



State of the Basin Report

Middle Amargosa Valley Groundwater
Basin, Inyo County, California

February 17, 2026

Prepared for:
American Bird Conservancy

Prepared by:
Roux Associates, Inc.
555 12th Street, Suite 250
Oakland, California 94607

Table of Contents

Executive Summary	iv
1. Background	1
1.1 Current Scope of Work	1
1.1.1 Spring, Groundwater-level and River Monitoring	2
1.1.2 Replacement of Groundwater-Level Monitoring Instrumentation	2
1.1.3 Groundwater Numerical Modeling	2
1.1.4 Data Assessment and Reporting	3
1.2 Location and Physiographic Setting	3
1.3 Climate	6
1.3.1 Climate Change in the Amargosa Basin	6
1.4 Land Use	6
1.4.1 Water Rights	6
1.4.1.1 Devil's Hole & Ash Meadows	7
1.5 Groundwater Management	9
1.6 Sources of Information	10
1.6.1 Previous Studies	10
1.6.1.1 Death Valley 3 (DV3) Model	11
2. Current Field & Laboratory Methods	13
2.1 Spring Discharge, Groundwater Level, and River Surface Flow Monitoring	18
2.2 Spring Discharge Monitoring	18
2.3 Groundwater Level Monitoring	20
2.4 Amargosa River Flow Monitoring	20
2.5 Water Chemistry – State of the Basin Studies (2015, 2018, 2020)	22
3. Amargosa Wild & Scenic River – Conceptual Model	27
3.1 Regional Setting and Geologic Conditions	27
3.2 Hydrogeologic Units	28
3.2.1 Valley Fill	28
3.2.2 Volcanic Rocks	28
3.2.3 Bedrock Units	28
3.3 Geologic Structure	29
3.4 Surface Water	31
3.5 Groundwater System	32
3.5.1 Aquifer Characteristics	35
3.5.2 Regional Groundwater Inflow and Outflow	35
3.6 Springs	38
3.6.1 Amargosa Canyon Springs	40
3.6.2 Borax Spring	40
3.6.3 The Borehole (aka Borehole Spring)	40
3.6.4 Chappo Spring	41
3.6.5 Christian Spring	42
3.6.6 Dodge City Spring	42
3.6.7 Homestead Spring	42
3.6.8 Stormy Spring	42

3.6.9 Tecopa Hot Springs.....	43
3.6.10 Thom Spring.....	43
3.6.11 Vole Spring	43
3.6.12 West-side Spring.....	44
3.6.13 Willow Creek	44
3.6.14 Trends	45
3.7 Groundwater Quality.....	45
3.8 Groundwater Discussion	45
3.9 Groundwater Trends.....	47
3.10 California and Nevada Future Water Use.....	48
4. Recommendations	50
4.1 Water Management	51
4.1.1 Monitoring	51
4.1.2 Considerations	51
4.1.3 Tamarisk.....	51
4.2 Science	52
4.2.1 Monitoring / River Monitoring Alternative	54
4.2.2 Groundwater Modeling.....	55
5. References.....	56

Tables

1. Amargosa River Basin Spring List
2. Depth to Water Measurements
3. Mean Annual Flow – Amargosa River
4. Summary of Pumping – Amargosa Valey
5. Summary of Pumping – Pahrump Valley

Figures *(in-text)*

1. Amargosa River Basin Watershed Location
2. Nevada Hydrographic Basins
3. California Groundwater Basins
4. Ash Meadows NWR Location Map
5. Spring Monitoring Locations
6. Groundwater Monitoring Locations
7. Amargosa River Hydrographs
8. Regional Geochemical Piper Plots
9. Regional Stable Isotope Plots

10. Arsenic and pH Relationships for the Middle Amargosa Valley Groundwater Basin
11. Regional Geologic Map
12. Geology of the Shoshone-Tecopa Area
13. Extent of Death Valley Regional Flow System
14. Geology of the Chicago Valley Area
15. Paths for Regional Groundwater Flow
16. Amargosa Valley Pumping History
17. Pahrump Valley Pumping History
18. Borehole Discharge Data

Appendices

- A. Catalog of Springs
- B. Roux Review of Death Valley Regional Flow System Model 3
- C. Cal-Adapt Climate Change Summary Report
- D. Water Right Summary – California
- E. Water Right Summary – Nevada
- F. Well Data Sheets
- G. Conceptual Cross-Sections
- H. Spring Parameter Trends
- I. Well Hydrographs
- J. Roux Technical Memorandum – Beatty Area
- K. Roux Technical Memorandum – Ash Meadows Hydrogeological Analysis
- L. References

Executive Summary

This 2025 State of the Basin Report (SOBR) was prepared by Roux Associates, Inc. (Roux) on behalf of the American Bird Conservancy (ABC) as part of a much larger effort that is being conducted between ABC, the Amargosa Conservancy (AC), California Botanical Garden, River Partners, and the University of California, Davis (UCD) under a grant from the California Wildlife Conservation Board (WCB). This report focuses on conditions in the Middle Amargosa Valley Groundwater Basin (California Department of Water Resources [DWR] groundwater basin #6-20). Despite that focus, descriptions of conditions and issues in surrounding basins that may affect the Middle Amargosa Valley Groundwater Basin are also described.

This report also describes field activities, and analyses inclusive of monitoring since Fall 2020 (the year in which the last SOBR was developed), numerical groundwater modeling and other activities that have been conducted between 2020 and 2024 with funding from the Inyo County Planning Department, Amargosa Conservancy, California Department of Fish and Wildlife, The Nature Conservancy (TNC), Center for Biological Diversity (CBD), and others. The goals of the hydrogeologic work to date in the Middle Amargosa Valley Groundwater Basin are to improve the understanding of the water that sustains the Amargosa River and desert ecosystems that flourish along the river, inclusive of adjoining springs, and to provide the knowledge necessary to identify and avert impacts to those water sources.

The purpose of the current scope of work is to improve our understanding of the groundwater flow paths to the Amargosa River and surrounding springs, and to continue to develop baseline spring, river flow and groundwater-level monitoring, update and improve upon the southern Death Valley portion of the United States Geological Survey (USGS) developed Death Valley Regional Flow System Model (DV3), to prepare a current SOBR, and to draft another SOBR at the end of the project during the first quarter of 2028.

In 2009, the Amargosa River between Shoshone, California, and the terminus of the Amargosa Canyon received Wild and Scenic status through an act of Congress. As a result, the Bureau of Land Management (BLM) is charged with developing a management plan for the Wild and Scenic portion of the Amargosa River. It is essential that hydrogeologic characterization of the California portion of the basin take place for that management plan, and its associated management recommendations, to have firm basis, and to assure that monitoring is conducted in a meaningful way to identify potential impacts to the river and its feeder springs before potential irreversible impacts from future development occur, or if occurring, accelerate.

Except for domestic wells in the Tecopa Heights area, the Shoshone-Tecopa area derives its domestic and municipal water supplies from springs. Shoshone Spring is the source of water for the Village of Shoshone. Tecopa Hot Springs provides a recreational opportunity that is the economic hub of Tecopa. Additionally, China Ranch Date Farm obtains its irrigation water from spring-fed Willow Creek.

Many of the springs that feed the Amargosa River are relatively small springs that individually are not significant components to the overall area water budget. Additionally, other small springs and watering holes are present away from the Amargosa River. Nonetheless, these springs, regardless of size and/or location, are important ecological resources. This SOBR provides up to date hydrologic information and a current real-time snapshot of water resource conditions in the Middle Amargosa Valley Groundwater Basin area.

Springs and watering holes such as those identified in this SOBR are frequently overlooked in hydrologic investigations since their discharges are frequently inconsequential to the overall water budget of the area being studied. This is unfortunate as these sensitive receptors are critically important resources for

vegetation, and wildlife (both resident and migratory). It is essential that baseline hydrologic characterization of the region take place for future land and water resource management to have a firm basis.

Prior to the initial reconnaissance work conducted by Source Group, Inc. (SGI) from 2010 through 2011 (SGI, 2011), regional hydrogeologic investigations in the Middle Amargosa Valley Groundwater Basin had been virtually non-existent. Therefore, to build a better understanding of the Middle Amargosa Valley Groundwater Basin, the objectives of the 2020 SOBR, current SOBR, and future SOBR were/are to:

- Conduct new groundwater geochemical analyses to evaluate potential groundwater flow paths;
- Enhance previous reconnaissance-level information on the springs of the southern half of the Amargosa Basin, generally between Death Valley Junction and Saratoga Spring;
- Continue to develop an understanding of Amargosa River conditions in the Middle Amargosa Valley Groundwater Basin;
- Describe the results of groundwater-level monitoring;
- Describe the on-going efforts to update and improve the hydrogeologic predictive tools that can provide analyses that assist land managers in decision-making; and
- Continue to enhance the conceptual model of the Middle Amargosa Valley Groundwater Basin.

1. Background

An understanding of the complexity around the Middle Amargosa Valley Groundwater Basin (California Department of Water [DWR] Resources groundwater basin #6-20) is a work in progress. Which is driven by multiple faulting regimes overprinted on the terminus of a carbonate rock regional aquifer system that extends upgradient into Nevada. Through investigations that have led to the “State of the Basin Report” series, publications by the United States Geological Survey (USGS), and peer-reviewed published journal articles developed by the project team (e.g., Zdon, Davisson and Love, 2015), aspects of Amargosa groundwater knowledge that had been accepted wisdom have been found to be incorrect (e.g., flowpath directions) or more complex (such as spring sourcing)..

New understanding has been developed through a series of projects funded by California Department of Water Resources (through Proposition 84 funding); California Department of Fish and Wildlife (for Amargosa vole related activities); Inyo County Planning Department (for Yucca Mountain related work and monitoring); and non-profit organizations such as the Amargosa Conservancy (AC) and The Nature Conservancy (TNC). This work has provided substantial benefits and has not only been relied upon by California land management stakeholders, but also by the State of Nevada’s Department of Water Resources, which in this bi-state basin, is critical.

Currently, groundwater and spring monitoring, modeling activities, and the development of this report is being conducted under funding through a California Wildlife Conservation Board (WCB) grant. The work described in this SOBR , inclusive of tasks under the current WCB grant, contributes blocks of essential information and provide maintenance of existing monitoring infrastructure that will influence how well this river system is understood and managed. The need for this work is further highlighted in the AC’s 2020 State of the Basin Report (SOBR) - which is now out of date. At the time, the 2020SOBR presented and analyzed the current state of knowledge of the area’s hydrology and outlined the critical need to extend this knowledge base.

Beyond additional data collection, a numerical groundwater model (Death Valley 3 [DV3] Groundwater Model) for the regional flow system, which includes the Middle Amargosa Valley Groundwater Basin, was developed by the USGS. Unfortunately, during its development, the data set existing for the California portion of the Amargosa Basin in the Shoshone-Tecopa area was not included. As a result, the model, which is relied upon by Federal and State managers, has calibration problems in the Shoshone-Tecopa area that limit the reliability of predictive water management scenarios for that area. The current scope of work corrects this issue and provides a tool for evaluating long-term effects on the groundwater-dependent Amargosa River ecosystems resulting from various water resource management issues facing the basin.

1.1 Current Scope of Work

The current scope of work included for this updated SOBR are the following tasks:

- Comprehensive monitoring of springs, groundwater levels, and river flow;
- Replacement of groundwater-level monitoring instrumentation in the existing Shoshone-Tecopa region groundwater-level monitoring network;
- Updating and recalibration of the Death Valley portion of the DV3 groundwater model developed by the USGS (Halford & Jackson, 2020); and
- Data analysis and preparation of this SOBR and a follow-up SOBR in the first quarter of 2028.

1.1.1 Spring, Groundwater-level and River Monitoring

Spring discharge and related information as well as groundwater elevation and river flow measurements have been collected on a periodic basis from a select group of springs and wells within the Middle Amargosa Valley Groundwater Basin area since November 2010. During this timeframe, the USGS periodically conducted seepage run studies on the Amargosa River between Shoshone and Tecopa, California to the bottom of the Amargosa River Canyon. The results from the USGS seepage studies are described in their Conceptual Model Report for the area of the Amargosa Wild and Scenic River (AWSR) (Belcher, et.al., 2019). Basic water quality data (e.g. temperature, pH, conductivity) were also collected by the USGS at all discharge, elevation, and seepage run monitoring points.

For the current scope of work, spring monitoring has been conducted at the following locations: Shoshone Spring (including features such as Historic Spring, Phragmites Seep, and Red Seep), Borax Spring (well), the Borehole, Dodge City Spring, Thom Spring, Wild Bath Spring, Tecopa Hot Springs, Twelvemile Spring, Scofield Spring, Tule Spring, Crystal Spring, Horse Thief Spring, Wildhorse Springs (upper and lower), Willow Spring (creek), Cowboy Canyon Springs 1 through 4, Salt Creek Spring, and Amargosa Spring. Other springs occasionally monitored included Chappo Spring and Sheep Creek Spring. River monitoring was primarily focused on the Amargosa River at Dumont Road although the Amargosa River below Cowboy Canyon has recently been monitored as part of this program. Spring summaries for the springs within the Middle Amargosa Valley Groundwater Basin are presented in Appendix A.

1.1.2 Replacement of Groundwater-Level Monitoring Instrumentation

Replacement of transducer/data logger instrumentation in monitoring wells ARHS-01 through ARHS-10 (exclusive of ARHS-07 which does not exist) has been completed. Transducers have been set to measure groundwater levels at 4:00 PM and 4:00 AM daily.

1.1.3 Groundwater Numerical Modeling

The principal hydrogeologic predictive tool available in for the Middle Amargosa Valley Groundwater Basin is the DV3 groundwater model developed by the USGS (Halford & Jackson, 2020). The DV3 model is comprised of two model components, a steady state version (DV3-SS) and a predictive transient component (DV3-PRED) that provide a means for predicting the impacts of different pumping scenarios on natural spring and evapotranspiration discharges across the model domain. Linearizing the unconfined flow conceptual model and delineating the model into a steady-state condition and a transient model intended to simulate only changes in flow conditions, facilitates applications of the model that should be largely spared the numerical issues or long run times associated with similar multi-layer, regional groundwater models. The limited discharge capture conceptualization is novel and provides a convenient mechanism by which to directly constrain the model to specific discharge fluxes.

A review of the DV3 model was previously conducted by Roux (Roux, 2022) and is provided as Appendix B. That review identified areas of the model covering the Middle Amargosa Valley Groundwater Basin requiring additional work. These were due to long-term groundwater-level data sets from monitoring wells (ARHS-01 through ARHS-09) not being considered during calibration, and key areas of flow paths toward the AWSR that were inconsistent with data collected in the Middle Amargosa Valley Groundwater Basin over the past 15 years.

As part of the current scope of work under the California WCB grant, Roux is updating and recalibrating the Death Valley portion of DV3 model covering the Shoshone-Tecopa area and the AWSR. More detailed descriptions of this effort will be provided in the 2028 SOBR.

1.1.4 Data Assessment and Reporting

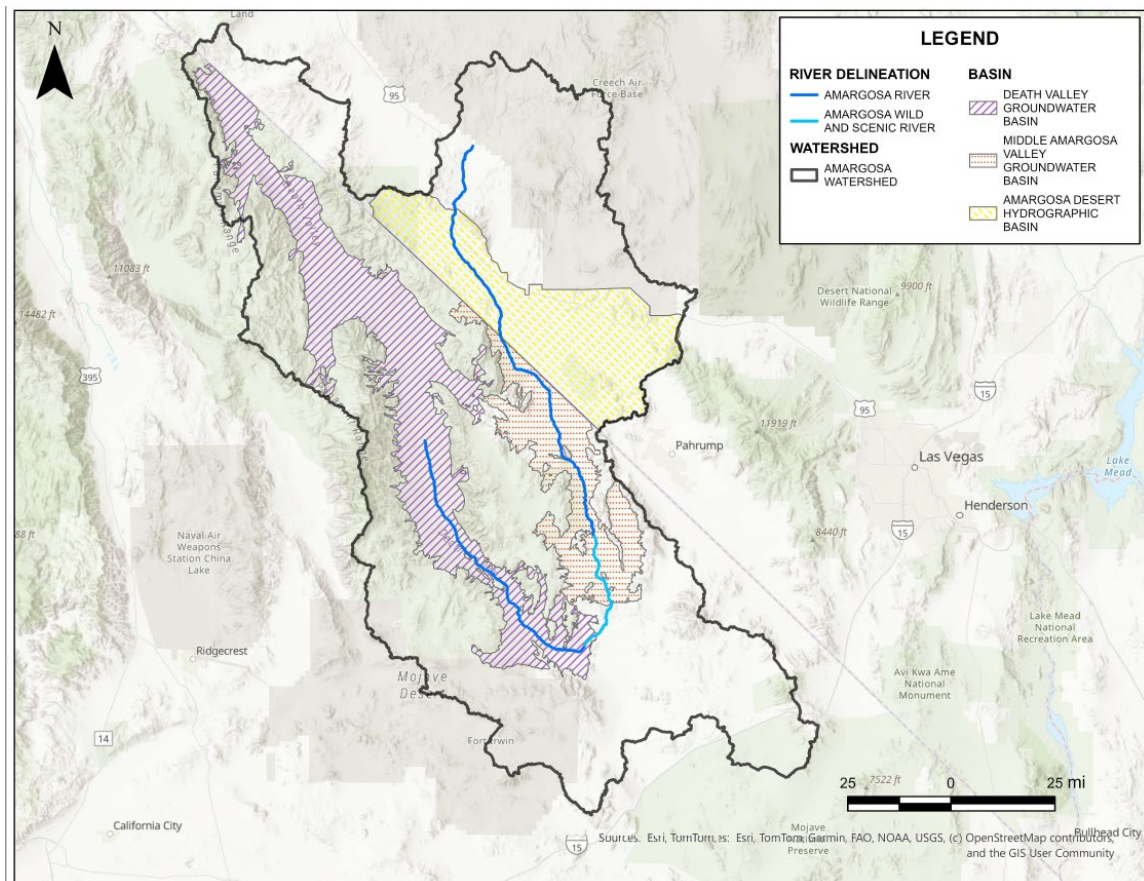
This task included the time required to analyze the data obtained from the wells, along with the newly collected monitoring data and other sources to be compiled in this updated SOBR. This included updating and expanding the existing “catalog of springs” provided in Appendix A. A subsequent SOBR will be prepared in 2028 that will incorporate all aspects of the current scope of work under the California WCB grant, as well as additional related information that becomes available during the next three years.

1.2 Location and Physiographic Setting

The Amargosa River Basin covers an area of 3,124 square miles in east-central California and west-central Nevada (Figure 1). The Amargosa River Basin is subdivided into three basin areas:

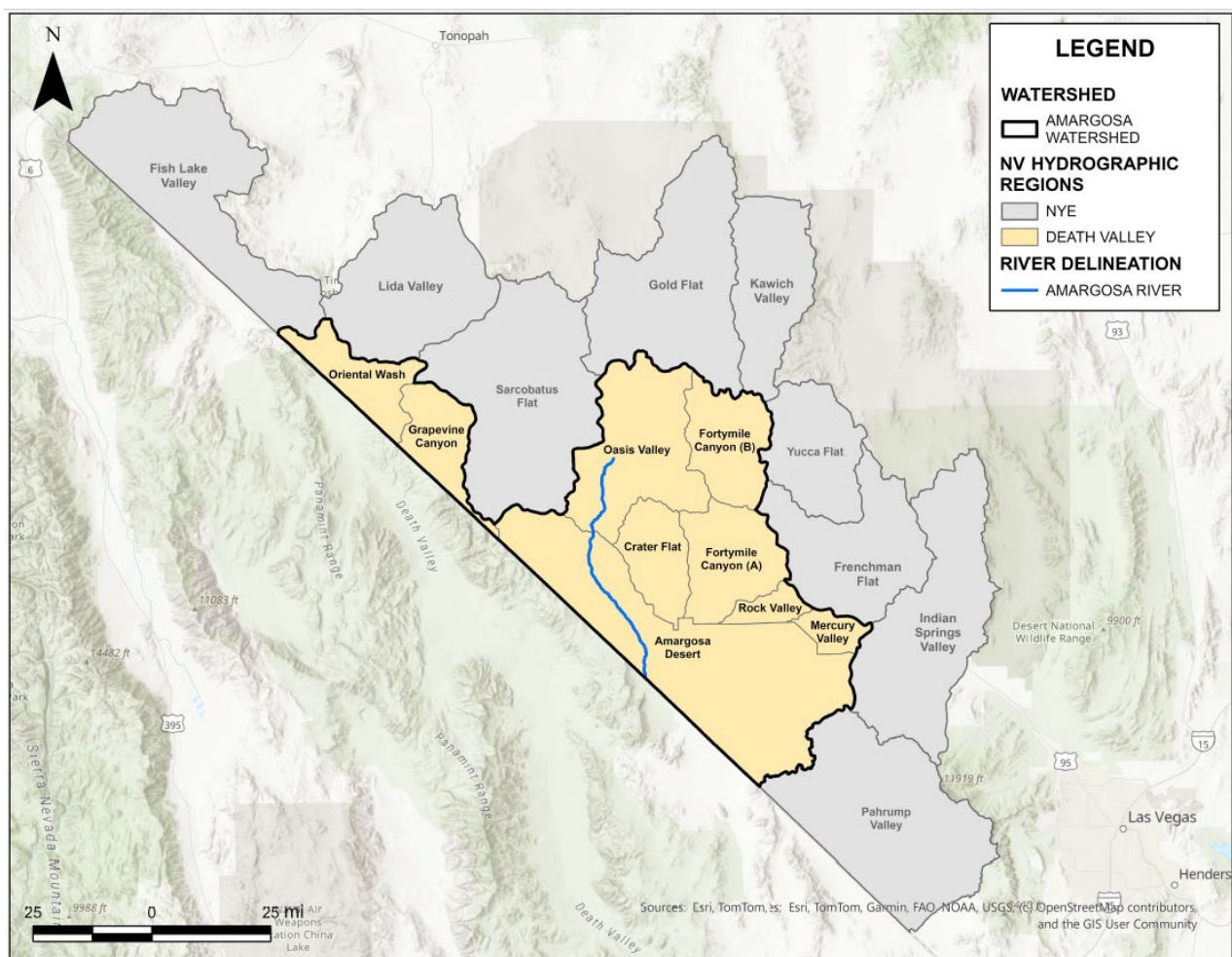
- Northern Amargosa Valley (Nevada);
- Middle Amargosa Valley Groundwater Basin (California); and,
- Death Valley Groundwater Basin (California-Nevada).

