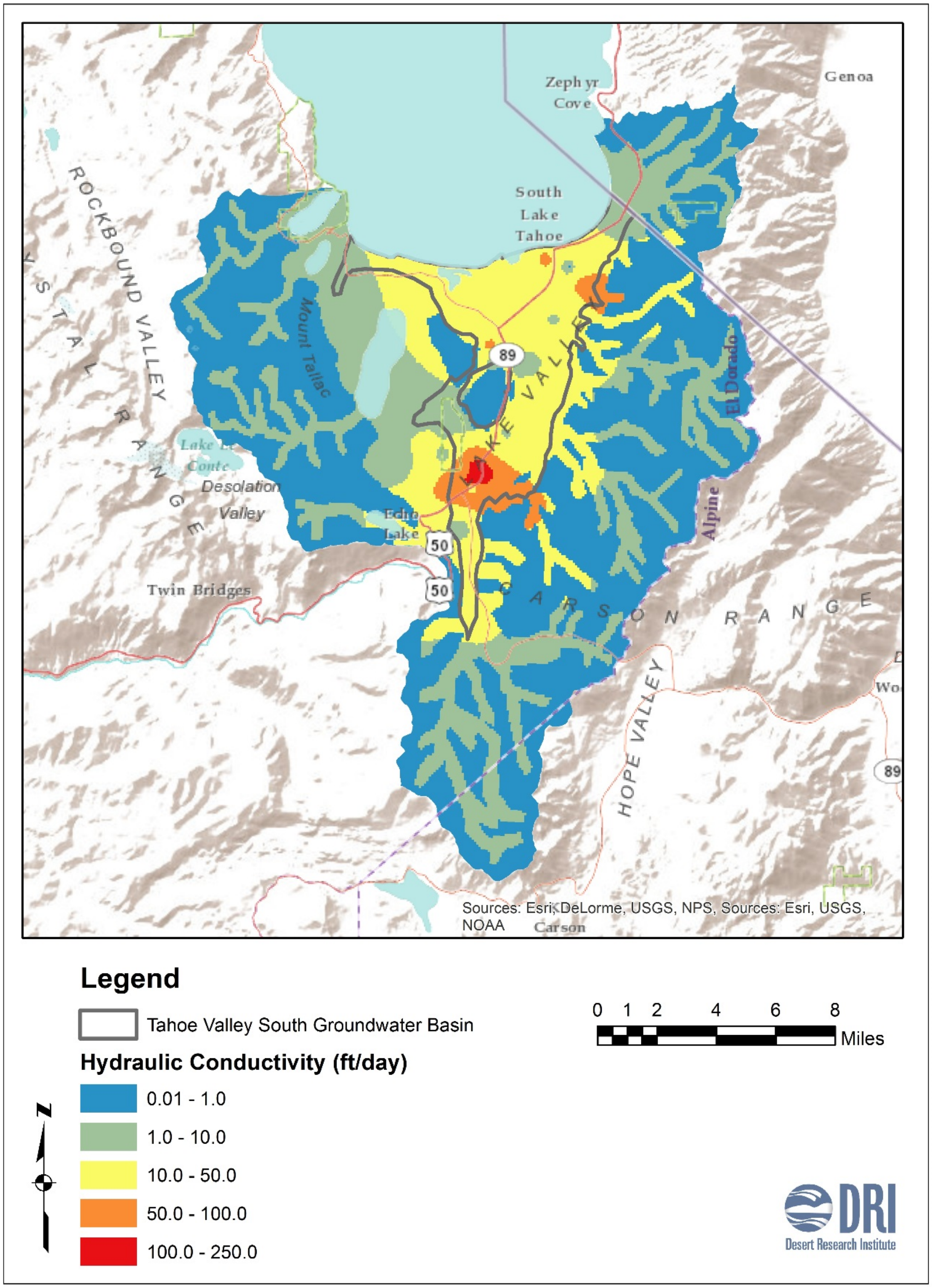


Figure 3-27. Hydraulic conductivity field (ft/day) used in the uppermost layer of the groundwater flow model.

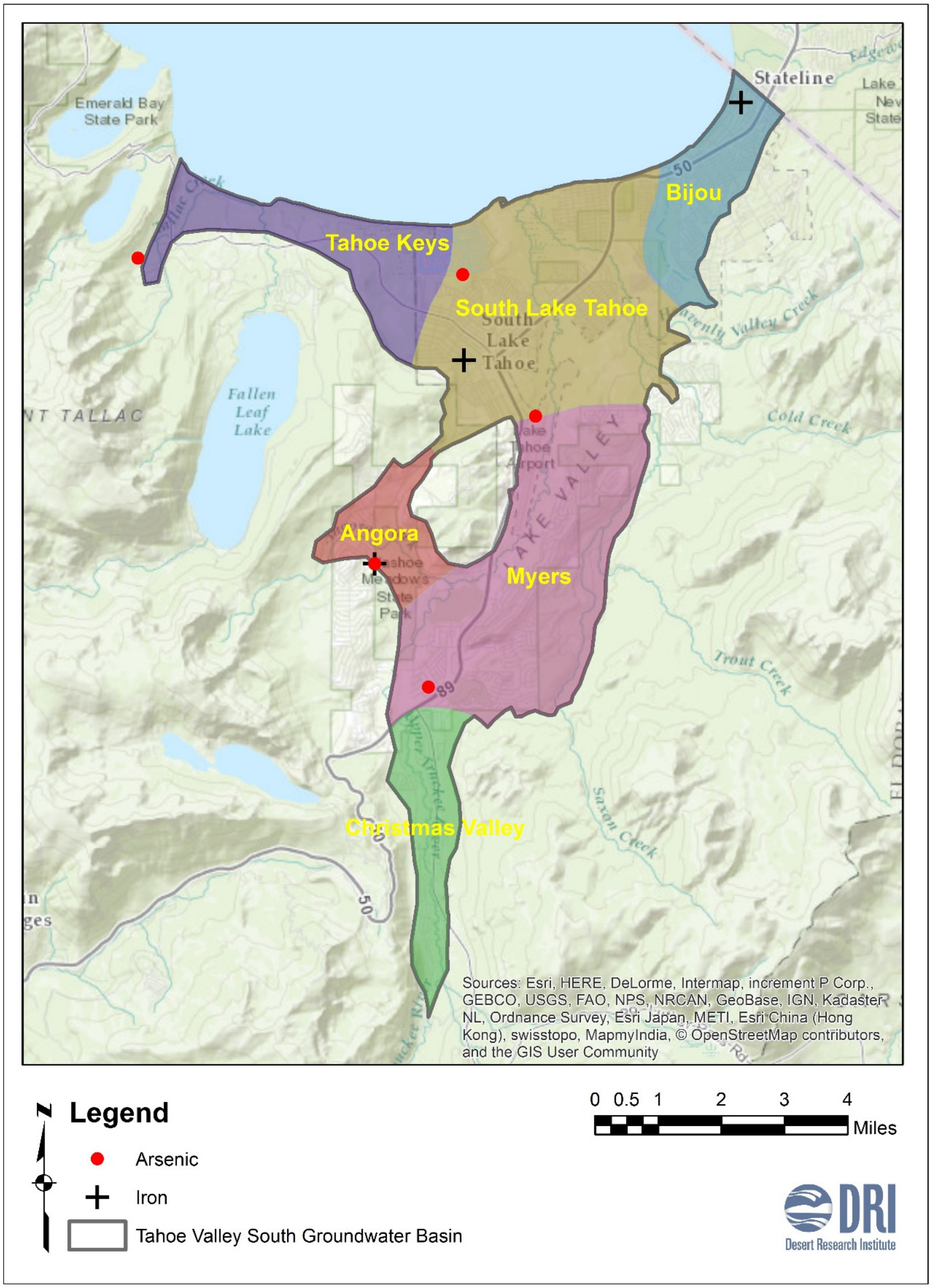


Figure 3-28. Incidences of inorganic constituents above MCLs detected in water samples collected over the past 10 years from water supply wells within the TVS Basin (Data Source: GeoTracker GAMA, November 2016).

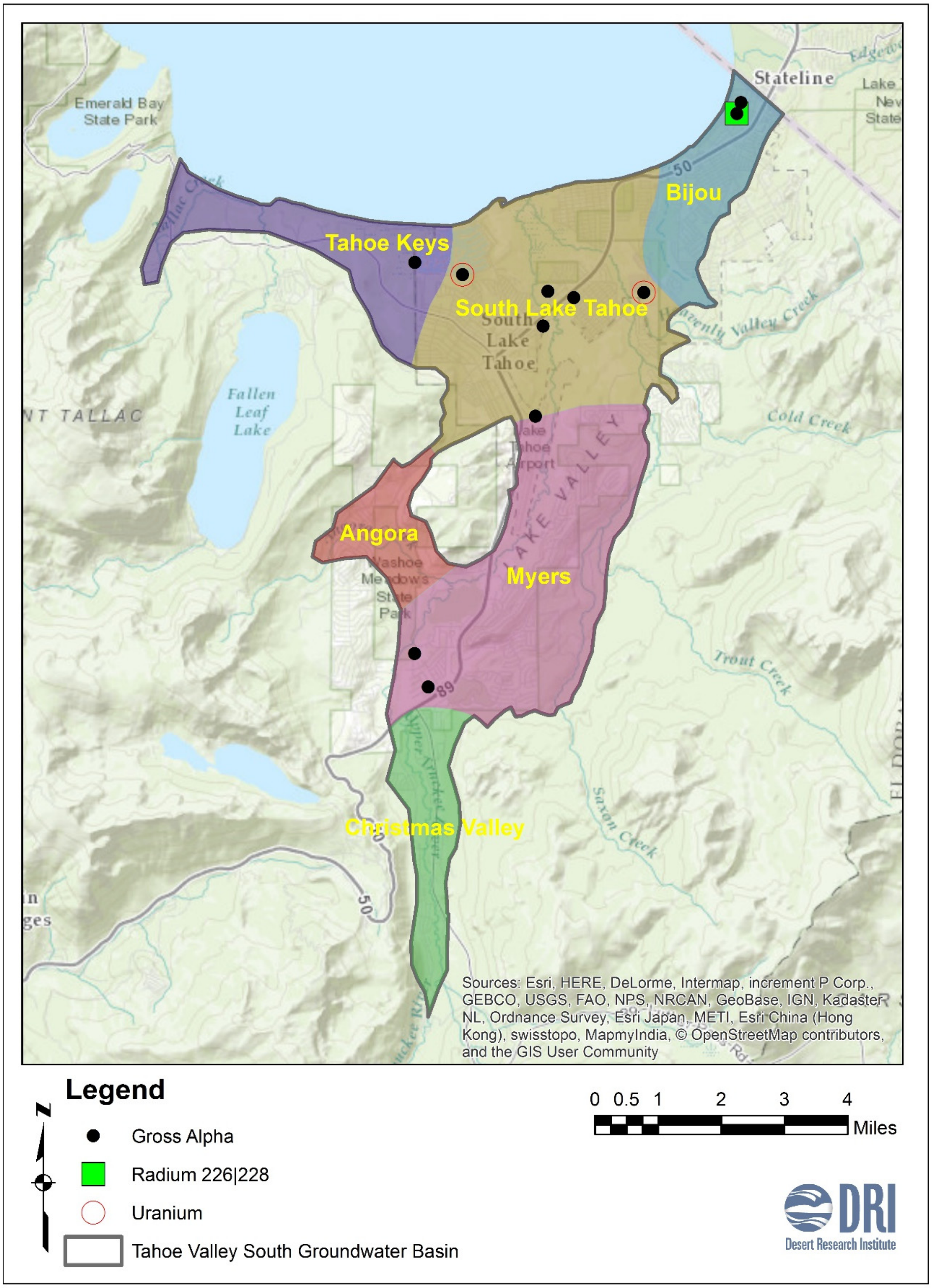


Figure 3-29. Incidences of radionuclide constituents above MCLs detected in water samples collected over the past 10 years from water supply wells within the TVS Basin (Data Source: GeoTracker GAMA, November 2016).

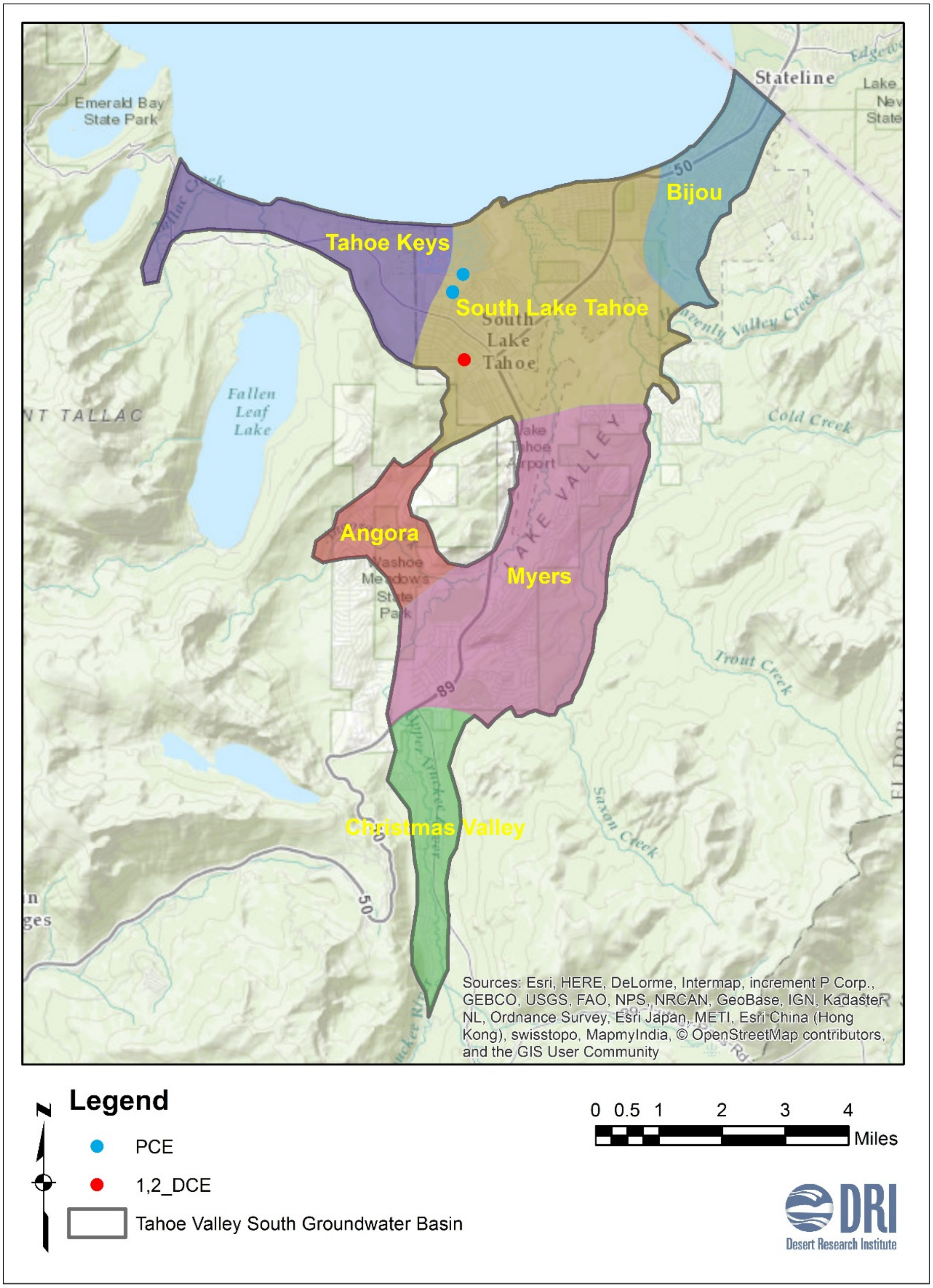


Figure 3-30. Incidences of chemical constituents above MCLs detected in water samples collected over the past 10 years from water supply wells within the TVS Basin (Data Source: GeoTracker GAMA, November 2016).

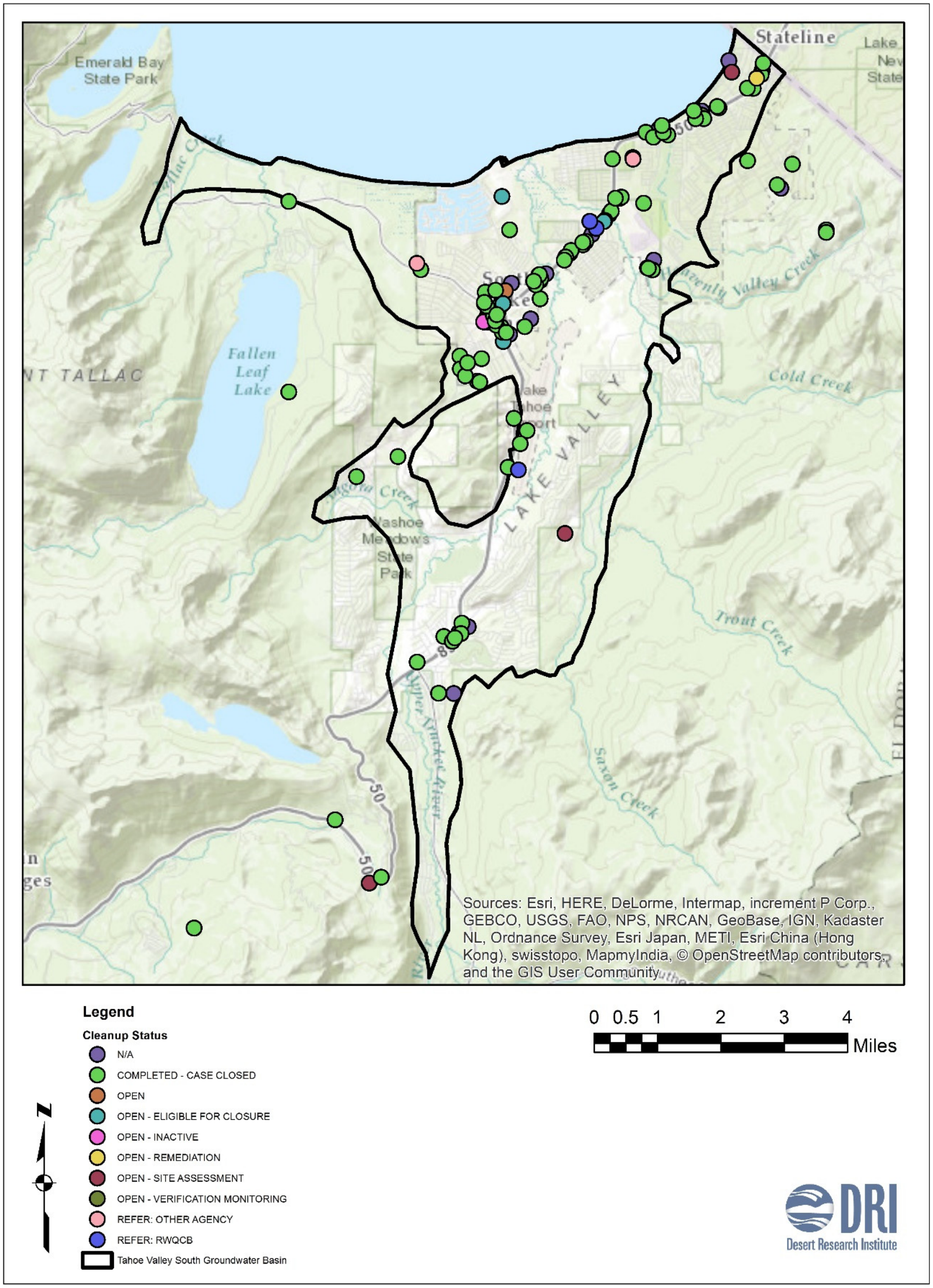


Figure 3-31. Locations of groundwater clean-up sites.

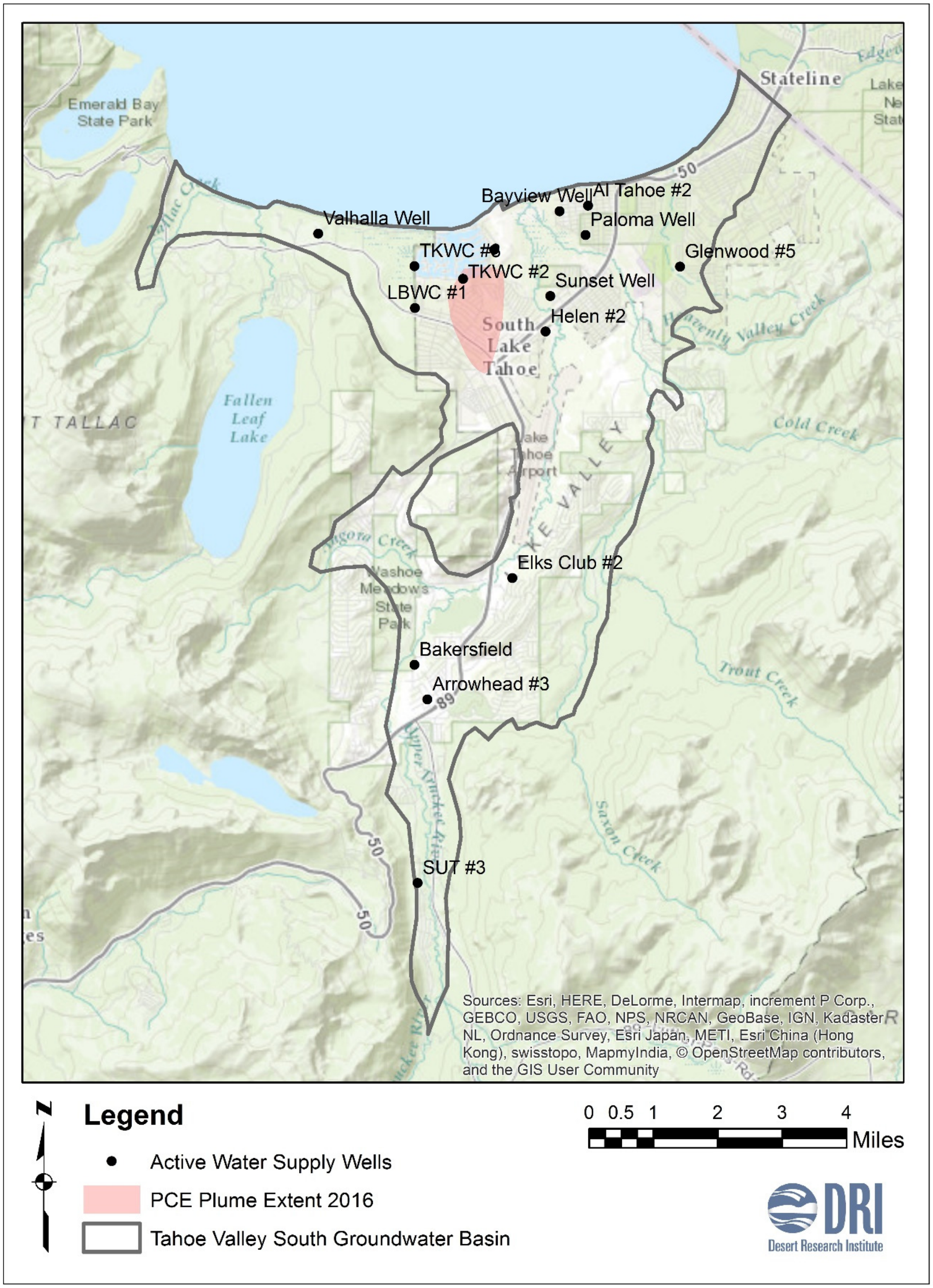


Figure 3-32. Location of the PCE plume extent within the TVS groundwater basin. PCE plume is defined by wells with PCE concentrations in excess of the MCL (5 ug/L). Adapted from GEI Consultants, 2016.

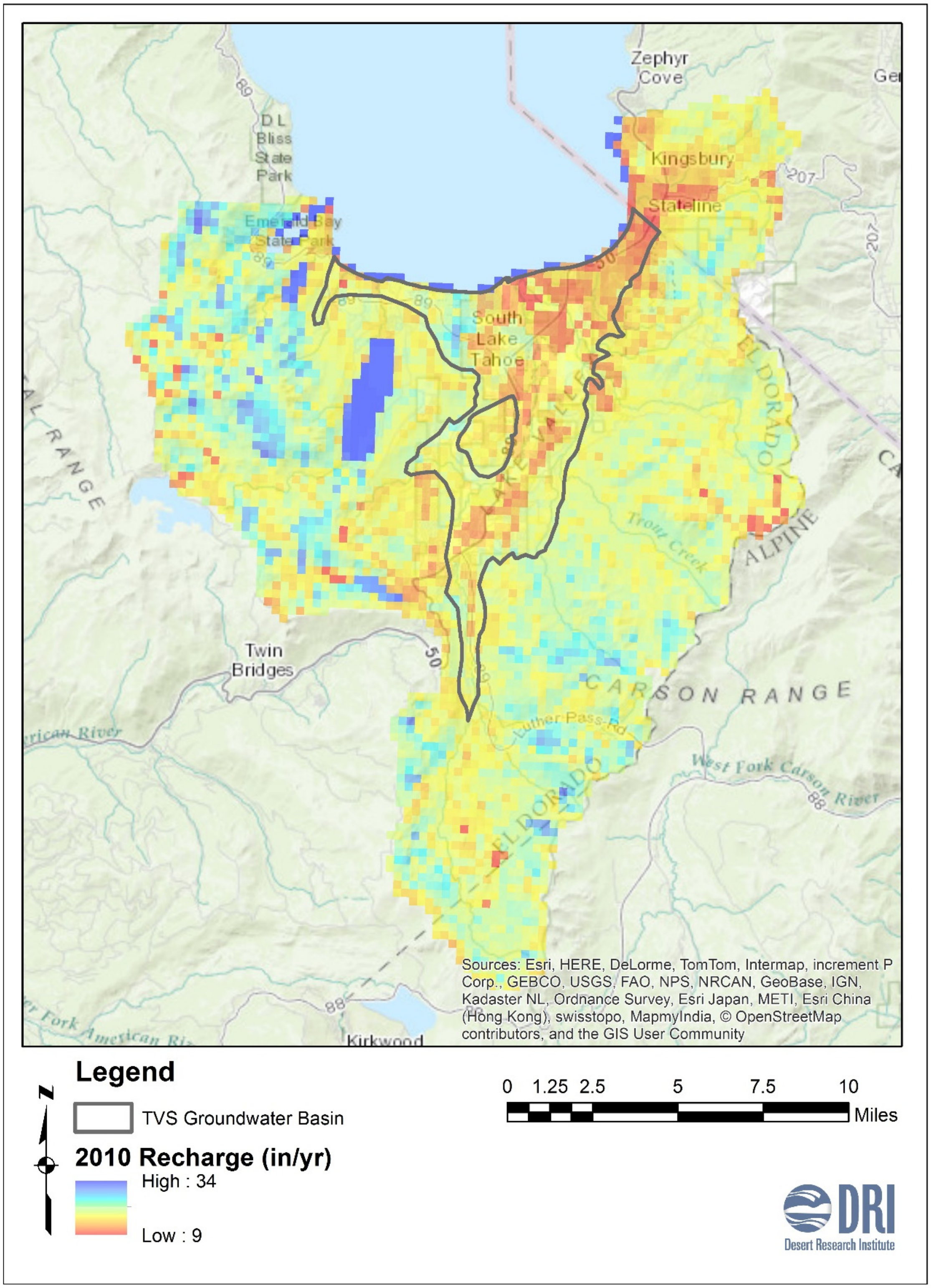


Figure 3-33. Groundwater recharge rates for 2010 as simulated with the GSFLOW model.

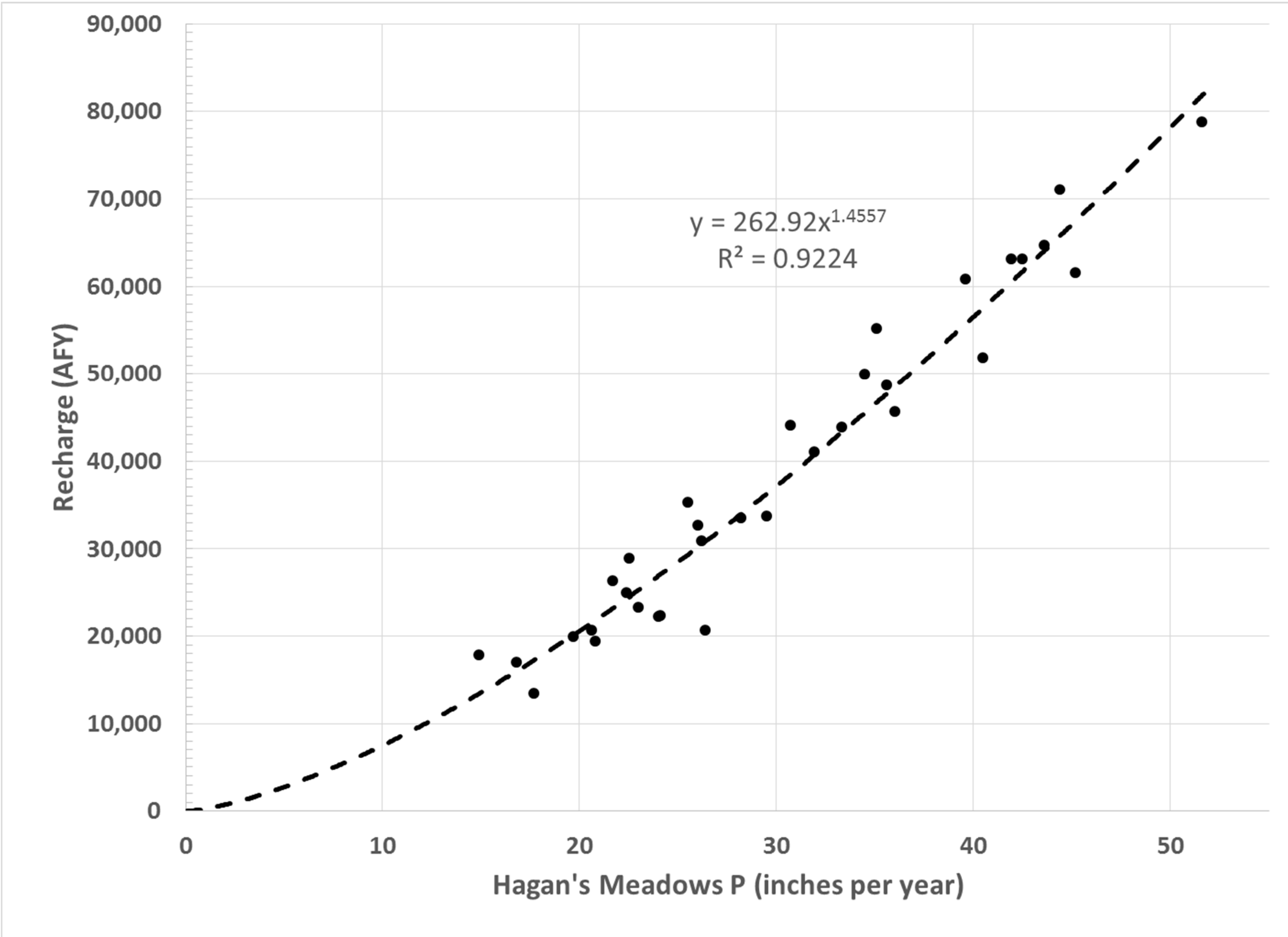


Figure 3-34. Hagan's Meadow annual precipitation versus groundwater recharge within the hydrologic analysis area. Also shown is a non-linear regression.

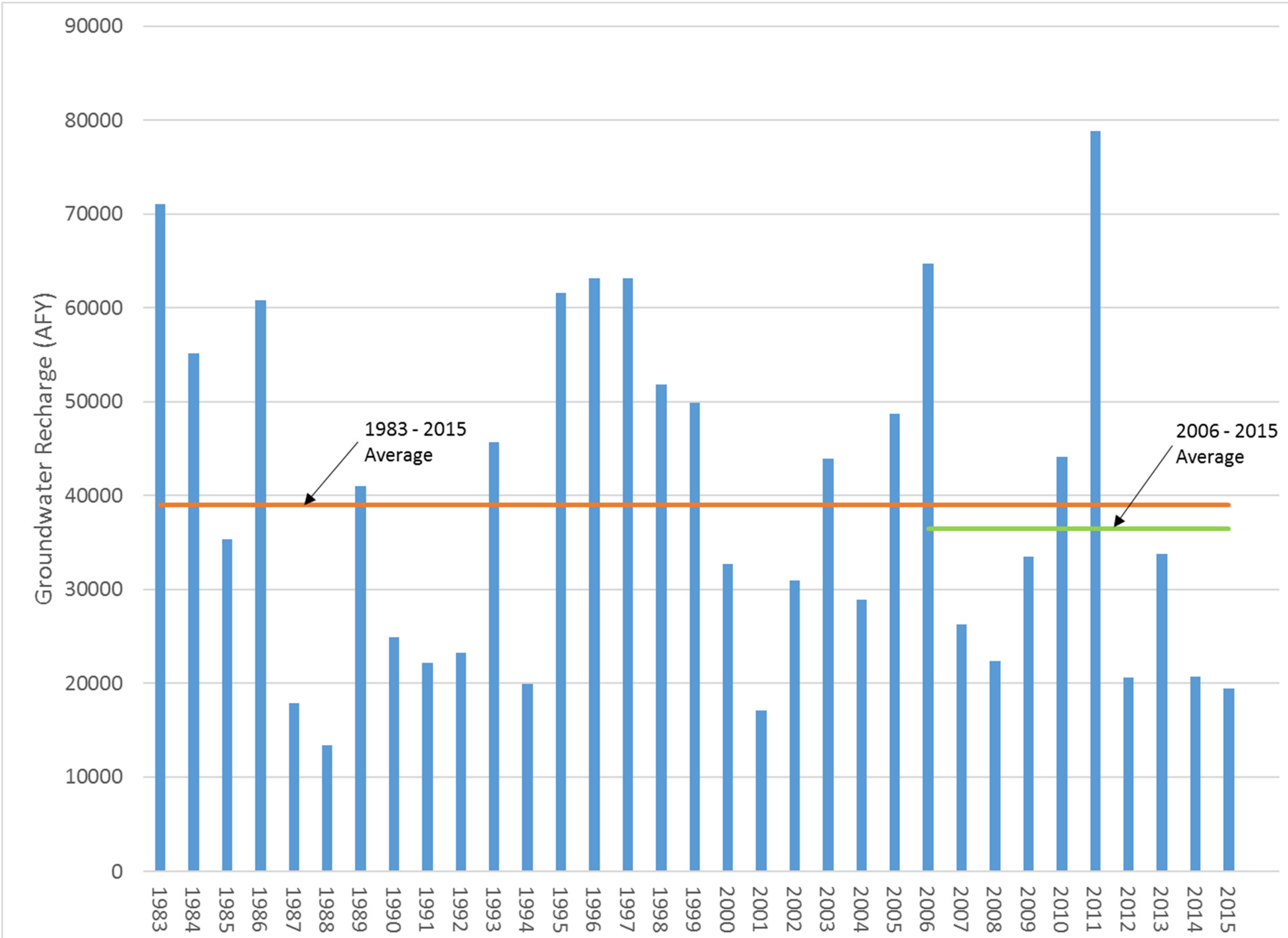


Figure 3-35. Groundwater recharge from water year 1983 – 2015. Green line represents average recharge over the period 2006 – 2015.

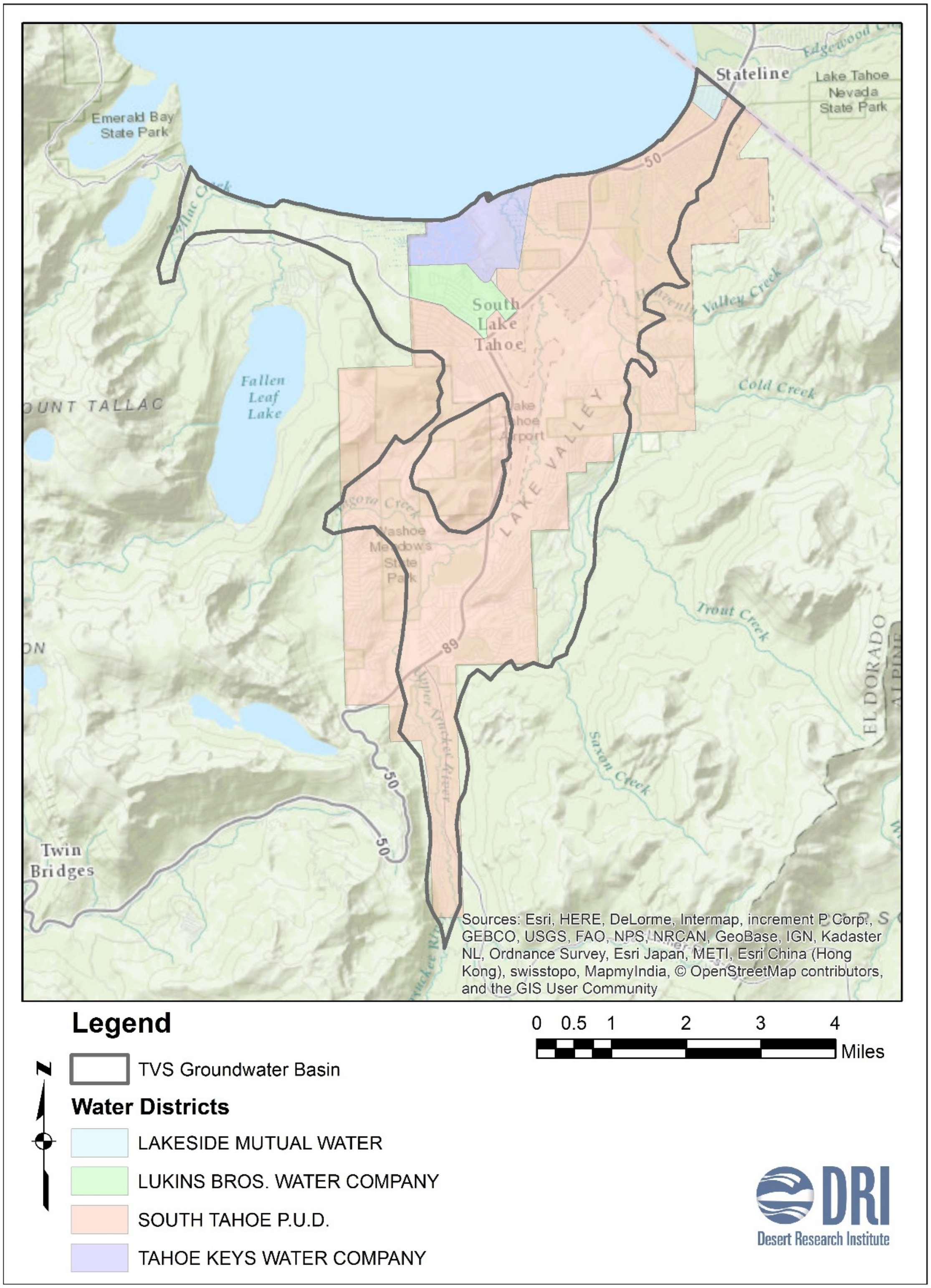


Figure 3-36. Service areas for water purveyors within the Tahoe Valley South Basin.

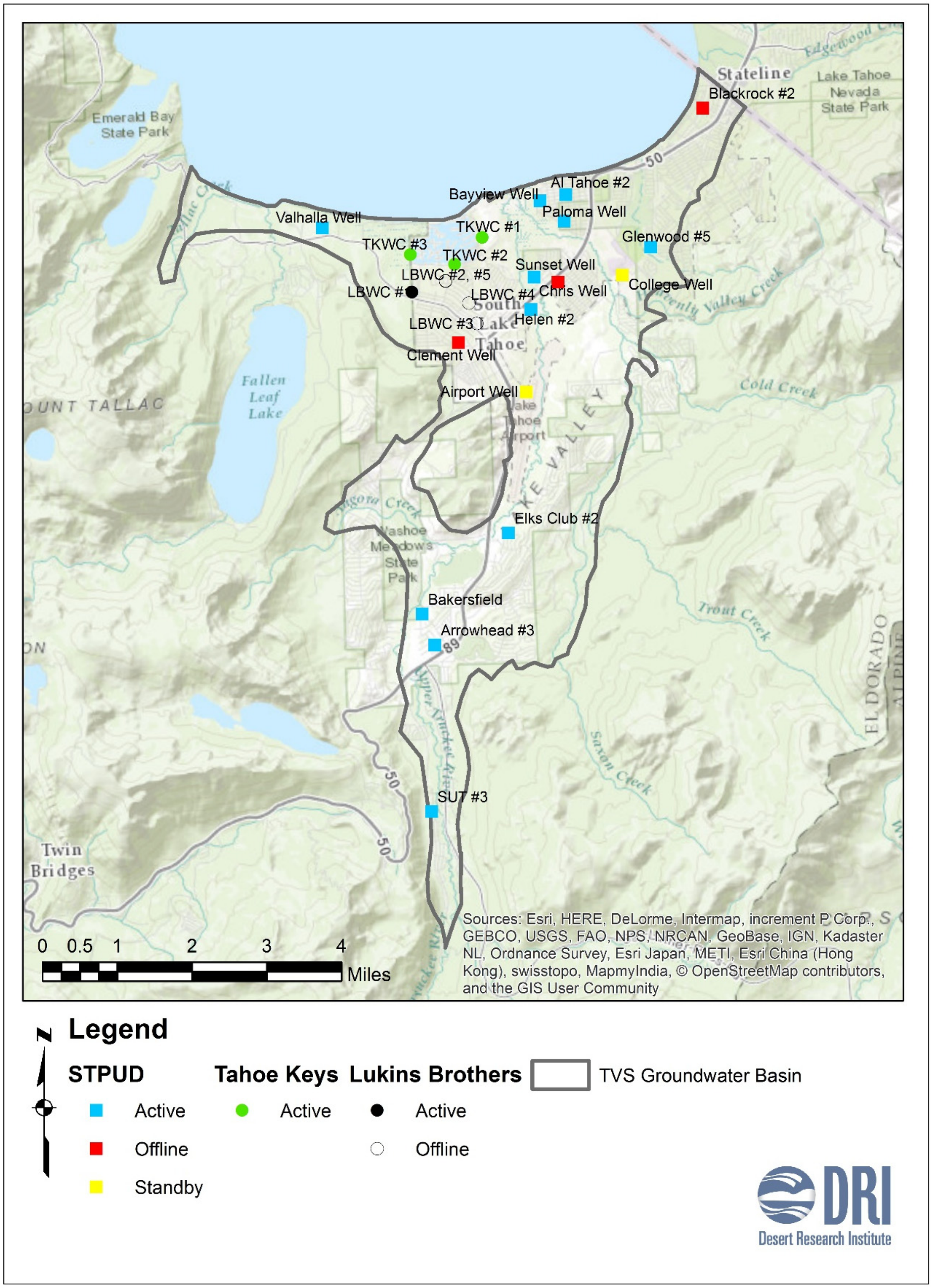


Figure 3-37. Location of water supply wells.

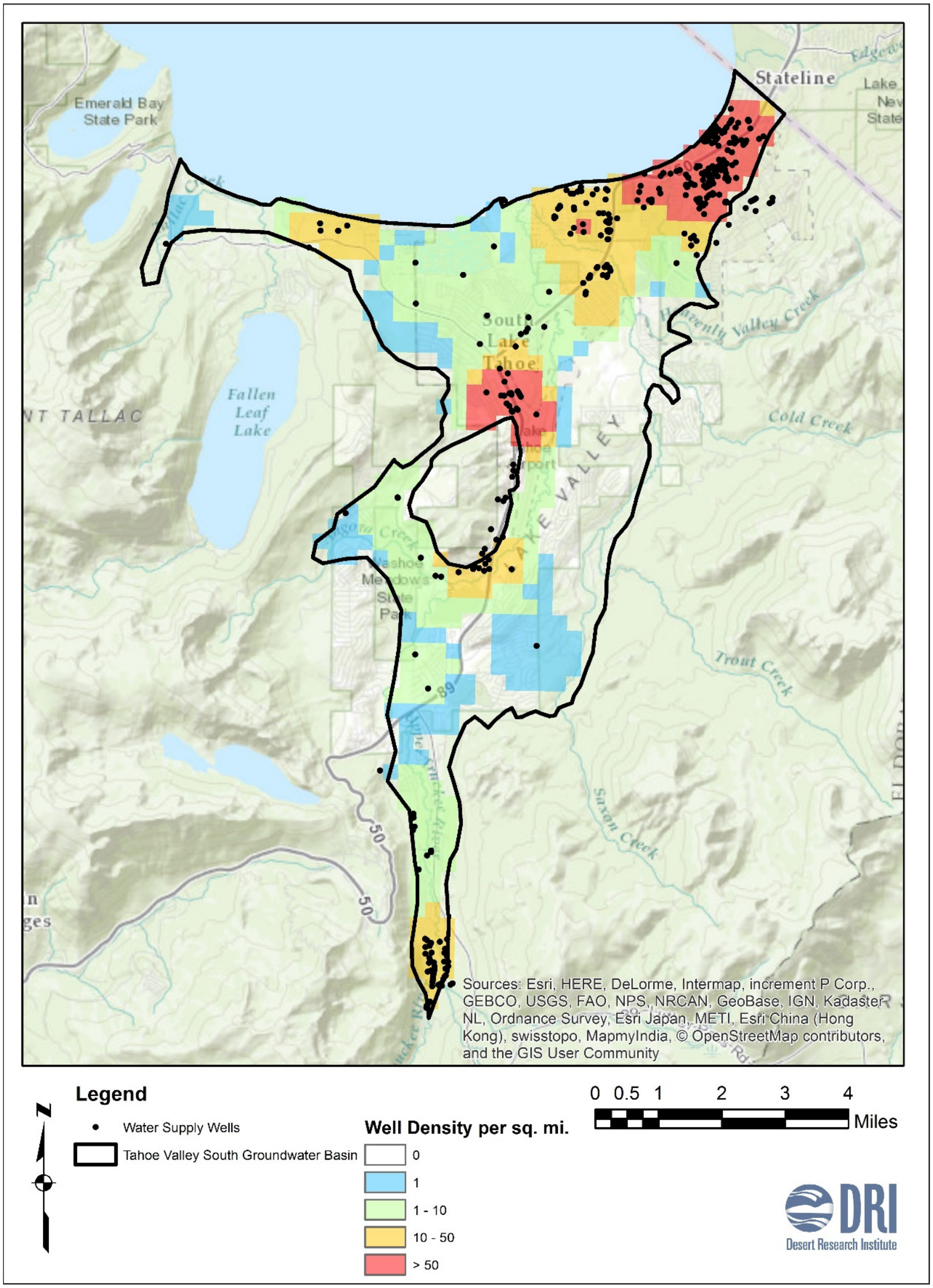


Figure 3-38. All wells and well density within the Tahoe Valley South Basin.

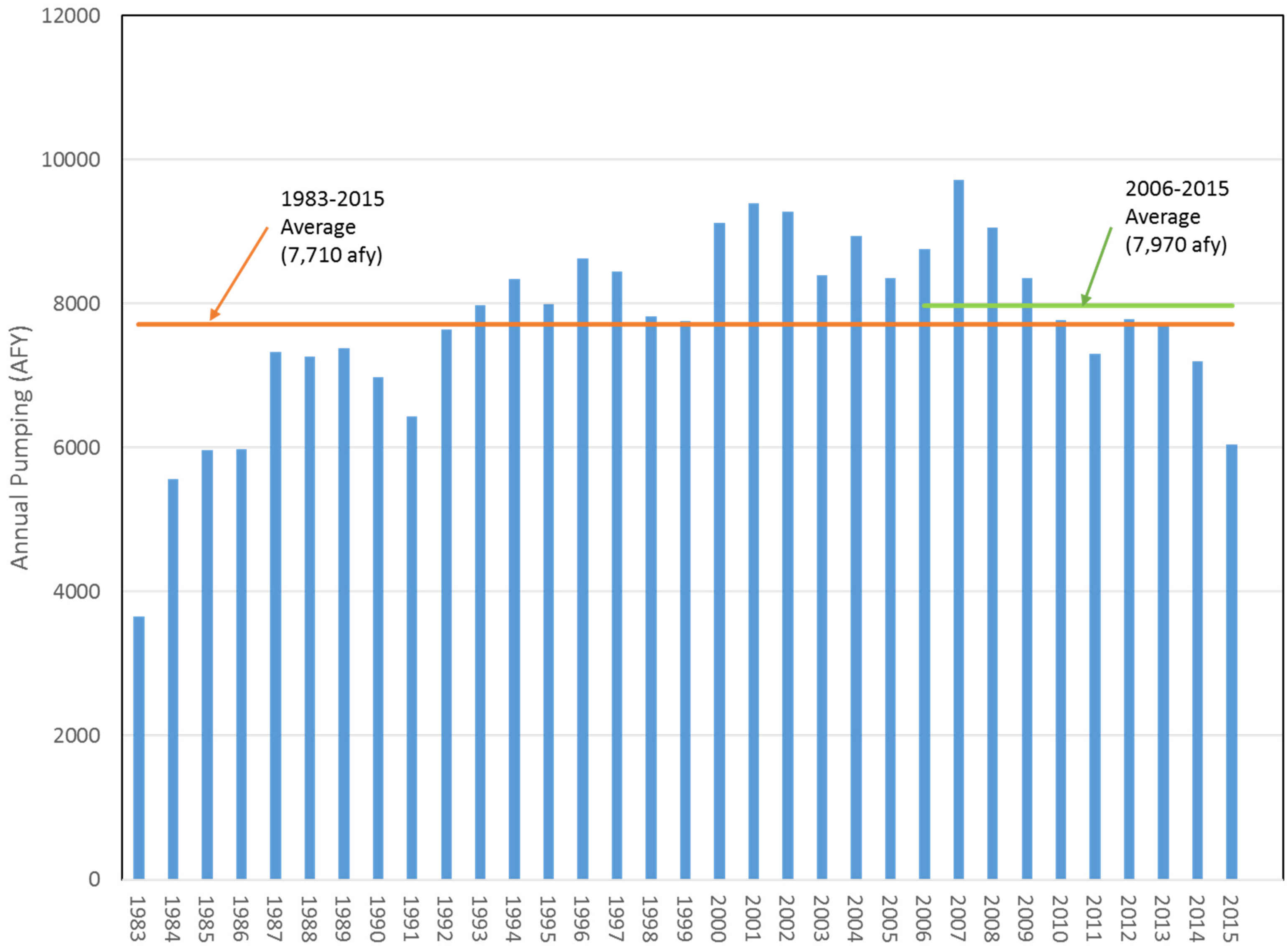


Figure 3-39. Annual pumping rates within the TVS groundwater basin.

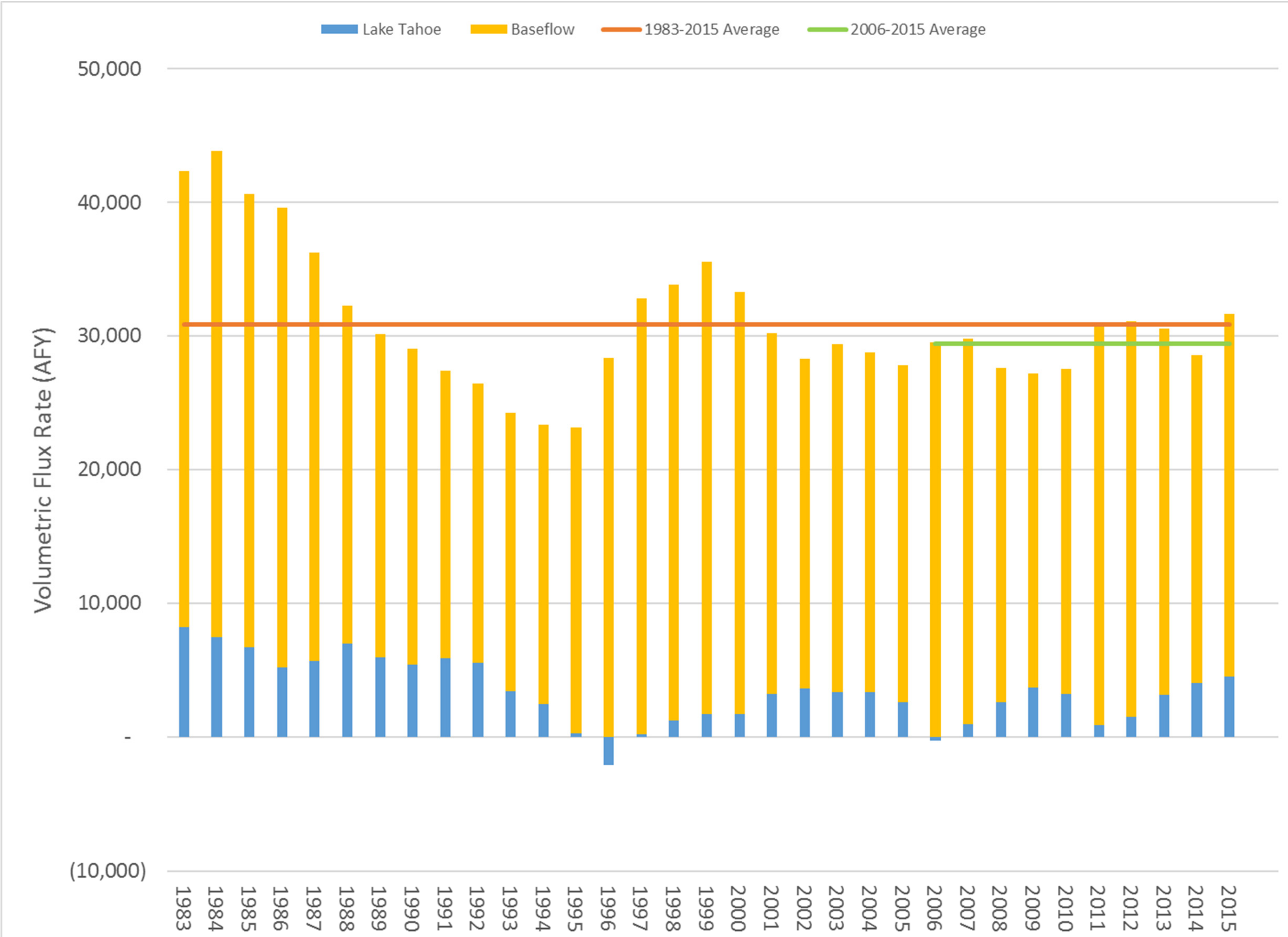


Figure 3-40. Baseflow to local streams and groundwater flow to Lake Tahoe.