Figure 1. Amargosa River Basin Watershed Location



The Northern Amargosa Valley (generally comprising Nevada's hydrographic basins inclusive of Amargosa Desert Hydrographic Basin #14-230, Oasis Valley Hydrographic Basin #14-228, and other interconnected subdivisions) comprise the Amargosa River Valley from the river's headwaters northeast of Beatty, Nevada, to the California-Nevada state line (Figure 2). Elevations in this portion of the Amargosa River Basin range from 6,317 feet above mean sea level (ft msl) at Bare Mountain south of Beatty and east of the Amargosa River, to about 2,300 ft msl at the California-Nevada state line near Death Valley Junction, California. The basin is bounded by consolidated rocks of the Yucca Mountain/Pahute Mesa area to the northeast, Bare Mountain on the east, and the Funeral Range to the west. The Northern Amargosa River Basin as defined covers approximately 900 square miles.

Figure 2. Nevada Hydrographic Basins (Nevada Department of Conservation & Natural Resources, 2024)

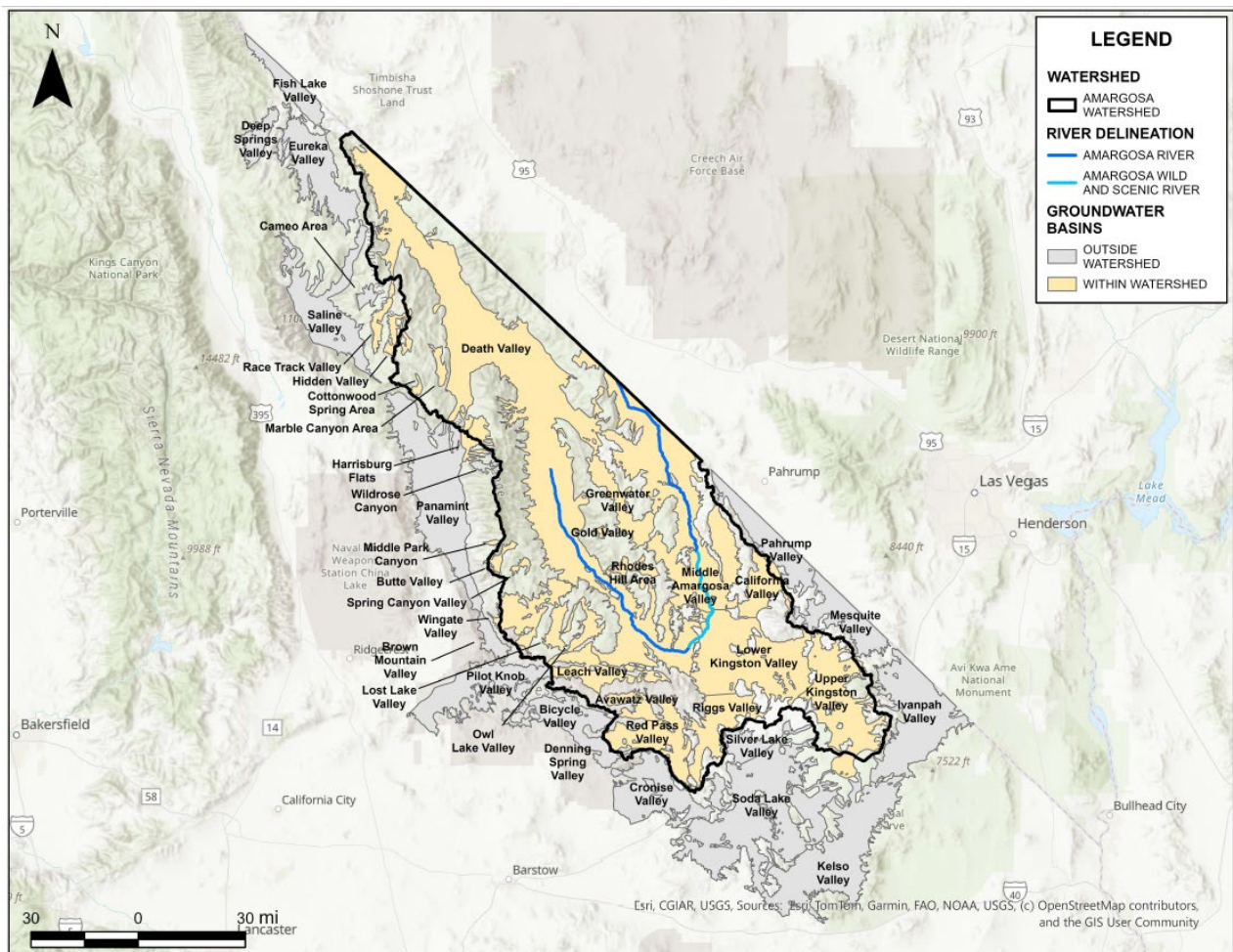


The Middle Amargosa Valley Groundwater Basin (Groundwater Basin #6-20 as designated by the California DWR) is comprised of the Amargosa River Valley along with Chicago Valley and parts of Greenwater Valley within Inyo and San Bernardino Counties, California (Figure 3). The California-Nevada state line is considered the northern boundary of the Middle Amargosa Valley Groundwater Basin. The elevation of the valley floor generally ranges from about 400 ft msl near Salt Creek in the southern portion of the basin to about 2,300 ft msl at the California-Nevada state line near Death Valley Junction. The basin is bounded by

consolidated rocks of the Resting Spring and Nopah Ranges on the east, the Dumont Hills on the south, and the Greenwater Range and Ibex, Black, and Funeral Mountains (collectively known as the Amargosa Range) on the west. The surrounding mountains range from 6,275 ft msl at Pyramid Peak, the high point of the Funeral Range to the northwest to 7,335 ft msl at Kingston Peak in the Kingston Range to the southeast. The Middle Amargosa Valley Groundwater Basin covers approximately 609 square miles. Although considered a separate groundwater basin, California Valley Groundwater Basin (California DWR Groundwater Basin #6-079), and the Lower and Upper Kingston Wash Groundwater Basins adjoin (California DWR Groundwater Basins #6-021 and #6-022, respectively) the Middle Amargosa Valley Groundwater Basin on the east.

The Death Valley Groundwater Basin (California DWR Groundwater Basin #6-18) is comprised of the Amargosa River Valley from the Salt Creek area to the sink at Badwater Basin in Death Valley, and northward to the northern physical terminus of Death Valley in Nevada (Oriental Wash Hydrographic Basin #14-232 [Figure 2] of the Death Valley Region [Hydrographic Region 14] as designated by the Nevada DWR). Elevations in this portion of the Amargosa Basin range from -282 ft msl at Badwater Basin to 11,049 ft msl at Telescope Peak, the high point of the Panamint Range along the west side of Death Valley. The combined area of the California and Nevada portions of this lower part of the Amargosa River Basin is 1,622 square miles.

Figure 3. California Groundwater Basins (California DWR, 2003)



1.3 Climate

The climate of the area is arid with low precipitation and high, mean annual temperatures and evaporation rates. Summer temperatures can exceed 120 degrees Fahrenheit (°F) while winter temperatures can fall below freezing. The average annual precipitation at Shoshone, California (at an elevation of 1,546 ft msl) is 4.79 inches based on a record from 1972 to 2011 (Calclim, 2025). The average maximum high temperature is 83.2°F and average minimum is 58.8°F. Mean monthly high temperatures range from 58.8°F in December to 108.7°F in July. Mean monthly low temperatures in Shoshone range from 38.0°F in December to 78.3°F in July. Temperatures decrease and precipitation increases in the surrounding mountains with increasing elevation.

1.3.1 Climate Change in the Amargosa Basin

The effects of climate change in California are assumed to result in warmer, higher intensity storms that produce more frequent flash flood runoff events, greater evapotranspiration (from both warmer temperatures and longer growing seasons), and reduced groundwater recharge resulting from these described phenomena. These changes are anticipated to be incremental in nature, but of sufficient significance to account for these future climate-related impacts in long-term groundwater management planning.

Roux applied the Cal-Adapt climate data tool (Cal-Adapt, 2025) to develop a Tecopa Hot Springs – Amargosa River Basin Local Climate Change Snapshot Report for the Middle Amargosa Valley Groundwater Basin area (Appendix C). The climate report is consistent with the observations above, with anticipated significant, average elevated temperature increases by the mid-century (2035 to 2064) of 4°F to 6°F and increases of 6°F to 9°F by the end of the century. The range of values is based on the use of either medium emissions or high emissions models. Although, predictions about precipitation in the Middle Amargosa Valley Groundwater Basin shows that it remains relatively constant over the next century. The effects of climate change on groundwater-dependent ecosystems in the Amargosa River Basin, inclusive of the AWSR, are discussed in Section 3 of this SOBR.

1.4 Land Use

The principal land uses (not including open space and wild lands) in the Middle Amargosa Valley Groundwater Basin are agricultural, recreational, wildlife, and domestic/municipal uses. With increasing regional development (including solar development, mining, and indications of future cannabis growing), use is expected to increase in the future. Agricultural and domestic water is supplied with groundwater from springs or private wells. Shoshone Spring provides water for the Village of Shoshone.. The Town of Beatty, Nevada to the north derives its water from groundwater wells and local springs; however, some residents rely solely on spring water alone. Sewage is treated by individual septic systems with the exceptions of Beatty, Nevada, Shoshone, California, and Tecopa, California where sewage systems are present serving some areas. Agricultural land use consists of crops such as alfalfa (Nevada) and to a much lesser extent dates (California). Recreational uses include bathing at Tecopa Hot Springs, the Borehole, and Wild Bath Spring.

1.4.1 Water Rights

Water right summaries for California and Nevada are provided in Appendices D and E, respectively. Additional discussion regarding permitted rights, water usage, and estimated recharge for the Amargosa Basin are provided in Section 3.0. In California, there has been no change in the status of water rights in the Middle Amargosa Valley Groundwater Basin since 2011. BLM has recorded water rights with the State of California

for most springs on BLM-managed lands, and there is one private water rights filed in Tecopa Hot Springs. It is important to recognize that, with respect to groundwater, California does not have a system of “groundwater rights” such as in Nevada. Groundwater rights are specified only in adjudicated groundwater basins of which the Middle Amargosa Valley Groundwater Basin is not. With respect to water rights in Nevada, changes in Nevada water rights for the Amargosa Desert Hydrographic Basin (Nevada Hydrographic Basin #230) during the past ten years (since 2014) were a net decrease of approximately 2,400 acre-feet per year (afy) in annual duty (underground). The current annual duty (underground) for the Amargosa Desert Hydrographic Basin is 24,663.03 afy. Of note is the perennial yield of the Amargosa Desert Hydrographic Basin system inclusive of the Oasis Valley, Crater Flat, and other sub-basins is 24,000 afy. Underground active water rights in Amargosa Desert Hydrographic Basin system is 26,564 afy.

Changes in water rights for the Pahrump Valley Hydrographic Basin (Nevada Hydrographic Basin #162) during the past ten years were a net increase of approximately 124 afy in annual duty (underground). The current annual duty (underground) for Pahrump Valley Hydrographic Basin is 60,232.75 afy. Of note is the perennial yield of Pahrump Valley Hydrographic Basin is 20,000 afy.

A new development in the Amargosa Desert Hydrographic Basin and related subdivisions of the Amargosa River Basin is an increase in applications for mining-related uses. Up to seven proposed open-pit gold mining operations are in the Oasis Valley, Sarcobatus Flat, and Crater Flat Hydrographic Basins of the Nevada portion of the Amargosa River Basin. The full extent of what future appropriations for mining will look like in the area are unclear at this time. However, an analysis of anticipated groundwater impacts of the proposed North Bullfrog Mine north of Beatty, Nevada indicates that up to ten feet of drawdown could occur at groundwater-dependent features (e.g. springs in Springdale, Nevada) because of potential project pumping. Drawdowns from other groundwater extractions for other proposed operations would be additive to that drawdown.

Another area of potential groundwater extraction has been proposed lithium mining in the Amargosa Basin A minerals withdrawal area has been proposed on over 300,000 acres in the Ash Meadows NWR area; however, that is still in the regulatory process and has yet to be finalized. The full effect of that withdrawal on water rights (if any) is unclear currently.

1.4.1.1 Devil's Hole & Ash Meadows

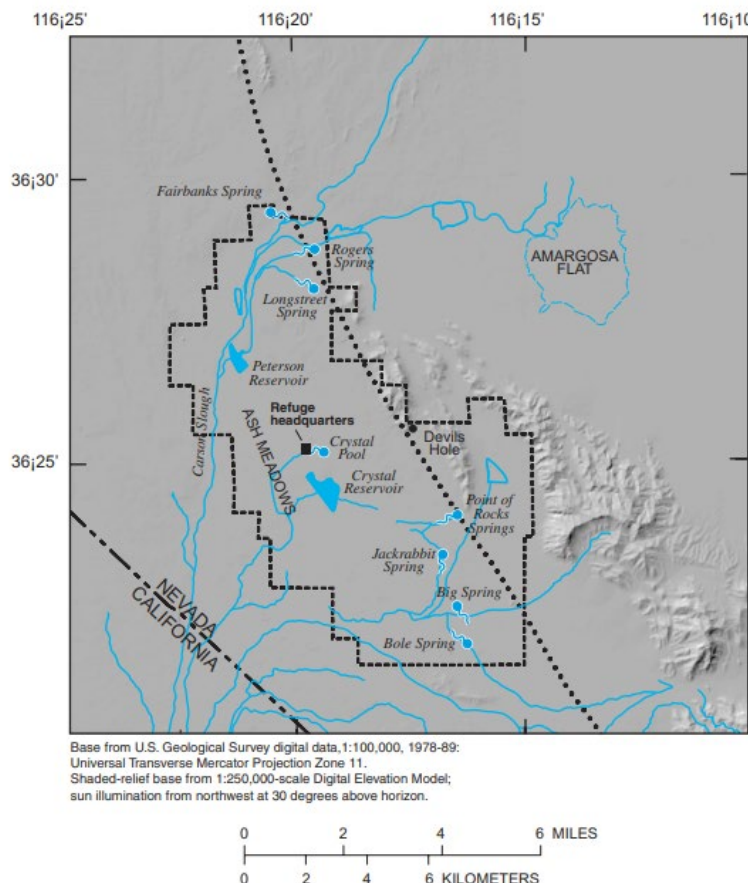
Ash Meadows NWR and the Devil's Hole Unit of Death Valley National Park are within the Amargosa Desert Hydrographic Basin in Nye County, Nevada (Figure 3). The Ash Meadows NWR is noted as a groundwater discharge location in the Amargosa Desert Hydrographic Basin, within the Death Valley Regional Flow System, with numerous large springs and sensitive habitat for desert pupfish and numerous other Endangered Species Act (ESA) listed wildlife and plant species. Flow from the large springs in the Ash Meadows NWR is derived from the carbonate rock aquifer of the Death Valley Regional Flow System. Discharge from the carbonate rock aquifer in the Ash Meadows area occurs both directly, via spring discharges, and indirectly, via the shallow basin-fill aquifer, which in turn contributes to spring discharges. In other words, the shallow and deep aquifers in this region are hydrologically connected and contributes flow to surface springs in the Ash Meadows NWR.

In 2008, Nevada State Engineer issued Order #1197 concerning applications to appropriate additional groundwater from the Devil's Hole area. This order stated that:

"...with the following exceptions, any applications to appropriate additional underground water and any application to change the point of diversion of an existing ground-water right to a point of diversion closer to Devil's Hole, described as being with a 25-mile radius from Devil's Hole within the Amargosa Desert Hydrographic Basin, will be denied:

- *Any application within the described area that seeks to change an existing point of diversion closer to Devil's Hole but remains within its existing place of use and is no more than half mile from its original point of diversion;*
- *Those applications filed which seek to appropriate 2.0 acre-feet per year or less, may be considered and shall be processed according to Nevada Revised Statutes (NRS) 533 and 534;*
- *For projects that require change of multiple existing rights the State Engineer may compare the net impact to Devil's Hole of the proposed changes to the impacts to Devil's Hole of the base rights. If the net impact of the proposed changes is the same or less than its base right impacts, as determined by the State Engineer, such change applications may be considered and shall be processed subject to NRS 533 and 534. In no such case shall new points of diversion be allowed within ten (10) miles of Devil's Hole;*
- *Those applications for environmental permits filed pursuant to NRS 533.437 and 533.4377, inclusive; and,*
- *Those applications filed pursuant to NRS 533.571."*

Figure 3. Ash Meadows NWR Location Map (Lacznia et. al., 1999)



For point of reference, NRS 533 and 534 are the chapters of the Nevada water law that pertain to adjudication of vested water rights/appropriation of public water and underground water and wells, respectively. Environmental permits referenced in NRS 533.437 and 533.4377 are temporary permits for wells used for avoidance of groundwater contamination (e.g. remediation wells).

In 2022, the Nevada State Engineer issued Interim Order #1330 which amended the procedures for review of applications to appropriate or change existing rights for groundwater in the Amargosa Desert Hydrographic Basin. Order 1130 vacated the previous Order #1197A. It further ordered that:

- Any applications to appropriate additional underground water in the Amargosa Desert will be denied, and applications to change the points of diversion of existing underground rights within Amargosa Desert will be processed subject to NRS Chapters 533 and 534.
- Change applications will be evaluated utilizing the USGS Death Valley Regional Flow System numerical groundwater model, to determine if there will be no net increase in water level decline at Devil's Hole over a subsequent fifty-year period (and that the State Engineer may supplement that analysis and require additional information to assure application change does not cause increased impacts to Devil's Hole).

A discussion of recent conditions and groundwater-related issues in the Ash Meadows NWR Refuge are presented in Section 4.0.

1.5 Groundwater Management

The Middle Amargosa Groundwater Basin is not within the boundary of a Groundwater Sustainability Agency under the Sustainable Groundwater Management Act (SGMA). The Middle Amargosa Valley Groundwater Basin has a very low SGMA priority ranking. Of note is that the California DWR Bulletin 118 (California DWR, 2025) description of the Middle Amargosa Valley Groundwater Basin is obsolete and does not present existing conditions in an accurate manner. Additional discussion related to this issue is presented later in Section 3.0 of this SOBR.

The California State Water Resources Control Board regulates groundwater quality issues in the California portion of the Amargosa River Basin – Lahontan Region (CRWQCB-Lahontan). Within the Inyo County, California portion of the Amargosa River Basin, the county conducts water-related activities such as issuing well permits through the Inyo County Environmental Health Department, and water-quality functions such as monitoring groundwater conditions and quality at the Shoshone landfill through the Inyo County Waste Management Department (most recent groundwater monitoring was conducted during October 2025). Other community planning and environmental review activities are conducted through the Inyo County Planning Department. Currently, there is little to no development in the San Bernardino County portion of the Amargosa River Basin; however, similar departments as those for Inyo County exist for San Bernardino County should development occur in the future.

In Nevada, the Nevada DWR manages Nevada's water resources through the appropriation and reallocation of the public waters. In addition, the Nevada DWR is responsible for quantifying existing water rights; monitoring water use; distributing water in accordance with court decrees; licensing and regulating well drillers and water rights surveyors; reviewing flood control projects; monitoring water resource data and records; and providing technical assistance to the public and governmental agencies. The Nevada State Engineer determines the limit and extent of water rights and establishes conditions regarding those rights. The Nevada Department of Environmental Protection manages Nevada's stormwater pollution program.

Within Nye County, Nevada, the Nye County Water District was established in 2007 to develop sustainable water development planning, characterize the groundwater resource, and to evaluate and mitigate impacts caused by groundwater use. Nye County's Water Resource Plan (Buqo, 2004) provides guidance for ensuring adequate supplies of water remain available for Nye County for the benefit of the county's residents and environment.

For federal lands, Death Valley National Park oversees water-related issues (i.e., surface water, groundwater, and groundwater dependent ecosystems) within the Death Valley National Park inclusive of the Devil's Hole section of the park in Nevada. Currently, Death Valley National Park staff monitor selected springs (e.g. Saratoga Spring and Devil's Hole) throughout the park. Likewise, the BLM oversees water-related issues on BLM-managed lands. As part of those responsibilities, BLM is also charged with developing a management plan for the Wild and Scenic portion of the Amargosa River.

1.6 Sources of Information

Information gathered by Roux and used in this report were from the archives and reports by the USGS, Nevada DWR, CRWQCB-Lahontan Region, Nye County Water District, Nevada Bureau of Mines and Geology, AC, Death Valley National Park, BLM, California Department of Water Resources, and groundwater level and spring data collected by Roux and others.

1.6.1 Previous Studies

Additionally, a number of previous reports have been published on groundwater geochemistry and isotope abundances in southern Nevada and southeastern California. Notable reports relevant to the Amargosa River area include those of Winograd and Thordarson (1975), Thomas et al. (1996), Davisson et al. (1999), and Larsen et al. (2001). Additional studies that include related data can be found in Thomas et al. (2003) and Hurst (2012). The following paragraphs provide summaries for context of the various research projects over time. *Of note is that conclusions drawn from each of the studies may not be accepted today due to long-term groundwater and spring monitoring efforts, geochemical investigations, numerical modeling results and other more current research.*

Winograd and Thordarson (1975) developed one of the early frameworks for groundwater flow in southern Nevada related to the Nevada Test Site, and that included extensive discussion of the Ash Meadows springs discharge area. Based on earlier work, they also summarized the types of groundwater hydrochemistry that showed calcium magnesium bicarbonate groundwater associated with both the carbonate rock of the Spring Mountains and adjacent Pahrump Valley. In contrast, sodium potassium bicarbonate groundwater drains the largely volcanic rock areas south of the Nevada Test Site (e.g., Oasis Valley and Jackass Flats). Ash Meadows spring discharge consequently has calcium magnesium sodium bicarbonate water that Winograd and Thordarson inferred as a mixture of recharge of the two latter water types.

Thomas et al. (1996) also compiled and summarized groundwater chemistry types as well as isotope abundances in areas that included groundwater throughout southern Nevada and southeastern California with a focus on the regional carbonate aquifers. They concluded from isotope results that the calcium magnesium sodium bicarbonate water discharging from Ash Meadows springs comprised 60 percent Spring Mountains recharge and 40 percent from Pahrump Valley to the east. They also argue from radiocarbon data that groundwater velocities ranged from 10 to 144 feet per year.

Davisson et al. (1999) showed that radiocarbon was not a reliable method for age dating groundwater in the regional carbonate aquifer due to continual isotope exchange reactions combined with mixing of local recharge sources during long-range transport. They further showed that stable isotopes of oxygen-18 and deuterium measured in southern Nevada groundwater had been previously evaporated during its original recharge as melted snow in central Nevada (Rose et al., 1999). By applying a methodology that removed the effects of evaporation on oxygen-18 and deuterium they showed a systematic decrease in their abundances with increasing latitude and local elevation throughout southern Nevada, a result inconsistent with previous studies purporting Pleistocene age groundwater recharge during the last glacial period (Claassen et al., 1986).

Larsen et al. (2001) studied the water quality and stable isotope abundances of groundwater in the Tecopa and Death Valley regions of the Amargosa River and related them to groundwater of southern Nevada to delineate potential recharge sources. They recognized three water types comprising a Spring Mountains recharge source, a deep regional groundwater derived from fracture flow of southern Nevada, and groundwater derived from basin-filled groundwater of the Amargosa River Basin as a whole.