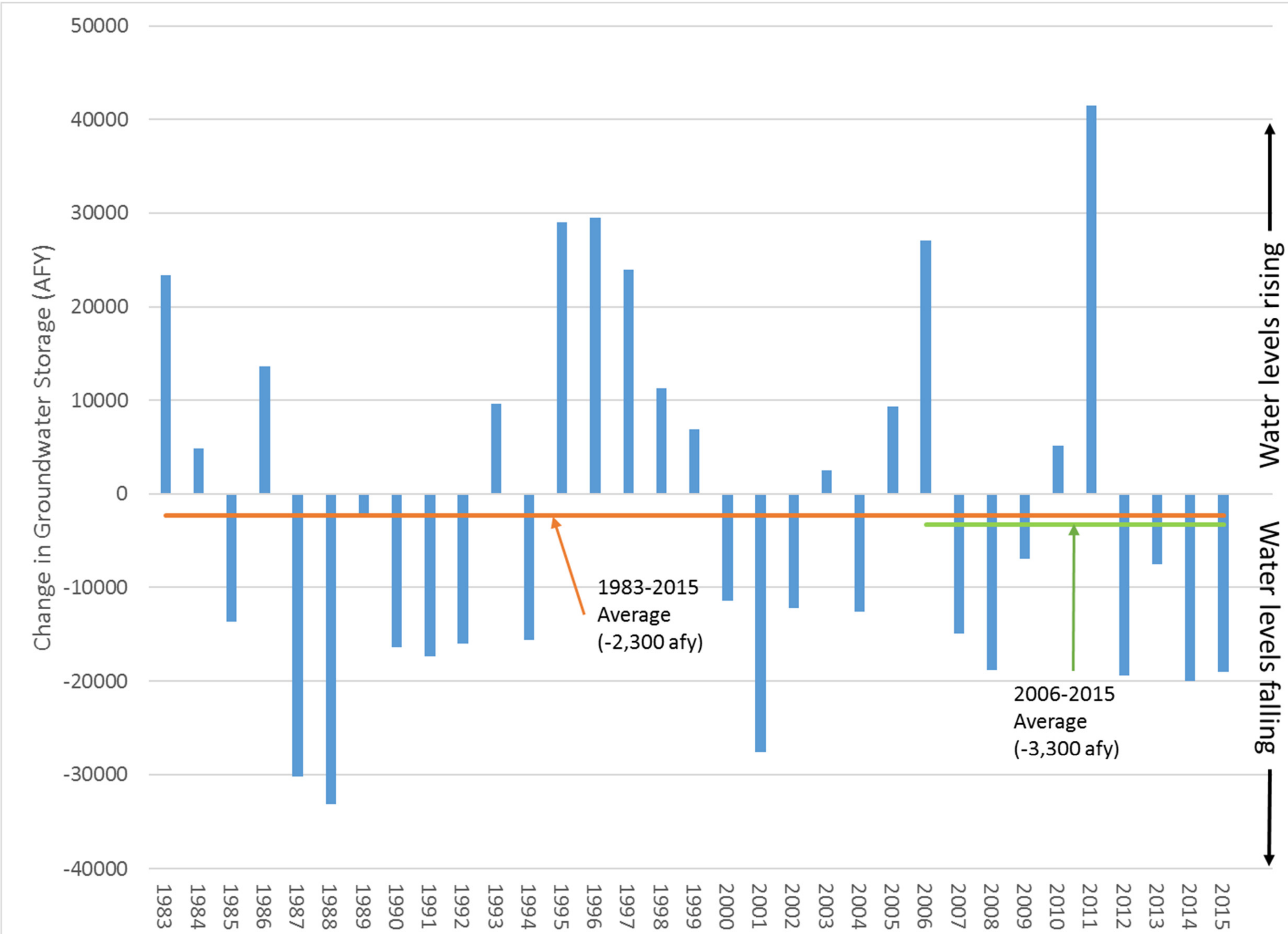


Figure 3-41. Change in groundwater storage from water years 1983 – 2015 as calculated by the Tahoe Valley South groundwater model.

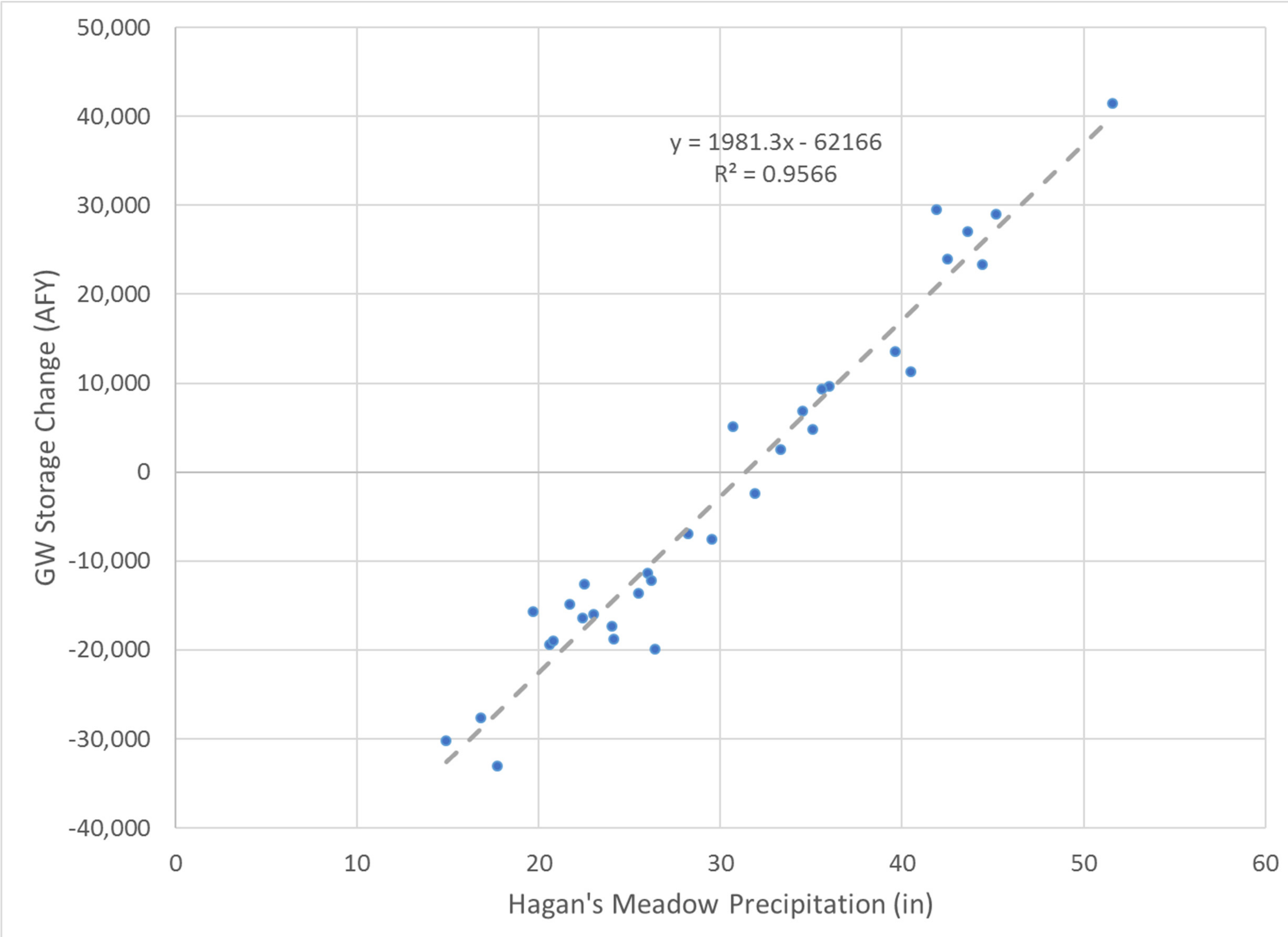


Figure 3-42. Hagan's Meadow precipitation versus groundwater storage change.

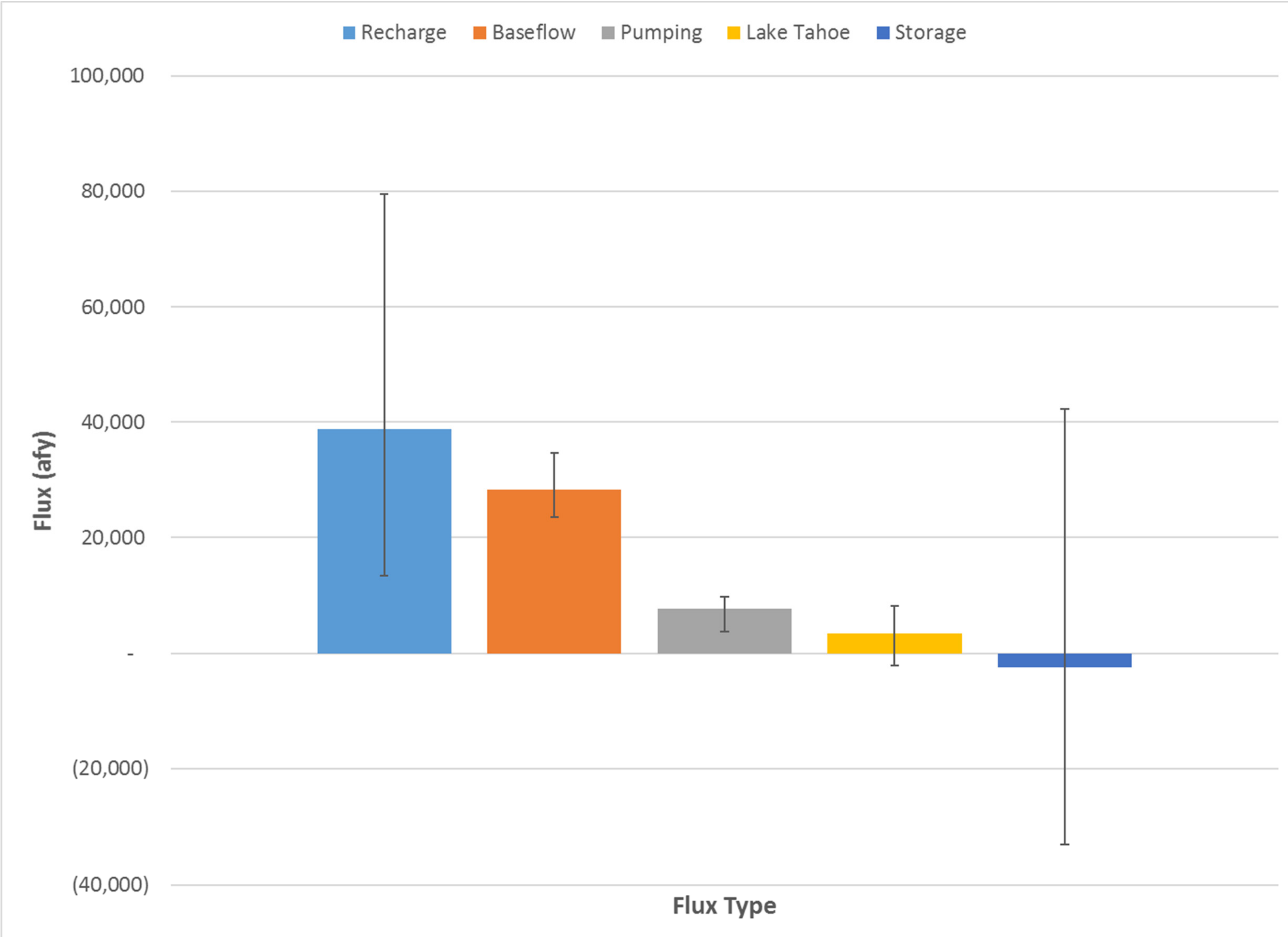


Figure 3-43. Simulated water budget (1983 – 2015). Bars represent average conditions over the simulation period 1983 – 2015 and bars represent the total range in each flux value.

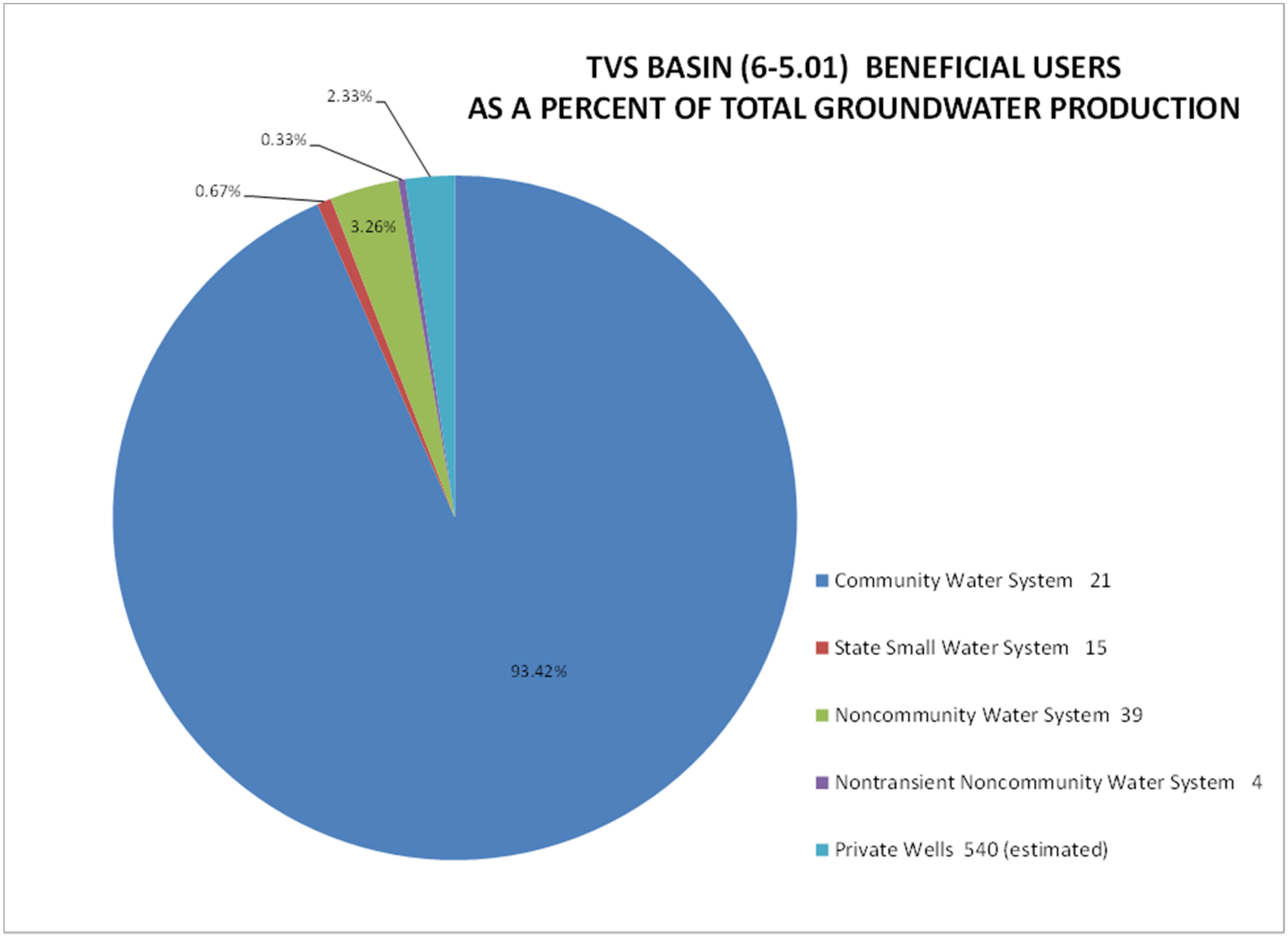


Figure 5-1. Beneficial users of groundwater within the TVS Basin (6-5.01) as a percent of the total groundwater production produced during WY 2016. Number of wells for each user is also shown.

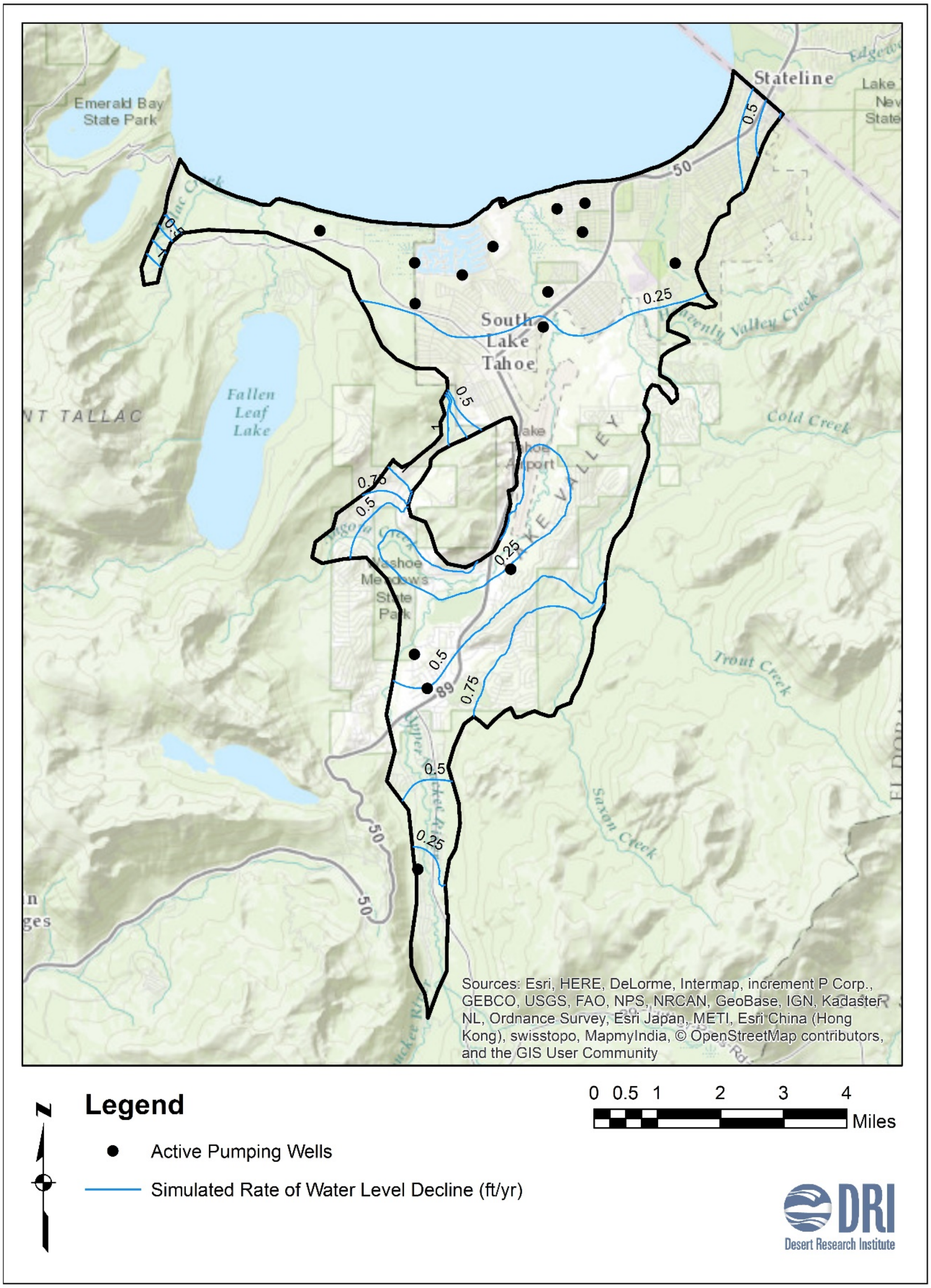


Figure 5-2. Simulated rate of water level decline (drawdown) in feet per year assuming groundwater recharge is 34 percent of normal (15,000 acre-ft/yr). The recharge rate is equivalent to 16 inches of precipitation at Hagan's Meadow which is the threshold for lowest (critical) water year classification.

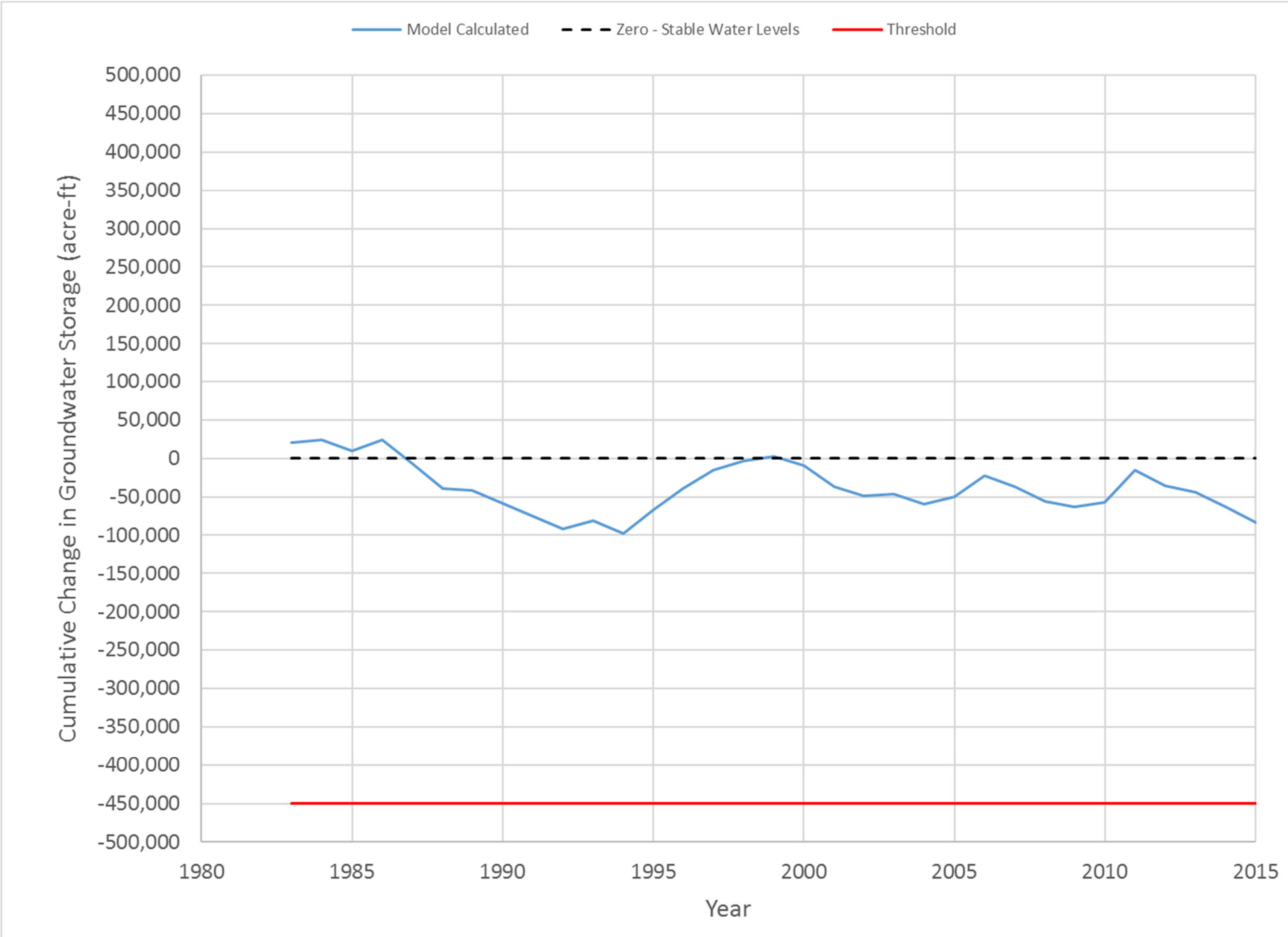


Figure 5-3. Simulated groundwater storage changes as calculated by the Tahoe Valley South groundwater model and minimum threshold defined for the reduction in groundwater storage indicator.

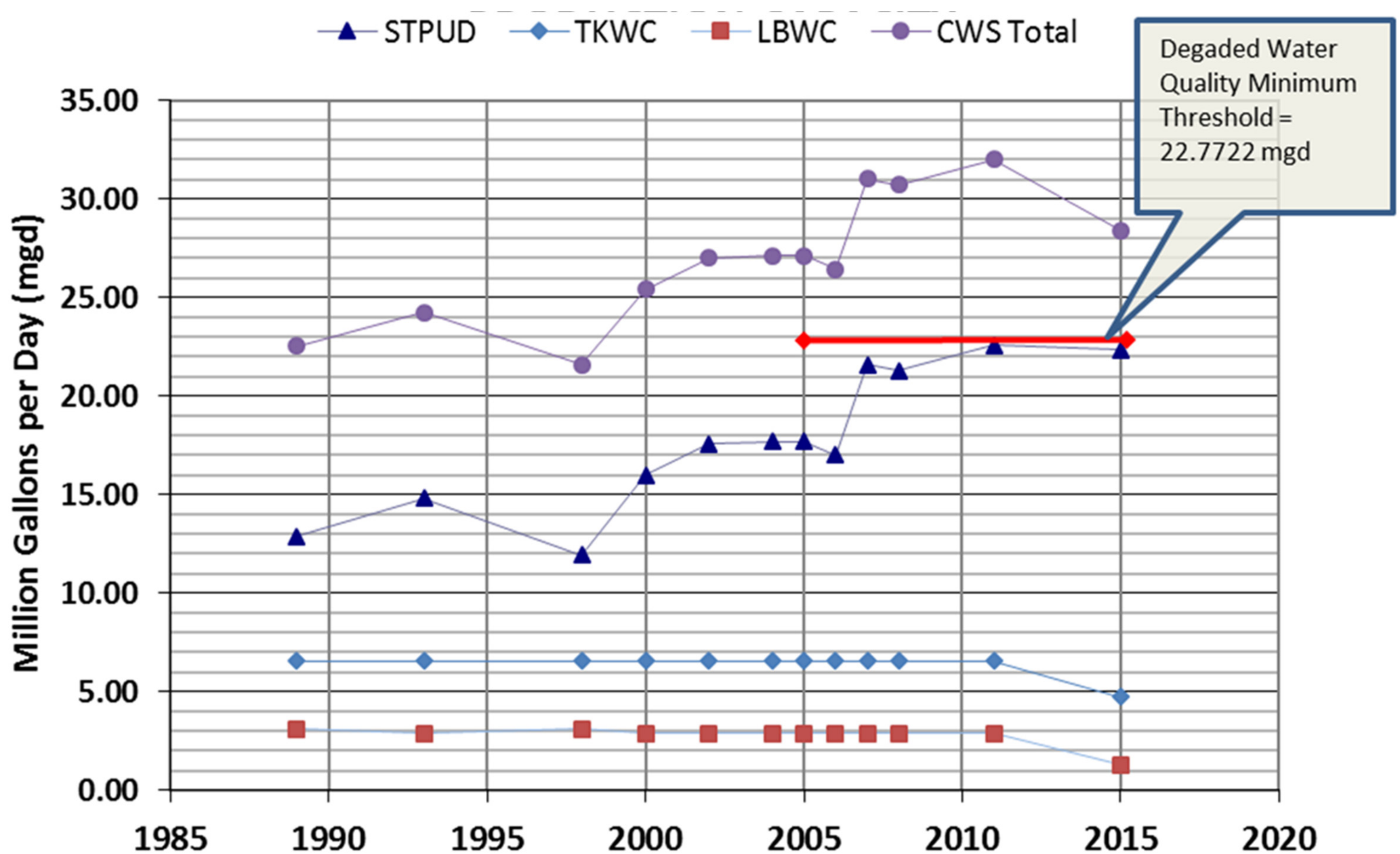


Figure 5-4. Source water production capacities, in millions gallons per day, for community water system wells operating within the TVS Basin (6-5.01) from 1989 through 2015.