Additional studies providing a greater variety of isotope measurement types have been reported by Thomas et al. (2003a) and Hurst (2012). Thomas et al. (2003a) focused specifically on Oasis Valley Hydrographic Basin and its hydraulic connection to Pahute Mesa, showing that Oasis Valley groundwater is replenished by groundwater flow through Pahute Mesa that was derived further north. The Oasis Valley groundwater ultimately replenishes the Amargosa Desert Hydrographic Basin fill aquifers. Hurst (2012) specifically focused on tritium, oxygen-18, deuterium, strontium isotopes, and uranium isotopes in regions along the Amargosa River. He showed that spring samples are tritium absent, the oxygen-18 and deuterium show only limited evaporation, and that strontium and uranium isotopes show mixing along the entire length of the Amargosa River.

Lastly, one study reported by Thomas et al. (2003b) measured dissolved noble gases in the regional carbonate aquifer of southern Nevada. They showed that noble gas abundances that are typically incorporated in recharging groundwater and reflect the local recharge temperature were systematically lost during long-range transport from Pahrnagat Valley in east-central Nevada towards Ash Meadows at its terminal discharge point. They concluded this loss of dissolved gas was due to fault barriers and cavities in the regional carbonate aquifer that forces groundwater to migrate upward and encounter gas loss in air pockets. This subsequently masked the calculated recharge temperatures derived from the noble gases.

1.6.1.1 Death Valley 3 (DV3) Model

The following text is derived from a technical memorandum prepared by Roux (2022) on behalf of the County of Inyo describing the DV3 Model and providing a review of the model which was submitted by the County of Inyo to the Nevada State Engineer's Order Interim Order #1330. Order #1330 indicates that,

"...any applications to appropriate additional underground water within Amargosa Desert will be denied, and applications that seek to change the points of diversion of existing underground rights within Amargosa Desert will be processed subject to NRS Chapters 533 and 534. Change applications will be evaluated by utilizing the USGS Death Valley Regional Flow System numerical groundwater model, to determine if there will be no net increase in water level decline at Devils Hole over a subsequent fifty-year period. The State Engineer, in his discretion, may conduct additional analysis and require additional information to assure that any application to change an existing right does not result in an increased impact to the water level at Devils Hole."

The full technical memorandum is provided in Appendix B. As noted in the technical memorandum, the model components provide a means for predicting the impacts of different pumping scenarios on natural spring and evapotranspirative discharges across the model domain. Linearizing the unconfined flow conceptual model and delineating the model into a steady-state condition and a transient model intended to simulate only changes in flow conditions, facilitates applications of the model that should be largely spared the numerical issues or long run times associated with similar multi-layer, regional groundwater models. The limited discharge capture conceptualization is novel and provides a convenient mechanism by which to directly constrain the model to specific discharge fluxes.

An issue with the DV3 Model is that the groundwater level data from the nine groundwater monitoring wells in the Middle Amargosa Basin were not used as calibration points. The use of incomplete data sets for calibration and validation, along with simulated flow paths that may not be consistent with observational data in some areas, were recommended as areas needing refinements which are being developed as part of the current scope of work under the WCB grant.

Despite these areas of needed further work (e.g., underestimation of north to south flow toward Shoshone, generally less groundwater movement toward the Amargosa Wild & Scenic River than indicated by groundwater-dependent ecosystems and other groundwater-balance aspects) the model currently provides the most robust tool for evaluating groundwater changes in the Amargosa Desert area and associated effects on Devil's Hole. Prior to using the model for evaluating hydrologic changes in the Shoshone-Tecopa area (California) additional work to refine the model as it represents the southern portion of the flow system should be conducted. Additionally, if the Nevada State Engineer anticipates the use of the model for purposes beyond that of the interim order and Devil's Hole, the anticipated uses, and types of questions that are desired to be answered should be defined to determine the model's utility for answering those questions.

2. Current Field & Laboratory Methods

The field activities performed during this project were designed following the previous reconnaissance and cataloging of the known springs and wells in and beyond the Middle Amargosa Valley Groundwater Basin, an area encompassing 1,000 square miles. The results of the initial reconnaissance published in the 2011 SOBR (SGI, 2011) and subsequent SOBRs (2014 by Andy Zdon & Associates, 2020 SOBR by Partner), were used as the foundation for the design and implementation of more detailed hydrogeologic investigations. Additionally, methodologies for describing spring conditions developed by others (Sada & Pohlmann, 2002; Sky Island Alliance, 2012) formed the basis for our field observations.

Periodic monitoring in the Middle Amargosa Valley Groundwater Basin has typically been conducted one to three times per year based on funding availability. Three monitoring events per year has been the goal for monitoring in the area, and the current scope of work provides funding for nine monitoring events through the first quarter of 2028. The locations of all points monitored or reconnoitered during this work are shown on Figures 5 and 6