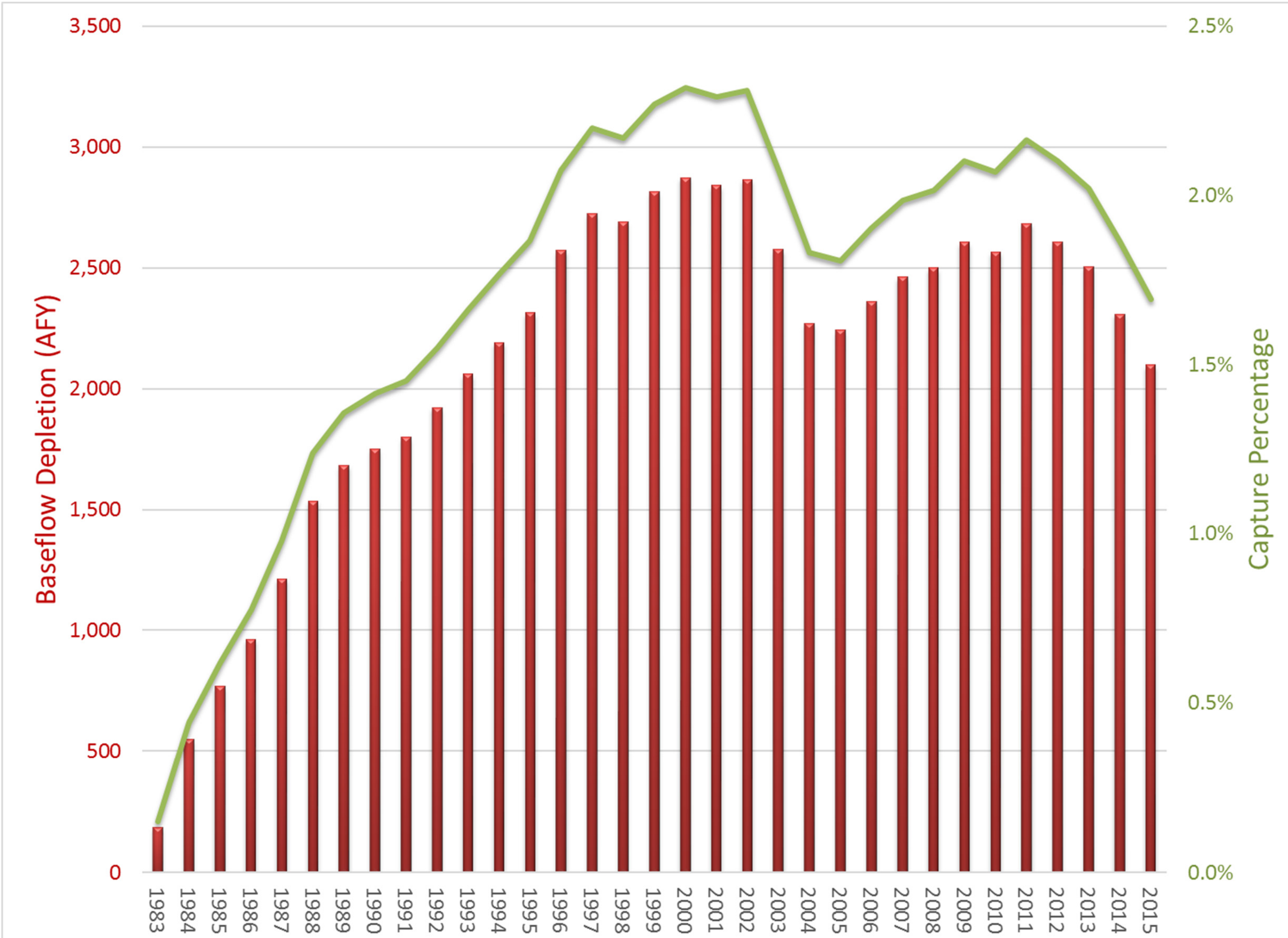


Figure 5-5. Baseflow depletion for the TVS Basin caused by groundwater pumping. The capture percentage is calculated as the ratio of baseflow depletion and average annual runoff (124,000 acre-ft/yr).

ATTACHMENTS

ATTACHMENT A

RESOLUTION 3044-16

RESOLUTION OF THE BOARD OF DIRECTORS OF THE SOUTH TAHOE PUBLIC UTILITY DISTRICT AUTHORIZING STAFF TO SUBMIT TWO ALTERNATIVE GROUNDWATER SUSTAINABILITY PLAN UNDER WATER CODE SECTION 10733.6(b)(1) AND 10733.6(b)(3)

WHEREAS, the California Legislature has adopted, and the Governor has signed into law, the Sustainable Groundwater Management Act of 2014 ("Act"), which authorizes local agencies to manage groundwater in a sustainable fashion; and

WHEREAS, the legislative intent of the Act is to provide for sustainable management of groundwater basins, to enhance local management of groundwater, to establish minimum standards for sustainable groundwater management, and to provide local groundwater agencies with the authority and the technical and financial assistance necessary to sustainably manage groundwater; and

WHEREAS, the South Tahoe Public Utility District ("District") overlies the Tahoe Valley South Groundwater Basin (designated basin number 6-5.01 in the California Department of Water Resources' ("DWR") CASGEM groundwater basin system) ("TVS Basin"), which has been designated as a medium-priority basin pursuant to the DWR's initial prioritization; and

WHEREAS, for groundwater basins designated by DWR as medium- and high-priority, the Act requires adoption of either a groundwater sustainability plan ("GSP") or an alternative groundwater management plan ("Alternative Plan") by January 31, 2022 or January 1, 2017, respectively; and

WHEREAS, on November 17, 2015, DWR recognized the District as the exclusive Groundwater Sustainability Agency for the portion of the TVS Basin within its service area boundaries and on December 28, 2016, DWR is expected to recognize the District as the nonexclusive Groundwater Sustainability Agency for the portion of the TVS Basin outside its service area boundaries; and

WHEREAS, the Act identifies several forms of acceptable Alternative Plans, including an existing Groundwater Management Plan ("GWMP Alternative") and an analysis of basin conditions that demonstrates that the basin has operated within its sustainable yield for a period of at least ten years ("Analysis of Basin Conditions Alternative"); and

WHEREAS, the District adopted a robust groundwater management plan ("2014 GWMP") in 2014, which has successfully and sustainably been used to manage the TVS Basin since that date; and

WHEREAS, the District has determined that the 2014 GWMP satisfies the requirements for the GWMP Alternative and the objectives of the Act; and

WHEREAS, The District has developed and compiled a significant historical amount of information and data on the operation of the TVS Basin; and,

WHEREAS, the District has determined that the TVS Basin has operated within its sustainable yield for at least ten years and satisfies the requirements of the Analysis of Basin Conditions Alternative and the objectives of the Act; and

WHEREAS, the District has determined that it is within its best interest, and within the best interest of the continued sustainable management of the TVS Basin, to submit both a GWMP Alternative and an Analysis of Basin Conditions Alternative to DWR for its review and consideration; and

WHEREAS, upon submission, the District will note its preference for acceptance of the GWMP Alternative over the Analysis of Basin Conditions Alternative; and

WHEREAS, the District has discussed this approach with the twelve-member Stakeholder Advisory Group ("SAG") convened under the 2014 GWMP, who all support this approach; and

WHEREAS, the District desires to submit both the GWMP Alternative and the Analysis of Basin Conditions Alternative to DWR by the Act's deadline of January 1, 2017; and

NOW, THEREFORE, BE IT RESOLVED, AS FOLLOWS:

1. The foregoing recitals are true and are incorporated by reference.
2. The Board of Directors authorizes staff to submit both the GWMP Alternative and the Analysis of Basin Conditions Alternative to DWR by the Act's

deadline of January 1, 2017, with a preference for acceptance of the GWMP Alternative over the Analysis of Basin Conditions Alternative.

3. That the direction to submit both the GWMP Alternative and the Analysis of Basin Conditions Alternative is statutorily exempt from the California Environmental Quality Act ("CEQA").

4. This resolution shall take effect immediately.

WE, THE UNDERSIGNED, do hereby certify that the above and foregoing Resolution was duly adopted and passed by the Board of Directors of the South Tahoe Public Utility District as a regularly scheduled meeting held on the 15th day of December, 2016, by the following vote:

AYES: Cefalu, Jones, Vogelgesang, Sheehan, Wallace
NOES: NONE
ABSENT: NONE

Randy Vogelgesang, Board President
South Tahoe Public Utility District

ATTEST:

Melonie Guttry, Clerk of the Board
South Tahoe Public Utility District

ATTACHMENT B

Overview of Local Governmental Agencies

A key goal of the GWMP update is to further expand collaboration with local land use and regulatory agencies for groundwater management and water quality protection in the TVS Basin. The following section outlines the existing regulatory agencies and authorities to provide the context in which increased support for groundwater quality protection can be built.

History of Collaboration

This GWMP is updated within the context of an existing, on-going coordination and collaboration with water issues in the South Lake Tahoe area primarily focused on Lake Tahoe clarity issues. Because of this, many long-established relationships already exists that form the foundation of coordination and collaboration which will be honored and expanded to include consideration of groundwater management issues with an emphasis on water quality. A key objective of this GWMP update is to continue to build off of these existing relationships to further enhance groundwater management and protection in the TVS Basin.

Table 4-1 provides a summary of the many different agencies with jurisdictions and regulatory oversight related to groundwater quality, hazardous materials management and land use management in the TVS Basin. Additional, more detailed information on the agency responsibilities is presented in Appendix B. The following discussion provides a summary of the roles and responsibilities for the various agencies that are relevant for managing and protecting groundwater in the TVS Basin.

Groundwater Regulatory Authorities

Groundwater quality regulation is largely from the perspective of drinking water and hazardous materials management. The following provides a summary of actions and programs for groundwater protection in the TVS Basin.

State Water Resources Control Board and Lahontan Regional Water Quality Control Board

The primary responsibility for the protection of groundwater quality in California rests with the State Water Resources Control Board (SWRCB) and nine Regional Water Quality Control Boards (Regional Boards). The SWRCB sets statewide policy for the implementation of federal and state laws and regulations. The Regional Boards adopt and implement Water Quality Control Plans (Basin Plans) which recognize regional differences in natural water quality, actual and potential beneficial uses, and water quality problems associated with human activities. The Water Quality Control Plan (Basin Plan) for the Lahontan Region (LWRCB, 1995) is the primary regional water quality planning document in the California portion of Lake Tahoe and is also the basis for regulation by the Lahontan Regional Water Quality Control Board (LRWQCB).

The Basin Plan establishes beneficial uses and water quality objectives of both surface water bodies and groundwater basins. It also outlines implementation programs such as control and enforcement actions, and describes current monitoring activities. Programs used to implement Basin Plan objectives include waste discharge prohibitions; spills, leaks, investigations, and cleanups; storm water, erosion, and sedimentation control measures; wastewater treatment, disposal, and reclamation measures; oversight of land disposal of solid and liquid waste; groundwater protection and management; TMDLs; and other measures related to specific resource uses and development activities.

As described in the LRWQCB Basin Plan, the beneficial uses of groundwater in the TVS Basin are designated as municipal, industrial and agricultural. Ground waters designated as municipal shall not contain concentrations of chemical constituents in excess of the maximum contaminant level (MCL) or secondary maximum contaminant level (SMCL) based upon drinking water standards specified in the Title 22 of the California Code of Regulations.

The enforcement of groundwater cleanup is primarily conducted through two LRWQCB programs in the TVS Basin, the Underground Storage Tank (UST) Program and the Site Cleanup Program. The Underground Storage Tank Program addresses the potential for, and cleanup of, groundwater contamination from leaking tanks (primarily at gasoline stations. The UST Program includes these four program elements:

- Leak Prevention - The Leak Prevention Program element includes requirements for tank installation, construction, testing, leak detection, spill containment, and overfill protection (State Water Board responsibility; also see El Dorado County responsibility under CUPA in Section 4.2.2).
- Cleanup - Cleanup of leaking tanks often involves a soil and groundwater investigation and remediation, under the direction of a regulatory agency (Joint LRWQCB/ El Dorado County responsibility).
- Enforcement - The SWRCB UST Enforcement Unit provides assistance to local agencies enforcing UST requirements.
- Tank Tester Licensing - Tank integrity testing is required by law, must meet the requirements of the State Water Resources Control Board, and must be conducted by State licensed tank testers (SWRCB responsibility).

Special programs also reside within the SWRCB's UST Cleanup Fund for a variety of situations involving underground storage tanks. These include the Comingled Plume Account; Emergency, Abandoned, and Recalcitrant Account; Removing, Replacing, or Upgrading Underground Storage Tanks; and the Orphan Site Cleanup Fund.

The Site Cleanup Program regulates and oversees the investigation and cleanup of "non-federally owned" sites where recent or historical unauthorized releases of pollutants to the environment have occurred. The types of pollutants are varied and include solvents, pesticides, heavy metals, fuel constituents, etc. The Regional Board oversees the investigation and remediation of pollution to ensure the dischargers cleanup and abate the effects of discharges to promote attainment of either background water quality, or the best water quality which is reasonable if background levels of water quality cannot be restored.Important SWRCB and LRWQCB policies used to protect groundwater resources include:

- SWRCB Resolution No. 68-16: Statement with Respect to Maintaining High Quality Water.
- SWRCB Resolution No. 92-49: Policies and Procedures for Investigation and Cleanup and Abatement of Discharges under Water Code Section 13304.
- SWRCB Resolution No. 2012-0016: Low Threat Underground Storage Tank Case Closure Policy (LTCP), which the SWRCB adopted in November 2012.

El Dorado County

The El Dorado County Department of Environmental Management (EDCEMD), Hazardous Waste Division is typically the lead agency for responding to hazardous waste issues. Through permit and inspection processes, as well as public education programs, the objective of the

Hazardous Materials Program is to protect human health and the environment by ensuring that hazardous materials and hazardous waste are properly managed. EDCEMD programs are summarized in the sections that follow and detailed in Appendix B.

The Hazardous Materials Program is approved by Cal-EPA as the local Certified Unified Program Agency (CUPA) for El Dorado County. The Unified Program is intended to provide relief to businesses complying with the overlapping and sometimes conflicting requirements of formerly independently managed programs. The CUPA Program includes the following:

- California Accidental Release Prevention (CalARP) Program
- Underground Storage Tank Program
- Above ground Petroleum Storage Act Requirements for Spill Prevention, Control and Countermeasure (SPCC) Plans
- Hazardous Waste Generator and Onsite Hazardous Waste Treatment Programs which has five tiers of permitting and includes submittal of Hazardous Materials Business Plan which includes Hazardous Materials Release Response Plans and Hazardous Waste Contingency Plan with associated inspections
- California Uniform Fire Code: Hazardous Material Management Plans and Hazardous Material Inventory Statements
- The El Dorado County Hazardous Materials Emergency Response Program (HMERP) works in close cooperation with law enforcement, fire and allied health agency officers and staff. Special attention is given to the hazardous materials used and transported frequently in the county by local businesses.

STPUD

In December 2000, the District enacted Ordinance No. 477-00 adding Division 7 to the Administrative Code. The ordinance was developed for the purposes of regulating, managing, conserving and protecting local groundwater resources. A primary focus of Ordinance No. 477-00 was to establish a Basin Monitoring Program to provide a means for the early detection and immediate response to the release of petroleum products into groundwater, and development of management plans to prevent or minimize the impact of contamination from possible contaminating activities.

Ordinance No. 477-00 is being updated concurrently with this GWMP update. The objective of the updated Ordinance is to provide the District with an enforcement mechanism to protect the District’s beneficial use of the aquifer and the water supply infrastructure. However, the District would first look to the regulatory authority of LWQCB and County CUPA. Another key modification to the updated Ordinance will be to reduce the prescriptive monitoring requirements included in the original Ordinance. A copy of the updated Groundwater Management Ordinance No. 558-14 is included in Appendix G.

In 1999, the District adopted a policy to not supply drinking water containing detectable concentrations of Methyl Tertiary Butyl Ether (MtBE) to its customers (STPUD, 2004). MtBE has a primary and secondary MCL of 13 and 5 micrograms per liter (µg/L), respectively. The Districts MtBE policy is not a regulatory drinking water standard, and the policy applies only to the District. This policy requires that any District well producing groundwater at a level of 0.5 µg/L of MtBE be placed on increased observation and testing to determine if the initial measurement is an anomaly. If the concentration of MtBE in the well continues to increase or average greater than 0.5 µg/L the District’s Board is notified and actions will be determined. These actions have included suspending production from the public water supply wells or adding wellhead treatment in order to remove MtBE below detectable levels. Therefore, areas of degraded groundwater quality at levels below MCLs, have also affected groundwater supplies in the TVS Basin.

Potential Collaboration on Groundwater Protection

STPUD and other water purveyors in the TVS Basin have a vested interest in preserving groundwater quality in the TVS Basin. The key objectives for the water purveyors are the following:

- Protecting existing water supply infrastructure from groundwater contamination to avoid loss of production capacity and incurring costs of replacing impacted infrastructure,
- Maintaining the water quality of the available groundwater supply in the TVS Basin for providing drinking water to the community, and
- Preserving potential future production well sites from being impacted by groundwater contamination.

Historical issues have demonstrated the vulnerability of the aquifer in TVS Basin. In the 1990s and early 2000s, releases of fuel hydrocarbons and MtBE from leaking underground tanks at gasoline stations resulted in several of the District's groundwater supply wells having to be taken offline when contamination levels exceeded drinking water standards. This resulted in a loss of the beneficial use of portions of the aquifer and caused the District to incur additional costs to replace the impacted wells.

The LRWQCB and County are the primary agencies for implementing the groundwater regulations in the TVS Basin and providing regulatory oversight for groundwater remediation. An objective of this GWMP update is for STPUD and other water purveyors to continue to work with LRWQCB and the County to better achieve the above objectives.

There are several areas for increased collaboration between the LRWQCB, County, District and other water purveyors to insure information about identification, site investigations, remediation, site inspections and case closures at groundwater cleanup sites is communicated to the potentially affected water purveyors, and that issues and concerns of the water purveyors is communicated to LRWQCB and County staff. It is anticipated that additional protocols would need to be established to identify who should be contacted in such an event.

Land Use Planning Agencies and Programs

A number of agencies have jurisdiction and programs for land use and resource management responsibilities. State law requires that every county and municipality adopt a long-term General Plan that includes seven required elements. Water-related issues are generally addressed directly in the Conservation element. Currently in California, general planning by counties and municipalities, and groundwater and urban water management planning by large water suppliers are the primary means of collaboration between water management and land use planning entities. The following provides a brief summary of the land use planning agencies for the South Lake Tahoe area.

Tahoe Regional Planning Agency (TRPA)

All land surrounding Lake Tahoe, including the City of South Lake Tahoe and the District's service area, falls under the jurisdiction of the TRPA as defined in the Tahoe Regional Planning Compact (Compact) created in 1969. The Compact requires that all local jurisdiction planning be consistent with a series of Environmental Thresholds. TRPA was granted the authority to adopt and implement environmental threshold carrying capacities for the entire Lake Tahoe

Basin through the development and enforcement of a regional plan and ordinances. It is generally acknowledged that the TRPA Environmental Thresholds effectively provide a growth control mechanism for Lake Tahoe area.

Within the Lake Tahoe Basin, local land use planning has taken into account regional water issues for decades under the jurisdiction of the TRPA. The basic framework for review and approval of activities in the Lake Tahoe area is established by the following TRPA documents (additional information on these key documents is provided in Appendix B):

- The Tahoe Regional Planning Agency Bi-State Compact
- The Lake Tahoe Water Quality Management Plan (208 Plan),
- The TRPA Regional Plan Goals and Policies which includes
  - Environmental Threshold Carrying Capacities for nine resource areas including Water Quality
  - Best Management Practices (BMP) Handbook for storm water infiltration and hazardous material management
  - Environmental Improvement Plan (EIP)
- Other Regional-Scale Plans and Reference Documents
- Plans for Specific Geographic Areas within the Region
- TRPA Code of Ordinances
- TRPA Programs
- TRPA Administrative Manuals.

The 208 Plan was updated by the TRPA in 2012, is mandated by the CWA, and describes the framework for water quality management in the entire Lake Tahoe Basin, the desired water quality outcomes, and the methods to achieve those outcomes. The 208 Plan incorporates, by reference, many documents by local, state, and federal agencies including the TRPA Regional Plan and Regional Plan Environmental Impact Statement, LRWQCB Basin Plan, USFS-LTBMU Land and Resource Management Plan, and General Plans for the City of South Lake Tahoe and El Dorado County.

The 208 Plan includes regulatory protections and restoration of SEZs that provide significant filtering of nutrients and sediment. The BMP Handbook of the Regional Plan describes methods to help developed properties function more like natural, undisturbed forest and meadowland. By implementing BMPs, property owners can help slow the loss of lake clarity. Owners of developed properties must ensure BMPs remain functional and effective to retain their BMP Certificate and comply with the TRPA Code of Ordinances. If BMPs are not functioning effectively due to property owner's failure to inspect, maintain, and monitor them, a BMP Certificate may be revoked by TRPA.

El Dorado County

The land area within the TVS Basin that is located outside of the City of South Lake Tahoe is contained within El Dorado County. As a result land use regulation outside of the City of South Lake Tahoe is shared by the County and TRPA. The County's General Plan regarding land area in the South Lake Tahoe area emphasizes coordination with TRPA and other state and federal agencies with land use jurisdiction in the Lake Tahoe Basin (Policies 2.10.1.1 through 5, Measure LU-O). The General Plan also requires buffers to be established around future water supplies (Policy 2.2.5.14).

City of South Lake Tahoe

Land use regulation is shared by the City and TRPA because the City of South Lake Tahoe is located within the Lake Tahoe Basin. The City's General Plan (adopted 2011) contains many mutually-adopted policies of the two bodies. In addition to coordination with TRPA, coordination with South Tahoe PUD and other water providers is highlighted in the General Plan (Goal PQP-2 and Policies PQP-2.2, 2.5, and 2.7).

Other CSLT land use policies in the General Plan related to protection of water quality include protection of the groundwater basin from overdraft and contamination (Policy PQP-2.9), protection of Lake Tahoe and other surface water streams from storm water pollution through storm water management (Goals PQP-4 and NCR-2, and Policies PQP-4.1 through 4.3, NCR-2.1 through 2.5, NCR-2.13 and NCR-2.14), considerations of snow removal practices (Policy PQP-11.8), and protection and restoration of SEZs and floodplains (Goal HS-4, Policies HS-4.1, 4.2, and 4.4, NCR-2.9 and NCR-2.12). The CSLT is also a co-permittee to the Municipal NPDES Permit to reduce pollutants in storm water.

US Forest Service

The portions of national forest lands that overlie the TVS Basin are in the US Forest Service Lake Tahoe Basin Management Unit (LTBMU). The LTBMU established the Draft Revised Land and Resource Management Plan (LRMP) in 2013 to bring consistency in planning within the portions of the National Forests that lie within the Lake Tahoe Basin. The management of the LTBMU is focused on forest ecosystem and watershed restoration, with an emphasis on erosion control and water quality improvement.

The LTBMU and TRPA share the same planning area, and by law the LTBMU must cooperate with TRPA. Among the relevant goals of the LTBMU Draft Revised LRMP are to preserve clarity in Lake Tahoe by maintaining or improving water quality, soil function, riparian areas, stream process to reduce erosion, and sustained aquatic habitats including for Lahontan cutthroat trout.

In 2014, the Forest Service proposed to amend its internal Agency directives for Watershed and Air Management to establish direction for management of groundwater resources on USFS lands as an integral component of watershed management (USFS 2014). Specifically, the proposed Groundwater Directive FSM 2560 would provide direction on the consideration of groundwater resources in agency activities, approvals, and authorizations; encourage source water protection and water conservation; establish procedures for reviewing new proposals for groundwater withdrawals on USFS lands that include requirements to evaluate the potential impacts on USFS resources; and provide for measurement and reporting for some larger groundwater withdrawals.

Potential Collaboration on Land Use Planning

Land use decisions can have significant effects on groundwater resources, yet land use groundwater management planning is commonly not done in a collaborative and coordinated fashion. However, the Lake Tahoe Region has a rich and complex history of managing land use to protect Lake Tahoe water quality. While source water protection has been an integrated theme in multi-decade, bi-state negotiations, it has had minor emphasis relative to groundwater quality subjects. There is opportunity to increase understanding of source water issues and to raise the profile of the subject in this Region where water quality is the focus of much attention.

Coordination with TRPA on the update of the Regional Plan is a means to better address the needs and issues of water purveyors for groundwater management and protection in the TVS Basin. There are other administrative activities that can also be done. For example, STPUD will provide TRPA with an updated map of water supply source area protection zones and the newly DWR-required recharge area map that can be incorporated into the current TRPA planning, permitting and inspection process. In addition, the USFS is another key agency active in the TVS Basin with land use planning and water resources protection. Addition of the USFS to the SAG may provide mutual benefits in the areas of land use planning and management, groundwater protection, and data and information sharing.

Oversight of Drinking Water Supply and Wells

Several agencies have responsibilities for regulatory oversight of public water supply systems and water wells to provide a safe water supply to the community and protect groundwater from potential contamination sources.

SWRCB Division of Drinking Water

The DDW classifies these water systems based on the number of connections and whether the users are full time residents or short-term users. The Drinking Water Program is responsible for enforcing the federal and state Safe Drinking Water Acts. The main responsibilities are to: (1) issue permits to drinking water systems, (2) inspect water systems, (3) monitor drinking water quality, (4) set and enforce drinking water standards and requirements, and (5) award infrastructure loans and grants.

DDW Field Operation Branches are responsible for the enforcement of the federal and California Safe Drinking Water Acts and the regulatory oversight of public water supply systems. Water purveyors are required to submit regular water quality analysis data to DDW as part of the Consumer Confidence Reporting Requirements.

County Small Water System Program

The El Dorado County Department of Environmental Health (EDC-DEH) Small Water System Program permits, inspects, and monitors the small public water systems in the County including within the TVS Basin. The County is the Local Primacy Agency, under contract with the DDW (formerly CDPH), to perform the program requirements that are specified in State and Federal Regulations. The purpose of the program is to ensure that small water systems deliver safe, adequate, and dependable potable water. EDC-DEH reviews new applications and changes of ownership to verify that the system will be able to meet technical, managerial, and financial capabilities.

Well Construction and Abandonment Policies

The EDC-DEH is responsible for issuing permits for the construction, destruction, deepening, and repair of water wells. The County Water Well Program is conducted to help prevent potential contamination reaching groundwater via vertical conduits formed by poorly constructed or abandoned wells.

Drillers are required to follow the California Water Well Standards, Bulletin 74-81 and supplements, developed by the DWR for the construction, destruction, deepening, and repair of a water well (DWR, 1981, 1991). EDC-DEH reviews permits submitted by Licensed Well Drillers for setback and development issues; and conducts inspections as required on specific parcels prior to permit approval, during the placement of the annular seal, and at any other time deemed necessary. Well completion reports are required to be submitted within 60 days of well completion and are reviewed prior to final of the well permit.

The District and other public water supply systems will continue to comply with all County permit requirements regarding well construction and abandonment. However, there is no required reporting on the condition or operation of the estimated 600 private wells within the TVS Basin. Information on the condition and use of these wells would be beneficial for supporting groundwater management and water quality protection. This is a potential area for interagency collaboration to document private wells on properties that require BMP or other site inspections as part of their permitting process.

US Forest Service

A special use authorization is required for all individuals or entities other than the USFS to develop water wells or construct water pipelines on USFS lands. The proposed Groundwater Directive FSM 2560 includes provisions for applicants to evaluate other reasonable alternatives before the USFS would authorize new or increased groundwater pumping on USFS lands. This requirement may be waived if the applicant is a public water supplier and the proposed water source is located in a designated municipal watershed (USFS 2014). The USFS may deny proposals to construct wells on or pipelines across USFS lands which can reasonably be accommodated on non-USFS lands and which the proponent is proposing to construct on USFS lands because they afford a lower cost and less restrictive location than non-USFS lands (USFS 2014).

The District currently has one well located on USFS land in the TVS Basin. The District is concerned that the provisions of the proposed Directive may add unnecessary costs to public works projects and make meeting future drinking water demands more difficult to achieve.

The District is the authorized groundwater management agency by the State of California, and has concerns how this Directive on Public Water Systems will affect the efficient management of the shared groundwater resources within the TVS Basin. The District has provided questions and comments to the USFS regarding the Draft Groundwater Directive and will work with the USFS on implementing the proposed Directive and invite the USFS to join the SAG.

Lake Tahoe Water Quality Management and TMDL

The USEPA has designated Lake Tahoe an Outstanding National Resource Water, which provides for the highest level of protection under USEPA's Antidegradation Policy. There is a rich and complex history of managing land use to protect Lake Tahoe water quality.