Figure 5. Spring Monitoring Locations

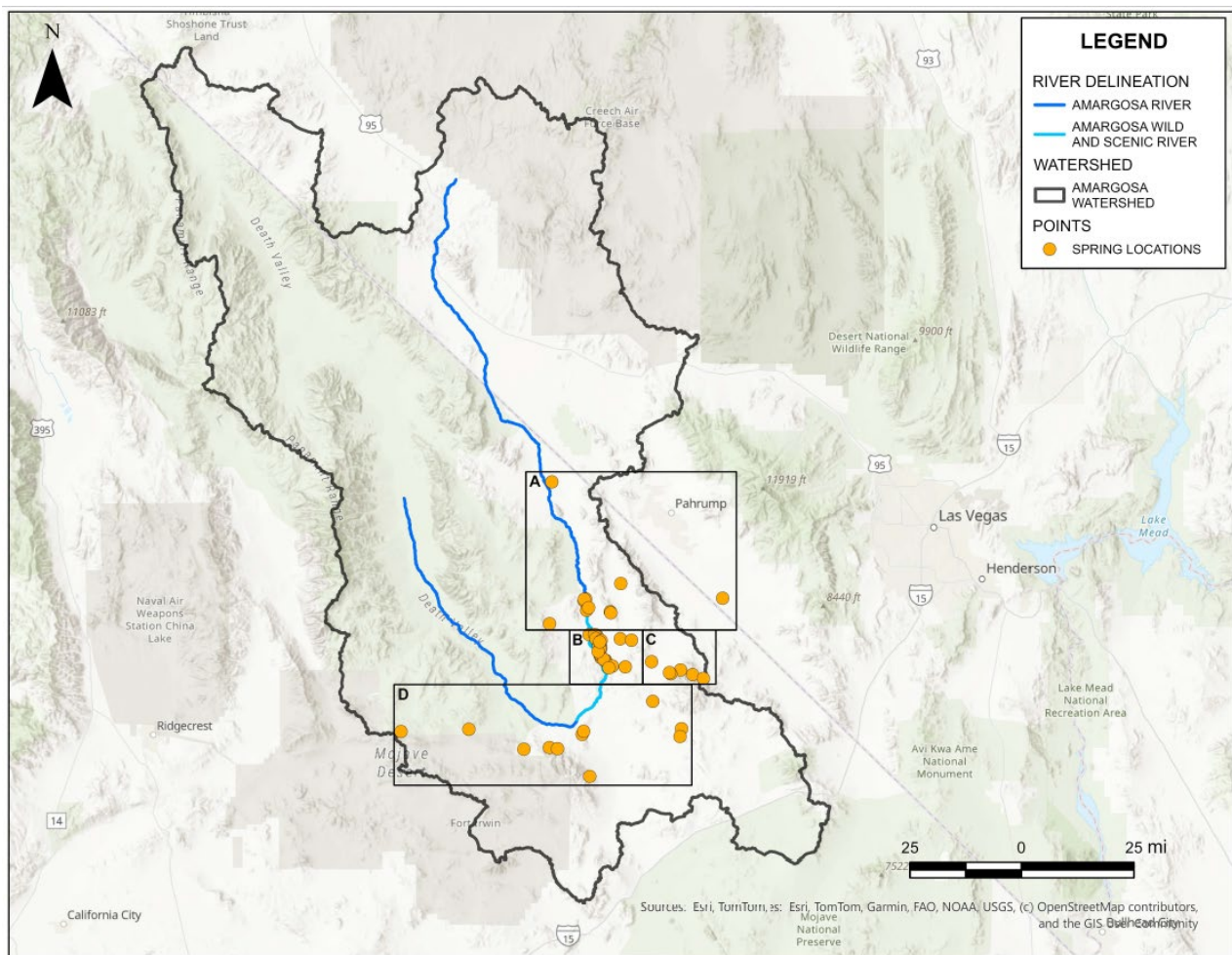


Figure 5A. Spring Monitoring Locations

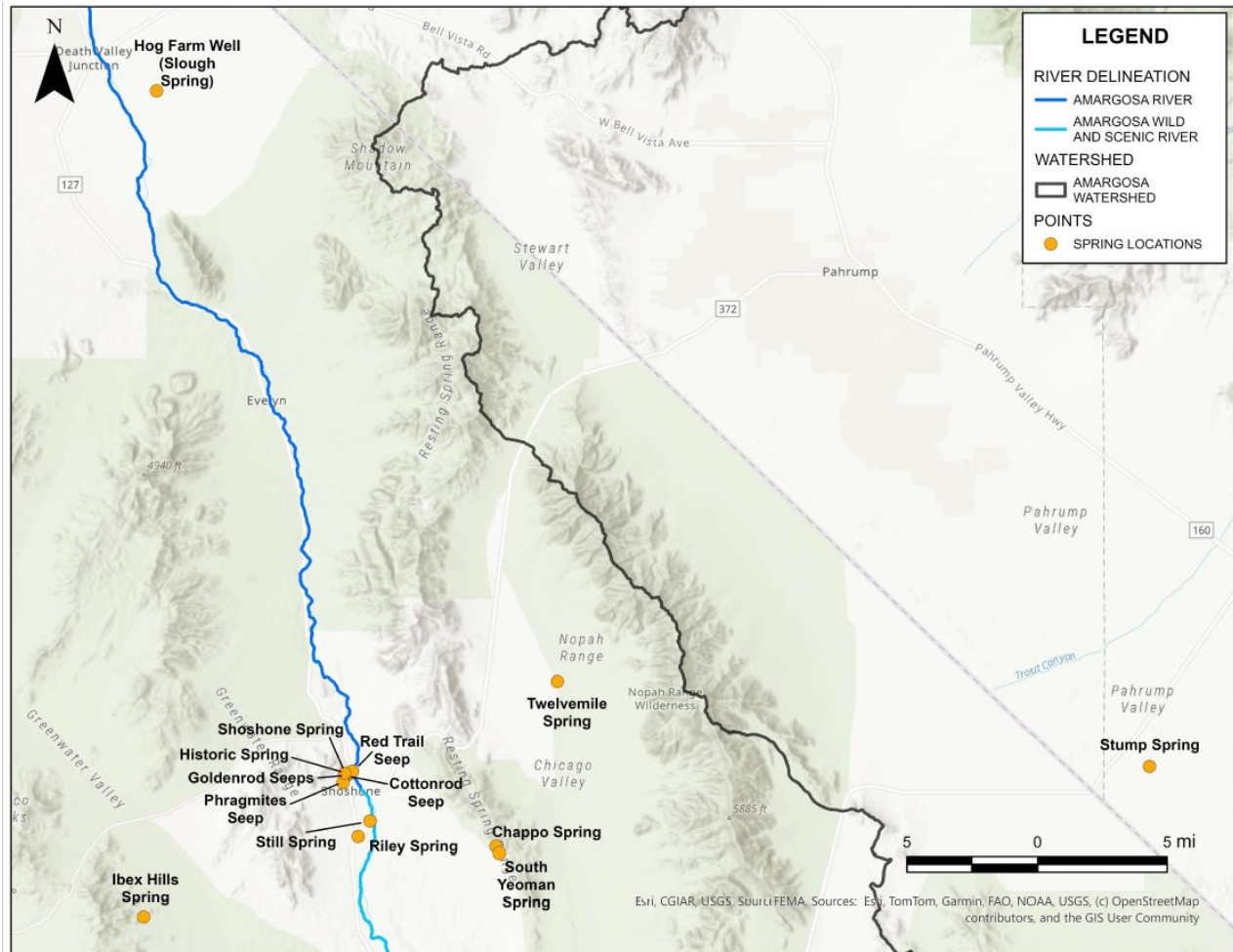


Figure 5B. Spring Monitoring Locations

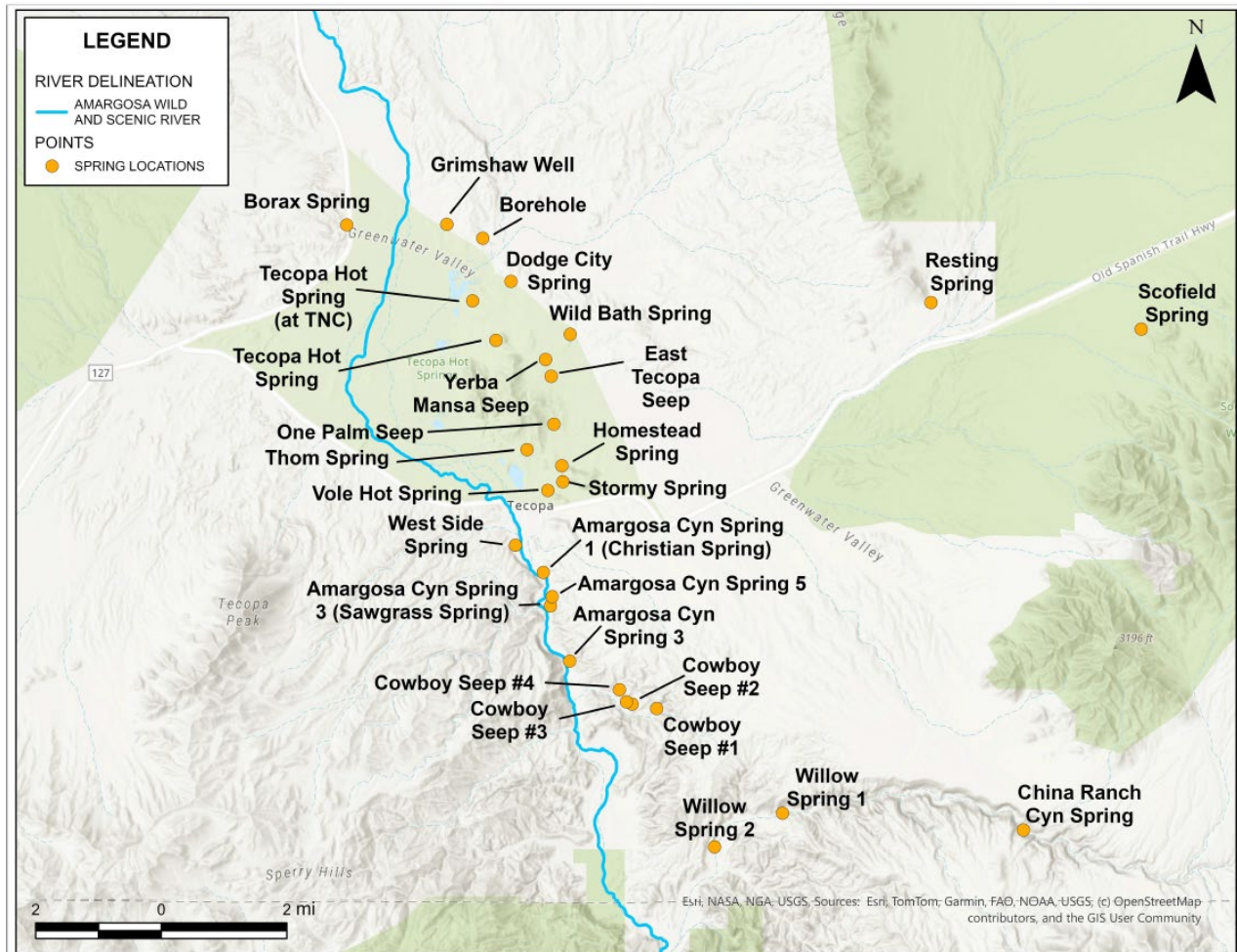


Figure 5C. Spring Monitoring Locations

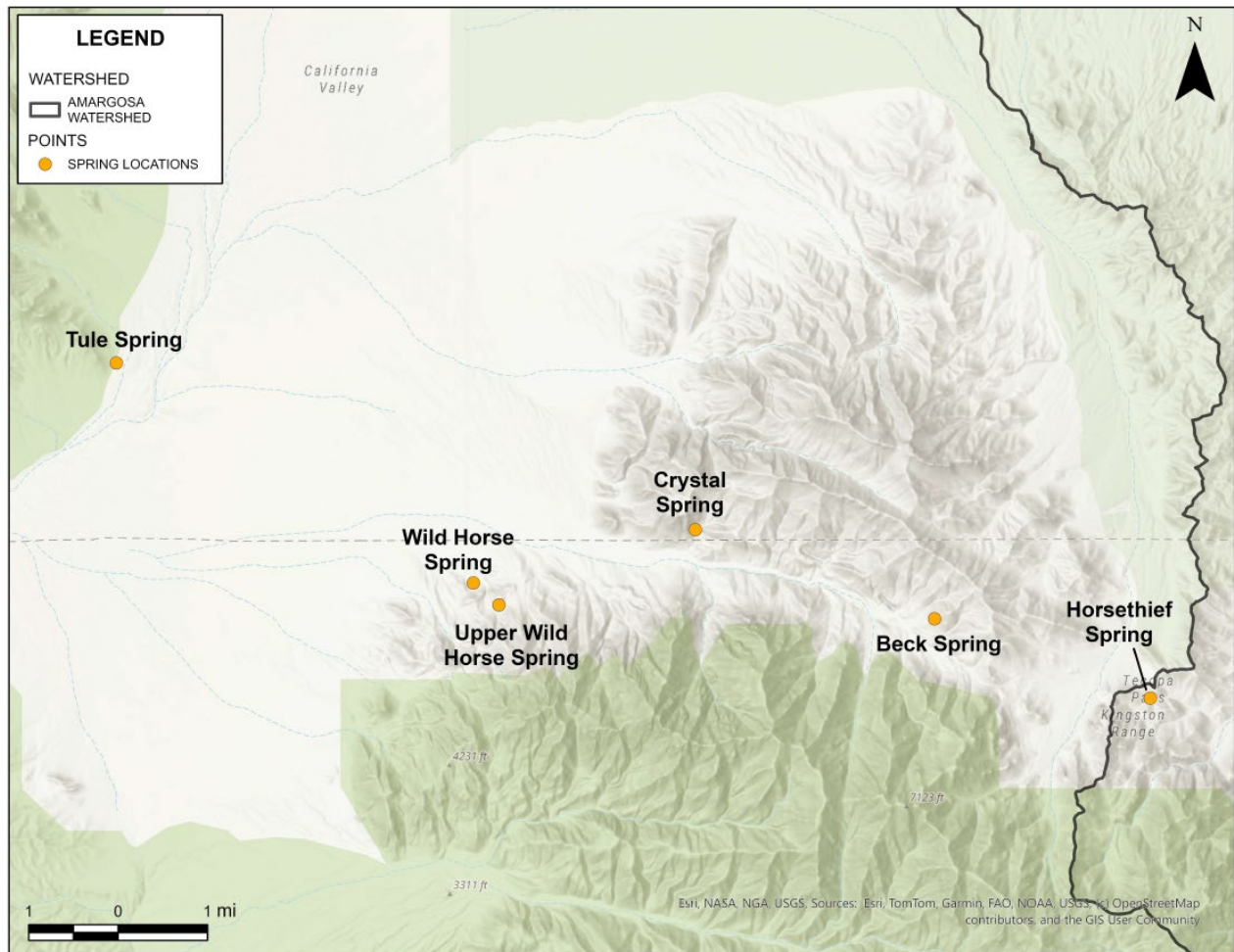


Figure 5D. Spring Monitoring Locations

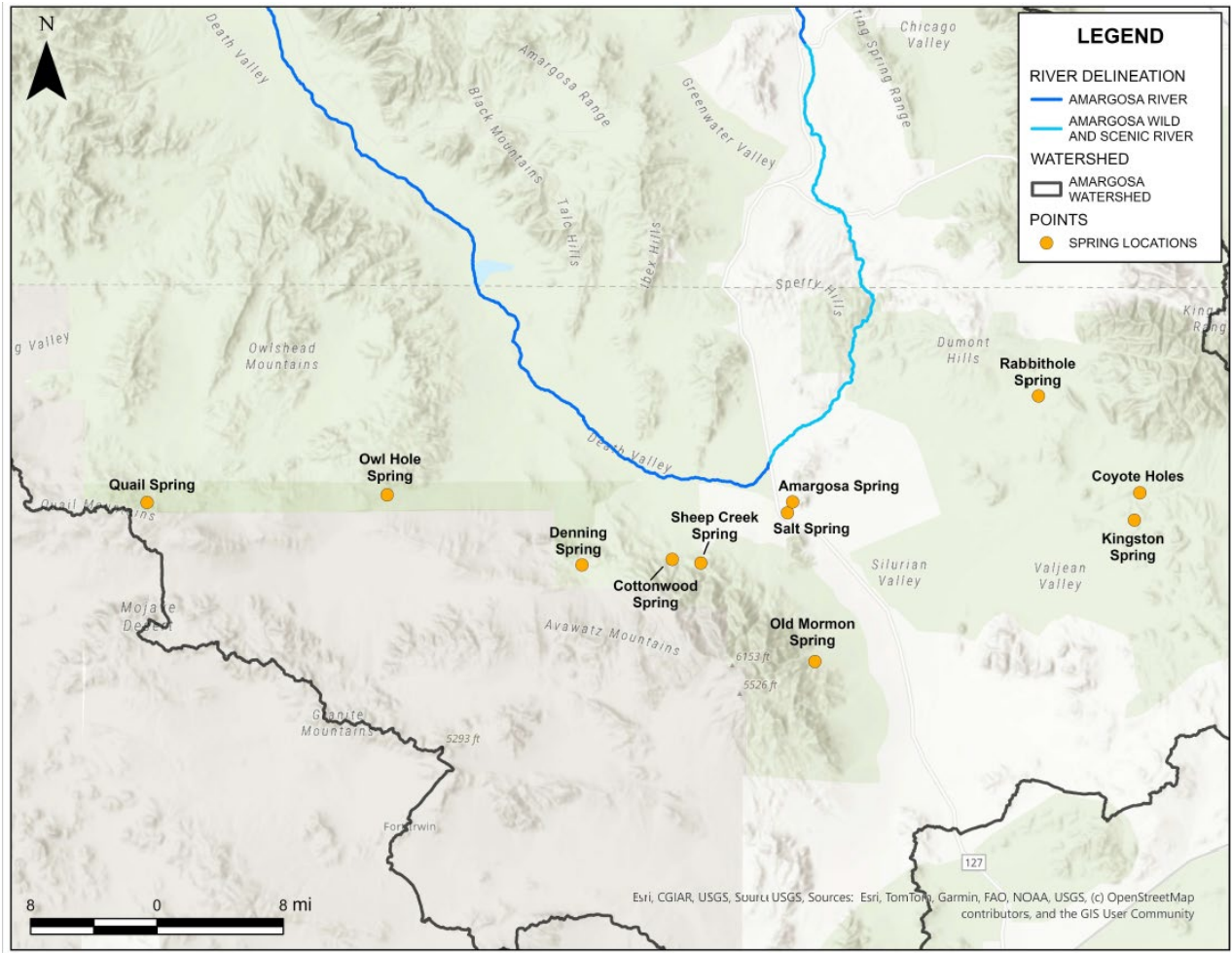
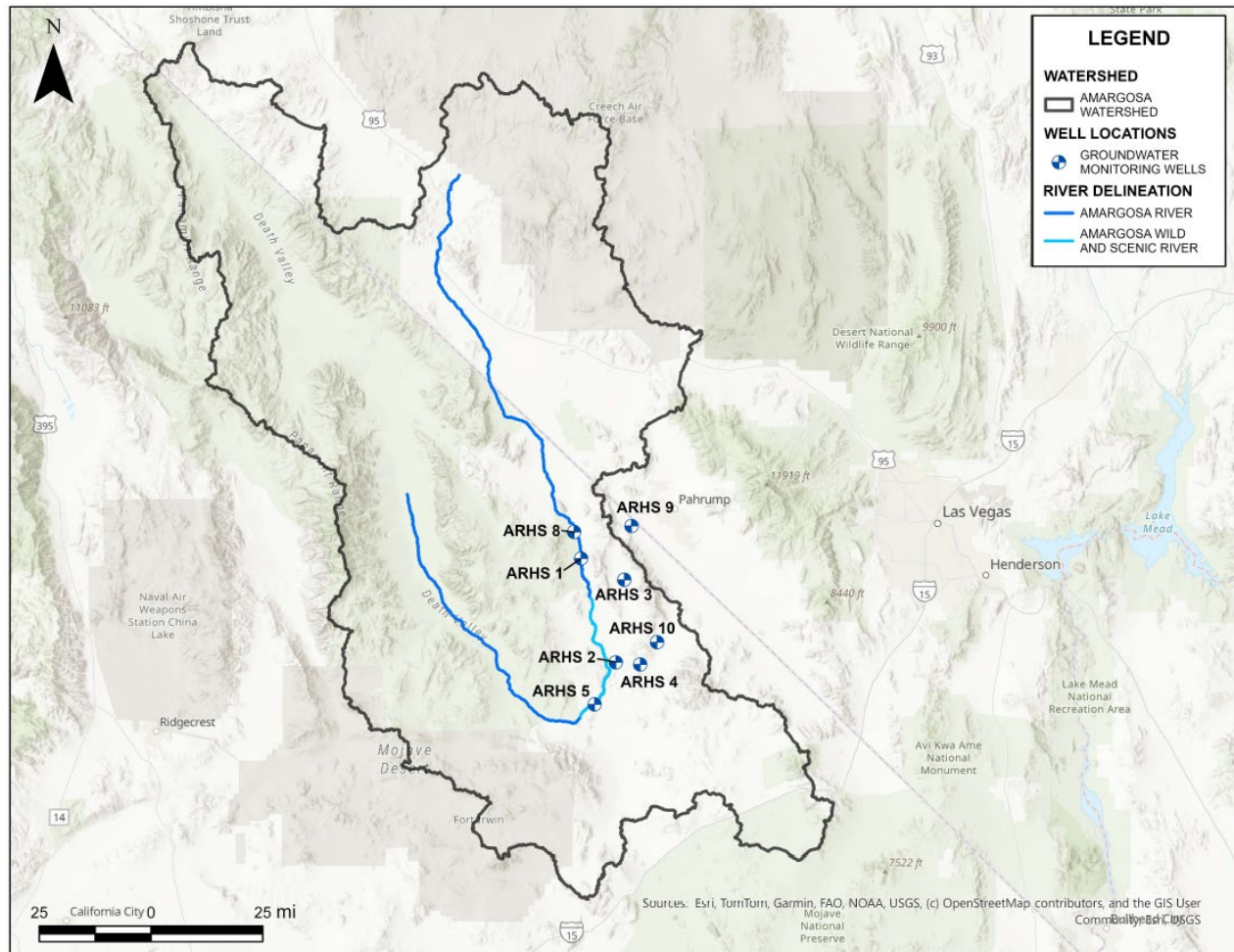


Figure 6. Groundwater Monitoring Locations



2.1 Spring Discharge, Groundwater Level, and River Surface Flow Monitoring

During the past 15 years, spring flow discharge and groundwater elevation data have been gathered from springs and wells in the Middle Amargosa Valley Groundwater Basin. The three goals of the ongoing spring discharge, groundwater water level, and river flow monitoring are as follows:

- To quantify spring discharge rates, groundwater elevations, and river surface flow which will provide estimates of seasonal variations;
- To establish a record of discharge from the springs and wells selected for monitoring, including seasonal trend information to provide a more robust baseline for future comparisons, and
- To establish flow gains and losses along the perennially flowing portion of the Amargosa River, including seasonal trend information to provide a more robust baseline for future comparisons.

2.2 Spring Discharge Monitoring

For the current scope of work, the following springs are being monitored:

- Amargosa Spring;

- Borax Spring (flowing well);
- The Borehole;
- Cowboy Canyon Seeps 1 through 4;
- Crystal Spring;
- Dodge City Spring;
- Horse Thief Spring;
- One Palm Seep;
- Salt Creek Spring;
- Scofield Spring;
- Shoshone Spring (inclusive of Historic Spring, Cottonrod Spring, and Phragmites Seep);
- Thom Spring;
- Tule Spring;
- Twelvemile Spring;
- Vole Spring;
- Wild Bath Spring;
- Wildhorse Spring (upper and lower); and
- Willow Creek (two locations).

The primary method used to quantify spring discharge was the velocity-area method (Gordon, et.al., 2004). This is used at Dodge City Spring, Thom Spring (when flow was present), Willow Creek, Crystal Spring, and Salt Creek Spring.

Another method used includes measuring the time it takes for spring flow to fill a bucket of a known volume. In some cases, such as Borax Spring and Wild Bath Spring, the spring discharged over a lip or out a pipe which enabled direct measurement of spring flow. At other locations, such as at Crystal Spring and Amargosa Canyon Spring #4, spring discharge was temporarily captured and channeled into a pipe or a flume to facilitate direct measurement using the bucket filling technique.

A secondary method that was formerly used to quantify spring discharge was direct measurement using a Marsh-McBirney Flo-Mate solid-state flow meter placed in a flowing channel of water. Measurements from the flow meter are combined with cross-sectional dimensions of the flow channel to yield spring discharge. This measurement technique was used at Amargosa Canyon Spring #1 and the Borehole. Due to changes in the Borehole, flow measurements (by USGS), the flow meter method is no longer used on springs in this area.

The spring flow measurements recorded starting with the initial spring survey (including visual estimations of flow) are summarized on Table 1. Spring flow measurements are also found in the Catalog of Springs (Appendix A) and on the individual field reconnaissance data sheets included within that appendix. It should be noted that Table 1 and Appendix A include springs not monitored as part of this SOBR. However, information about these springs (some located as far north as Beatty, Nevada) is included within the SOBR because they are located within the Amargosa River Basin and therefore are pertinent to this Middle Amargosa Valley Groundwater Basin hydrogeologic overview.

There are compromises in the use of the spring flow measurement options described above that can result in underestimation or over-estimation of free-flowing discharge. In the velocity-area method, variations in spring brook or stream channel geometry can lead to minor inaccuracies due to assessing a specific location on the feature which is visually identified in the field. Ideally, the flow from a spring would be fully captured and channeled into a pipe or flume, allowing for much greater accuracy in measurement of flow however for many

features this is impracticable. Measurement of flow using the solid-state flow meter requires estimates of cross-sectional area and the use of one to two flow measurement points as the meter is often large relative to the width of the channel. The spring flow measurements within this report should be seen as an estimate for the range of flows emanating from each spring. Significant alteration to spring discharge locations would be required to achieve the accuracy needed to resolve fine, seasonal changes in spring discharge.

2.3 Groundwater Level Monitoring

The wells designated for ongoing groundwater elevation measurement include those wells previously installed as part of the Amargosa Hydrologic Survey (wells ARHS-01 through ARHS-010).¹ Additionally, in the past the Eagle Mountain Well near the California/Nevada state line and Cynthia's Well in Tecopa have periodically been measured. None of these wells have a surveyed mark for ground surface elevation, thus surface elevation has been estimated using USGS topographic maps. Depth to water was measured from the same point during each monitoring event so accurate comparisons between events can be made. The depth to water measurements recorded starting with the initial well survey are summarized on Table 2. Depth to water measurements is also found in the individual well data sheets included in Appendix F.

The nine ARHS wells have been outfitted with In-Situ transducer/data-logger set-ups and collect groundwater level measurements and previously collected data at one-hour intervals. The transducer/data-logger instrumentation will be replaced during the October 2025 monitoring event, and groundwater levels will be recorded at 4:00 pm and 4:00 am each day.

2.4 Amargosa River Flow Monitoring

Additionally, until 2017, seepage run monitoring (i.e. the measurement of flow at several distinct locations) was conducted by Andy Zdon & Associates, Inc. (AZI) and Partner Engineering and Science (Partner) along the stretch of river from Tecopa to below the Dumont Dunes area where the River crosses California Route 127. The seepage runs were conducted at five distinct monitoring locations along the Amargosa River, including two USGS gauge locations and three manual monitoring points as measured during previous monitoring events. Seepage runs were subsequently discontinued as due to changes in channel geometry resulting from seasonal flooding, flow measurement locations, and character of flow (e.g., defined single channel vs. braided channel) was resulting in temporally non-comparable flow data. Subsequent seepage runs were conducted by the USGS for a longer reach of the Amargosa River and have been reported in a data report on the USGS website (for example USGS, 2025).

Field water quality measurements have continued to be measured by Roux at the Amargosa River below the confluence with Willow Creek, and at the Dumont Road crossing (and periodically at the Highway 127 crossing). Additional monitoring has discontinuously included following the movement (progression and regression) of the leading edge of the River near the Dumont Dunes area and seepage run monitoring of Willow Creek just upstream of the confluence with the Amargosa River. Additionally, beginning with the current scope of work, Amargosa River flow below Cowboy Canyon (between Tecopa and Willow Creek) has been initiated by Roux.

River flow was formerly measured at five locations along the Amargosa River from the town of Tecopa south to the California Route 127 undercrossing near Dumont Dunes. Two of the measurement points were flow gauges

¹ There is no well ARHS-07.

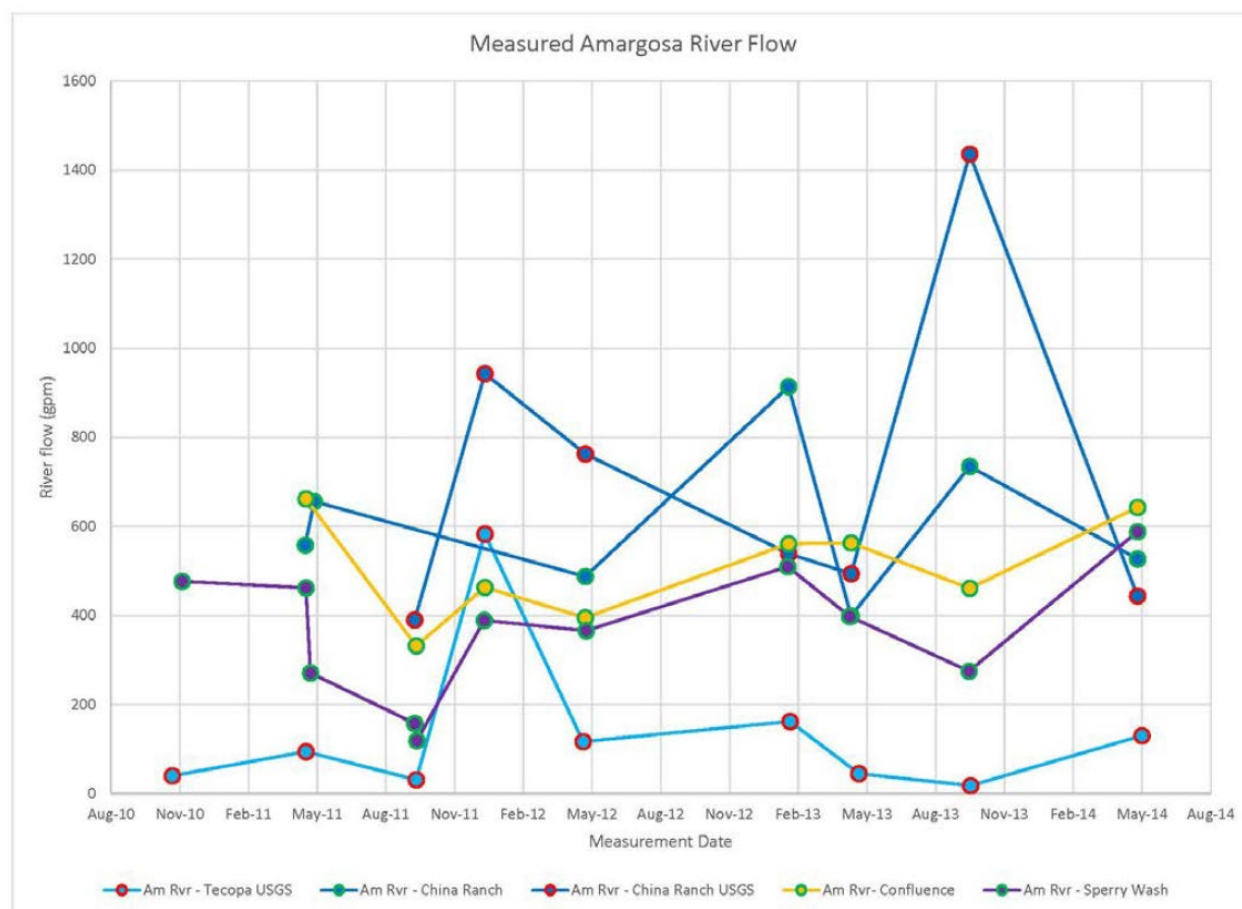
established by the USGS. The first was the USGS gauging station located in the town of Tecopa, California (station no. 10251300) and the second is located near China Ranch, just above the confluence with Willow Creek (station no. 10251330). The three manual flow measurement stations were located at the intersection with Sperry Wash, the crossing of Dumont Dunes Road and the undercrossing of California Route 127. As the project progressed, additional measurements were obtained from the Amargosa River just below the confluence with Willow Creek as well as at the base of Cowboy Canyon.

A Marsh-McBirney Flo-Mate electromagnetic velocity meter and associated equipment was used to gauge river flow at each measurement location along the Amargosa River. Surface water flow velocity was measured and recorded at 0.5-foot intervals across the width of the Amargosa River along a measurement transect oriented perpendicular to the direction of river flow. Concurrent with each velocity measurement, depth to river bottom was recorded. The full profile of river velocities and depths for the complete cross-section of the river could then be aggregated to determine total river volumetric flow at the measurement location. Each measurement transect location was recorded using a hand-held GPS receiver, so subsequent measurements were performed approximately along the same river cross-section. Due to the changing characteristics of the Amargosa River channel at the gaging point below the confluence of Willow Creek and the Amargosa River, and the likelihood that all surface flow was not being captured due to the presence of impenetrable brush in areas of river flow combined with those sections of channel not being appropriate channel characteristics for measurement method, the flowmeter approach was abandoned. Currently, the Velocity-Area method as described in Gordon, et.al. (2004) has been adopted by Roux.

During the spring reconnaissance field activities conducted during November 2010 and January 2011, the leading edge of the Amargosa River extended to an indeterminate point downstream of the California Route 127 undercrossing. This was also the case during the May 2014 monitoring event. The initial visit to this section of the Amargosa River in late April 2011 showed that the leading edge had retreated to a point between the California Route 127 undercrossing and the crossing of Dumont Dunes Road. A subsequent visit a week later (early May 2011) showed the retreat of the Amargosa River continued such that the leading edge was approximately 1,000 feet upstream of the Dumont Dunes Road crossing. The monitoring event September 2011 showed the leading edge of the Amargosa River in the same place. During the December visit, the leading edge of the Amargosa River had advanced beyond the Dumont Dunes Road crossing but did not extend as far as the California Route 127 undercrossing.

This data, along with consistent later observations and visual observations by long-time residents, provides strong indications that flow in the Amargosa River is controlled by evapotranspiration. The increase in evapotranspiration that occurs during the longer, hotter summer days reduces water availability for surface flow resulting in the retreat of the Amargosa River. The reduction in evapotranspiration that occurs during the shorter and cooler winter days increases the water available for surface flow, thus the leading edge of the Amargosa River advances independent of precipitation. The management of non-native vegetation along the Amargosa River (i.e., tamarisk removal) will have a significant effect on the flow of water in the Amargosa River. The leading-edge monitoring has been discontinued. Hydrographs of the Amargosa River based on the historical periodic monitoring events from 2014 are presented on Figure 7.

Figure 7. Amargosa River Hydrographs (Andy Zdon & Associates, 2014)



2.5 Water Chemistry – State of the Basin Studies (2015, 2018, 2020)

As a continuing step to determine relationships between waters found in the Middle Amargosa Valley Groundwater Basin, water samples were previously collected under a Proposition 84 – Integrated Regional Water Management grant described in the 2020 SOBR (Partner, 2020).

Zdon, Davisson and Love (2015) considered the entire stable isotope data record from springs and wells in the Amargosa Basin (within Nevada and California) along with geologic conceptualization to update and test the existing conceptual model of the Amargosa Basin.

Geochemical data (Figure 8) and stable isotope data (Figure 9) indicate that the Middle Amargosa Valley Groundwater Basin appears to be a mixture of Ash Meadows, Spring Mountains, and Kingston Range sources. The pathways for that groundwater to reach the area consist of one or a combination of:

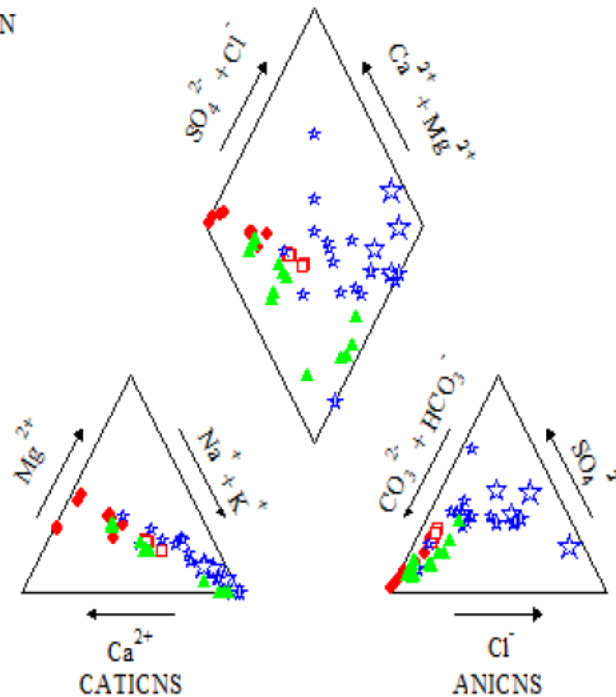
- Water that moves through carbonate rocks from the Spring Mountains to the Ash Meadows and then southward toward the Shoshone-Tecopa area;
- Water that moves through carbonate rocks beneath the northern portion of the Nopah Range into Chicago Valley, then toward the Amargosa River; and,
- Water that moves from Pahrump Valley through the low, faulted divides into California Valley, then combining with water from the Kingston Range into Willow Creek and onwards towards the Amargosa River.

Figure 8. Regional Geochemical Piper Plots (Zdon, Davisson and Love, 2015)

Regional Carbonate, NTS, and Amargosa River Valley

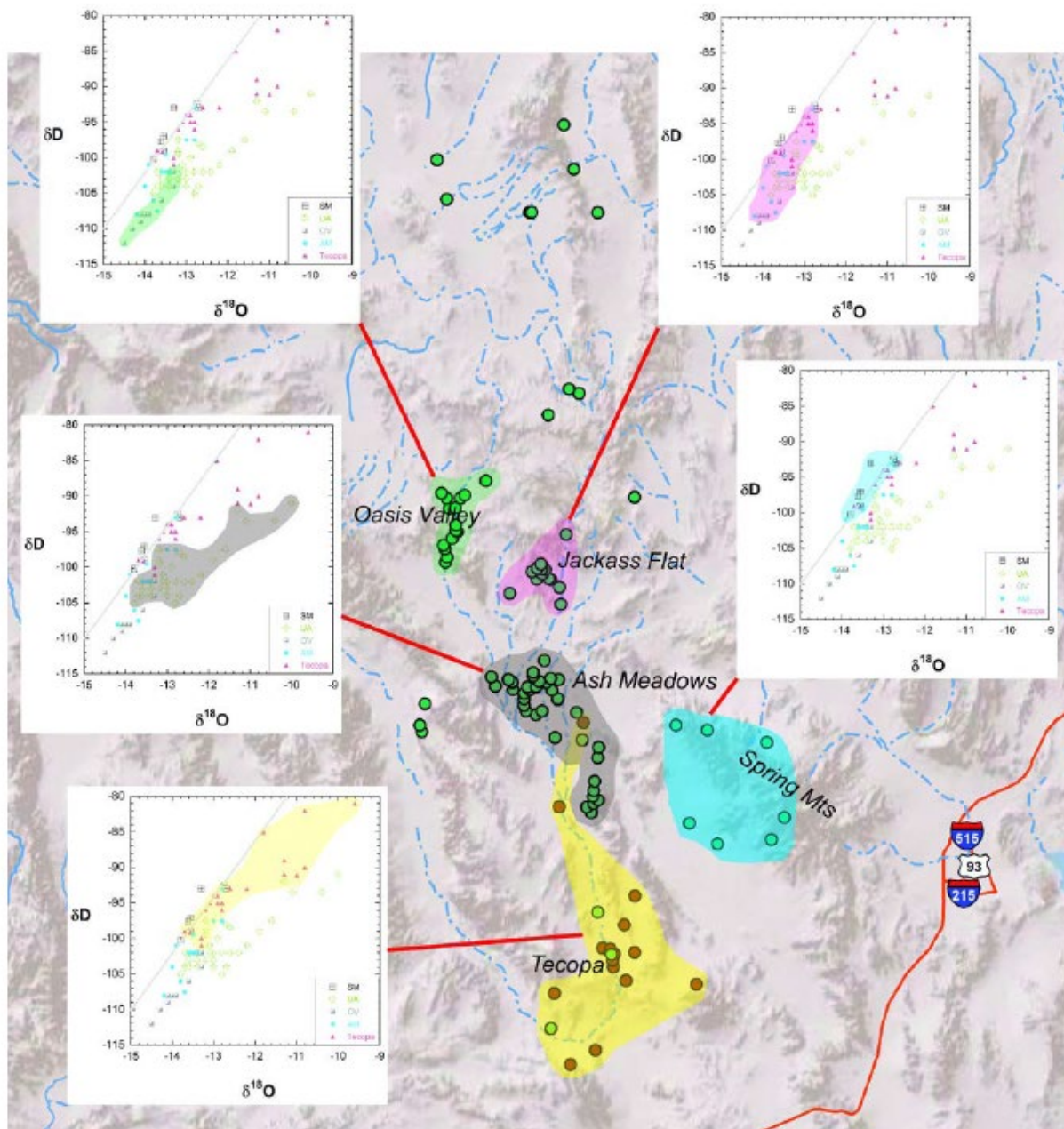
EXPLANATION

- ♦ 200
- 5100



Piper plot comparing cation and anion relative concentrations in groundwater of the regional carbonate aquifer (red circles), Ash Meadows (open red squares), Nevada Test Site (green triangles), and Amargosa River Valley (open blue stars). Note that between the regional carbonate aquifer and the Amargosa River Valley groundwater, water quality changes from Ca-Mg- HCO_3 type toward Na-K- HCO_3 -Cl- SO_4 type accompanied by increased salinity.