Lake Tahoe TMDL

A large portion of water quality regulation in the Lake Tahoe Region is targeted at improving the clarity of Lake Tahoe which has impaired status under CWC Section 303 (d). LRWQCB leads Lake Tahoe TMDL implementation efforts by coordinating local government storm water treatment and erosion control projects, facilitating stream channel restoration work, and overseeing forest management practices. The LRWQCB is working closely with the TRPA to implement its Regional Plan and associated Environmental Improvement Program. In partnership with the Nevada Division of Environmental Protection, the LRWQCB is developing a detailed TMDL accounting, tracking, and reporting program that will provide for regular TMDL progress assessment and adaptive management.

The LRWQCB Basin Plan (LRWQCB, 1995) and TRPA Code of Ordinances (TRPA, 1987) provide a number of water quality standards and control measures to protect the beneficial uses of surface and groundwater. Previously, LRWQCB set maximum concentration limits for runoff discharged to infiltration systems. Amendments to the Basin Plan, including Basin Plan Section 5.6 describes the differing storm water treatment requirements for municipal and public roadways and new development, redevelopment and existing development projects.

Other efforts to reduce potential contamination sources for Lake Tahoe clarity in many cases also reduce potential sources for groundwater contamination as well. For example, wastewater (particularly in septic systems) which constitutes the largest potential source of nutrients has been treated and exported out of the Lake Tahoe watershed since the 1960s. However, there are other potential man-made chemical contaminants from uncontrolled releases from storage, and accidents that are important to manage for groundwater quality. Further integration of groundwater protection into the existing programs to protect surface waters can provide improved groundwater protection in the TVS Basin.

Storm water Management and Monitoring

The LRWQCB has the obligation to implement and enforce the Lake Tahoe TMDL through NPDES storm water discharge permits issued to the California governmental entities (City of South Lake Tahoe, El Dorado County, and the California Department of Transportation). Efforts to improve Lake clarity have included implementation of nonpoint source pollution BMPs for storm water management that is focused on reducing potential contamination sources.

Storm water management includes on-site infiltration. Infiltration to groundwater can be beneficial by providing additional recharge, but may also provide a conduit for contaminants to reach groundwater. The benefit from storm water management BMPs is to limit pollutants to storm water as well as to groundwater through source control, inspections, and other measures.

Both the LRWQCB and the TRPA include vertical separation requirements for constructing infiltration basins to protect groundwater beneficial uses. The Basin Plan states five feet separation between the highest anticipated groundwater level and the bottom of an infiltration system. The TRPA recommends a distance of 12 inches between the bottom of dry wells and seasonal high groundwater. This requirement is set given the potentially higher risk of groundwater contamination in areas with high groundwater underlying infiltration basins.

The LRWQCB adopted the revised storm water municipal NPDES Permit (Board Order No. R6T-2010-1010) (Municipal Permit) for co-permittees that include El Dorado County and the City of South Lake Tahoe. The Municipal Permit, which is consistent with the TRPA Regional Plan, includes particle number and mass-based load reduction requirements in accordance with the Lake Tahoe TMDL Implementation Schedule. The Municipal Permit required the submittal of a Storm Water Management Plan (SWMP) which describes a clear process to expand existing storm water related activities into a program that incorporates a minimum of twelve components.

Storm water for the California Department of Transportation (Caltrans) is regulated under statewide storm water permit Order No. 2012-0011-DWQ issued by the SWRCB. Caltrans is responsible for reducing sediments and nutrients by managing erosion and storm water runoff along US 50 and SR 89 under the TMDL. Caltrans has several erosion/sediment control projects underway to meet the TMDL as well as ongoing operations and maintenance work including street sweeping and abrasive management.

Storm water monitoring to evaluate the effectives of sediment and load reduction is conducted regionally in both California and Nevada by the Tahoe Resource Conservation District (TRCD) under two grants. The TRCD Regional Storm water Monitoring Program represents 8 agencies to fulfill NPDES permit requirements. and involves collecting and analyzing samples of storm water at eleven sites around the perimeter of Lake Tahoe for total nitrogen, total phosphorus, total suspend solids, turbidity and fine sediment particles. (TRCD, 2013)

The Underground Injection Control (UIC) regulations under the USEPA address the subsurface disposal of fluids through drains, pipes, and other constructed conveyances that are intended to permanently infiltrate water below ground surface. Drywells, unlined sumps, seepage pits, and infiltration galleries are some of the terms used to describe the subcategory of injection wells known as shallow Class V injection for non-hazardous fluids. USEPA acknowledges that storm water wells can be a community asset or liability (USEPA, 2002).

Integrated Regional Water Management Planning

Another activity with potential relevance to the GWMP is the Tahoe-Sierra Integrated Regional Water Management (IRWM) Plan which defines a vision for the management of water resources in the Tahoe-Sierra IRWM Region. The IRWM Region is an area that extends from the Carson River watershed to the south to the Truckee River watershed to the north including the Lake Tahoe Basin. The IRWM Plan highlights important actions needed to accomplish a broad vision through the year 2035 planning horizon and are intended to be a planning tool that provides a framework to address the major water-related challenges facing the IRWM Region.

The updated Tahoe-Sierra IRWM Plan was completed in summer 2014 and the information contained within this IRWM Plan was developed through the time and contributions of more than 30 water supply, wastewater treatment, land use management, public interest, and ecosystem-focused organizations with interests in the water resources of the Tahoe-Sierra IRWM Region. Six local agencies submitted projects in the IRWM Plan that directly or indirectly influence groundwater management which are detailed in Appendix B.

The IRWM Plan process provides another venue for collaboration with other local water districts, land use planning and regulatory agencies in the area, and provides an opportunity developing and funding projects to support groundwater management.

TABLE 4-1
LIST OF GROUNDWATER RELATED GOVERNMENTAL AGENCIES IN LAKE TAHOE AREA

		Regulatory Authority/Programs That Relate to Groundwater				
Agency	**Geographic Jurisdiction**	**Surface Water Quality**	**Ground Water Quality**	**Drinking Water**	**Land Use**	**Hazardous Materials**
USEPA	Nationwide and some programs in California (CA)	Clean Water Act (CWA)	Underground Injection Control (UIC)	Safe Drinking Water Act (SDWA)	--	TSCA, CERCLA
Tahoe Regional Planning Agency (TRPA)	CA and Nevada (NV) within the Lake Tahoe Basin	Lake Tahoe Water Quality Management Plan under Section 208 of CWA and TRPA Regional Plan		--	TRPA Regional Plan and associated Storm water BMP Handbook	
State Water Resources Control Board (SWRCB)	CA Statewide	With RWQCBs regulates discharges to surface water and groundwater statewide under CWA[1] and Porter Cologne Water Quality Control Act (WQCA)		DDW[2] - SDWA for large water systems	--	Brownfields and Land Disposal Program
Lahontan Regional Water Quality Control Board (LRWQCB)	Lahontan Region including CA portion of Lake Tahoe Basin	Basin Plan[3]/TMDL and Lake Tahoe Municipal Storm water Permit	Basin Plan, Underground Storage Tank (UST), Site cleanup Program,	--	--	
El Dorado County Environmental Health (EDC-DEH)	El Dorado County portion of Lake Tahoe Basin	--	Water Well Program	SDWA for small water systems Water Well Program	County General Plan outside of City limits	Certified Unified Program Agency (CUPA), Hazardous waste/material generator permits
City of South Lake Tahoe (CSLT)	Within City Limits	Complies with Lake Tahoe Municipal Storm water Permit	--	--	City General Plan	--
US Forest Service – LTBMU	National Forest Lands in CA and NV within the Lake Tahoe Basin	Land and Resource Management Plan	Proposed Groundwater Directive FSM 2560	--	Land and Resource Manage-ment Plan	--

Notes:

(1) SWRCB/RWQCB has primacy to implement much of CWA regulatory activity

(2) SWRCB –Division of Drinking Water (DDW, formerly CDPH), El Dorado County is a Local Primacy Agency under contract to SWRCB-DDW for regulating small public water systems;

(3) Basin Plan implements, for the Lahontan Region, state and federal laws including CWA, Porter Cologne WQCA, SDWA, and other hazardous material laws by setting water quality standards

ATTACHMENT C

South Tahoe Public Utility District

Groundwater Elevation Monitoring Plan – Tahoe Valley South (Basin No. 6-5.01)

Version 1.0

Ivo Bergsohn, P.G., C.Hg.
12/1/2011

1 Introduction

In December 2010, the South Tahoe Public Utility District (District) submitted a notice of intent to serve as a monitoring entity in the California Statewide Groundwater Elevation Monitoring (CASGEM) Program. The District is the largest drinking water provider in the Lake Tahoe Basin and is an authorized groundwater management agency within the meaning of California Water Code Section 10753(a). Groundwater serves as the principal source of drinking water within the District's service area. As part of its efforts to manage this resource, the District has been actively monitoring groundwater elevations since March 2001. The following document has been prepared by the District to satisfy the CASGEM monitoring plan requirement.

1.1 Purpose

The purpose of this plan is to describe the well network and methods used by the District to monitor groundwater elevations within the Tahoe Valley-South Groundwater Basin (TV-South Basin).

1.2 Objectives

The District collects groundwater elevation readings from both observation wells and municipal water supply wells. The objective of the CASGEM monitoring program is to provide elevation data capable of demonstrating seasonal and long-term groundwater elevation trends. To satisfy this objective, the District shall only report groundwater elevation data collected from observation wells to the California Department of Water Resources (DWR) for CASGEM use.

1.3 Plan Organization

This plan has been prepared in general accordance with the monitoring plan requirements as presented in the Procedures for Monitoring Entity Reporting (DWR, 2010). The information presented in Section 2.0 serves as the rationale for the groundwater elevation monitoring plan and includes a description of the general hydrology, geologic setting and recharge conditions in the TV-South Basin. The other key components required of CASGEM monitoring plans are presented in Sections 3.0.and include: a description of the well network (Section 3.1); a monitoring schedule (Section 3.2); and a description of field methods used for data collection (Section 3.3). Section 4.0 describes the reporting procedures used by the District to record and archive the collected water level data.

2 Tahoe Valley-South Groundwater Basin (TV-South Basin)

2.1 Location and Geographic Scope

The TV-South Basin is regarded by DWR as a sub-basin of the Tahoe Valley Groundwater Basin, located at the south end of the Lake Tahoe Basin Hydrographic Area, about 150 miles east of the San Francisco Bay area and about 90 miles east of the Sacramento Valley(Figure 2.1).

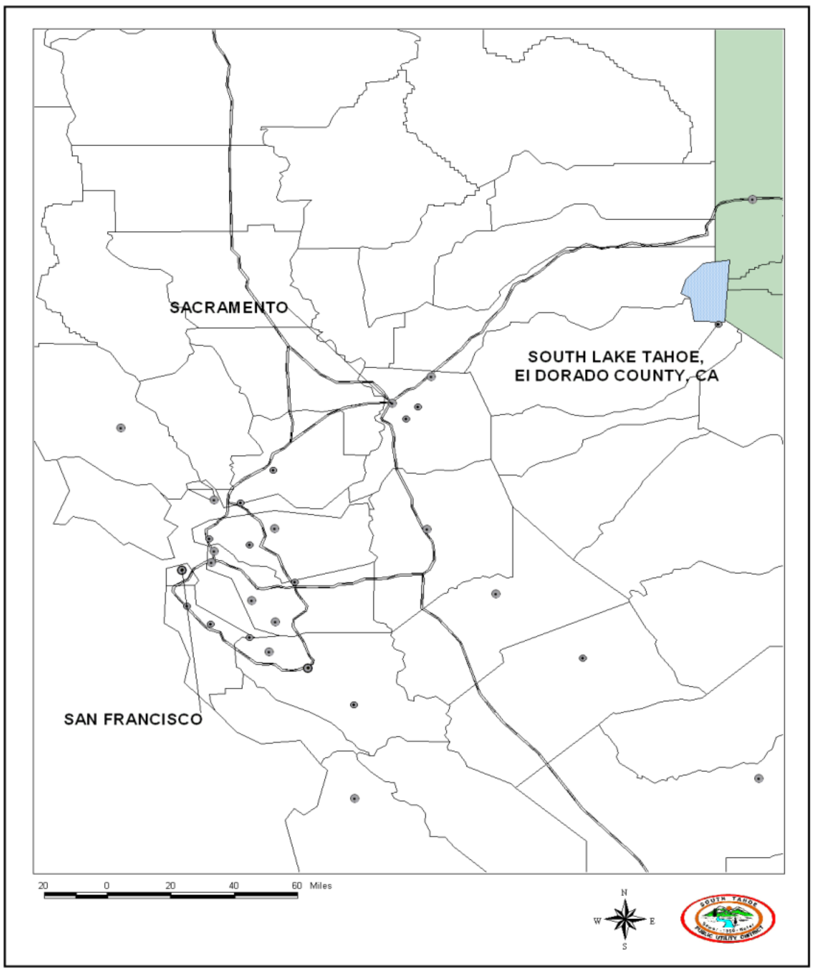


Figure 2.1 Regional Location

The TV-South Basin occupies a roughly triangular area, bounded on the southwest and southeast by mountain blocks of the Sierra Nevada; on the north by the south shore of Lake Tahoe; and to the northeast by the California-Nevada State line. The Basin's southern boundary extends about 3 miles south of the town of Meyers, and forms the triangular apex. Elevations within the Basin range from 6,225 feet at lake level rising to above 6,500 feet to the south, approaching the mountain front. The Upper Truckee River is the largest stream within the Lake Tahoe Hydrographic Area and flows near the center of the TV-South Basin, ultimately discharging into Lake Tahoe through the Upper Truckee Marsh at the north end of the Basin. The District service area covers approximately 27,000 acres (42 square miles) overlying the Basin, and includes portions of El Dorado County, the City of South Lake Tahoe, the Community of Meyers and Christmas Valley (Figure 2.2).

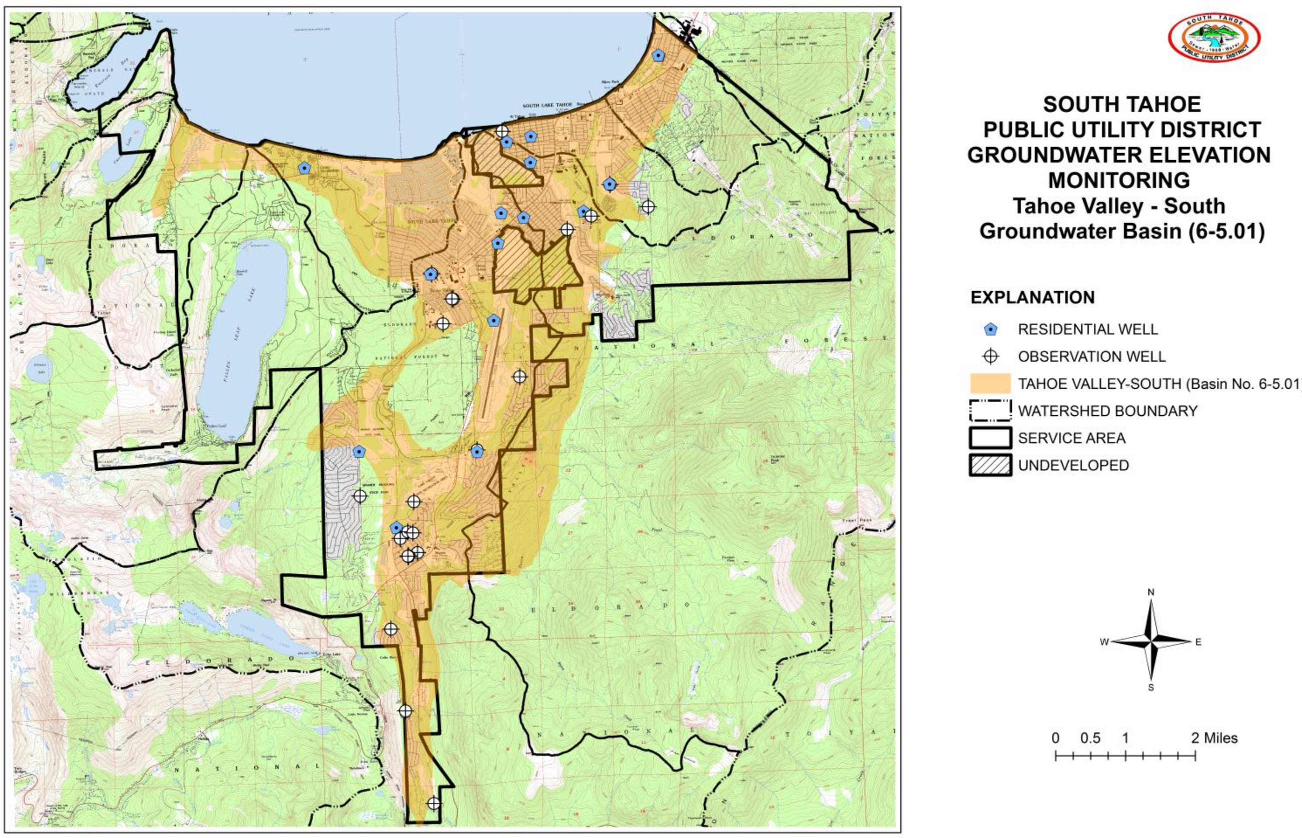


Figure 2.2 Tahoe Valley-South Basin and South Tahoe Public Utility District Service Area. Areas marked by diagonal lines represent undeveloped private lands not included within the service area as defined by the El Dorado Local Agency Formation Commission.

2.2 General Hydrology

2.2.1 Watersheds

Seven watersheds occur across the District's service area. The two largest watersheds are the Upper Truckee River and Trout Creek watersheds. The Upper Truckee River watershed is centrally located within the service area and is the largest in the Lake Tahoe Hydrographic Area comprising an estimated 18% of the total land area tributary to Lake Tahoe. Main tributary drainages to the Upper Truckee River include Grass Lake Creek; Big Meadow Creek and Angora Creek. The Trout Creek Watershed is located immediately east of the Upper Truckee River and is the second largest in the Hydrographic Area comprising an estimated 13% of the total land area tributary to Lake Tahoe. The main tributaries to Trout Creek include Cold Creek, Saxon Creek, Heavenly Valley Creek and Hidden Creek (USGS WRIR 00-4001).

2.2.2 Precipitation

Isohyetal maps for the Lake Tahoe Hydrographic Area show that for South Tahoe watersheds, mean annual precipitation ranges from over 60 inch/year at high elevation areas near the western boundaries of the Upper Truckee and Taylor Ck. watersheds to less than 25 inch/year near Lake Tahoe and the eastern boundary of the Trout Ck. watershed. At valley elevation <6500 ftmsl, mean annual precipitation ranges two-fold from a high of ~44 inch/year in the southwest to ~22 inch/year in the northeast portion of the Basin. Frontal systems from November through May account for over 85% of Tahoe Basin precipitation. Most annual precipitation is in the form of snow. Snowmelt is believed to generate more than 80% of the annual runoff within the Hydrographic Area (USGS WRIR 99-4110).

Snow water equivalent readings for the Heavenly Valley (Station 518) and Hagan Meadows (Station 508) SNOTEL stations, located along the east mountain block of the TV-South Basin, are plotted along with the stream discharge readings for Trout Creek near Tahoe Valley gage (USGS 10336780) to show the intimate relationship between snow melt and stream discharge within the TV-South Basin (Figure 2.3) Inspection of Figure 2.3 shows maximum stream flows typically occurs as the accumulated winter snow pack melts, starting in May and June (spring discharge), when high mountain temperatures rise above 32 degrees Fahrenheit. A second peak in stream discharge may also occur in response to warm pacific-frontal storms and rain-on-snow events at any time prior to spring discharge. In January 1997, a rain-on snow event produced the largest recorded flood peak within the Basin (USGS FS-035-02).

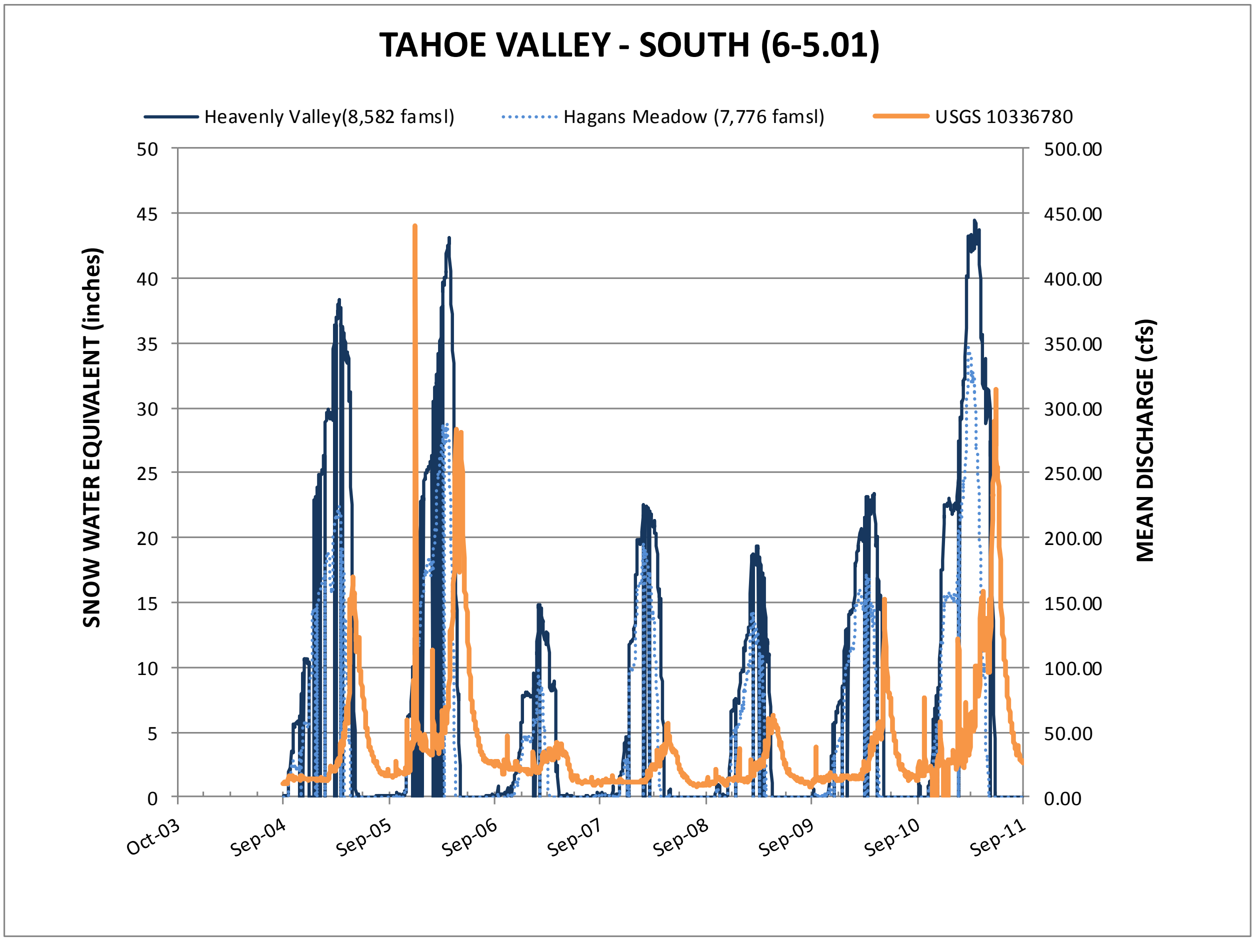


Figure 2.3 Basin precipitation and stream discharge relationships

2.3 Geologic Setting

Figure 2.4 shows the general geology of the TV-South Basin including major mapped units, faults and the bedrock contact with the basin-fill deposits.

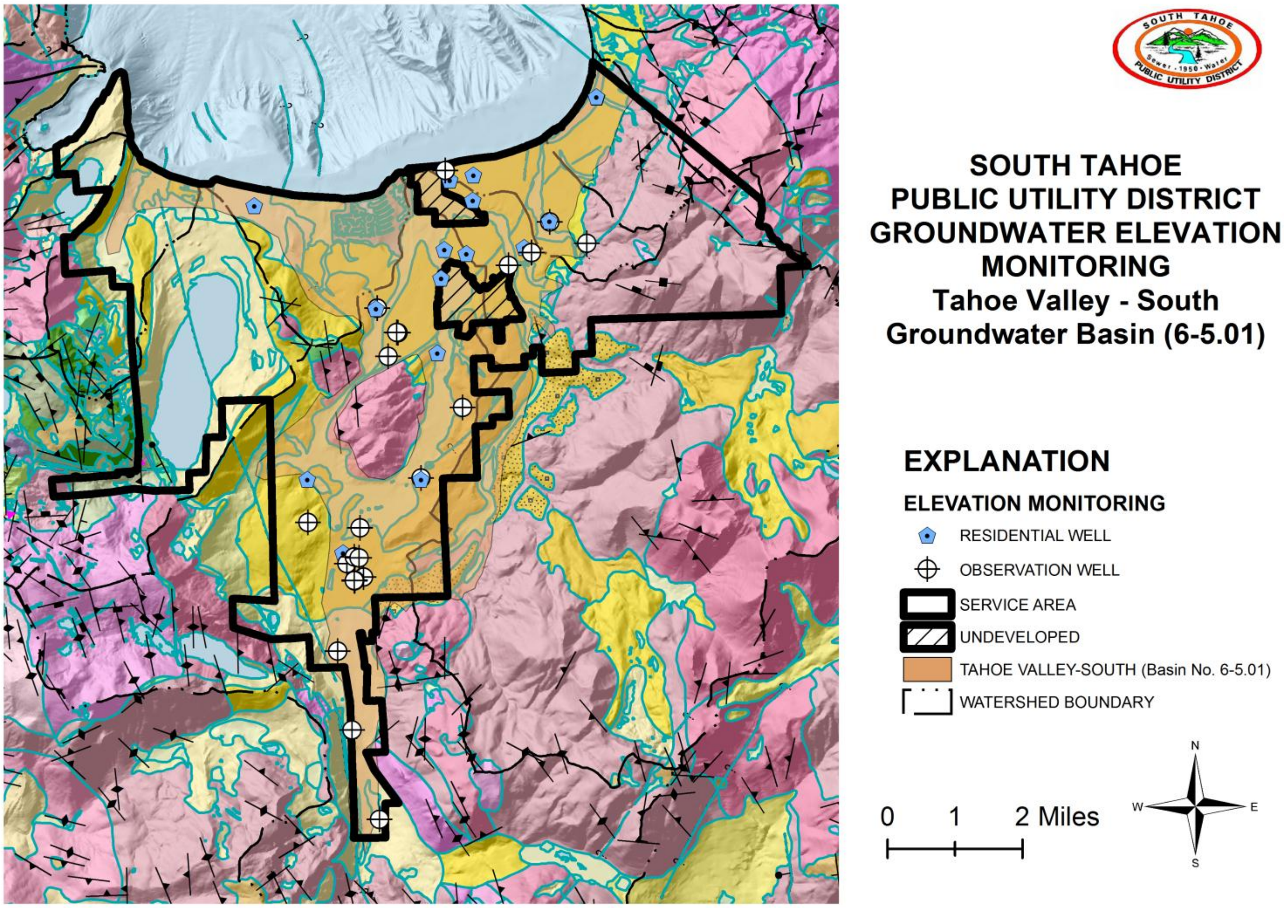


Figure 2.4 Generalized geology of the Tahoe Valley- South Basin (GIS Geologic Data; CGS CD 2008-01)

Structurally, the TV-South Basin lies within a west-tilted asymmetric half-graben. The West Tahoe Fault Zone defines the west side of the graben and is believed to be an east-dipping normal fault, with east-side-down normal displacements. This northwest-southeast trending fault zone extends, from Eagle Point toward the Celio Ranch, near the south end of the Basin. A second zone of faulting occurs near the east side of the graben. This east side fault zone trends in a northeast-southwest direction along the mountain front of the Carson Range, from Stateline toward Meyers. This east side fault zone is also believed to be an east-dipping normal fault, with northwest-side-down normal displacements.

Geologic materials contained within the Basin are broadly subdivided into bedrock and basin-fill deposits. Bedrock consists of metamorphic, granitic and volcanic rocks. These rocks occur along the upper portions of the steep mountain slopes and peaks that form the mountain blocks surrounding the margins of the Basin and floors the structural valley into which the basin-fill deposits lie. A smaller region of bedrock, composed of meta-sedimentary and granitic rocks, is exposed within the north-central portion of the Basin at Twin Peaks and through an adjoining area of low lying hills northwest of Twin Peaks at Tahoe Mountain. Bedrock is not a source of municipal drinking water supply within the Basin.

Basin-fill deposits, in general, 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. Across the Basin, the thickness of these deposits is variable. In general, the basin-fill deposits are relatively thin toward the margins of the Basin and where they cover shallow bedrock areas exposed within the Basin. The basin-fill deposits typically thicken away from these bedrock areas to fill the deepest portions of the Basin, referred to as depocenters. Gravity survey and well drilling information suggests that at least three depocenters occur within the Basin. The largest of these depocenters underlies the City of South Lake Tahoe. A second depocenter is located north of Fallen Leaf Lake, underlying the present drainages of Baldwin and Taylor Creeks. A third depocenter underlies the Meyers area, between the Crystal range and Twin Peaks. Within these depocenters, basin-fill deposits may be on the order of 600 feet to more than 1,000 feet thick.

The principal source of groundwater in the Basin is the basin-fill deposits. Glacial deposits form the majority of the aquifers in the Basin. Valley glaciers advanced north toward Lake Tahoe through the Upper Truckee River Valley during at least three episodes of glaciation between 3 million and 12,000 years ago. As these glaciers advanced and receded they formed lateral moraines along the edges of the glaciers path and terminal moraines at the ends of the glaciers advance. These moraine deposits are typically jumbled deposits of clay to boulder size material, with moderate permeability. Sediment-laden melt-waters from the receding glaciers flowed in streams, in front of the terminal moraines, north toward Lake Tahoe. These streams dropped their sediment loads along their stream channels and in broad coalescing flood fans, referred to as outwash plains. These outwash fan and fluvial channel deposits are composed of layered beds of well sorted gravel, sand and silt size material, with moderate to high permeability. Where these glacial streams deposited sediment directly into Lake Tahoe, thick deltas were formed of inter-layered sand and fine-grained silt and clay. These delta sequences grade laterally with: 1) lakeshore deposits, consisting of moderately well sorted sand and gravel deposits with relatively high permeability; 2) inter-fan and marsh deposits, consisting of fine-grained sand, silt and clay; and 3) lake deposits, consisting of silt and clay. Both the inter-fan, marsh and lake deposits have relatively low permeability. The relatively high permeability glacial outwash and delta deposits form excellent groundwater reservoirs. The best of these reservoirs have been found in the north half of the Basin, beneath the present day Truckee Marsh. The relatively low permeable inter-fan, marsh and lake deposits form at least four locally extensive aquitards that separate the reservoirs into a minimum of at least five distinct regional aquifers, which can be further sub-divided into 26 water-bearing zones, of which 18 are actively used for drinking water supply. The water-bearing zone designations are informal and are based on local geographic area and the stratigraphic order in which they occur (1 = lowermost zone; 5 = uppermost zone). Local water-bearing zone designations are provided in Table 1.

AREA	**ZONE**	**IDENTIFIER**	**SOURCE WATER**
CHRISTMAS VALLEY- southern-most portion of Basin, south of Lake Valley and Highway 50.	4	CVZ4	Yes
	3	CVZ3	Yes
	2	CVZ2	Yes
	1	CVZ1	Potential
MEYERS- south Lake Valley portion of Basin, from Highway 50 north to Twin Peaks.	5	MZ5	No
	4	MZ4	Yes
	3	MZ3	Yes
	2	MZ2	No
	1	MZ1	No
ANGORA –south Lake Valley portion of Basin, west of Twin Peaks.	2	AZ2	Yes
	1	AZ1	Yes
SOUTH LAKE TAHOE – north Lake Valley from Lake Tahoe Airport north to the south shore of Lake Tahoe, west of the Tahoe Keys to Johnson Boulevard.	5	SLTZ5	Yes
	4	SLTZ4	Yes
	3	SLTZ3	Yes
	2	SLTZ2	Yes
	1	SLTZ1	No
TAHOE KEYS –north Lake Valley, from Camp Richardson east to the Tahoe Keys.	5	TKZ5	Yes
	4	TKZ4	Yes
	3	TKZ3	Yes
	2	TKZ2	Yes
	1	TKZ1	Yes
BIJOU – northwest portion of the Basin from Johnson Boulevard east to Bijou Park.	5	BZ5	No
	4	BZ4	Yes
	3	BZ3	Yes
	2	BZ2	No
	1	BZ1	Yes

Table 1 Local water-bearing zone designations and current District use.

2.4 Recharge

Sources of recharge to the TV-South Basin are believed to be predominantly direct infiltration of precipitation and/or downward percolation of surface water with a lesser unknown proportion attributed to mountain front recharge. On average, the total groundwater recharge into the Basin (1990 – 2004) is estimated at about 28,846 acre-feet per year (AFY). A breakdown of the average monthly recharge into the Basin between 1990 through 2004 is provided in the following table (Table 2).

	MONTHLY AVERAGE RECHARGE	
MONTH	**(Galls)**	**Acre-Feet (AF)**
Jan	509,459,396	1,563
Feb	686,686,748	2,107
Mar	1,816,443,624	5,574
Apr	2,543,561,418	7,805
May	2,242,410,232	6,881
Jun	993,021,440	3,047
Jul	103,088,371	316
Aug	11,369,118	35
Sept	23,130,706	71
Oct	27,112,284	83
Nov	176,886,543	543
Dec	267,785,851	822
ANNUAL AVERAGE (1990 – 2004)	9,400,955,731	28,846

Table 2 Average monthly groundwater recharge in the Tahoe Valley-South Basin.

2.4.1 Groundwater Levels

Groundwater elevations in the TV-South appear to fluctuate in response to seasonal changes in precipitation and stream runoff. Figure 2.5 shows the groundwater elevations measured in five groundwater basin observation wells along with the snow water equivalent readings for the Heavenly Valley SNOTEL site (Station 518). Figure 2.6 shows the same groundwater elevation hydrographs along with the stream discharge readings for the Upper Truckee River at the South Lake Tahoe gage (USGS 10336610).

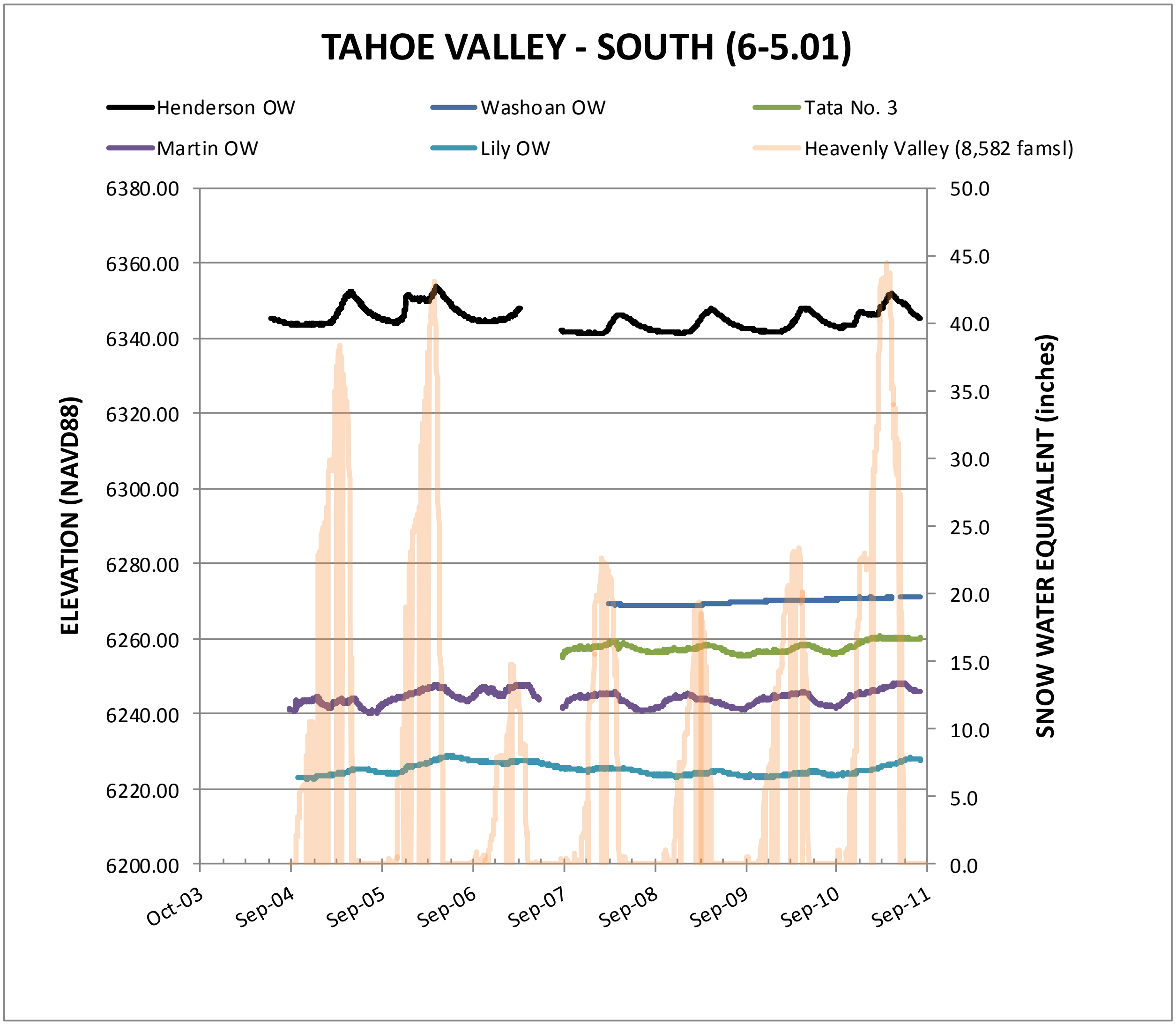


Figure 2.5 Groundwater elevation hydrographs and basin precipitation as measured by snow water equivalent.

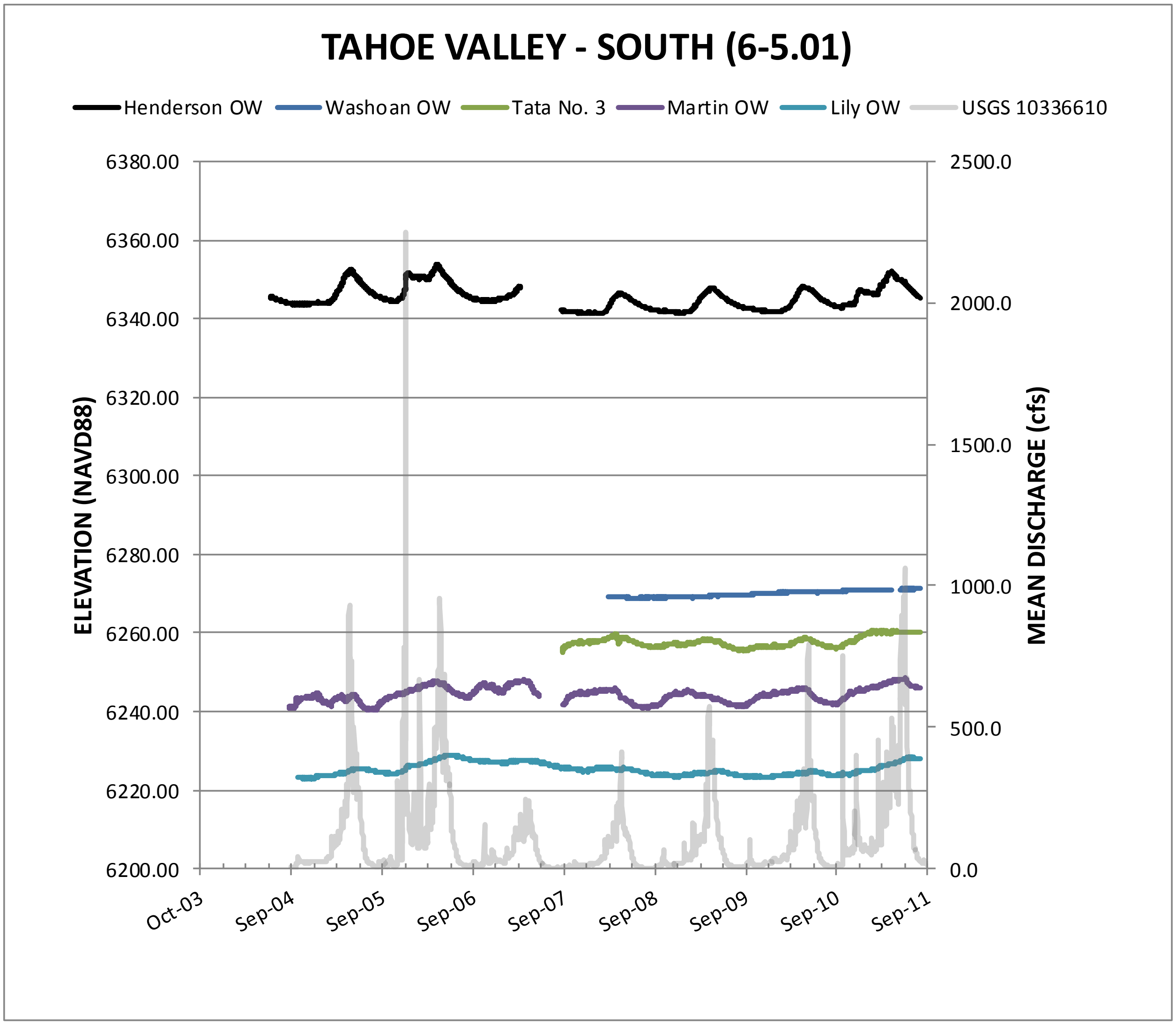


Figure 2.6 Groundwater elevation hydrographs and surface water runoff as measured by mean discharge.

Comparison of Figures 2.5 and 2.6 shows that groundwater elevations fluctuate in response to both seasonal changes in precipitation and surface water runoff. Groundwater elevations tend to rise during the winter storm season with seasonal high groundwater occurring between early-April through mid-June (Figure 2.5) and tend to decline during the summer and into the fall, as stream flows recede and approach baseflow, resulting in seasonal low groundwater elevations occurring between mid-July through mid-November (Figure 2.6). The Washoan Observation Well (OW) and Lily OW do not show this trend. The Washoan OW is screened through a confined portion of the aquifer below the uppermost water-bearing zone (SLTZ5) and does not appear to be strongly influenced by seasonal recharge events. The Lily OW is screened through the uppermost water-bearing zone (SLTZ5) and is located along the north margin of the groundwater basin, fringing Lake Tahoe. Comparison of the Lily OW hydrograph and elevation readings from the Tahoe City gage (USGS 10337000) suggest that groundwater elevations in this portion of the TV-South Basin are strongly influenced by lake level.

3 Groundwater Elevation Monitoring

3.1 Well Network

The District well network includes thirty (30) observation wells and seventeen (17) residential wells. All of the residential wells are active and are used for municipal drinking water supply. Two 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 proposed for use in the CASGEM program. The location and distribution of these observation wells are shown below (Figure 3.1).

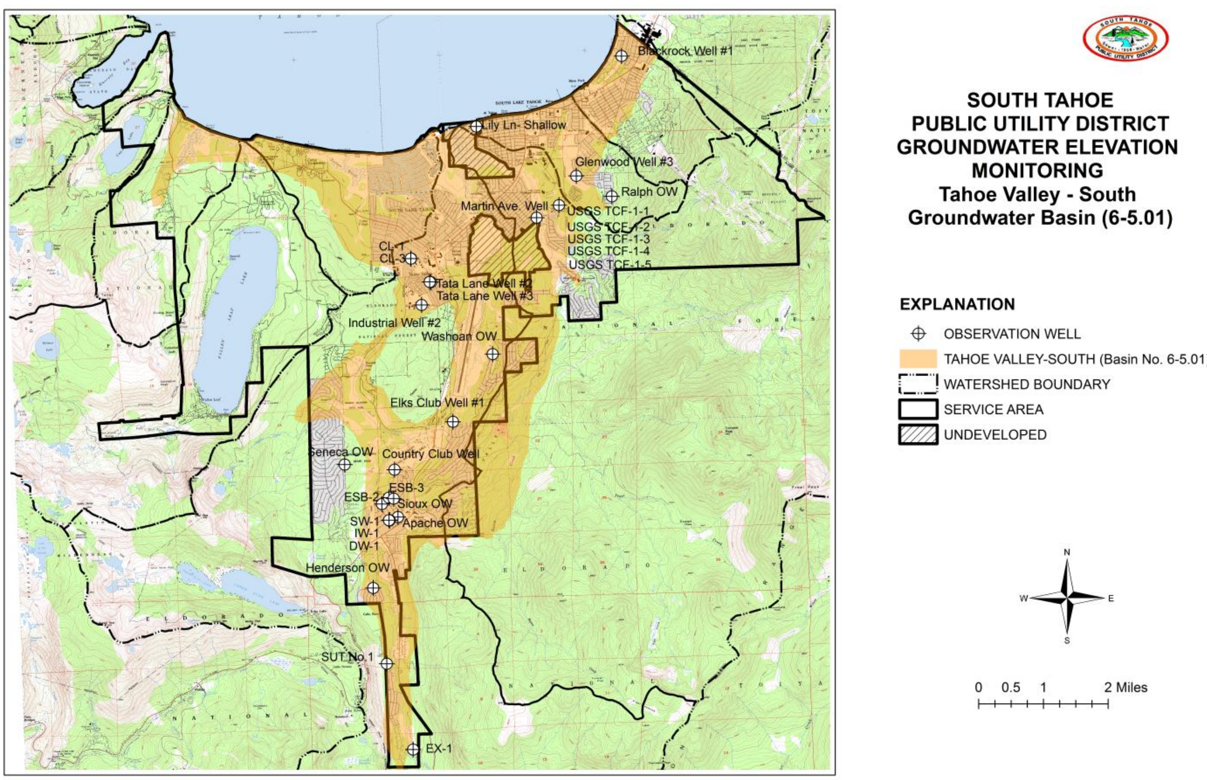


Figure 3.1 District observation wells available for use in the CASGEM program.

As mentioned previously, the observation wells include wells that were constructed for varying purposes. As such, the perforation intervals are also variable, as a consequence of the original intended use of that particular observation well. Figure 3.2 shows the approximate screened intervals, using the top of screen and total depth elevations for each of the observation wells, arranged from the head of the basin (at the south), north toward Lake Tahoe. The water-bearing zones through which these observation wells are screened are identified in Table 3. CASGEM required information for these wells is provided in Attachment A.

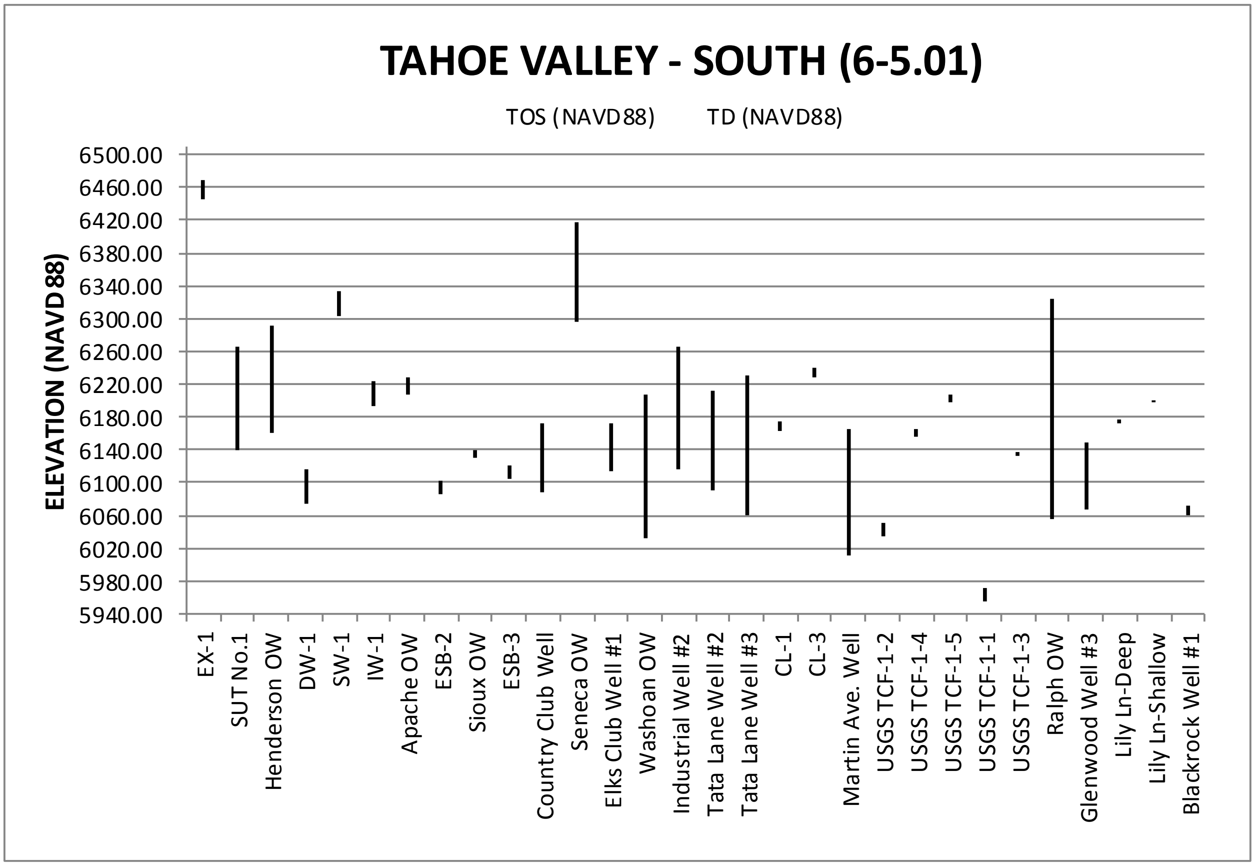


Figure 3.2 Approximate elevation ranges of the observation well screened intervals. The observation wells are arranged in order of geographic location (south to north) across the basin.

3.1.1 Data Gaps

DWR suggests a recommended density of from 2 to 10 observation wells per 100 square miles (DWR, 2010). The District observation well network satisfies this general criterion for the TV-South Basin. The well network is fairly well distributed geographically through most areas with the exception of the Taylor Creek and Tallac Creek watersheds in the northwest corner of the TV-South Basin. Groundwater through these areas is typically used by private wells serving seasonal summer-time residences, and transient and non-transient noncommunity water systems.

There are currently no plans or funding to install dedicated monitoring wells within watersheds situated within the District's service area where there are no wells monitored or where data gaps exist. The District would be interested in discussing the installation of dedicated monitoring wells in portions of the TV-South Basin where data gaps exist should outside funding become available. In the event future monitoring wells are installed by other agencies, the District would consider the possibility of adding such wells to the current monitoring network to reduce data gaps.

3.2 Monitoring Schedule

The District uses two methods for collecting static water level readings from the well network;

1) Hand measurements using an electric well sounder; and
2) Automated readings using a submersible pressure transducer/data logger.

Hand readings are collected from all wells in May and November of each year. May and November are optimal for static water level readings because these months generally coincide with seasonal high and low groundwater elevations and District water demands are low, allowing production wells to be strategically shut-off to attain static water conditions during measurements.

Due to the number, geographic distribution and coordination of temporary shut-offs of active wells, hand readings are completed over a two-day period. Almost half of the observation wells are fitted with dedicated water-level monitoring equipment. The data loggers are programmed to collect daily pressure head and temperature readings at 6:00 AM and 6:00 PM. Table 3 lists the local water-bearing zones screened and the frequency and type of measurements collected from each of the observation wells.

OBSERVATION WELL	WATER-BEARING ZONE	SEMI-ANNUAL HAND READINGS (May and November)	AUTOMATED READINGS (12 Hour Frequency)
Apache OW	CVZ4	X	
Blackrock Well #1	BZ4	X	
CL-1	SLTZ5	X	
CL-3	SLTZ5	X	
Country Club Well	MZ4	X	
DW-1	MZ4	X	
Elks Club Well #1	MZ4	X	
ESB-2	MZ4	X	X
ESB-3	MZ4	X	

EX-1	CVZ4	X	X
Glenwood Well #3	BZ4	X	X
Henderson OW	CVZ3, CVZ4	X	X
Industrial Well #2	SLTZ3, TKZ5	X	
IW-1	CVZ4	X	X
Lily Ln-Deep	SLTZ5	X	
Lily Ln-Shallow	SLTZ5	X	X
Martin Ave. Well	SLTZ4	X	X
Ralph OW	BEDROCK	X	X
Seneca OW	MZ5	X	X
Sioux OW	MZ4	X	
SUT No.1	CVZ2, CVZ3	X	X
SW-1	CVZ4	X	
Tata Lane Well #2	SLT3, TKZ5	X	
Tata Lane Well #3	SLT3, TKZ5	X	X
USGS TCF-1-1	BZ2	X	
USGS TCF-1-2	BZ3	X	
USGS TCF-1-3	BZ4	X	X
USGS TCF-1-4	BZ4	X	
USGS TCF-1-5	BZ5	X	
Washoan OW	SLTZ1, SLTZ2, SLTZ3, SLTZ4	X	X

Table 3 Proposed schedule for TV-South groundwater elevation monitoring.

3.3 Field Methods

3.3.1 Reference Point Elevations

In 2003, Tri-State Surveying, Ltd. established a geo-referencing survey control network across the District’s service area. The control survey includes five monuments set by Tri-State State surveying and eleven control monuments from the National Geodetic Survey, Caltrans and El Dorado County DOT. The control network is referenced to NAD’ 83, California State Plane Coordinate System, Zone 2 and NAVD88 vertical datum. All coordinate and elevation data for each of the wells in the well network are tied by a Professional Land Surveyor to the control survey. Survey information collected for each well is as follows:

1) Point Identifier;
2) Physical description of identifier;
3) Date of measurement;
4) SP CA 2 Northing coordinate (feet);

5) SP CA 2 Easting coordinate (feet);
6) Latitude (WGS84), in decimal degrees;
7) Longitude (WGS84), in decimal degrees;
8) NAVD88 vertical elevation - ground (feet);
9) NAVD 88 vertical elevation – top of casing measuring point(feet);
10) NGVD 29 vertical elevation - ground (feet);
11) NGVD 29 vertical elevation – top of casing measuring point (feet);
12) Horizontal accuracy (feet); and
13) Vertical accuracy (feet)

Reference points for any new observation well added to the well network will be surveyed by a Professional Land Surveyor in accordance with District surveying requirements.

3.3.2 Groundwater Elevation Readings

3.3.2.1 Semi-Annual Readings

As indicated in Section 3.2 static water level readings are collected over a 2-day period in May and November of each year. Collection over a 2-day period is required to allow production wells to be turned-off for next day static water-level readings. Production wells are allowed a minimum 12 hours recovery time prior to measurement. For most District production wells, minimum 12 hour recovery time has been adequate to attain static water conditions. The shut-off date and time for each production well is recorded on the District's field sheet. An example copy of this field sheet is provided in Attachment B.