Figure 9. Regional Stable Isotope Plots (Zdon, Davisson and Love, 2015)

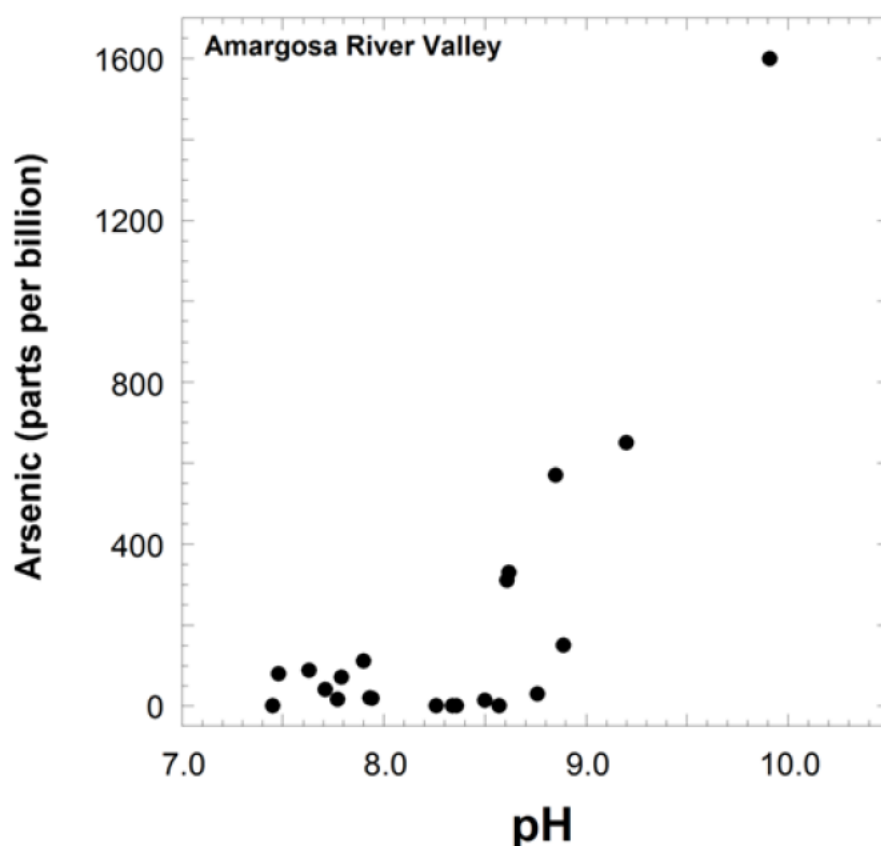


δD - $\delta^{18}O$ plots are compared as regional groupings in this map view. Note that the range in δD and $\delta^{18}O$ values decreases in general from north to south and that the Tecopa region groundwater overlaps most with Spring Mts. and Ash Meadows. This suggests that either are potential sources for Tecopa groundwater, although for the latter mixing with Spring Mts. or possibly Kingston Range recharge would be required.

Most of the spring and groundwater samples have characteristics indicative of having been influenced by Spring Mountain recharge by some route. Most of the mixing is probably occurring via fractured rock at depth, and less so in the alluvium. Water quality in the springs in the Shoshone-Tecopa area likely evolves from a mixture of regional carbonate and Tertiary volcanic rock influences but acquires increased chloride and

sulfate from the Tecopa lakebed deposits. Additionally, regional subsurface heat flow increases groundwater temperature and contributes to increased dissolved silica, decreased bicarbonate, and increased pH, with the latter resulting in the high arsenic concentrations. The source of the arsenic could be from multiple sources, but as pH increases the solubility increases to significantly elevated levels as presented on Figure 10.

Figure 10. Arsenic and pH Relationships for the Middle Amargosa Valley Groundwater Basin (Andy Zdon & Associates, 2014)



Arsenic solubility increases with increasing pH as illustrated by groundwater in the Amargosa River Valley region. The ultimate source of arsenic is not known but could be associated with the Tecopa lake beds deposits.

Noble gas concentrations of the water in the Shoshone-Tecopa area (Andy Zdon & Associates, 2014) are strongly like those measured in the regional carbonate – Ash Meadows (of southern Nevada) groundwater noted by Thomas, et.al. (2003b). Their conclusions were that dissolved gas loss occurred during subsurface transport across faulty boundaries and compromised recharge temperature/elevation calculations. The noble gas recharge temperatures/elevation calculations for Amargosa River Valley groundwater mostly supports the conclusions of Thomas, et.al. (2003b).

The $^3\text{He}/^4\text{He}$ ratios (Andy Zdon & Associates, 2014) for the four measured springs (Thom Spring, Wild Bath Spring, Tecopa Spring, and the Borehole) were unusually low, indicating old groundwater ages. The

values were 5 to 10 times lower than measured groundwater under the Nevada Test Site. These low ratios could be due to high influx of ^4He from the Earth's crust caused by deep faults. Otherwise, if the low ratio is due to steady-state accumulation from local deposits, then groundwater ages greater than 100,000 years would be required. Additionally, the helium ratios did not suggest the presence of a shallow magmatic heat source for the Tecopa Hot Springs area and indicate that the heat source is via deep circulation, along with the faults that run through the area. The elevated temperature of the Tecopa Hot Spring water is not unusual since similar temperatures are seen at depth under the Nevada Test Site. However, at Tecopa, the warm water is driven to the surface by some structural control (Andy Zdon & Associates, 2014).

Groundwater residence times/ages for the monitoring wells and springs are presented on Table 1. The ages indicate the following.

- ARHS-05 is a mixture of modern water (tritium was detected in the water sample) and older spring-fed river waters. Given that ARHS-05 is adjacent to the Amargosa River, it is reasonable for older groundwater that makes up baseflow in the river to mix with percolating surface runoff from flood events and contributions from local groundwater.
- ARHS-06 and ARHS-10 in California Valley are sourced in Pahrump Valley and assuming for the purposes of this report that these waters are recharged at the top of the Manse alluvial fan approximately 28 miles distant from these wells, groundwater takes approximately 16,900 years and 20,400 years to reach MW-6 and MW-10, respectively. As MW-10 is approximately three miles downgradient from MW-6, this indicates that groundwater moves at a rate of 4.5 feet per year from MW-6 toward MW-10. This low rate is consistent with the presence of fine-grained lakebed deposits as observed in the well logs for these wells. Additionally, this is indicative of groundwater moving at an average rate of approximately 9 feet per year from the Manse alluvial fan to MW-6.
- ARHS-08 is likely a mixture of water that rises from a fault that trends northward up the valley north of Shoshone, southward moving alluvial groundwater parallel to the Amargosa River and from limited recharge that may occur on Brown Peak in the Greenwater Range to the west (the apparent age being a weighted-average of the apparent ages of the different sources).
- ARHS-09 is water that is sourced in the Spring Mountains/Pahrump Valley moving northwest toward Ash Meadows NWR.

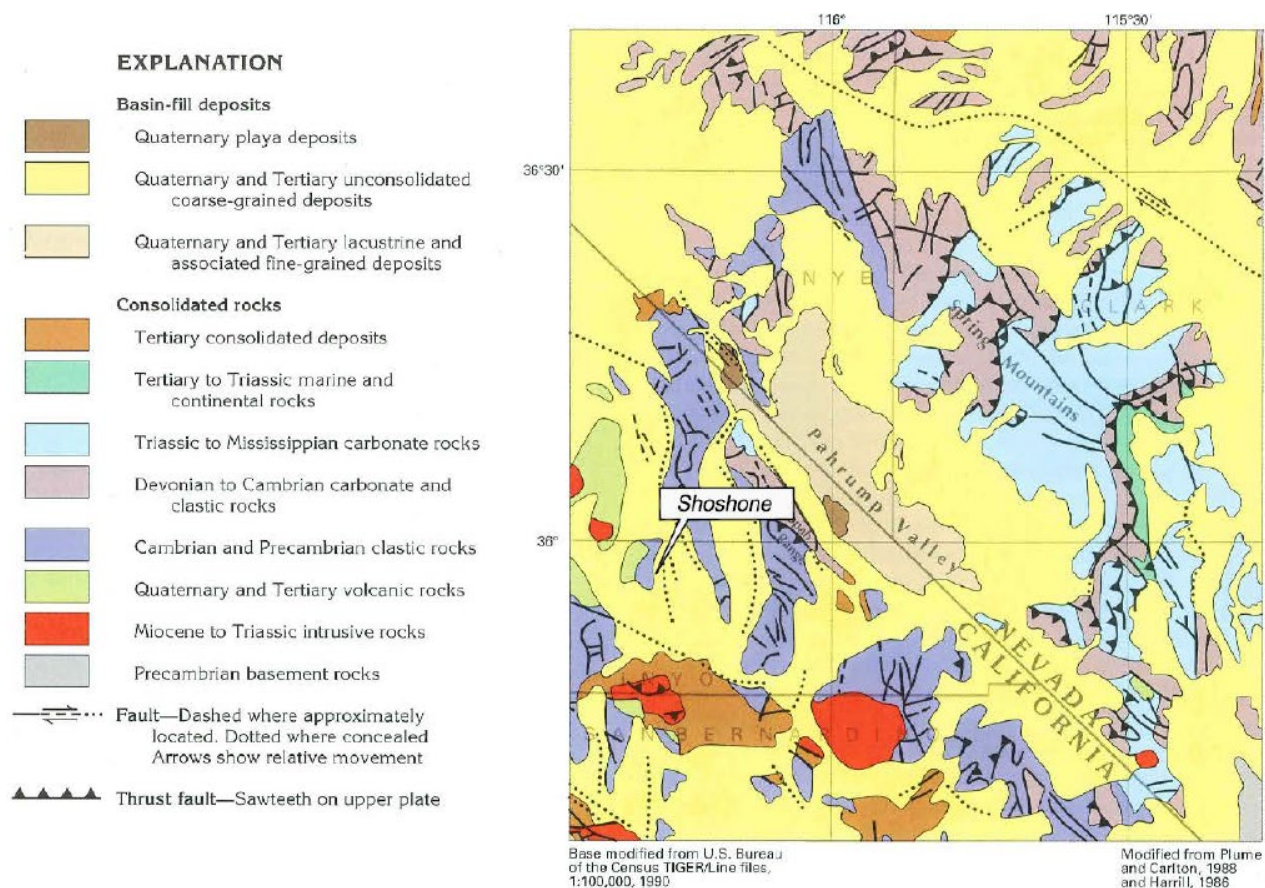
3. Amargosa Wild & Scenic River – Conceptual Model

3.1 Regional Setting and Geologic Conditions

The Amargosa River Basin is in Inyo and San Bernardino Counties, California, and Nye County, Nevada. The Amargosa Wild and Scenic River (AWSR) is entirely within the California portion of the basin in what is called the Middle Amargosa Valley Basin by the California DWR. The principal communities in the area are Shoshone and Tecopa. The Middle Amargosa Valley Groundwater Basin extends from the California-Nevada state line on the north, roughly to the boundary of Death Valley National Park on the south. The AWSR is fed by groundwater sourced in both California and Nevada. Because of this, a more regional description of the hydrogeology AWSR is provided.

The AWSR is within the Basin and Range geomorphic province, an area characterized by basins of internal drainage with considerable topographic relief. The topography alternates between narrow faulted mountain chains and flat arid valleys or basins. The ranges trend north-northwest parallel to the regional geologic structures. The geology of the Amargosa Basin is remarkably diverse containing Precambrian, Paleozoic, and Mesozoic metamorphic and sedimentary rocks, Mesozoic-aged igneous rocks, Tertiary and Quaternary-aged volcanic rocks, and playa, fluvial and alluvial deposits (Planet and Williams, 1995). A regional geologic map is provided on Figure 11

Figure 11. Regional Geologic Map (Planet and Williams, 1995)



The valley areas are covered by coalescing alluvial fans forming broad slopes between the surrounding mountains and the valley floors. The Middle Amargosa Valley Groundwater Basin is marked by several unique features including the badland-type topography of the Tecopa lakebed deposits and the Amargosa River Canyon. Between Shoshone and Tecopa, the slope of the valley floor flattens among the lakebed deposits and then steepens as the river flows through the Amargosa River Canyon. Downstream of the canyon, the topography reverts to an area of broad, coalescing alluvial fans, with the river eventually reaching the Death Valley playa.

3.2 Hydrogeologic Units

In the Amargosa River Basin, the principal water-bearing hydrogeologic units consist of unconsolidated valley fill materials, volcanic rocks (primarily in Nevada), and the carbonate rock (limestone) aquifer. The following provides a summary of these three hydrogeologic units. Other less permeable bedrock units are also present.

3.2.1 Valley Fill

Tertiary and Quaternary-aged valley fill deposits are present throughout the basin as alluvial (shed from the surrounding mountains), fluvial (river) and lacustrine (lakebed) deposits. Coarse-grained deposits (primarily sand and gravel) within the valley fill are responsible for transmitting the greatest quantities of groundwater and are most relied upon for groundwater production in the region. With the exception of minor pumping in the Tecopa Heights area of California, nearly 100% of the groundwater pumping in the Middle Amargosa Basin and upgradient is in Nevada. The valley fill is unconsolidated, moderately to well-sorted sand, gravel, silt and clay, and wells completed in the valley fill can yield several hundred gallons per minute (Walker and Eakin, 1963). As the axes of the valleys are reached, the sorting of the sediments will increase, which can serve to significantly increase the permeability of the sediments. With increasing depth, groundwater production can be expected to decrease in these deposits as increasing lithostatic pressure and infilling of pores coincidence with their greater age may occur reducing permeability.

Within the valley fill, the fine-grained (clay and silt) deposits that comprise the lakebed deposits (for example in the Shoshone – Tecopa area) serve as aquitards. Aquitards are low permeability geologic units that inhibit groundwater flow and can serve as confining units. Wells and boreholes that are completed in aquifer materials underlying these aquitards may exhibit artesian conditions such as those observed from flowing wells and borings such as at Borehole Spring and Borax Spring in the Shoshone-Tecopa area.

3.2.2 Volcanic Rocks

Tertiary and Quaternary-aged volcanic rocks are present within the Amargosa River Basin particularly in the headwaters of the Amargosa River near Beatty, Nevada and in the Greenwater Mountains immediately west of Shoshone, California. In the area of the AWSR, the volcanic rocks are of less importance to the overall groundwater system as opposed to the northern portion of the basin in Nevada.

3.2.3 Bedrock Units

Bedrock units underlie the alluvial valleys and make up the mountain ranges (Nopah and Resting Spring Ranges, the Amargosa Range, and portions of the Sperry Hills) through which the AWSR flows. These bedrock units consist of Precambrian to Mesozoic-aged metamorphic and sedimentary rocks, including Paleozoic-age carbonate rocks (the “carbonate rock aquifer”); quartzite; and shale which have been folded and faulted (Figure 11). Generally, bedrock units such as these (with the exception of carbonate as further discussed below) produce little water except where they are fractured and faulted, providing pathways for groundwater movement. Other bedrock units consist of the Mesozoic-aged granitic rocks as found in the

Kingston Range. Within the granitic rocks, groundwater flow can be assumed to be negligible except where fracturing is present yielding modest quantities of groundwater.

Where carbonate rocks are present, greater movement of groundwater can occur due to the unique depositional and erosional characteristics of those rocks. Fractures and secondary solution openings along bedding planes can transmit considerable quantities of groundwater. Groundwater that discharges from the springs at Ash Meadows NWR involves groundwater moving through these secondary openings in the carbonate rocks. Within the basin, significant groundwater flow through the carbonate rock aquifer occurs within the lower to middle Paleozoic-age carbonate rocks that comprise a package of rocks approximately 26,000 feet thick (Sweetkind, Belcher, et.al., 2017).

Groundwater flow in carbonate rocks can be extraordinarily complex. Carbonate rocks with extensive solution channels may transmit large volumes of groundwater and when fractures are primarily developed in one direction will have permeabilities that are highly oriented in specific directions. Therefore, the groundwater flow may not be predictable simply by drawing flow lines perpendicular to regional groundwater surface contours representative of the regional carbonate aquifer (Davis & DeWiest, 1966). Although carbonate rock aquifers transmit large volumes of groundwater in the region, permeability is limited to areas of fracturing and solution channels which proportionally make up a small portion of the carbonate rock volume. Therefore, despite the potential for wells to obtain large yields from the carbonate rocks, that success is dependent on intersecting those fractured zones (Fetter, 2001)..

3.3 Geologic Structure

The rocks in the Amargosa River Basin and along the AWSR have been extensively deformed by a variety of fault types that have occurred in the distant past as well as the present. These fault types include:

- Normal faulting typical to the Basin and Range with vertical displacement being dominant;
- Strike-slip faulting (lateral displacement dominant) typical of larger-scale regional fault systems such as the Furnace Creek – Fish Lake Valley Fault System and Las Vegas Valley Shear Zones; and
- Thrust faults (low angle faults) that during the Paleozoic and Mesozoic resulted in displacing rock units in a manner that can affect groundwater movement in the present.

Springs may discharge at the locations of faults due to either the lower fracture permeability of the fault in rock, or the displacement of permeable valley fill or rock adjacent to relatively impermeable materials. For example, Tecopa Hot Springs rises along a fault (Waring, 1915) that runs north-northwest through the basin (Figure 12). Just north of the AWSR, Shoshone Spring rises along the northward extension of the same fault that passes through Tecopa, part of the Furnace Creek Fault Zone (California Division of Mines, 1954). The Death Valley – Furnace Creek Fault System (inclusive of the Furnace Creek Fault Zone) is part of a large, currently active, northwest directed pull-apart zone. Movement along the Furnace Creek Fault Zone is primarily strike-slip (Brogan, Kellog, Slemmons and Terhune, 1991). The Death Valley – Furnace Creek Fault System is the second longest fault system in California (the San Andreas Fault System being the longest).

Thrust faults are present throughout the region; however, given their age, in many areas their presence is concealed by overlying volcanic or valley fill deposits. Fracture permeabilities along thrust faults are insignificant due to the age of the structures and fracture filling and the low angle nature of the faulting not supporting fractures with significant apertures. However, in areas where impermeable rocks are thrust against more permeable rock in the subsurface (e.g., quartzite thrust against carbonate rocks), those faults may also serve as a barrier to groundwater flow.

Figure 12. Geology of the Shoshone-Tecopa Area



3.4 Surface Water

The principal surface water body in the Middle Amargosa Basin is the Amargosa River, an intermittent river with headwaters issuing from springs northeast of Beatty, Nevada, and extending approximately 180 miles to the river's terminus at the playa in Death Valley National Park. A portion of the Amargosa River between Shoshone and the Dumont Dunes Road has been federally designated as a Wild and Scenic river. Other surface water bodies of note including Devil's Hole and the springs at Ash Meadows, and other springs throughout the basin.

Except for the perennial Wild and Scenic portions of the river in California, and perennial segments of the river near Beatty, Nevada, the Amargosa River typically flows only after periodic storms. In those areas where the river is usually dry, the flow of water is in the subsurface. The perennial reach of the Amargosa River between Shoshone and Dumont Dunes was designated as a National Wild and Scenic River in 2009. As described earlier, except during runoff events from rainstorms, the perennial flow in the Wild and Scenic section of the river is completely supplied by groundwater.

On a regional basis, the Amargosa River rises as spring flows from the southwest side of Pahute Mesa in Nevada. From here, the river flows southwest toward Beatty, Nevada, and after passing through the Amargosa Narrows where water is forced to the surface, enters the Amargosa Desert. After crossing the border into California, the river runs southward along a valley that follows the trend of the Furnace Creek Fault Zone, adjacent to California State Highway 127 near Death Valley Junction. Here, the river meets with Carson Slough (which drains Ash Meadows NWR and is the chief tributary to the Amargosa River in Nevada) and continues its southward route passing to the east of the community of Shoshone and on to Tecopa. The wild and scenic-designated reach of the river begins just south of Shoshone.

Between Shoshone and Tecopa, California, the Amargosa River alternates between perennially flowing segments and an ephemeral stream channel (seasonal or flood flow only). The perennial segments are in areas where low permeability units within the Tecopa lakebeds forces water to the surface providing limited perennial surface flow. South of Tecopa, the river enters the Amargosa Canyon and is augmented by spring flow along its course. South of the Amargosa Canyon, the river flows by Dumont Dunes, and then heads west rounding the Amargosa Range on the south, and then northward flowing into Death Valley.

A series of conceptual cross-sections following the course of the Amargosa River from near the California-Nevada state line to Sperry below the Amargosa River Canyon in California are provided in Appendix G. As can be seen, areas with continual flow are typically where rock units create constrictions to flow, and that flow is driven to the surface. Beyond the constrictions, the flows typically percolate into the subsurface some distance downgradient. In the general area of the AWSR, this prominently occurs at Shoshone Spring area, and at the Amargosa River Canyon south of Tecopa. As can also be seen in the cross-sections (Appendix G), the groundwater surface tends to flatten up-gradient of these constrictions, then steepens once past them, as would be anticipated.

This condition also emphasizes the sensitivity of the relatively constant, or perennial reaches of the AWSR to changes in groundwater level. A considerable portion of the underflow moving through the Middle Amargosa system can be accounted for by 1) the flow observed at the surface for example in the Amargosa River canyon), 2) spring discharge inclusive of evapotranspiration, and 3) minor pumping. This does not result in a substantial amount of underflow and further highlights the sensitive nature of the river system.