Static water level readings are collected using an electric portable water level sounder. The well sounder uses a battery and an electrode attached to the end of a sounding cable. The sounding cable is a 2 conductor PVC, 20 AWG size cable marked in 1-foot increments. A milli-ampere analog meter is used to show contact of the electrode with the water level. The water level is determined by using an engineer's tape to measure the static level to the nearest 0.01 foot from the nearest 1-foot increment on the sounding cable. Methods employed for static-level readings are as follows:

Prior to Use

- Check the connection between the electrode and the sounding cable to insure that it is in good condition
- Check that the sounding cable is clean and free of kinks
- Check the charge on the battery

Measurement

- Inspect and note the general condition of the well cover
- Open the well cover and remove the well cap. Allow the well several minutes to equilibrate with atmospheric pressure. Note the general condition of the well cap and if not vented, any excess pressure or vacuum on the well cap during removal.
- Decontaminate the well sounder electrode and cable using a spray bottle filled with fresh potable water
- Check previous year readings to estimate anticipated water level range
- Lower the sounding cable into the well and measure static water level relative to the established reference point. Take at least three soundings to insure the electrode is in true contact with static level. If the reference point has changed from the previous year's measurement; measure the new reference point elevation in relation to ground surface and note the distance in the field book.
- Hold the cable at the reference point and measure the depth to water to the nearest 0.01 foot from the nearest 1-foot increment on the sounding cable.
- Record the following information in a bound field book;
    - Date and time of measurement
    - Well Name
    - Depth to water reading
    - Notes/Observations
- Reel in the sounding cable and wipe clean with a clean towel
- Replace the well cap and lock the well cover.

3.3.2.2 Automated Readings

Submersible pressure transducers with internal data loggers have been installed in 13 observation wells to collect pressure head readings on a daily (12-hour frequency) basis (Refer to table 3). The majority of these are absolute pressure transducers. In order to compensate pressure head readings for atmospheric pressure, a set of barometric pressure transducers have been deployed in seven of the 13 observation wells. Barometric pressure readings are collected at the same time and frequency as the pressure head readings to provide the most accurate compensated reading. Both the submersible and barometric transducers are typically suspended on a stainless steel wire line attached to the bottom of the well cap. Several wells are fitted with direct read cables that allow retrieval of submersible transducer readings without removal from the well. Pressure and barometric head readings from the well transducers are routinely downloaded at least once per year during the summer or early fall. These files are then used to update long-term head monitoring records and convert the compensated head readings to water-level elevations.

4 Data Reporting

Static water level readings are recorded in bound field books and on the field sheets. Following each measuring event, the collected depth to water field readings are reviewed, checked for errors and entered into a standard MS-excel worksheet. The worksheet is used to convert the field readings to NAVD88 elevations and update water-level hydrographs for each well. The field readings are also used to check the accuracy of the automated readings. Information contained in the water level worksheet for each measuring event is as follows:

- Location ID
- Well Name
- Latitude
- Longitude
- Reference Point Elevation (NAVD88)
- Water Level Date
- Depth to Water Reading (feet)
- Water Level Elevation (NAVD88)
- Data Quality Assurance Code (1 = low to 4 = high)
- Quality Assurance Reviewer (initial)
- Quality Assurance Date
- Quality Assurance Source
- Notes/Comments regarding the measurement

5 References

California Department of Water Resources (DWR). 2010. California Statewide Groundwater Elevation Monitoring (CASGEM) Program, Procedures for Monitoring Entity Reporting, December 2010.

California Geological Society (CGS). 2008. GIS Data for the Geologic Map of the Lake Tahoe Basin, California and Nevada; CGS CD 2008-01.

United States Geological Survey (USGS). 1999. Precipitation-Runoff Simulations for the Lake Tahoe Basin, California and Nevada; Water-Resources Instigations Report 99-4110.

United States Geological Survey (USGS). 2000. Surface- and Ground-Water Characteristics in the Upper Truckee and Trout Creek Watersheds, South Lake Tahoe, California and Nevada, July- December 1996; Water-Resources Instigations Report 00-4001.

United States Geological Survey (USGS). 2002. Estimated Flood Flows in the Lake Tahoe Basin, California and Nevada; Fact Sheet 035-02.

ATTACHMENT A

South Tahoe Public Utility District

Observation Well Network Information

Local Well Designation	State Well Number	RP Elevation	RP Description	GS Elevation
Apache OW		6340.12	Top Well Casing - N'ly Edge	6340.32
Blackrock Well #1	0910002-005	6242.72	Top of sounding tube	6240.73
CL-1		6278.37	Top Well Casing - N'ly Edge	6278.76
CL-3		6278.49	Top Well Casing - N'ly Edge	6278.64
Country Club Well	0910002-011	6286.19	N Bolt on Well Case	6285.49
DW-1		6342.07	Top Well Casing - N'ly Edge	6342.38
Elks Club Well #1	0910002-013	6284.63	Top of sounding tube	6282.95
ESB-2		6319.57	Top Well Casing - N'ly Edge	6319.87
ESB-3		6316.07	Top Well Casing - N'ly Edge	6316.37
EX-1		6475.09	Top Well Casing - N'ly Edge	6475.50
Glenwood Well #3	0910002-020	6261.68	Top Well Casing - N'ly Edge	6259.83
Henderson OW		6369.78	Top Well Casing - N'ly Edge	6366.18
Industrial Well #2	0910002-025	6305.95	1-1/2" Well casing penetration	6305.64
IW-1		6342.88	Top Well Casing - N'ly Edge	6343.22
Lily Ln-Deep		6236.03	Top Well Casing - N'ly Edge	6236.35
Lily Ln-Shallow		6236.08	Top Well Casing - N'ly Edge	6236.35
Martin Ave. Well	0910002-027	6262.42	Top of sounding tube	6260.93
Ralph OW	0910002-031	6351.97	Top of sounding tube	6351.41
Seneca OW		6476.12	Top Well Casing - N'ly Edge	6476.38
Sioux OW		6326.84	Top Well Casing - N'ly Edge	6327.36
SUT No.1	0910002-032	6401.22	Top Well Casing - N'ly Edge	6401.75
SW-1		6342.65	Top Well Casing - N'ly Edge	6343.00
Tata Lane Well #2	0910002-038	6286.11	Top of sounding tube	6284.11
Tata Lane Well #3	0910002-039	6288.34	Center Well Casing	6286.10
USGS TCF-1-1		6296.48	Top Well Casing - N'ly Edge	6295.70
USGS TCF-1-2		6296.47	Top Well Casing - N'ly Edge	6295.70
USGS TCF-1-3		6296.65	Top Well Casing - N'ly Edge	6295.70
USGS TCF-1-4		6296.63	Top Well Casing - N'ly Edge	6295.70
USGS TCF-1-5		6296.63	Top Well Casing - N'ly Edge	6295.70
Washoan OW		6307.84	Top Well Casing - N'ly Edge	6308.02

Local Well Designation	Measurement Method	Measurement Accuracy	Well Use	Well Status
Apache OW	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Blackrock Well #1	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
CL-1	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
CL-3	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Country Club Well	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
DW-1	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Elks Club Well #1	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
ESB-2	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
ESB-3	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
EX-1	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Glenwood Well #3	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Henderson OW	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Industrial Well #2	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
IW-1	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Lily Ln-Deep	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Lily Ln-Shallow	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Martin Ave. Well	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Ralph OW	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Seneca OW	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Sioux OW	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
SUT No.1	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
SW-1	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Tata Lane Well #2	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Tata Lane Well #3	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
USGS TCF-1-1	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
USGS TCF-1-2	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
USGS TCF-1-3	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
USGS TCF-1-4	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
USGS TCF-1-5	Surveyed to a benchmark	0.1 ft.	Observation	Inactive
Washoan OW	Surveyed to a benchmark	0.1 ft.	Observation	Inactive

Local Well Designation	Latitude (N)	Longitude (W)	Coordinates Method	Coordinates Accuracy
Apache OW	38.85517110	120.01712996	Surveyed	1 ft.
Blackrock Well #1	38.95668558	119.94877095	Surveyed	1 ft.
CL-1	38.91288586	120.01097127	Surveyed	1 ft.
CL-3	38.91290350	120.01100542	Surveyed	1 ft.
Country Club Well	38.86577423	120.01766464	Surveyed	1 ft.
DW-1	38.85443311	120.01962396	Surveyed	1 ft.
Elks Club Well #1	38.87606433	120.00050420	Surveyed	1 ft.
ESB-2	38.85819517	120.02160914	Surveyed	1 ft.
ESB-3	38.85956555	120.01955093	Surveyed	1 ft.
EX-1	38.80300347	120.01496678	Surveyed	1 ft.
Glenwood Well #3	38.93021083	119.96286318	Surveyed	1 ft.
Henderson OW	38.83947140	120.02488426	Surveyed	1 ft.
Industrial Well #2	38.90244944	120.00839594	Surveyed	1 ft.
IW-1	38.85454253	120.01955268	Surveyed	1 ft.
Lily Ln-Deep	38.94199789	119.99102375	Surveyed	1 ft.
Lily Ln-Shallow	38.94199808	119.99102512	Surveyed	1 ft.
Martin Ave. Well	38.92113864	119.97461360	Surveyed	1 ft.
Ralph OW	38.92535292	119.95288053	Surveyed	1 ft.
Seneca OW	38.86729305	120.03190638	Surveyed	1 ft.
Sioux OW	38.85929897	120.01817452	Surveyed	1 ft.
SUT No.1	38.82239164	120.02168130	Surveyed	1 ft.
SW-1	38.85451434	120.01971651	Surveyed	1 ft.
Tata Lane Well #2	38.90748125	120.00549011	Surveyed	1 ft.
Tata Lane Well #3	38.90754721	120.00585776	Surveyed	1 ft.
USGS TCF-1-1	38.92376702	119.96812692	Surveyed	1 ft.
USGS TCF-1-2	38.92376598	119.96812789	Surveyed	1 ft.
USGS TCF-1-3	38.92376704	119.96812770	Surveyed	1 ft.
USGS TCF-1-4	38.92376616	119.96812719	Surveyed	1 ft.
USGS TCF-1-5	38.92376655	119.96812806	Surveyed	1 ft.
Washoan OW	38.89093162	119.98850802	Surveyed	1 ft.

Local Well Designation	Well Completion Type	Total Well Depth (feet)
Apache OW	Single Well	134
Blackrock Well #1	Single Well	180
CL-1	Single Well	115
CL-3	Single Well	50
Country Club Well	Single Well	197
DW-1	Single Well	268
Elks Club Well #1	Single Well	168
ESB-2	Single Well	233
ESB-3	Single Well	211
EX-1	Single Well	31
Glenwood Well #3	Single Well	192
Henderson OW	Single Well	210
Industrial Well #2	Single Well	190
IW-1	Single Well	151
Lily Ln-Deep	Part of a nested/multi-completion well	64
Lily Ln-Shallow	Part of a nested/multi-completion well	38
Martin Ave. Well	Single Well	250
Ralph OW	Single Well	295
Seneca OW	Single Well	180
Sioux OW	Single Well	198
SUT No.1	Single Well	262
SW-1	Single Well	40
Tata Lane Well #2	Single Well	193
Tata Lane Well #3	Single Well	225
USGS TCF-1-1	Part of a nested/multi-completion well	340
USGS TCF-1-2	Part of a nested/multi-completion well	260
USGS TCF-1-3	Part of a nested/multi-completion well	163
USGS TCF-1-4	Part of a nested/multi-completion well	140
USGS TCF-1-5	Part of a nested/multi-completion well	98
Washoan OW	Single Well	275

Local Well Designation	Well Completion Report #	Associated Basin	Associated Basin Portion	Well Location Description
Apache OW		6-5.01-Tahoe Valley South	south-central	12N/18E-29
Blackrock Well #1	33505	6-5.01-Tahoe Valley South	north-east	13N/18E-27
CL-1	535956	6-5.01-Tahoe Valley South	central	12N/18E-05
CL-3	535958	6-5.01-Tahoe Valley South	central	12N/18E-05
Country Club Well		6-5.01-Tahoe Valley South	south central	12N/18E-20P01
DW-1		6-5.01-Tahoe Valley South	south central	12N/18E-29
Elks Club Well #1	56760	6-5.01-Tahoe Valley South	central	12N/18E-21
ESB-2		6-5.01-Tahoe Valley South	south central	12N/18E-29
ESB-3		6-5.01-Tahoe Valley South	south central	12N/18E-29
EX-1		6-5.01-Tahoe Valley South	south	11N/18E-08
Glenwood Well #3	6492	6-5.01-Tahoe Valley South	east	12N/18E-02D3
Henderson OW		6-5.01-Tahoe Valley South	south	12N/18E-31
Industrial Well #2		6-5.01-Tahoe Valley South	central	12N/18E-08G02M
IW-1		6-5.01-Tahoe Valley South	south central	12N/18E-29
Lily Ln-Deep		6-5.01-Tahoe Valley South	north-central	13N/18E-32
Lily Ln-Shallow		6-5.01-Tahoe Valley South	north-central	13N/18E-32
Martin Ave. Well	115601	6-5.01-Tahoe Valley South	east	12N/18E-03B01M
Ralph OW		6-5.01-Tahoe Valley South	east	12N/18E-02B6
Seneca OW		6-5.01-Tahoe Valley South	west-south	12N-18E-19
Sioux OW		6-5.01-Tahoe Valley South	south central	12N/18E-29
SUT No.1	91552	6-5.01-Tahoe Valley South	south	11N/18E-05N1
SW-1		6-5.01-Tahoe Valley South	south central	12N/18E-29
Tata Lane Well #2		6-5.01-Tahoe Valley South	central	12N/18EA03M
Tata Lane Well #3		6-5.01-Tahoe Valley South	central	12N/18E-08A04M
USGS TCF-1-1		6-5.01-Tahoe Valley South	east	12N/18E-03
USGS TCF-1-2		6-5.01-Tahoe Valley South	east	12N/18E-03
USGS TCF-1-3		6-5.01-Tahoe Valley South	east	12N/18E-03
USGS TCF-1-4		6-5.01-Tahoe Valley South	east	12N/18E-03
USGS TCF-1-5		6-5.01-Tahoe Valley South	east	12N/18E-03
Washoan OW		6-5.01-Tahoe Valley South	central-south	12N/18E-16

Local Well Designation	Additional Comments	Is Voluntary Well	County
Apache OW		No	El Dorado
Blackrock Well #1	Artesian well	No	El Dorado
CL-1		No	El Dorado
CL-3		No	El Dorado
Country Club Well	Well screen liner; plugged at 197'	No	El Dorado
DW-1		No	El Dorado
Elks Club Well #1	Well screen liner; plugged at 143'	No	El Dorado
ESB-2		No	El Dorado
ESB-3		No	El Dorado
EX-1		No	El Dorado
Glenwood Well #3		No	El Dorado
Henderson OW		No	El Dorado
Industrial Well #2	Screen intervals inferred from well videoscan	No	El Dorado
IW-1		No	El Dorado
Lily Ln-Deep		No	El Dorado
Lily Ln-Shallow		No	El Dorado
Martin Ave. Well		No	El Dorado
Ralph OW	Screen interval inferred from well videoscan	No	El Dorado
Seneca OW		No	El Dorado
Sioux OW		No	El Dorado
SUT No.1		No	El Dorado
SW-1		No	El Dorado
Tata Lane Well #2		No	El Dorado
Tata Lane Well #3		No	El Dorado
USGS TCF-1-1		No	El Dorado
USGS TCF-1-2		No	El Dorado
USGS TCF-1-3		No	El Dorado
USGS TCF-1-4		No	El Dorado
USGS TCF-1-5		No	El Dorado
Washoan OW		No	El Dorado

Local Well Designation	Screen Interval 1 Top	Screen Interval 1 Bottom	Screen Interval 2 Top	Screen Interval 2 Bottom
Apache OW	112.500	134.000		
Blackrock Well #1	168.000	180.000		
CL-1	104.000	114.000		
CL-3	39.000	49.000		
Country Club Well	114.000	184.000		
DW-1	225.000	265.000		
Elks Club Well #1	110.000	142.000		
ESB-2	218.000	228.000		
ESB-3	196.000	206.000		
EX-1	6.000	21.000		
Glenwood Well #3	112.000	192.000		
Henderson OW	79.000	100.000	142.000	205.000
Industrial Well #2	40.000	92.000	97.000	107.000
IW-1	120.000	150.000		
Lily Ln-Deep	59.000	64.000		
Lily Ln-Shallow	35.000	37.500		
Martin Ave. Well	95.000	115.000	125.000	145.000
Ralph OW	28.000	237.000		
Seneca OW	60.000	91.000	133.000	175.000
Sioux OW	188.000	198.000		
SUT No.1	136.000	262.000		
SW-1	10.000	40.000		
Tata Lane Well #2	73.000	193.000		
Tata Lane Well #3	55.000	75.000	200.000	220.000
USGS TCF-1-1	325.000	335.000		
USGS TCF-1-2	245.000	255.000		
USGS TCF-1-3	158.000	163.000		
USGS TCF-1-4	130.000	135.000		
USGS TCF-1-5	88.000	93.000		
Washoan OW	102.000	144.000	165.000	186.000

Local Well Designation	Screen Interval 3 Top	Screen Interval 3 Bottom	Screen Interval 4 Top	Screen Interval 4 Bottom
Apache OW				
Blackrock Well #1				
CL-1				
CL-3				
Country Club Well				
DW-1				
Elks Club Well #1				
ESB-2				
ESB-3				
EX-1				
Glenwood Well #3				
Henderson OW				
Industrial Well #2	110.000	190.000		
IW-1				
Lily Ln-Deep				
Lily Ln-Shallow				
Martin Ave. Well	160.000	180.000	200.000	240.000
Ralph OW				
Seneca OW				
Sioux OW				
SUT No.1				
SW-1				
Tata Lane Well #2				
Tata Lane Well #3				
USGS TCF-1-1				
USGS TCF-1-2				
USGS TCF-1-3				
USGS TCF-1-4				
USGS TCF-1-5				
Washoan OW	207.000	228.000	249.000	270.000

ATTACHMENT B

South Tahoe Public Utility District

Static Water-Level Measurements for District Wells

Standard Operating Procedure (Example)

South Tahoe

Public Utility District

1275 Meadow Crest Drive
South Lake Tahoe, CA 96150
Telephone: (530)544-6474
Fax: (530)541-0614

STATIC WATER-LEVEL MEASUREMENTS FOR DISTRICT WELLS
STANDARD OPERATING PROCEDURE
(November 8th – November 10th, 2011)

REQUIRED TOOLS LIST

- Sockets/Ratchet
  - ½-inch
  - 9/16-inch
  - ¾-inch
  - 15/16-inch
  - 1 1/8-inch
- Pipe Wrench
- Slot-Head Screwdriver
- Water-level Sounder
- Pick
- Snow Shovel
- Wire Brush
- Hand-Broom
- Gloves
- Spray Bottle
- Towels
- Rags

DAY 1 (Tuesday, November 8^{th}, 2011)

1. If operating, turn-off the following wells for next-day static water-level measurements.

WELL	SHUT-OFF DATE/TIME
Bakersfield Well	
Arrowhead Well	
Airport Well	Stand-By Well – *Out of Service*
Valhalla Well	
Glenwood Well No. 5	
Industrial Well No. 2	Removed from Service - OW
Country Club Well	Removed from Service - OW
Martin Ave. Well	Removed from Service - OW
Blackrock Well No. 1	Removed from Service - OW
Blackrock Well No. 2	

DAY 2 (Wednesday, November 9th, 2011)

2.) Collect static water-level measurements from the following wells (minimum 12-hour recovery time)

WELL	DATE/ TIME	Depth to Water (feet)	Measuring Point	Turn-on Well Post Static DTW	NOTES
Apache Street Sentinel Well			Top of 2-inch PVC casing		
SW-1 (Arrowhead Monitoring Well)			Top of 4-inch PVC well casing		Arrwhd FF = 6343.00
IW-1 (Arrowhead Monitoring Well)			Top of 4-inch PVC well casing		PXD Station
DW-1 (Arrowhead Monitoring Well)			Top of 4-inch PVC well casing		Orig. = 6338.93
Arrowhead Well No. 3			Top of 1" sounding tube		
Sioux Street Sentinel Well			Top of 4-inch well casing		
ESB-3 Sentinel Well			Top of PVC well casing		Accessible (?)
ESB-2 Sentinel Well			Top of PVC well casing		PXD Station
Bakersfield Well			Top of PVC sounding tube		
Country Club Well (in-active)			Top of well casing		
Washoan Test Well			Top of 4-inch well casing		
Airport Well			Well house XD reading (PXD @ 200.47')		
Industrial Well No. 2			Well casing access port		
Tata Well No. 3 (OW)			Top of well casing		PXD Station
Tata Well No. 2 (in-active)			Top of sounding tube		
Clement Well (in-active)			Top of pitless unit flange.		

WELL	DATE/ TIME	Depth to Water (feet)	Measuring Point	Turn-on Well Post Static DTW	NOTES
CL-1 (Clement monitoring well)			Top of 2-inch PVC well casing		
CL-3 (Clement Monitoring well)			Top of 2-inch PVC well casing		
Martin Well (OW)			Top of PVC ST		
Glenwood Well No. 3 (OW)			Top of 4-inch casing.		PXD Station
Glenwood Well No. 5			Well house XD reading (PXD @ 161')		
Ralph Well			Top of casing flange (0.4' above ff elev.)		PXD Station
College Well			Top of 3-inch sounding tube		
USGS TCF-1			Top of PVC casing		
USGS TCF-2			Top of PVC casing		
USGS TCF-3			Top of PVC casing		PXD Station
USGS TCF-4			Top of PVC casing		
USGS TCF-5			Top of PVC well casing		
Blackrock Well No. 2 (in-active)			Top of PVC ST		
Blackrock Well No. 1 (OW)			Top of PVC ST		
Seneca Test Well			Top of 4-inch well casing		PXD Station
Valhalla Well			Well House XD Reading (PXD @ 65.71')		*TTA Combo. = 3185*

3.) Following the days static water level measurement collection, if operating, turn-off the following wells for next day static water-level measurements.

WELL	SHUT-OFF DATE/TIME
South Upper Truckee No. 3	
Mountain View Well	
Elks Club Well No. 2	
Helen Well No. 2	
Chris Well	
Paloma Well	
Bayview Well	
Al Tahoe Well No. 2	
Sunset Well	

DAY 3 (Thursday, November 10th, 2011)

4.) Collect static water-level measurements from the following wells (minimum 12-hour recovery time)

WELL	DATE/ TIME	Depth to Water (feet)	Measuring Point	Turn-on Well Post Static DTW	NOTES
Sunset Well			Top of ST		
Helen Well No.2			Top of PVC ST		
Chris Ave. Well			Top of ST		
Paloma Well			Top of ST		PXD Station
Al Tahoe Well No. 1 (OW)			Top of ST		Accessible (?)
Al Tahoe Well No. 2			Top of ST		
Bayview Well			Top of ST; PXD @ 169.65’		
Lilly - Deep			Top of 1” PVC Casing		
Lilly - Shallow			Top of 2” PVC Casing		PXD Station
South Upper Truckee Well No. 3			Top of 1 ½” ST; PXD @ 124’ below FF		FF=6401.75’
South Upper Truckee No. 1 - OW			Top of casing		FF=6401.75’
LPPS/ EX-1			Top of Well Casing		
Henderson Test Well			Top of Well Casing		PXD Station
Mtn. View Well			Top of 1-inch PVC ST		PXD= Q =
Elks Club Well No. 1			Top of ST		
Elks Club Well No. 2			Top of ST; PXD = 147’		

ATTACHMENT D

STATE OF CALIFORNIA – CALIFORNIA NATURAL RESOURCES AGENCY

EDMUND G. BROWN JR., *Governor*

DEPARTMENT OF WATER RESOURCES
1416 NINTH STREET, P.O. BOX 942836
SACRAMENTO, CA 94236-0001
(916) 653-5791

December 29, 2011

Mr. Richard Solbrig, General Manager
South Tahoe Public Utility District
1275 Meadow Crest Drive
South Lake Tahoe, California 96150

Monitoring Entity Designation for the South Tahoe Public Utility District
under the California Statewide Groundwater Elevation Monitoring Program

Dear Mr. Solbrig:

Thank you for volunteering to be a Monitoring Entity for the California Statewide Groundwater Elevation Monitoring (CASGEM) program. On December 28, 2010, the Department of Water Resources (DWR) received notification that the South Tahoe Public Utility District (STPUD) intends to assume responsibility for monitoring and reporting local groundwater elevations for the CASGEM program. Based on review and verification of the information that you submitted to DWR via the CASGEM Online System, STPUD is designated as the Monitoring Entity for the following groundwater subbasin:

- Tahoe Valley South subbasin (6-5.01)

You should begin monitoring the wells you have included in the CASGEM program by fall 2011. The CASGEM Online System is ready to accept submittal of your groundwater elevation data. *The Water Code* requires that the first set of groundwater elevations be reported on or before January 1, 2012.

Additional information is available on the CASGEM program website at http://www.water.ca.gov/groundwater/casgem.

If you have any questions about the CASGEM program, please contact Chris Bonds in DWR's North Central Region Office at 3500 Industrial Boulevard, West Sacramento, California 95799, or by phone (916) 376-9657, or e-mail cbonds@water.ca.gov.

Thank you for your participation in the CASGEM program.

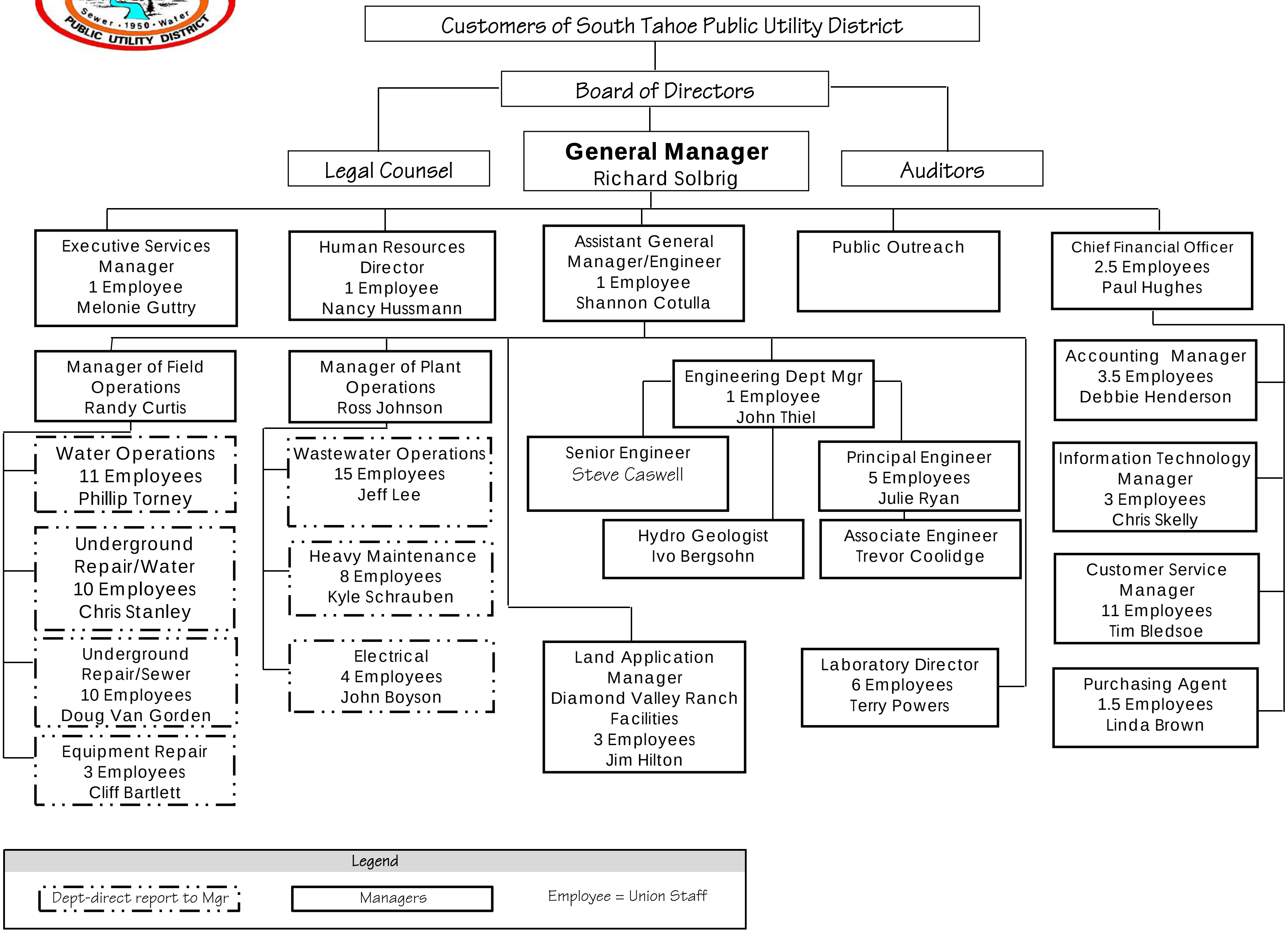
Sincerely,

Paula J. Landis, Chief
Division of Integrated Regional Water Management

cc: Chris Bonds, North Central Region Office
Brett Wyckoff, Bonderson Building, Room 213 A
Ivo Bergsohn, South Tahoe Public Utility District

ATTACHMENT E

South Tahoe Public Utility District



ATTACHMENT F

Basin Monitoring Program

This section describes the routine monitoring and reporting activities undertaken by STPUD regarding groundwater and surface water.