The USGS monitors the flow of the Amargosa River (USGS, 2025) at a gage 0.2 miles west (Gauge no. 10251300) of Tecopa. The USGS has monitored Amargosa River flow intermittently at other locations along the river over the past 45 years, but given the spotty nature of those records, they are of limited utility. The average flow of the river at this station (10251300) based on 45 full years of data between 1980 and 2025 (some years missing) is 16.1 cubic feet per second (cfs), though is skewed high because of flood flows. The maximum annual flow recorded there was 665 cfs in 1983. The median flow during the record period was 0.03 cfs. Mean annual flows of the Amargosa River at the Tecopa station along with the other stations mentioned are summarized on Table 3.

Field water quality parameters that have been measured indicate that Amargosa River waters are intermediate in chemistry between the more saline hot spring waters at Tecopa, and the freshwater springs identified in the area (e.g., Willow Spring/Creek and Shoshone Spring). This monitoring has provided strong indications that the extent of flow in the Amargosa River is significantly controlled by evapotranspiration. The increase in evapotranspiration that occurs during the longer, hotter summer days reduces water availability for surface flow resulting in the retreat of the River. The reduction in evapotranspiration that occurs during the shorter and cooler winter days increases the water available for surface flow, thus the leading edge of the River advances independent of precipitation. The management of non-native vegetation along the Amargosa River (i.e. tamarisk removal) will likely have a significant effect on the flow of water in the river.

Other surface water bodies in the AWSR area consist of spring-fed Grimshaw Lake in the Tecopa area, and streams that issue from springs only to end where either that flow is utilized by vegetation, or percolates back into the subsurface. One exception to this is Willow Creek, a significant spring-fed stream that rises northeast of China Ranch (south of Tecopa) and flows into the Amargosa River within the Amargosa River Canyon.

As described in the climate change section earlier in this report, anticipated warming is likely to lead to greater evaporation and longer growing seasons along the Amargosa River that may result in measurable decreases in surface flow along the Wild and Scenic reach of the river and southwestward toward Death Valley National Park.

3.5 Groundwater System

The regional groundwater flow system is more extensive than the Middle Amargosa Valley Groundwater Basin watershed (Figure 13). This is due to the extensive area beyond the watershed boundary underlain by the carbonate rock aquifer that drains toward Death Valley. In this large flow system, groundwater recharge results from precipitation in the form of snowmelt and rainfall that falls within the mountains of southern and central Nevada and reaches the Amargosa River Basin where it is discharged (Halford and Jackson, 2020).

Of note in Figure 13, is that a westward-pointing blue flow arrow is shown crossing the southern Nopah Range. Based on the work conducted by Roux and others as part of our investigations of the Amargosa Wild & Scenic River System, that arrow should instead be pointing southwest adjacent to the illustrated China Ranch Wash and California Valley toward the Amargosa River. The arrow as is would have groundwater passing through low permeability rocks such as the Zabriskie Quartzite instead of adjacent higher permeability basin fill and rocks.

Within the Middle Amargosa Valley Groundwater Basin it had formerly been assumed that groundwater moves directly through the carbonate aquifer southwest from the Spring Mountains and beneath Pahrump Valley toward the Tecopa – Shoshone – Chicago Valley – California Valley areas (Faunt, D’Agnese and O’Brien, 2004). However, based on more recent aqueous geochemistry investigations such as Andy Zdon &

Associates (2014) and Zdon, Davisson and Love (2015), and more recent detailed mapping by the USGS (Workman, et.al., 2002), it appears that the mechanism by which groundwater moves from the Spring Mountains/Pahrump Valley area toward the Shoshone-Tecopa area may be more complicated.

Figure 13. Extent of Death Valley Regional Flow System (Halford & Jackson, 2020)

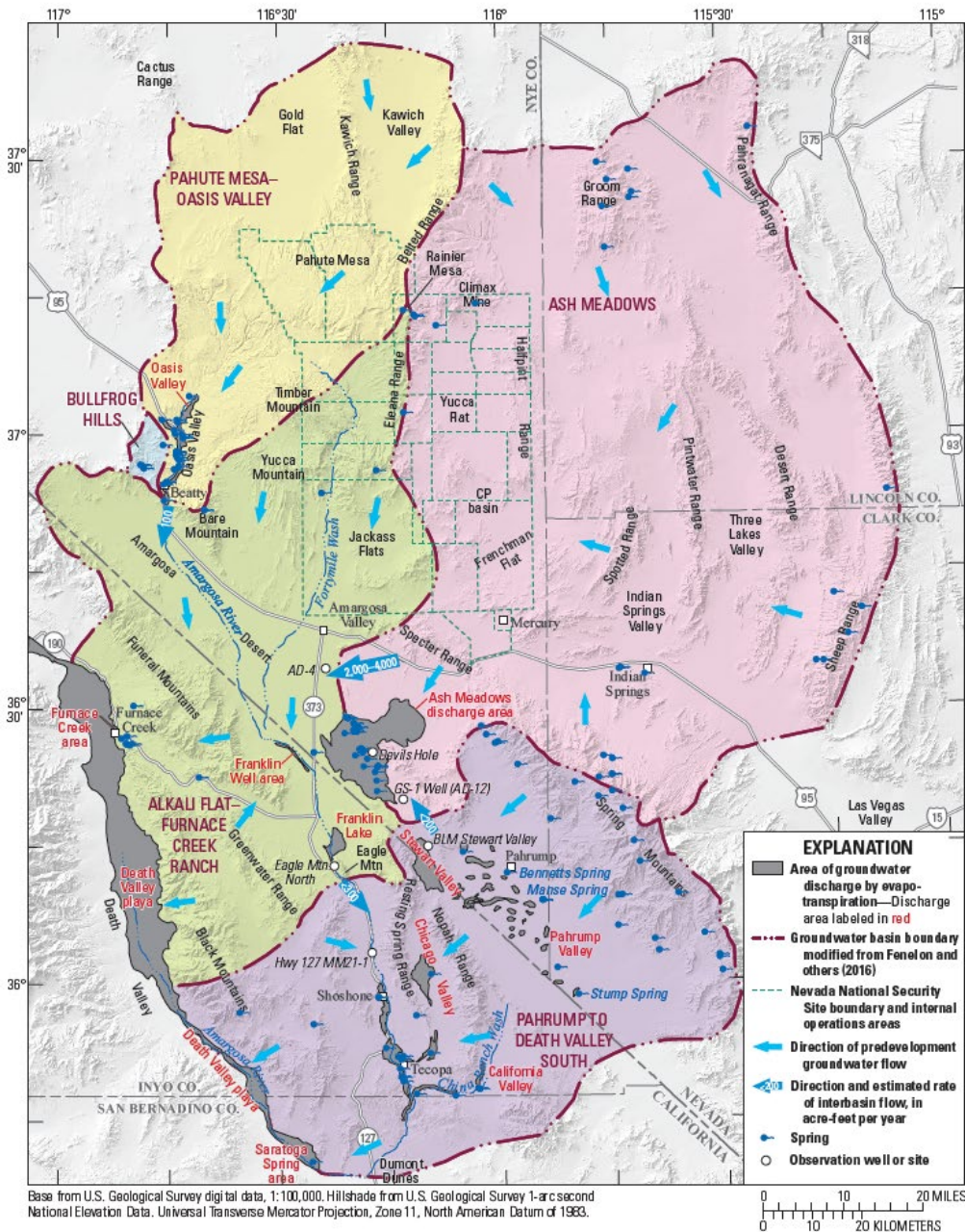
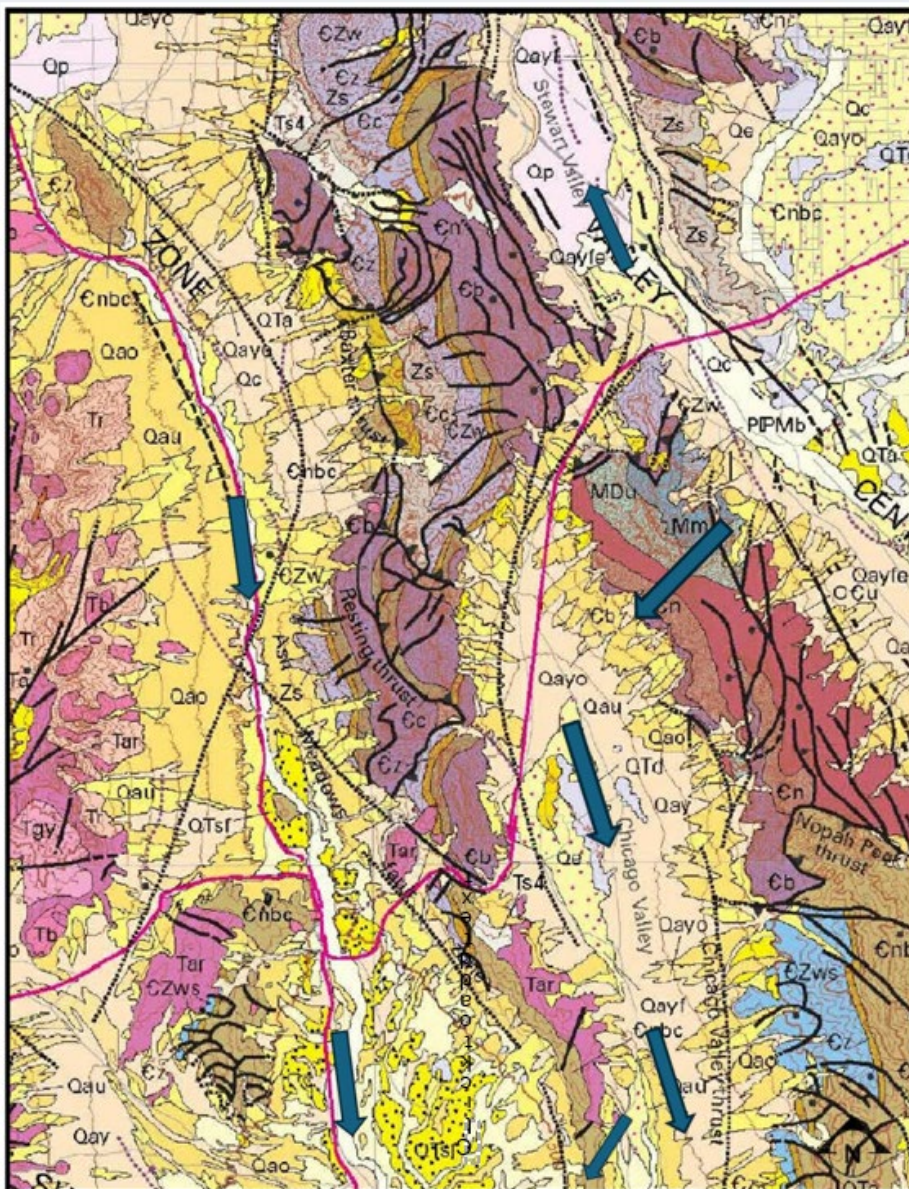


Figure 14 presents a portion of the 2002 geologic map indicating that Precambrian to Cambrian bedrock units underlying the carbonate rock units' outcrop along the western base of the Resting Spring Range and the portion of the Nopah Range south of the Nopah Peak Thrust. This would indicate that the saturated rocks beneath these ranges are primarily comprised of quartzite, shale, siltstone, and dolomite of lesser

permeability than would be expected of the Paleozoic-age carbonate rocks. Alternative groundwater flow paths toward the AWSR include one or more of the following:

- Spring Mountain recharges moving toward Ash Meadows through carbonate rocks and valley fill via Stewart Valley, then southward following the trace of the Amargosa River toward the Shoshone-Tecopa area;
- Via carbonate rocks at the north end of the Nopah Range into Chicago Valley then toward the Shoshone-Tecopa area and,
- From Pahrump Valley, beneath the Charleston View subdivision area, via the shallow divide into California Valley then toward Willow Creek with likely minor seepage into the Chicago Valley flow path, and on to the Amargosa River.

Figure 14. Geology of the Chicago Valley Area with Principal Flow Paths (adapted from Workman, 2002)



These deeper flowpaths are influential on the spring flows and discharge to the alluvium. The deeper flowpath beneath the northern Nopah Range was previously discussed (JWI, 2013a) as a potential source for Twelvemile Spring in Chicago Valley. As described earlier, beyond the Middle Amargosa Valley Groundwater Basin, groundwater moves west toward the Death Valley Basin, then, upon entering Death Valley National Park, it flows north augmented by underflow from the Owlshead Mountains area to the Death Valley playa.

3.5.1 Aquifer Characteristics

Groundwater within the basin is held within the sand, gravel, silt and clay that make up the valley fill aquifer. Within the Amargosa Desert in Nevada, hydraulic conductivity (the ability for a geologic material to transmit water) in the valley fill can range from 0.02 feet per day (f/d) in the low permeability clayey deposits, to 140 f/d in the coarse-grained sands and gravels (Belcher, 2004). Roux is unaware of any aquifer testing that has occurred within the valley fill in the Middle Amargosa Valley Groundwater Basin or the Death Valley Basin, but it is likely that hydraulic conductivities fall within the same range as those described above.

The aquifer characteristics of the carbonate rock aquifer can be highly variable. Where fractures and solution openings exist, these rocks can be the most permeable materials in the basin. Absent fracturing, hydraulic conductivities can be extremely low. Carbonate rock hydraulic conductivities can range from 30 f/d or greater to much less than 0.001 f/d (Spitz & Moreno, 1996).

3.5.2 Regional Groundwater Inflow and Outflow

Groundwater inflow components within the Amargosa River Basin include recharge from precipitation that falls within the drainage basin and groundwater underflow into the basin, primarily through the carbonate rock aquifer. In this area, large uncertainties exist regarding recharge rates, and currently, groundwater pathways for underflow into the basin. Therefore, best estimates of recharge are most available by evaluating groundwater discharge and changes in storage/changing groundwater levels in the area.

In the Middle Amargosa Valley Groundwater Basin and Death Valley Basin, water supplies are more reliant on spring flow, and groundwater pumping is insignificant in comparison to the Nevada portion of the basin. Groundwater pumping for domestic or public use is on the order of less than 100 AFY (Belcher, et.al., 2019). Water used for irrigation of date palms is supplied by spring water. It is unlikely that water use in the Shoshone-Tecopa area has changed significantly since the last State of the Basin Report (Partner, 2020).

Desert Research Institute (2016) developed a groundwater flow model for the Pahrump Valley area which puts this discussion of inflow and outflow in better context. Although the details of the modeling effort are not provided here, given that the model provides a groundwater budget for the system, and the simulated underflow from Pahrump Valley is a reasonable estimate assuming the modeled recharge and evapotranspiration numbers are also reasonable averages. The model estimates 7,550 acre-feet per year of underflow from Pahrump Valley to the Middle Amargosa Valley Groundwater Basin under pre-pumping, steady-state conditions. This is an important number when looking at sources of springs in the California portion of the basin.

The USGS (Laczniak, et.al., 2001) have estimated the following losses of evapotranspiration:

- Chicago Valley: 430 acre-feet per year;
- Tecopa – California Valley: 6,400 acre-feet per year;
- Shoshone area: 2,100 acre-feet per year; and
- Stewart Valley: 1,000 acre-feet per year (part of the outflow in the model is toward Stewart Valley).

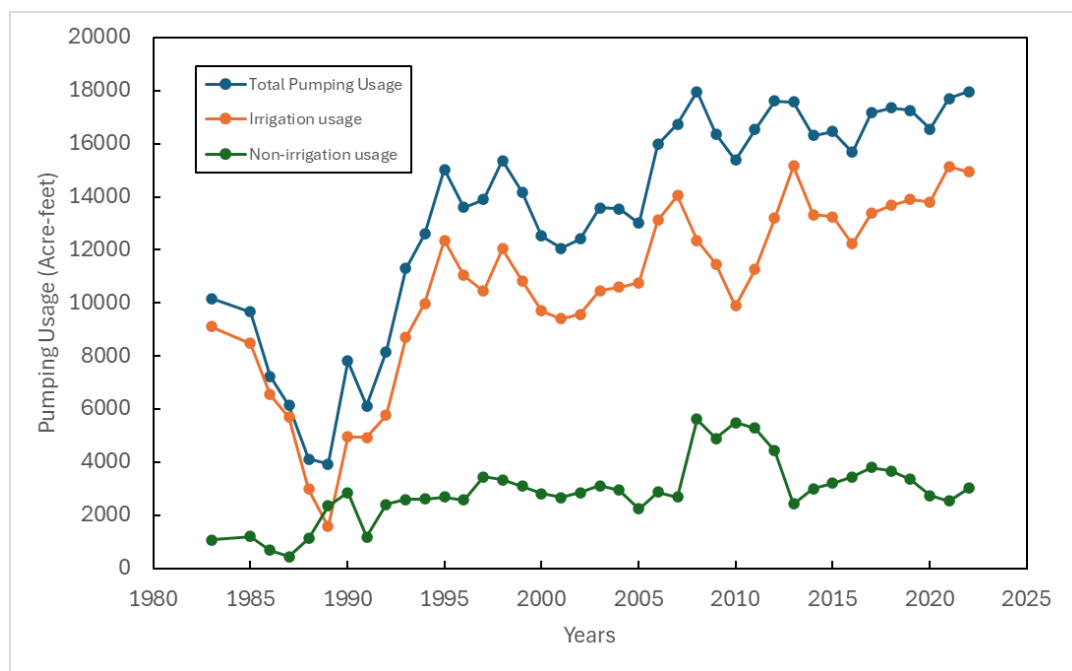
Additionally, USGS has estimated that approximately 720 acre-feet per year of underflow (equivalent of average river baseflow below Dumont) from below the Amargosa Canyon into southern Death Valley (Halford & Jackson, 2020); and there is an estimated 100 acre-feet per year of pumping/use in the basin (Belcher, et.al., 2019). This ends up totaling 10,750 acre-feet per year of groundwater discharge from the California portion of the basin in the Shoshone-Tecopa area. Johnson Wright (2013) estimated, based on Maxey-Eakin approach, 728 acre-feet per year of recharge into the basin from the Kingston Range. Recharge from the Nopah Range and others is minimal. Subtracting out the Kingston Range recharges this leaves approximately 10,022 acre-feet per year of discharge. This estimate is higher than that estimated by Halford & Jackson of 8,830 afy of pre-development recharge (2020).

Going back to the Desert Research Institute model, as can be seen, the estimated outflow from Pahrump Valley is insufficient to account for discharge estimated in the Shoshone Tecopa area (the difference is 2,550 acre-feet per year. This represents a good estimate of what could be expected to enter the basin from the north (Amargosa Desert/Ash Meadows area). Therefore, in the Shoshone-Tecopa area, approximately 75% of groundwater could be sourced from the Spring Mountains/Pahrump Valley with 25% coming from the north from the Ash Meadows and Amargosa Desert areas. This is consistent with past work in the area (Zdon, Davisson and Love, 2015). Following this approach using the Halford & Jackson estimate would significantly decrease the north-south underflow flow component from the Death Valley Junction to Shoshone reach of the Amargosa River. This is described in the technical memorandum described in Section 1.4.1.1 and provided in Appendix B (Roux, 2022). Given the measured discharge of Shoshone Spring at approximately 350 gallons per minute (565 afy), and geochemical data indicating that Shoshone Spring is sourced from a north to south flow path, and not via a direct westward flow path, it is likely that the underflow falls somewhere between these estimates.

A subsequent evapotranspiration investigation by the USGS (Pavelko and Damar, 2023) was developed and estimated total evapotranspiration for the Middle Amargosa Valley Groundwater Basin as being 8,220 afy. However, the Pavelko and Damar estimates redistribute the evapotranspiration as estimated previously by Laczniaik. The Chicago Valley evapotranspiration estimate is particularly curious as west of the faulting (associated with Twelvemile Spring) in the central part of the valley, groundwater levels were found to be greater than 60 feet below ground surface below at least a portion of the central part of the Chicago Valley mesquite area (JWI, 2012). Additionally, field work was not focused on that area, so the wide range of evapotranspiration estimates in Chicago valley between Laczniaik work and those reported by Pavelko and Damar (differ by a factor of four) deserves additional work. In these cases, although the total evapotranspiration for the area remains similar, the redistribution of evapotranspiration in the basin has substantial implications to the conceptual model of the basin. Given the additional field investigations needed to verify the Pavelko and Damar results, at this time the conceptual model presented in this SOBR is relying upon previous researchers (e.g., Laczniaik).

Outside of the Middle Amargosa Valley Groundwater Basin but within the regional flow system, pumping is primarily within the Amargosa Desert Hydrographic Basin to the north and the Pahrump Valley Hydrographic Basin, both in Nevada. This water is largely used for irrigation. Table 4 (presented behind the text due to size) summarizes groundwater pumping from the Amargosa Desert since 1983 (NDWR, 2025). This represents the most up to date pumping data available from the Nevada Division of Water Resources at the time of this report. Total pumping over time is also represented on Figure 15.

Figure 15. Amargosa Valley Pumping History (NDWR, 2025)

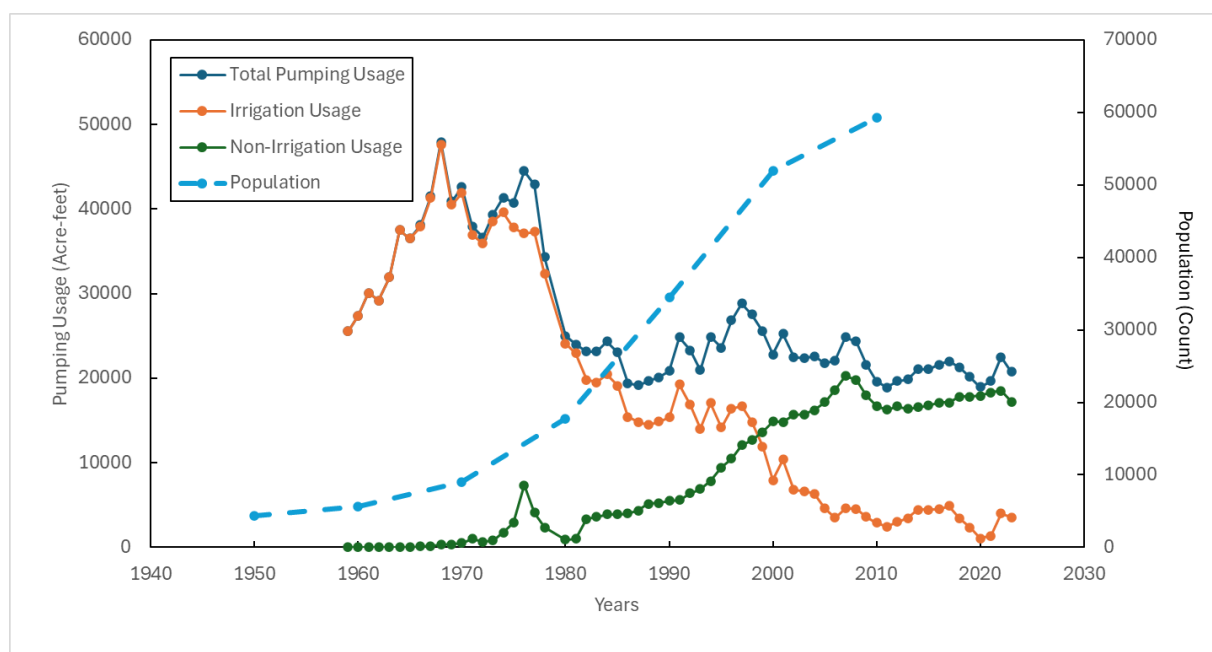


Note: From 2013 to 2022, domestic usage has been calculated by assigning a 1.0 acre-foot usage for each well.

Average annual pumping in the Amargosa Desert area since 1983 and through 2023 has been 13,415 AFY (NDWR, 2025). In the most recent year reported (2023), pumping was 17,963 AFY. As can be seen, over the 39 years of pumping records, the Amargosa Desert has seen a steady increase in pumping. For comparison purposes the annual duty for the Amargosa Desert is 24,663 AFY (includes certificate, permit, and ready for action) as of April 9, 2025, compared to the estimated annual perennial yield of the basin of 24,000 AFY (Walker and Eakin, 1963).

In Pahrump Valley, pumping records available since 1959 (NDWR, 2025) indicate that beginning with in 1959, groundwater pumping in the Pahrump Valley rapidly increased to a maximum pumping of 47,950 AFY in 1968 (Table 5; Figure 17). During the period of 1964 through 1978, pumping in the Pahrump Valley averaged more than 37,000 AFY. Since that time, groundwater pumping in the Pahrump Valley has gradually decreased to the point that in 2011, total groundwater pumping in the Pahrump Valley was 18,905 AFY, the lowest pumping since the initial record in 1959. The 2011 pumping rate was attributable to economic conditions and represented a temporary decrease from the 20,000 to 25,000 AFY of pumping that has been characteristic of the Pahrump Valley since 1980. In 2023 (the most recent record), total pumping in Pahrump Valley was 20,787 AFY, a 10% increase in pumping from 2011 to 2023 (NDWR, 2025).

Figure 16. Pahrump Valley Pumping History (NDWR, 2025)



Note: From 2009 to 2023, domestic usage has been calculated by assigning a 1.0-acre-foot usage for each well. From 1959 to 1965, non-irrigation usage has been assumed none.

Groundwater levels in the Pahrump Valley were noted to have declined steadily over the period of record, but of note is that prior to previous SOBRs (Andy Zdon & Associates, 2014, Partner, 2020), impacts to springs in the Middle Amargosa Valley Groundwater Basin, particularly in the Shoshone – Tecopa area, had not been reported. However, Thompson (1929) referred to a site called Yeoman Spring that had at the time an estimated flow of 90 gpm. Although there is no spring currently called Yeoman Spring, this appears to be the same spring now referred to as Chappo Spring. The only surface expression of flow at Chappo Spring is a “puddle” surrounded by trees (including non-native palms) and shrubs. Additionally, early reports indicated that Resting Springs had flows of more than 200 gpm (up to 250 gpm). Both springs flow at rates lower than those reported in the first half of the 1900’s. While this may be the result of spring modification and additional vegetation uptake, it is possible then that spring flow in the Middle Amargosa Valley Groundwater Basin may have been affected by past pumping in the Nevada portion of the basin.

Recently, localized stabilization and recovery has been reported in selected areas of Pahrump Valley indicative of a basin beginning to come closer to balance with recently reduced pumping rates, primarily in areas of heavy pumping during the 1960’s. However, based on Roux’s groundwater monitoring and that of others over the last 15 years (e.g., Partner, Andy Zdon & Associates) in some areas, groundwater levels continue to decline (e.g. California Valley, Chicago Valley) despite the absence of the groundwater pumping in California Valley and minimal pumping in Chicago Valley.

3.6 Springs

Spring flow and evapotranspiration have been combined as an outflow component in the Amargosa River Basin, as they are unavoidably linked. Groundwater-dependent vegetation (phreatophytes) is present along the Amargosa River and in spring areas. Springs discharge water from the groundwater system, but in all

cases within the basin, that flow either evaporates, is used by plants, or percolates back to the groundwater system within a relatively short distance. One of the few exceptions to this is Willow Creek south of Tecopa which rises from spring flow within China Ranch and maintains surface flow to its confluence with the Amargosa River. In the Nevada portion of the basin, the discharge from spring flow and evapotranspiration has been estimated at 23,500 AFY (Walker & Eakin, 1963). Recommendations for a comprehensive look at spring discharge and evapotranspiration on the Nevada portion of the basin is provided later in the report.

In the Shoshone - Tecopa - Chicago Valley - California Valley area, the combined spring flow and evapotranspiration has been estimated at approximately 8,500 AFY (Belcher, 2019)

Based on the field reconnaissance activities, springs in the California portion of the Amargosa River Basin emanate from a variety of sources. These sources appear to range from those with deep circulation paths (such as Tecopa Hot Springs), and those with shallow and potentially more local circulation paths (such as at Willow Creek). With respect to specific spring flow (not including evapotranspiration or Amargosa River flow), Roux's total field estimated spring surface flow (not evapotranspiration) has typically been approximately 1.8 cfs during the spring reconnaissance activities (approximately 1,300 AFY). Springs such as Crystal and Horse Thief are sourced within the Kingston Range and are from recharge of precipitation that has fallen solely from on that range. Scofield Spring appears to be a mixture of northwest seepage from California Valley toward the southern end of Chicago Valley along with occasional bank storage/recharge from precipitation in the group of hills immediately south of the spring.

The following key springs **that fall within the boundaries of the AWSR** are described in more detail. Parameter trends are presented in Appendix H. Shoshone Spring, which is not within the boundary of the AWSR, is located just west of the northernmost portion of the designated AWSR. Shoshone Spring not only provides the Village of Shoshone with its entire water supply but also supports a spring habitat that has been the subject of substantial restoration of the spring's riparian, largely as habitat for the endangered Amargosa Vole but also as it provides habitat for the endangered Least Bell's Vireo, and other species such as the Shoshone Pupfish and the springsnail Amargosa Tryonia (Hershler and Sada, 1987). Being the water-supply for Shoshone, there is a substantial plumbing system associated with spring, however numerous small seeps are found indicating flow bypassing the Shoshone water collection system. On February 2, 2016, Andy Zdon & Associates along with the owners of Shoshone were able to temporarily shut down the town water supply and divert all captured spring water through a pipe at the community swimming pool. The resulting flow was measured at 260 gpm. Subsequently, Andy Zdon & Associates used a sonic flow meter to measure other springs and seeps issuing from the Shoshone riparian area that were indicative of groundwater flow that bypassed the collection system. The resulting additional flow of 37 gpm was measured resulting in an estimated total spring water discharge of 297 gpm. This is a measure of surface discharge only. Total spring discharge incorporating evapotranspiration would be greater. Based on past monitoring (e.g. Partner, 2020) spring flow appears stable at Shoshone Spring.

Another spring not within the AWSR boundary, Chappo Spring is included here as it is unique in the information it provides related to springs within the AWSR boundary. Numerous other springs and seeps are also present in the area, but for the purposes of this SOBR, the following key springs are presented in the following subsections. For a complete list and records of all the springs noted in the Middle Amargosa Basin, please see Appendix A.

3.6.1 Amargosa Canyon Springs

These are a series of springs/seeps (Amargosa Canyon Springs #2 through #4) along the eastern canyon wall below old Tecopa and above the confluence of the Amargosa River and Willow Creek. It is likely that many of the springs were exposed during the construction of the railroad bed, which was carved out of the eastern wall of the Canyon. A photograph is available showing a Tonopah & Tidewater Railroad car (#4) stopped to take on water at “Red Cut” where a pipe was bored into the hillside tapping into the water from one of the springs (Serpico, 2013).

These rheocene springs are present along the floor and wall of the eastern side of Amargosa Canyon along a 1.3-mile stretch of the Amargosa River. Flow at these springs range from less than 5-gpm to greater than 30-gpm. Total flow from all the springs in Amargosa Canyon remains unknown. Along the canyon wall carved out by the railroad, spring water is emanating from the contact between an alluvial conglomerate which is situated above a mudstone formation. It is likely that the water is flowing in the permeable alluvium overlying the much less permeable mudstone below.

Amargosa Canyon Spring #4 is a series of gushet (concentrated flow from a cliff face) springs located on the eastern bank of the Amargosa River, along the west-facing wall of the Amargosa Canyon. Water from this spring pours out of the canyon wall at the interface between a quartzite unit and the alluvium above. There is significant vegetation in the form of grass that grow on the canyon wall. Vegetation present includes mesquite, Gooding's and Coyote willow, three-square bulrush, baccharis (sp.), saltgrass, and sawgrass. The combined spring discharge enters a railroad cut at the base of the canyon wall. A manmade ditch from the railroad cut directs the flow to the Amargosa River.

3.6.2 Borax Spring

This is an artesian spring/well located at the site of a former borax processing facility northwest of the town of Tecopa. Ruins of the former 19th-century era facility can be seen on both sides of Highway 127. The source of the surface flow is a PVC pipe set in concrete with an approximately 1-inch diameter, cracked discharge pipe attached to the side. The spring is in a flat area, with low hills comprised of Tecopa lakebed deposits to the west. The discharging water forms a 1.0-acre riparian area consisting of a series of pools ringed by low grasses (salt grass). The pooled area is approximately 150 feet long in the north-south direction and 60 feet at its widest point. The flow parallels the adjacent road and eventually disappears into the alluvium approximately 700-feet south of the source.

Periodic monitoring conducted at Borax Spring since 2010 has ranged from 5 gpm (on April 30, 2020) to 17.6 gpm on October 1, 2019. Most recently, the flow was 12 gpm on January 12, 2026. Overall, flow appears steady long-term, with flow increasing during the winter months and decreasing during periods of higher evapotranspiration indicating that flow is affected by near-surface processes. Field water quality parameters including temperature, pH and electrical conductivity have remained constant throughout the monitoring record.

3.6.3 The Borehole (aka Borehole Spring)

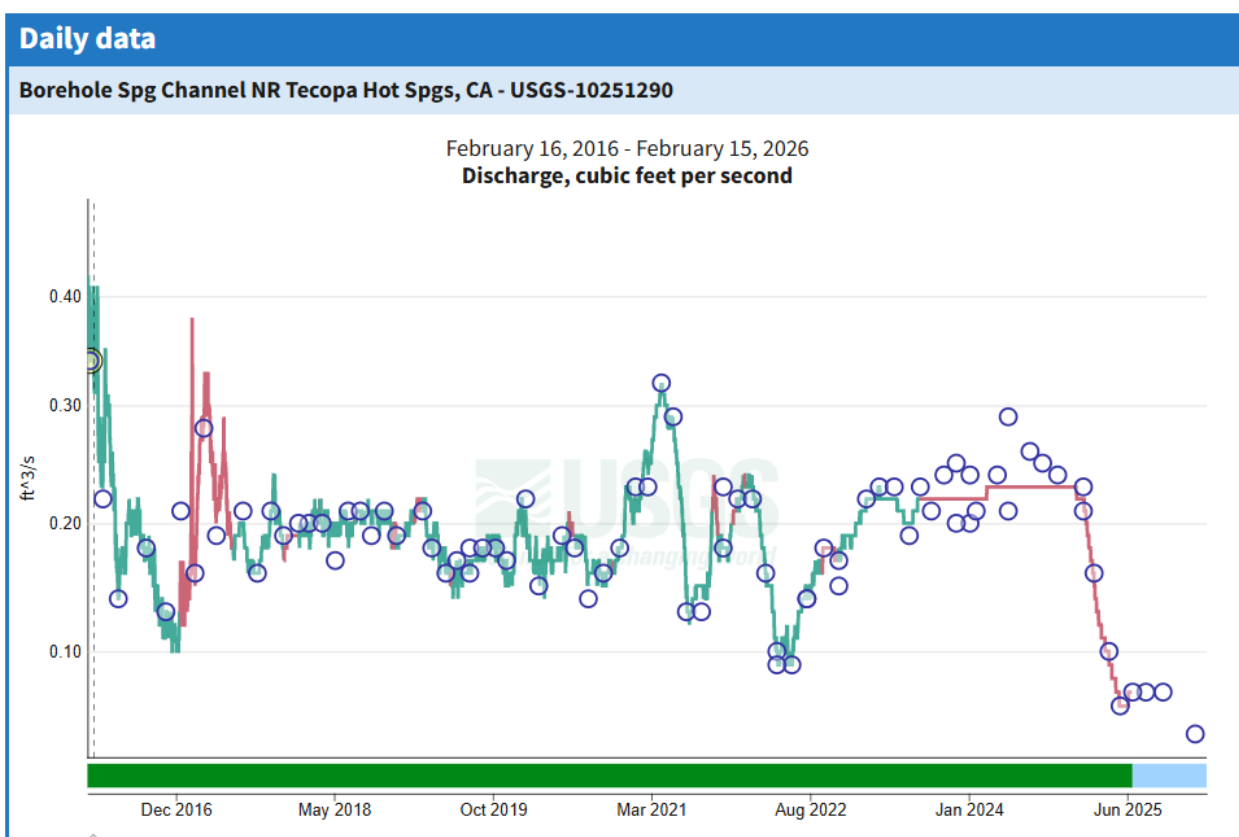
This feature was initially an exploratory drill hole that started in 1967 and was advanced by Stauffer Chemical for mineral exploration. Water was encountered under pressure at a depth of approximately 360 feet. Attempts were made to plug the boring but flowing under artesian conditions around each successive well seal, which also had the effect of creating a large void at depth. Attempts to seal the hole were abandoned and the Borehole came into being. The void was eventually backfilled with 10,000 cubic yards of fill/gravel,

though the flow was never completely contained. There is no obvious source of the water and no trace of the original well. The Borehole now is a series of connected pools (and several non-connected pools).

The water emanating at the Borehole is hot, with the hottest pool being farthest from the road. In this pool, small streams of bubbles can be seen emanating from an area on the bottom, which is the point at which the borehole is being fed. The water in the connected pools is hot, has a greenish tint, is relatively deep (3+feet in areas) and contains fish. The water in the disconnected pools is much cooler, reddish in color, very shallow and contains no fish. The water flows toward the road through a large expanse of three-square bulrush, reeds, and grass (covering approximately 2.5 acres).

At the road, a culvert directs the water under the road and into Grimshaw Lake. Flow is monitored by the USGS and can be altered, so to an extent, some flow changes may be human-induced by activities at the culvert (typically to maintain water conditions in the bulrush for Amargosa vole habitat). Flow has varied considerably since 2011 with measured flows ranging from 20 gpm to 148 gpm. There is a long-term decrease in flow at the Borehole as shown on the graph of Borehole discharge data presented below (USGS, 2026).. Other field water quality parameters (pH and electrical conductivity) are stable.

Figure 18. Borehole Discharge Data (USGS, 2026).



3.6.4 Chappo Spring

Thompson (1921) referred to this spring as Yeoman Spring and states that *“it yields a good flow of water that is warm but has been used for domestic purposes.”* Chappo Spring is the site of the old Yeoman Ranch cited again by Thompson (1929). It was reported that spring discharged at 10 miner’s inches at that time

[approximately 112 gallons per minute in California per Anderson (1993)]. The previous spring survey report (Andy Zdon & Associates, 2016) noted the flow as approximately 90 gallons per minute but that is based on miner's inches as measured in Nevada.

Despite the vegetation that is now present, spring flow has decreased significantly during the past 80+ years. Further historical research on this site is warranted. The California Department of Water Resources (1964) stated that at "*ranches at Resting Springs, Yeoman Hot Springs (Chappo Springs) and China Ranch, obtained continuous flowing water from springs.*"

The most recent monitoring of this spring was in 2019 when the spring's surface discharge was estimated at one gallon per minute (Appendix J).

3.6.5 Christian Spring

Christian Spring (formerly called Amargosa Canyon Spring #1) flows out of earthen bank above the Amargosa River south of the town of Tecopa. Spring was uncovered in the fall of 2010 following a fire that burned much of the vegetation in the northern part of the Amargosa Canyon. As the vegetation grows back, access to the spring is becoming more difficult. Vegetation at Christian Spring consists primarily of phragmites, coyote willow, baccharis (sp.), arrowweed, grapevine and Gooding's willow. Spring appears to result from an accumulation of springs, seeps, and pond outflow from the Zellhoeffer property to the north. Spring flow appears to vary over time (ranging from approximately 38 gpm to 85 gpm) and may be influenced by conditions in the pond on the Zellhoeffer property. Field water quality parameters have remained stable over the period.

3.6.6 Dodge City Spring

Dodge City Spring issues from a small, tule-choked pond immediately adjacent to Furnace Creek Road (just east of Tecopa Road) and follows a small channel approximately 50 feet to a marshy area that extends westward across Tecopa Road. The full extent of the riparian area of the spring is approximately 2.5 acres. Despite the proximity of the road, the site is generally undisturbed except where a culvert at the Tecopa Road allows drainage underneath. At the source, all vegetation is emergent, and along the channel, all vegetation is as bank-cover. Vegetation includes phragmites, three-square bulrush, salt grass, and yerba mansa.

Flow in Dodge City Spring appears to fluctuate with rainfall conditions but has ranged from 5 gpm to greater than 20 gpm (on multiple occasions for both). Most recently, flow at the spring was 20 gpm as estimated on January 12, 2026. Field water quality parameters have been steady since monitoring of this spring started in 2014.

3.6.7 Homestead Spring

This is a spring located east of Thom Spring and north of Stormy Spring. It is a bulrush and cattail-choked spring (surface water is present) in a bedrock narrows where groundwater flowing from the east is forced to the surface. It is a cool spring without discernible flow (standing water only).

3.6.8 Stormy Spring

Stormy Spring is in a dense thicket phragmites thicket against the low hills to the east of Vole Spring. The springs consist of seeps along the base of the hillside; there are probably multiple spring vents obscured by dense vegetation. Approximately 5.5 acres of phragmites, yerba mansa, saltbush (sp.) and saltgrass are present, as are tamarisk and cattails. Spring is in an undisturbed state.

3.6.9 Tecopa Hot Springs

This spring system encompasses the town of Tecopa Hot Springs. Historically, the spring was contained in two pools that produced approximately 225 gpm (Waring, 1915). The water temperature was noted to be about 107°F at that time. Now there are multiple outlets to the spring as people have directed the water to both public and private baths via the installation of wells. Runoff from the spring flows downhill into Tecopa Wetlands, located to the north and east of Tecopa Hot Springs. The temperature of the water at the county facilities currently is approximately 102°F as measured on the outlet south of Tecopa Road.

Mendenhall (1909) wrote: “There are two hot springs on the eastern edge of Resting Springs Dry Lake, about three miles southeast of Zabriskie. These springs yield about two hundred gallons per minute of water which contain, according to qualitative determinations, sulphates of soda and magnesia, some borax, and some niter. In the fall of 1908, there was an old tent at the springs, which are occasionally used for bathing purposes. The temperature of the water is about 107 degrees.”

Data was formerly collected on property owned by The Nature Conservancy. This spring outlet is simply a pipe in the hillside below and is derived from a well. Monitoring is now conducted primarily at the county park. The monitoring record at the county park is not of enough duration to describe trends currently for the individual measuring points.

3.6.10 Thom Spring

Flowing water emanates from the hillside beneath a large Athol tree on the south flank of the bedrock hills south of Tecopa Hot Springs. The actual point of discharge is obscured by the dense vegetation in the area. In general, the foliage around the spring is very dense and precludes an in-depth investigation of water flow. The vegetation at the spring and downstream covers approximately 1.1 acres and includes stressed and dead screwbean mesquite, three-square bulrush, phragmites, baccharis (sp.), bunchgrass, and cattails and tamarisk. There was considerable thistle present on May 31, 2016.

Downstream of the source, a group of cattails are growing out of a small pool of water. Water from this small pool runs overland for several hundred feet. The flow supports a population of small fish. Between April 2012 and January 2013, a small portion of vegetation was cleared out and several small hoses were pushed into the hillside. Spring water now emanates from the hoses. Under the Athol tree is a small pipe that was part of an old well that still has water in it.

The flow at Thom Spring was noted to have decreased when the borehole at Borehole Spring was developed in the 1960's. After a sustained period of surface discharge as much as 5 gallons per minute in 2010, flow slowly decreased and has been absent since October 2022, although phreatophytic vegetation is still present.

3.6.11 Vole Spring

Vole Spring's riparian area covers approximately 3.7 acres, and consists of a dense thicket of mesquite, three-square bulrush, baccharis (sp.), and tamarisk. The actual spring vent is unclear and inaccessible due to the thick brush. The mesquite is bimodal – screwbean mesquite is generally dead, while honey mesquite is healthy. There appears to have been a decrease in spring flow since 2015. Fish have been observed in the water here, and field water quality parameters have been stable. There has been some diversion of flow in the past (there are ditches and old piping present). More recently, new piping is present, and we have been unable to access the spring. Additionally, marijuana grown was observed here previously.

3.6.12 West-side Spring

This spring rises immediately west of the river south of Tecopa Hot Springs and north of the old Tecopa. Flow reaches Amargosa River via channel flowing at about 10 gpm. Site is undisturbed, with mesquites, rushes, willows, and cattails, present.

3.6.13 Willow Creek

Willow Spring at China Ranch has long been noted as a source of excellent quality water in the area. Mendenhall (1909) stated: "China Ranch...also known as Morrison Ranch and Willow Creek Ranch, is on the main road from Daggett to Resting Springs." Mendenhall continues, "The springs that furnish this water rise in Tertiary rocks, which outcrop around the ranch to a height of 500 to 600 feet. Good hay can be obtained here, the first to be had after leaving Daggett, 110 miles south. Willow Creek furnishes sufficient water to irrigate about 100 acres of land. This ranch is one of the real oases of the desert, and travelers appreciate the cool water, the supply of alfalfa, and the shade of fig trees.... J.C. Fremont passed this spot on April 29, 1844, on his way from Tomaso Springs to Resting Springs. He says of it "The ravine (Amargosa Canyon) opened into a valley (Willow Creek), where there were springs of excellent quality".

Waring (1915) reported that China Ranch Springs were flowing at a rate of 50 gallons per minute (water temperature 60°F) and being used for irrigation. Waring states, "The China Ranch is situated in the canyon of Willow Creek, half a mile or so above its junction with Amargosa River and 5 miles north of Sperry station on the Tonopah & Tidewater Railroad. Willow Creek is supplied by springs of considerable flow and of good quality, which issue from sandstones and clays of Tertiary age that form the canyon walls. The water is used to irrigate several acres of alfalfa and garden vegetables, and the ranch forms one of the few oases in the desert eastern part of the State. It is a stopping place and supply point on one of the main desert routes between the mining camps of eastern California and western Nevada. The springs were visited by Frémont in 1844, when returning eastward from his exploring expedition."

The riparian area of Willow Creek (spring) covers approximately 65 acres from the uppermost point of flow at China Ranch (designated as Willow #2 to a point approximately 1,500 feet below the lowest date grove). From there a ribbon of riparian vegetation extends all the way to the Amargosa River.