Groundwater Management Monitoring

STPUD currently has in place various programs to fulfill the DWR requirements. This section briefly describes the types of data collected and how and where they are acquired. A summary of the GWMP Monitoring Plan components are provided in Table 9-1.

As part of the GWMP Basin Monitoring Plan, the District will reach out to other water purveyors and other governmental agencies about sharing data. The District will work with other agencies to identify data that will help support the Basin Monitoring Program for all stakeholders.

Groundwater Levels

STPUD collects groundwater head elevation data semiannually from a suite of representative wells in order to facilitate analysis of seasonal and long-term trends in groundwater elevation. STPUD monitors groundwater head elevation in 30 observation wells located throughout the TVS Basin. Semi-annual measurements are collected in May and November of each year in all 30 observation wells; additionally, 13 of the observation wells are equipped with data loggers that measure and record groundwater head elevation twice daily. A more detailed description of the STPUD Groundwater Elevation Monitoring Plan for the TVS Basin, including procedures and protocols, is included in Appendix D.

Supplemental groundwater level data from GeoTracker (see Section 9.2.1), and from the Water Information Center and Water Data Library (see Section 9.3.1) are available online to be included in the GWMP or other groundwater assessments, if needed. The GeoTracker data is primarily collected from shallow monitoring wells screened across the water table, within the uppermost water-bearing zones of the TVS Basin.

Groundwater Quality

To ensure that water quality of drinking water is maintained, the Water Code includes a requirement that water purveyors regularly monitor groundwater quality at each drinking water source (i.e., well). The suite of required constituents includes various inorganic chemicals, radioactivity, and organic chemicals. This section describes the monitoring performed by STPUD and by other entities extracting water from the TVS Basin.

STPUD collects samples of groundwater from 15 active production and monitoring wells on at least an annual basis (from June to August), and submits those samples for analysis of the full suite of Title 22 analytes. Sampling procedures and protocols met all the requirements for Title 22.

The regulated groundwater purveyors listed in Table 3-3 are required to electronically submit laboratory reports for water quality samples to the DDW (see Section 9.2.3). These reported data will be incorporated into the data for the GWMP. These data can be obtained for use by public agencies from DDW rather than contacting each individual agency for the data.

Pumping Volumes

Tracking the volumes of groundwater extracted from the TVS Basin is a key data set for groundwater management, and is an additional authority provided to GSAs under the SGMA.

The largest groundwater pumper is STPUD who currently meters pumping volumes in each well continuously. These data are compiled by the District into monthly and annual pumping volumes. LBWC and TKWC are the next two largest pumpers. Pumping volumes for each of these three water purveyors accounts for more than 95 percent of the groundwater withdrawals from the TVS Basin and should be tracked on a monthly basis for the GWMP. The small private groundwater pumpers listed in Table 3-3 are currently permitted through the County, and have not been required to report groundwater pumping. As part of the GWMP, outreach to these small community water systems will be conducted to get a better understanding of their groundwater usage and encourage metering and reporting for the larger volume production wells.

Land Surface Subsidence

Because of the geologic composition and history of the TVS Basin, inelastic land surface subsidence is not anticipated to occur. The geology of the TVS Basin is discussed in Section 5 and summarized with respect for the potential for land subsidence in Section 5.5.2. The District will monitor groundwater levels, as required under BMO #1, as the primary tool for identifying potential land subsidence. If significant, sustained regional decreases in groundwater levels occur, the District will make an assessment on a case-by-case basis of whether the local geology at that location is susceptible to potential land subsidence, and, if necessary, take appropriate measures.

Surface Flow and Water Quality

The USGS collects and stores large amounts of data on streamflow and surface water quality. that is readily available for use in the GWMP through the National Water Information System (NWIS; http://waterdata.usgs.gov/nwis/). Within the District service area there are twenty streamflow gauges with historical data, with the period of record stretching from 1923 to the present. Of these, four are currently operational as shown on Figure 2-6. The service area also contains numerous sites where surface water quality samples have been collected. These data can be used to estimate recharge from streams for use in the groundwater budget, assess potential groundwater-surface water interactions and monitor surface water quality trends.

Additional Groundwater Quality Monitoring

In addition to the data sources described above, other data types are available from various agencies via the internet, as described in the following sections.

Groundwater Remediation Monitoring Data

The SWRCB GeoTracker website (http://geotracker.waterboards.ca.gov) acts as a clearinghouse for groundwater data from environmental sites, such as underground storage tanks, landfills, and contaminated sites. Figure 6-2 shows the locations of sites currently listed on GeoTracker. Many of these sites have current and historical data for groundwater levels and water quality associated with their investigation and remediation activities. These data can also be used to supplement the GWMP data.

El Dorado County CUPA Monitoring

The El Dorado County Environmental Management Division, Hazardous Waste Department (EDCEMD-HWD), has been defined as the Certified Unified Program Agency (CUPA) for El Dorado County. As of January 1, 2013 all existing businesses that store threshold quantities of hazardous materials or hazardous waste are required to annually update their hazardous materials information on California Environmental Reporting System (CERS). This is a statewide web-based system to support CUPAs and Participating Agencies (PAs) in electronically collecting and reporting various hazardous materials-related data as mandated by the California Health and Safety Code and new 2008 legislation (AB 2286). This includes all hazardous materials business plans, chemical inventories, site maps, underground and aboveground tank data, and hazardous waste related data for these businesses. These data can be available from EDCEMD-HWD for use in the GWMP.

El Dorado County Small Water System Monitoring

The El Dorado County Environmental Management Division, Environmental Health Department (EDCEMD-EHD) is responsible for managing the Small Water Systems Program for El Dorado County. The Small Water Systems Program is involved with the permitting, inspection, and monitoring of 175 small public water systems. The County is the Local Primacy Agency, under contract with the DDW, to perform the program requirements that are specified in State and Federal Regulations. The purpose of the program is to ensure that small water systems deliver safe, adequate, and dependable potable water. Environmental Health reviews new applications and changes of ownership to verify that the system will be able to meet technical, managerial, and financial capabilities.

A small water system is a private system for the provision of piped water to the public for human consumption that serves at least five, but not more than 14, service connections and does not regularly serve drinking water to more than an average of 25 individuals daily for more than 60 days out of the year. There are several private water systems that have wells which supply drinking water to schools, resorts, hotels, apartments and recreational areas located within the TVS Basin (Section 3.2.2).

Laboratory reports for water quality samples collected from small water systems wells are electronically submitted to the EDCEMD-EHD and DDW. EDCEMD-EHD maintains a database which includes both bacteriological and chemical water quality data for the small water systems wells, along with system number, address, number of service connections, population served and water quality violations. These data can be available from EDCEMD-EHD for use in the GWMP.

TRCD Storm Water and Watershed Monitoring

The Tahoe Resource Conservation District (TRCD) implements a storm water monitoring program. The TRCD monitors six locations around Lake Tahoe. One of the sites is located at Pasadena Avenue and the shore of Lake Tahoe, where the inflow to a storm water treatment device and the outfall to the Lake are both monitored. Samples are collected on an event basis; for the period from October 2013 to March 2014, samples were collected at the Pasadena station in the City of South Lake Tahoe during events starting on January 29 and February 8. Water quality results are available on the RSWMP website (http://tahoercd.org/tahoe-stormwater-monitoring/).

A monitoring plan has been developed to provide monitoring procedures and protocols (TRCD, 2013). Several parameters are measured including flow volume, total suspended solids, turbidity, particle size, and nitrate and phosphorus concentrations. These data are provided an annual report that is submitted to the LRWQCB and the Nevada Division of Environmental Protection (TRCD, 2014).

Compilation of Data from Other Sources

In addition to those sources described above, various additional types of data are available from different agencies and are typically available via the internet.

Supplemental Water Level Data

The DWR maintains databases and interactive maps available on the internet that provide data reported to DWR for public use. These sites can be accessed to retrieve supplemental data in addition to the data collected as part of this GWMP. These internet sites include:

- The Groundwater Information Center (GIC) is DWR's portal for groundwater information, groundwater management plans, water well basics, and statewide and regional reports, maps and figures. The web link for the GIC is http://water.ca.gov/groundwater/.
- The Water Data Library (WDL) is another portal that allows quick access to groundwater level and some water quality, surface water and climate data for many locations in California. Included in the WDL are data from the USGS NWIS also includes groundwater level and quality information. The web link for the WDL is http://www.water.ca.gov/waterdatalibrary/index.cfm.

CASGEM

STPUD undertakes to collect data to satisfy its responsibilities under the CASGEM Program. The CASGEM Program was created by SB-X7-6, enacted in November 2009. Under this program, local entities (such as STPUD) are required to collect groundwater head elevation data semiannually from a suite of representative wells in order to facilitate analysis of seasonal and long-term trends in groundwater head elevation. The CASGEM data is available via the internet through the DWR WDL discussed above.

The Groundwater Elevation Monitoring Plan attached as Appendix D details the activities STPUD undertakes to collect data to satisfy its responsibilities under the CASGEM Program. STPUD monitors groundwater head elevation in 30 observation wells located throughout the TVS Basin. Semi-annual measurements are collected in May and November of each year in all 30 observation wells; additionally, 13 of the observation wells are equipped with data loggers that measure and record groundwater head elevation twice daily.

Climate Data

Climate data for the South Lake Tahoe area is available from a variety of sources that are listed in Table 9-1. Climate data from the National Oceanic and Atmospheric Administration National Climate Data Center , USDA National Resources Conservation Service National, the DWR California Data Exchange Center, and the Western Regional Data Center, and the Tahoe Climate Information Management System.

Precipitation is the primary component of the climate data that will be compiled regularly to evaluate potential recharge and runoff in the TVS Basin. Tahoe City is the station with the longest period of record with more than 100 years of records. The South Lake Tahoe station has only 14 years of historic precipitation records, but more than 40 years of temperature records. The Tahoe Climate Information Management System has precipitation record back to 1968. Snowmelt runoff from the surrounding mountains is a key recharge component. Snow water equivalent measurements are available through the USDA Natural Resources Conservation Service from three stations in the South Lake Tahoe area (Figure 2-6).

TABLE 9-1
GWMP MONITORING PLAN DATA SOURCES

Organization	Contact	Data
STPUD	Ivo Bergsohn 1275 Meadow Crest Drive South Lake Tahoe, CA 530-544-6474	Groundwater levels Groundwater quality Pumping volumes
Lukins Brothers Water Company	Jennifer Lukins 2013 West Way South Lake Tahoe, CA 530-541-2606	Pumping volumes Groundwater levels
Tahoe Keys Water Company	Greg Trischler 356 Ala Wai Blvd. South Lake Tahoe, CA 530-542-6451	Pumping volumes Groundwater levels
USGS	National Water Information System http://waterdata.usgs.gov/nwis/	Groundwater levels Surface water flow and quality
DWR	Groundwater Information Center http://water.ca.gov/groundwater/ Water Data Library http://www.water.ca.gov/waterdatalibrary/index.cfm CASGEM http://www.water.ca.gov/groundwater/casgem/	Groundwater and climate data
SWRCB	GeoTracker http://geotracker.waterboards.ca.gov Groundwater Ambient Monitoring & Assessment Program (GAMA) http://geotracker.waterboards.ca.gov/gama/	Groundwater levels Groundwater quality Pumping data
TRCD	Regional Storm Water Monitoring Program http://tahoercd.org/tahoe-stormwater-monitoring/	Storm water quality
Desert Research Institute	Tahoe Climate Information Management System http://www.tahoeclim.dri.edu/ California Data Exchange Center http://www.wrcc.dri.edu/summary/Climsmcca.html Western Regional Climate Center http://www.wrcc.dri.edu/summary/Climsmcca.html	Climate data
NOAA	National Climate Data Center Global Historical Climate Network http://www.ncdc.noaa.gov/oa/climate/ghcn-daily/	Climate data
USDA	Natural Resources Conservation Service http://www.wcc.nrcs.usda.gov/ SNOTEL http://www.wcc.nrcs.usda.gov/snow/	Snow water equivalent

ATTACHMENT G

Stakeholder Involvement

A primary objective of this GWMP has been to provide input in the development of this GWMP update. This section provides a summary of the collaborative, community-building endeavors through stakeholder involvement.

Stakeholders Advisory Group

Within the Lake Tahoe area, there is an existing, on-going coordination and collaboration with water issues in the TVS Basin. A key objective of this GWMP update is to continue to build off of these existing relationships to further enhance groundwater management and protection in the TVS Basin. To further that objective, a Stakeholder Advisory Group (SAG) was formed to provide input for the development of this GWMP.

Formation of GWMP SAG

The SAG was convened to provide input for the development of this GWMP from various stakeholders that represented the District, local water purveyors, governmental agencies, business interests, and ratepayers representing a broad spectrum of interests to provide input to the update of the GWMP document. The objectives for the SAG are to:

- provide information and insight about key groundwater issues in the TVS Basin,
- develop a framework to expand and improve interagency collaboration particularly in the areas of regulatory oversight, coordinated land use planning, data collection and public education.
- provide review and recommendations to the GWMP document.

Four meetings were held from April through September 2014 to present information on the development of the GWMP, provide a forum to discussion local groundwater issues, and discuss areas of future collaboration among the stakeholders to improve groundwater management and groundwater quality protection. The GWMP is considered a “living document” that the District intends to update periodically to report, in collaboration with other stakeholders in the TVS Basin, on the progress made in managing groundwater resources and to reflect amendments to the CWC. Input from the SAG is considered an important function in the ongoing groundwater management in the TVS Basin.

SAG Members

The 2014 SAG has a roster of twelve members. These members were invited to participate by means of (1) public notice in the *Tahoe Daily Tribune (published March 7, 2014)*, (2) public announcement at the meeting of a local environmental group and (3) personal invitation. The District accepted applications from interested parties and communicated directly with contacts at the agencies whose participation is called out in the existing GWMP. This recruitment process resulted in the SAG consisting of twelve stakeholder members, three District representatives, and two consultants. Table 7-1 lists the SAG members.

The SAG consists of members who reside within the TVS Basin or who represent collaborating businesses or government agencies who have demonstrated a commitment to protecting groundwater resources. Participants on the SAG represent the categories of stakeholder called out in section 7.4 of the existing District GWMP (STPUD, 2000). The purpose of the stakeholder categories is to get a broad spectrum of community, business and agency interests to provide input on the GWMP. The District staff who participated as SAG members included the General

Manager, District Hydrogeologist and District Engineer. District staff participated in the SAG proceedings shared information and answered questions directed to them by other members of the SAG. The SAG also included two consultants who participated in the roles of Technical Advisor and Meeting Facilitator.

TABLE 7-1
STAKEHOLDER ADVISORY GROUP MEMBERS

Category	Name	Affiliation	Position
Agency	Jason Burke	City of South Lake Tahoe	Storm Water Program Coordinator
Agency	Robert Lauritzen	El Dorado County	Geologist
Agency	Brian Grey	Lahontan Regional Water Quality Control Board	Engineering Geologist
Agency	Tom Gavigan	Lahontan Regional Water Quality Control Board	Senior Engineering Geologist
Agency	Paul Nielsen	Tahoe Regional Planning Agency	Planning Manager
Business Rate Payer	Rodney Wright	Barton Health	Emergency Management Coordinator
Community Rate Payer	Harold Singer	Resident	Retired
Service Station Operator	Greg Daum	Chevron (Meyers)	Owner/Operator
Real Property Owner	Scott Carroll	Tahoe Conservancy	Associate Environmental Planner
Other	Steve Morales	Lake Tahoe Unified School District	Director of Facilities
Water Purveyor	Jennifer Lukins	Lukins Brothers Water Company	Vice President
Water Purveyor	Greg Trischler	Tahoe Keys Water Company	Supervisor
District	Richard Solbrig	STPUD	General Manager
District	Ivo Bergsohn	STPUD	Hydrogeologist
District	John Thiel	STPUD	Principal Engineer
Consultant	Mike Maley	Kennedy/Jenks Consultants	Hydrogeologist
Consultant	Michelle Sweeney	Allegro Communications	Meeting Facilitator

SAG Meetings and Workshops

STPUD invited the participation of stakeholders in a series of four meetings during the development of the 2014 GWMP Update. Workshops at the District offices in South Lake Tahoe were on April 16, May 14, June 4 and September 24, 2014.

The workshops provided an opportunity for the District to inform the SAG members regarding groundwater conditions in the Basin and for the SAG to identify potential topics for the updated GWMP. This helped the District construct a plan of action around the highest-priority topics. The SAG was also invited to provide edits and suggestions during development of the District's updated GWMP document.

Each workshop had an agenda and review material (sent to the SAG members several days in advance of the meeting). The workshops ran for three hours and included presentations by the District and Consultants on issues, question and answer periods, and designated open discussion periods on a range of topics. A summary of each of the four SAG workshops is provided in Appendix E.

The District has developed the following recommendations based on the discussion during the SAG meetings that have been included in this GWMP update. In summary these recommendations include:

- Maintain the Source Water Protection Map to serve the objectives of the plan document
- Prioritize action according to risk
- Maintain a long-term sustainable water supply
- Maintain and protect groundwater quality
- Coordinate regional monitoring to track groundwater conditions
- Study the interaction of water supply activities with environmental conditions
- Build collaborative capacity with local agencies, private water companies, businesses, private property owners and the public
- Integrate source water protection into local and regional land use planning.

These are not prioritized actions. At present each recommendation holds equivalent and independent importance. However, sequence is implied. That is, by first assessing risk posed by potential threats to groundwater and subsequently assessing the relative likelihood of risk events, the District should be in a position to prioritize actions so that the most damaging threats with the greatest likelihood of occurrence can be the first to receive attention during plan implementation.

Groundwater Management Collaboration Opportunities

This GWMP is updated within the context of existing, on-going coordination and collaboration in water issues in the TVS Basin. As noted in Section 4, water quality improvement programs, with a focus on Lake Tahoe clarity, have required the coordination and collaboration of many of the organizations and agencies within the Lake Tahoe Basin. Therefore, long-established relationships that form the foundation of coordination and collaboration which will be honored and expanded to include consideration of groundwater management issues with an emphasis on water quality.

The SAG identified numerous groundwater management collaboration opportunities. SAG recommendations on this subject can be summarized in terms of opportunities to (1) protect groundwater (2) coordinate with land use planning (3) share data and (4) enhance collaboration.

Protect Groundwater

Toward the goal of protecting groundwater, the overall goals for groundwater protection discussed by the SAG are summarized as the following:

- Integrate groundwater protection into existing site inspection protocol of the several agencies already conducting site inspections
- Create a private well owner education and cooperation campaign, and
- Maintain an infiltration facility inventory and educate spill responders regarding locations and District/water purveyor notification.

Site inspections of some storm water BMPs and other potentially relevant facilities occur with local agency staff. There are opportunities to leverage these inspections and include a few items such as presence and condition of water supply wells that could provide added groundwater protection.

There are an estimated 600 private wells currently operating within the TVS Basin. Existing private wells do not require permits or operational reporting; therefore, information is lacking on operational status and whether it is being maintained in good condition or allowed to deteriorate. The inspection programs above could be used to gather these data and used as the basis for education and outreach to private well owners regarding vertical migration potential and. These well inventory data could be added to well permitting programs for use in the GWMP. Private well information would be beneficial for supporting groundwater management and water quality protection. These well inventory data could be added to the El Dorado County Water Well Program for use in the GWMP.

Finally, one of the main concerns that have been raised has been the potential for spills to impact groundwater. This concern is highlighted if a spill were to occur near an infiltration facility. Therefore, an effort to locate infiltration facilities as well as education of spill responders regarding:

- the relative urgency of response depending on the spill location and
- the interest of the District and other purveyors to be notified of spills would be helpful for long-term groundwater protection.

Coordination with Land Use Planning

Opportunities exist for improved coordination of groundwater management and land use planning. Potential areas for collaboration include:

- Developing processes to ensure consistency between general plans and the GWMP
- Ensuring that land use plans use current maps, data and analyses from the local water purveyors
- Ensuring that water use projections are developed in coordination and consultation with the GWMP
- Discussing approaches on how to implement land use policies for areas in or approaching groundwater impairment.

Existing law requires a city or county upon adoption of its General Plan to use as a source document any Urban Water Management Plan submitted by a water agency. The SGMA does include language that will broaden the requirement of what is required to be included in future GWMPs.

The SGMA expands the role and responsibility of local water agencies as Groundwater Sustainability Agencies (GSAs) in order to achieve “Sustainable Groundwater Management”. Sustainable Groundwater Management is defined as the management and use of groundwater in a manner that can be maintained over a 50-year planning and implementation horizon without causing undesirable results. Undesirable results include one or more of the following effects:

- Chronic lowering of groundwater levels (Overdraft Condition)
- Significant and unreasonable reduction in groundwater storage
- Significant and unreasonable degradation of water quality, including migration of contaminant plumes that impair water supplies
- Significant and unreasonable land subsidence, and
- Surface water depletions that have significant and unreasonable adverse impacts on beneficial uses of the surface water.

In order to achieve groundwater sustainability goals, the SGMA provides additional authorities to GSAs, which may:

- Impose spacing requirements on new well construction to minimize well interference and excessive drawdown
- Require metering of wells producing more than 2 acre-feet per year (about 1,785 GPD)
- Require regular reporting of water production from metered wells, and
- Assess fees to develop and implement its adopted and state-approved Groundwater Sustainability Plan (GSP).

This may be an area for coordination with TRPA, LRWQCB, EDCEMD, LTBMU and the CSLT.

Sharing Data and Information

A key part of groundwater management is collecting data to monitor groundwater conditions. Multiple governmental agencies and water purveyors collect groundwater-related data in the TVS Basin. A goal of the GWMP is to better coordinate the sharing of this information among the various groups. Data sharing opportunities exist in the following categories: well construction, groundwater level, water quality sampling, volumes of groundwater extracted and surface water conditions. It is not recommended to try and develop a central database at this time because this would require a duplication of existing efforts of each agency maintaining its own database. Rather, the GWMP recommendation is to establish a listing of the available data and contacts on where the data can be obtained. Much of this data is already compiled by state and federal agencies and is readily available online. Listings of the online sources that are relevant to this GWMP are provided in Table 9-1. The mechanism for maintaining this listing is planned to be worked out through the SAG after the adoption of this GWMP update.

In addition, multiple governmental agencies and water purveyors perform regulatory oversight or develop water-resources plans in the TVS Basin and surrounding area. Data sharing between these different groups is recommended to ensure that groundwater management and water quality protection are integrated into the efforts of all the various agencies.

Appendix F includes a preliminary table that was developed during the SAG meetings as an example of how the data sharing could be documented and shared. It is anticipated that this table, or a variation developed subsequently, would be updated by the agencies and purveyors as a mechanism to inform all stakeholders in the area on available data, plans and programs that are related to groundwater management.

Convene an Ongoing SAG

The 2014 SAG made evident the groundwater protection opportunities made possible by the existence of such a group including:

- Improved information sharing on groundwater contamination sites that may impair water supplies
- Improved information sharing on groundwater cleanup activities
- Improved regulatory inspections with site information relevant to groundwater protection (e.g., dry wells, infiltration features, small community water wells and private wells)
- Enhanced investigation and cleanup of PCE contaminated groundwater impairing water supplies, and
- Enhanced investigation and cleanup of MtBE contaminated groundwater impairing water supplies.

The District will convene a new advisory group to facilitate collaboration in the implementation of this updated GWMP.

Formation of SAG

The current SAG was convened to provide input in the development of this GWMP update. The new SAG will be formed after adoption of the updated GWMP. The new SAG is recommended to be conducted in a similar manner that will meet on a regular, ongoing basis in order to provide a forum to discuss and propose actions for sustainable groundwater management. It is anticipated the procedures for running the SAG will be further developed and will evolve over time.

SAG Formation

The composition of the new SAG is anticipated to be similar to the GWMP SAG. All SAG members for the 2014 GWMP update will be asked to participate. In addition, other groups including the LTBMU will be asked to join the ongoing SAG. The proposed participants on the SAG should represent the key categories of local stakeholder including local water purveyors, agencies and ratepayer representatives. In addition to the District, private water companies including LBWC, Tahoe Keys and LMWC would be invited to join the SAG because of their vested interest in groundwater issues. Local agency representatives from the LTBMU, LRWQCB, TRPA, El Dorado County, and the CSLT would be invited to join to provide their insight on groundwater issues. Efforts would be taken to identify and encourage participation from different types of rate payers including real property owners, business owner, and non-business community members. It is anticipated that the composition of the SAG would change over time, but maintaining participation of the three primary groups (water purveyors, local agencies and rate payers) is considered essential to the long-term success of the SAG.

The SAG meetings would initially be planned to be conducted twice per year, in April and September. The SAG may decide to maintain this schedule or modify it after the first year. The meetings would be open to the public. Meeting times and locations would be announced through the District web page.

Following adoption of the updated GWMP, the District intends to further modify the GWMP as the basis for its Groundwater Sustainability Plan (GSP) and serve as the GSA for the TVS Basin. As such, the District will take the lead on organizing and running the SAG meetings. An agenda would be posted for each meeting. The meeting would initially consist of a brief update by the District and selected members on relevant groundwater issues. Other topics would be listed and presenters would be notified beforehand to allow time to prepare for the meeting. An open discussion period would be provided to let all members to bring up items for discussion not on the agenda. A public comment period would be provided to allow for input from non-member attendees on groundwater related issues. Action items would be recorded. These may include formation of Technical Subcommittees to further assess specific issues that would report back to the SAG in a future meeting. Meetings would conclude with identifying topics of discussion for future meetings and scheduling the date of the next meeting.

Potential Future SAG Topics

The purpose of the SAG is to provide is to provide a forum to facilitate the discussion of groundwater related issues and sharing of information between water districts, land use planning agencies, regulatory agencies, businesses and the public. The 2015 session will begin with an overview of issues and the recommendations of this GWMP.

The SAG will provide a forum for working out this coordination and sharing ideas about how to enhance groundwater protection and achieve groundwater sustainability. The anticipated topics for the 2015 SAG is continued discussion on how to improve interagency collaboration for groundwater management and water quality protection as discussed in Section 7.3.

In the future, the SAG may be called upon to provide input for recommending actions if the measurable goals for BMOs discussed in Section 8, especially regarding groundwater levels and water quality, are not met. The SAG may provide support for an agreed upon course of action to demonstrate regional support, if found to be warranted.