Spring flow is initially intercepted in a shallow french drain system installed across the Canyon by China Ranch for irrigation purposes. The captured water is directed through piping into a series of spring boxes and then into a holding tank. From the holding tank, the water is gravity fed into an irrigation system. The flow captured by this system is approximately 28-gpm. When the system is not in use, the water overflows a spring box and continues downstream as overland flow. The spring itself comes to the surface at a point downstream of the french drain capture system. All overland flow through China Ranch itself flows through a culvert near the entrance to the facility. The flow recorded at the culvert location was approximately 120 to 130-gpm (which at the time included the overflowing irrigation system water). This water continues down China Ranch Wash toward the Amargosa River.

Flow measurement on Willow Creek by the USGS is conducted at Willow #2. While problematic in relation to actual flow measurements (for example on September 25, 2013 an instream metered flow measured 37 gallons per minute while the gage was measuring 4.5 gallons per meter with the former flow more likely based on visual observation), the meter does provide a record of changes over time that are not captured by periodic field measurements.

At Willow Creek #1, vegetation included mesquite (honey and screwbean), willows (Gooding's and coyote), phragmites, three-square bulrush, grasses, saltbush (sp.) and tamarisk were present. In December 2015, the vegetation was quite overgrown as compared to past visits. At Willow Creek #2, vegetation present includes mesquite (screwbean and honey), willows (Gooding's and coyote), three-square bulrush, saltgrass, cottonwood and other riparian shrubs. At Willow Creek #1 there were Desert Bighorn Sheep tracks. There is much sign of coyote and bobcats, and these are frequently seen at these locations.

Spring flow and field water quality parameters at Willow Creek have remained stable since monitoring began in 2010.

A new measuring point has been added for lower Willow Creek below China Ranch. This new measuring point is adjacent to the newly created Bill Christian Trail below the China Ranch facility parking area. This measuring point provides an excellent monitoring point along Willow Creek below the China Ranch operations but above the confluence with the Amargosa River. Data for these measurement locations are provided in Appendix A.

3.6.14 Trends

Springs with downward discharge trends have been observed to be Thom Spring (surface discharge now absent), the Borehole (as observed in Section 3.6.3), Twelvemile Spring (although appears to be stabilizing), and Scofield Spring where surface water has been absent the last two monitoring events, potentially due to declining groundwater levels in California Valley, an apparent source of water to the spring through the South Nopah Range. Discharge trends on Tecopa Hot Springs is difficult due to measurements being tied to management of the hot spring facility. Discharge at Shoshone Spring and Willow Creek appears stable.

A north-south line of seeps along the eastern base of the Tecopa Hills appears dry now, possibly caused by either or both of decreased flow from Pahrump Valley and the Borehole presence.

3.7 Groundwater Quality

Groundwater quality in the Amargosa River Basin is highly variable. In recharge areas, the concentrations of dissolved solids in groundwater are low. However dissolved solids will increase as the groundwater moves through the groundwater system and is in contact with the rock materials present. For example, in the area of Willow Creek, dissolved solids may be high due to the presence of gypsum deposits in the geologic materials through which groundwater in that area flows. In the Amargosa Desert where groundwater pumping is focused, much of the water present is suitable for irrigation (not all of which is suitable for domestic use), however water of medium to high salinity is locally present.

3.8 Groundwater Discussion

The volume of groundwater in storage is an important aspect of the groundwater system. Changes in storage are identified in the field by changes in groundwater levels. A fundamental groundwater equation and the basis for evaluations of groundwater budgets (inflow vs. outflow estimates) is:

$$\text{Inflow} - \text{Outflow} = \text{Change in Storage}$$

When outflow exceeds inflow, there is a negative change in groundwater in storage and groundwater levels can be expected to decline. When inflow exceeds outflow, the reverse is true. When the system is in equilibrium, water levels will generally remain relatively constant despite short-term fluctuations. Long-term

groundwater level declines are a clear indication that outflow has been exceeding inflow for an extended period of time. It should also be noted that in many areas, the recovery of groundwater levels due to groundwater being removed from storage can take longer than the period to remove it depending on the volume removed from storage, precipitation trends and the geology of the basin.

Taking this one step further, under predevelopment conditions, a groundwater system is in equilibrium, a condition where inflow equals outflow. Groundwater pumping causes a disruption in this equilibrium, and recharge amounts and patterns can change. More often, discharge amounts and patterns are impacted. This includes the loss of phreatophytic vegetation (vegetation whose water requirements are met by roots tapping groundwater such as in springs) and reduction or elimination of spring flow. All pumped water must be supplied by one or more of the following:

- Decreases in groundwater storage;
- Increased or induced recharge; and
- Decreased discharge either in the form of reduced subsurface outflow or decreases in natural forms of discharge such as evapotranspiration, spring flow, or river base flow.

Regardless of the amount of groundwater pumped, there will always be groundwater drawdown (and the removal of water from storage) in the vicinity of pumping wells, a necessity to induce the flow of groundwater to said wells. For most groundwater systems, the change in storage in response to pumping is a transient phenomenon that occurs as the system readjusts to the pumping stress. The relative contributions of changes in storage, increases in recharge, and decreases in natural discharges evolve over time. As an example, upward leakage from the carbonate rock aquifer to the valley fill aquifer has been postulated as early as the 1960's (Walker & Eakin, 1963). Elevated pumping in the valley fill aquifer could induce greater upward leakage from the carbonate rock aquifer that correspondingly could result in reduced spring flow from those carbonate rocks.

If the system can come to a new equilibrium (i.e., a combination of increased recharge and/or decreased discharge), the storage decreases will stop, and inflow will again equal outflow. The amount of groundwater "available" for a future groundwater development project is therefore dependent on what these long-term changes are, and how these changes affect the environmental resources of the area. Numerical models are ideal tools to evaluate these issues in that the complexities of the groundwater system can be evaluated in detail, and assumptions of how the groundwater system works can be evaluated for internal consistency. Currently, there are no groundwater flow models with sufficient detail to develop this level of understanding in the AWSR area. With advances in software available to the groundwater professional, the efficiency and associated costs of groundwater modeling have significantly decreased over the last two decades.

Groundwater inflow, outflow and storage estimates were provided where available in the previous sections. Based on a review of limited shallow groundwater levels and springs in the Shoshone – Tecopa area, the groundwater system in the system appears to be going through a period of very slow hydrologic decline. Decreases in spring flow at Chappo Spring have been noted previously (Andy Zdon & Associates, 2014). That decrease in spring flow is likely due to the long-term groundwater level declines that were noted in Pahrump Valley. Springs in the Tecopa area have also decreased in flow since the 1960's, at least partially the result of the bore hole at the Borehole and likely due to the number of wells (pumped and artesian) used to tap the hot springs in Tecopa Hot Springs by private residents and businesses. In both cases, given the expanse of the groundwater system and the distant nature of the groundwater extraction that could most

affect the groundwater system that feeds the AWSR, changes to groundwater flow in springs and groundwater levels in wells will occur very slowly. These are changes that may only be noticeable on a generational basis. It follows that recovery of groundwater levels or springs in flows may occur on an even slower basis. Therefore, identifying change, and potential impacts, to the groundwater system early is essential for managing the AWSR.

3.9 Groundwater Trends

As part of this, and previous investigations, nine groundwater monitoring wells were installed in the Shoshone-Tecopa region and outfitted with groundwater-level recording devices. A summary of groundwater level trends in each of these wells follows and hydrographs for each of the wells are presented in Appendix I. The monitoring well discussed below are generally located northwest to southeast and are shown on Figure 6.

- ARHS-08: This is the northwestern-most monitoring well at the former railroad-side site of Evelyn, along the current Highway 127 north of Shoshone and south of Eagle Mountain. This monitoring well was installed during Spring 2018 and approximately 7 years of data have been recorded for this well. Groundwater levels have exhibited a very slow, but steady decline since installation. The rate of decline of 0.04 feet per year.
- ARHS-01: The first installed, also being one of the most informative in developing the conceptual model of the Shoshone-Tecopa area. This monitoring well was installed during 2012 and approximately 13 years of data have been recorded for this well (the transducer was pulled during Spring 2019 for repair and has been replaced as of September 2019. Approximately 0.3 feet of groundwater level decline was observed from 2012 to 2021, however, groundwater levels have been stable at this well since 2021.
- ARHS-09: This is the north-easternmost monitoring well, in southern Stewart Valley (within California). The monitoring well was installed during Spring 2018 and approximately 7 years of data have been recorded for this well. From 2018 to 2021, groundwater levels were lowering at a rate of 0.26 feet per year, with that rate moderating (but still declining) at a rate of 0.2 feet per year since 2021.
- ARHS-03: This monitoring well at Twelvemile Spring in Chicago Valley was installed in 2013 and approximately 12 years of data have been collected at this location. During the period of 2012 to 2021, groundwater levels were declining at a rate of 0.2 feet per year, but have stabilized and slightly recovered (0.32 feet of recovery) since 2021.
- ARHS-06: This monitoring well immediately north of Tule Well in California Valley was installed during spring 2018. This site has considerable phreatophytic vegetation (including tamarisk, and mesquite) and groundwater levels show a strong, seasonal evapotranspiration signal (with approximately 1.5 feet of lower groundwater levels during summer). The casing in this well is either broken or clogged by roots from surrounding vegetation. This well will need to be destroyed under permit with Inyo County, and a new well reconstructed in the future.
- ARHS-10: This monitoring well at the old Davis Well site in California Valley was installed in Spring 2018 and approximately 7 years of data have been collected. There is minimal groundwater-dependent vegetation and data collected to date indicate groundwater levels declining approximately 0.16 feet (a steady, slow decline) over the 2-1/2 years of data collection (absent a period immediate groundwater level rise after the 2020 earthquake on the Garlock Fault near Ridgecrest and then decline shortly thereafter following a microquake on the north base of the Kingston Range). Groundwater levels have continued to decline since 2021 at a rate of 0.25 feet per year. However, groundwater levels have recovered by nearly one foot since April 2025. The cause of this significant rise in groundwater levels is unclear and neighboring Tule Spring remains dry.

- ARHS-04: This monitoring well is at the head of China Ranch Canyon and at the former site of “Married-Man’s Camp.” This monitoring was installed in 2013. Shallow groundwater levels in this monitoring well have remained stable during the 12 years of monitoring.
- ARHS-02: This monitoring well is along Willow Creek at the upper end of the China Ranch date farm property and was installed during 2012. Groundwater levels in this monitoring well are affected by water usage at the date farm but appear relatively stable from a long-term perspective.

3.10 California and Nevada Future Water Use

There has been an increased use of groundwater in the Nevada portion of the Amargosa Basin over the past 25 years. The potential for future development will be limited by both the quantity and quality of water. However, as can be seen by the active duty for the Amargosa Desert, there is significant potential for pumping to increase considerably should water rights holders fully exercise their water rights. This is also true in the Pahrump Valley. Given the over-allocated nature of the Amargosa Desert and Pahrump Valley, significant impacts to the groundwater resource could result if that condition occurred. These uses are anticipated to increase due to future population growth, open pit mining, and the future addition of groundwater usage for solar energy development. Although wet cooling solar projects are not anticipated, groundwater usage for processes such as mirror washing, dust control, and other construction will still be needed. Additionally, potential development of the proposed Yucca Mountain Nuclear Waste Repository could result in an increase in groundwater usage and degradation of groundwater quality.

The competing demands for renewable energy, mining and other uses, and protection of the Amargosa River point to the need for increased knowledge and baseline hydrologic data in the Middle Amargosa Valley Groundwater Basin. Recommendations for future investigations are provided in the following sections of this report.

More recently, substantial advancement of up to seven gold mining operations in the Oasis Valley Hydrographic Basin in the upper Amargosa basin has occurred. One project, the North Bullfrog Mine, is currently going through the permitting and environmental review process. Roux conducted an analysis (Appendix J) of two applications for changing point of diversion of existing rights in the Oasis Valley, related to the North Bullfrog Project. It is our understanding that those applications have been withdrawn. While the proposed groundwater appropriations in the applications would have placed an additional stress on an already over-allocated groundwater system despite showing lesser effects to the Amargosa River, that pumping would ultimately have been combined with additional pumping from the mining operations the applications were intended to support. Those combined effects would be considered minimum impacts, as several other potential mining operations are either proposed or still in development stages in the Oasis Valley area. The analysis indicated that conflict with existing water right holders in Oasis Valley, particularly those that rely on spring water for a part, or all, of their water needs would have been likely. Additionally, substantial impacts to groundwater dependent ecosystems would be anticipated with the magnitude of drawdown presented herein.

What that analysis ultimately illustrated was a coming issue as more mining operations develop their projects and potentially apply to move points of diversion from elsewhere in the system to Oasis Valley to support those operations. The upper Amargosa Basin perennial yield and associated water rights in Nevada are treated as a system, with those values being combined over multiple basins including the Amargosa Desert Hydrographic Basin, Oasis Valley Hydrographic Basin, Crater Flat Hydrographic Basin, and more. Moving points of diversion from areas spread out across the system to a concentrated area in Oasis Valley is likely

to create substantial conflicts among water-right holders and cause significant impacts to groundwater-dependent ecosystems. Ultimately, a portion of the groundwater use from the Oasis Valley Hydrographic Basin will result in a reduction of groundwater movement towards the Amargosa Desert Hydrographic Basin, Death Valley National Park, and the Middle Amargosa Valley Groundwater Basin in California.

A water quality factor that should also be considered as was identified in that previous analysis was that as shown in DV3, drawdown derived from pumping in the Oasis Valley Hydrographic Basin tended to extend north-eastward as pumping continued, and after pumping ceased. The potential for increased hydraulic gradients from east to west in the Oasis Valley area due to the proposed new pumping stresses could lead to increase westward movement of contaminants from the Department of Defense and Department of Energy lands (located to the east). This is of particular note given the uncertainties associated with data gaps, modeling uncertainties, and the likelihood of additional mining and water development in the area (Roux, 2025, see Appendix J). Given the reliance of the DV3 model for evaluating water rights applications in the Oasis Valley by the Nevada State Engineer, a trend to move those points of diversion to the Sarcobatus Flat Hydrographic Basin may ensue. Sarcobatus Flat was incorporated into prior versions of the Death Valley Regional Flow System modeling; however, DV3 does not include Sarcobatus Flat into that numerical flow model. Moving groundwater applications to Sarcobatus Flat will have the effect of nullifying the use of DV3 and will result on a reliance of project proponent modeling efforts.

4. Recommendations

The Bureau of Land Management is currently developing a management plan for the AWSR. Given the regional nature of the groundwater source that feeds the AWSR, an effective monitoring program for the AWSR will include sites well away from the AWSR. Although the management plan will be for a specific water source (i.e., the AWSR), the unique hydrology and the expansive area that contributes to the Amargosa River through complex groundwater flowpaths makes purely river-centric monitoring of limited value. Based on the results of current and past work, decreases in groundwater level and associated underflow in the northern Amargosa basin and Pahrump Valley (both in Nevada) could affect springs in the Middle Amargosa Valley Groundwater Basin and the AWSR fed by those springs.

The Amargosa River Basin, which spans two states, three counties and one National Park, exists as one of the most ecologically important desert watersheds in the southwestern United States. Both the groundwater and surface water in the basin support a unique and diverse ecosystem, while also supporting human needs through domestic, agricultural, wildlife, stock-watering, mining, and other industrial uses. As the Amargosa River is a groundwater-fed surface water body, small variations in the groundwater surface elevation can have considerable effects on the ability for the river to maintain surface flow. While the Nevada portion of the Amargosa River Basin has been well-studied, primarily because of hydrologic studies centered on the Nevada Test Site and the Yucca Mountain Project, until recently the California portion of the basin has seen little in the way of regional hydrogeologic investigations. Therefore, it is essential that a monitoring program be incorporated into management of the AWSR that identifies changes in the groundwater system, prior to the Amargosa River being impacted.

In the Amargosa Desert, groundwater is already over-allocated (as it is in Pahrump Valley as well). Although pumping does not currently take place at the full amount entitled to by water rights holders, considerable impacts to the groundwater reservoir and associated springs could occur (and is already occurring) should those holders eventually fully exercise their water rights. Groundwater usage within the Amargosa Desert has steadily increased over the past 25 years, and the addition of new industries to the area (solar and mining) will provide additional pressure on the groundwater resource. As groundwater usage increases in the Amargosa Desert, combined with continued pumping in Pahrump Valley supporting a growing population that is currently approaching 50,000, it is likely that groundwater flow into the Middle Amargosa Valley Groundwater Basin is decreasing. Given the importance of the alluvial aquifer to many of the springs in the Middle Amargosa Valley Groundwater Basin, this issue is of key importance to sustaining the Amargosa River.

In 2009, the Amargosa River between Shoshone and the terminus of the Amargosa Canyon received Wild and Scenic status through an act of Congress. As a result, the BLM is charged with developing a management plan for the Wild and Scenic portion of the Amargosa River. It is essential that hydrogeologic characterization of the California portion of the basin continue to take place in order for that management plan, and its associated management recommendations, to have a firm basis, and to assure that monitoring is conducted in a meaningful way to identify potential impacts to the river and its feeder springs before irreversible impacts from future groundwater development occur. Based on the results of the current and past hydrologic work along the Amargosa River, the following sections highlight technical needs that should be incorporated into a management plan for the Amargosa WSR.

4.1 Water Management

Best Management Practices (BMPs) for future groundwater development projects in the Amargosa River Basin region should be established that are focused on protection of the Wild and Scenic Amargosa River. The monitoring proposed in this report is a starting point. With additional monitoring wells as listed in Section 4.2 and additional investigations being conducted, the monitoring program will need to adapt to meet our growing knowledge of how the Amargosa River system works. The Wild and Scenic management plan then will need to be a dynamic plan, able to guide the management of the Amargosa River with our ever-growing knowledge of how it works and sustains its fragile ecology.

4.1.1 Monitoring

One of the complexities of monitoring surface water flow in the Amargosa River Basin is the dynamic river channel that changes in character annually due to flood scouring, deposition of bedload from floods, and changing vegetation conditions. The current Amargosa River gaging location used by the USGS above the confluence with Willow Creek, was not part of the river channel 20 years ago. Nimbler river monitoring will be needed to account for surface flows but also to adjust with changing conditions. Given the groundwater-driven river system, depending on sedimentation in the Amargosa Canyon from one year to the next, the same amount of water flow through the canyon (surface water plus groundwater underflow) may produce less surface expression of river flow one year, and more the next. Linking river monitoring with both surface flow gaging with groundwater monitoring using shallow piezometers (that may occasionally need to be replaced due to flood events) will provide the best means for long-term river monitoring.

4.1.2 Considerations

The AWSR and surrounding groundwater system that feeds it appear to be in a state of slow change (decline). Given the limited groundwater pumping in the Shoshone-Tecopa area, the AWSR system and springs in the area are going to persist or continue to decline based on groundwater management decisions in Nevada. It follows that the ecological and economic benefits to the AWSR system in California will persist or decline based on groundwater management decisions in Nevada. Interstate groundwater management efforts and cooperation will be essential to protect the ecology of the Amargosa River system in California and the economy of eastern Inyo County.

This can be seen in reduced spring flow up-gradient of the Amargosa River such as at Chappo, Twelvemile, and Resting Springs (Partner, 2020) and the declining groundwater levels observed in California Valley as part of this investigation. As was described in the previous sections, there is the potential for increased groundwater usage in the Pahrump and Amargosa Desert Hydrographic Basins in Nevada. These basins are currently overallocated. Future groundwater development proposals (for projects throughout the groundwater flow system extending into Nevada) and associated environmental analyses should address how proposed activities will affect (long-term) the AWSR. That includes recent groundwater development projects proposed in the Oasis Valley, Amargosa Desert, and Pahrump Valley Hydrographic basins. This will include numerical groundwater flow modeling as described in other management documents such as the Desert Renewable Energy Conservation Plan (in California), use of the DV3 model (in California and Nevada) and associated model updating as described in Section 4.2.3.

4.1.3 Tamarisk

River gaging and monitoring, including monitoring the downstream extent of surface flow, has shown that the Amargosa River has peak flow and extent during periods of low evapotranspiration (winter) and lowest extent

and flow during late spring and summer during periods of maximum evapotranspiration. Given the extent of tamarisk growth in the Amargosa Canyon, removal of tamarisk could have a marked effect on enhancing river flow. Such activity would need to be conducted with careful planning as abrupt removal of tamarisk could remove valuable cover for birds such as Least Bell's Vireo that nest in willows where there is sufficient cover surrounding the willows. It is our understanding that vireo nesting is less in willows without the surrounding cover. Additionally, field mapping of vegetation, and water/soil conditions should be conducted in areas currently covered by tamarisk thickets to evaluate vegetation types that both provide maximum ecological/wildlife benefit.

4.2 Science

Attempting to evaluate groundwater recharge and groundwater underflow into the Middle Amargosa River Basin will be difficult both from a technical standpoint and in funding what would be a major investigative endeavor. Therefore, the most logical means to evaluate the groundwater budget for the Middle Amargosa Valley Groundwater Basin will be to develop a firm understanding of the various groundwater discharge components including evapotranspiration (including spring flow), subsurface underflow beyond Salt Creek and analyzing associated groundwater level trends. The recommendations for additional investigations are based on our experience in the Amargosa Basin and elsewhere.

Based on the results of past and current investigative work, and to accomplish the larger goals of the project, the following lines of investigation to refine the conceptual model for the Middle Amargosa Valley Groundwater Basin should be considered to fall into three categories including:

1. Groundwater monitoring well installation to improve our understanding of the system and provide protective monitoring points;
2. Additional investigation for sourcing of springs and the Amargosa River; and
3. Additional investigations to better understand the overall system.

These three key areas of further investigation are discussed below.

Additional Piezometer/Monitoring Well Installation

Shallow and deep piezometers/monitoring wells (wells) should be installed to further evaluate the conceptual model of this part of the Amargosa Basin with an emphasis on understanding groundwater flow paths; and for supplemental monitoring to evaluate baseline groundwater conditions and identification of impacts to groundwater levels in the future should they occur. Roux anticipates that the wells would consist of both shallow (assumed depth of 25 feet below ground surface (ft bgs) and deep wells extending possibly in excess of 1,000 ft bgs. We anticipate wells in the following general locations:

- Two shallow wells along the Amargosa River between Shoshone and Tecopa;
- At least one deep and shallow well-monitoring pair in Chicago Valley in the central portion of the valley west of Twelvemile Spring;
- Replacement of monitoring well ARHS-10 at Tule Well.

Deep monitoring wells as presented above would be particularly helpful in evaluating flow paths and refining the conceptual and numerical groundwater flow models. However, they would also be costly. At this time, as it is anticipated that most future groundwater production will occur in the valley fill aquifer, a focus on

monitoring wells in the valley fill is recommended here, although there has been recent consideration in Nevada of introducing deep production wells to tap the aquifer (e.g. in Pahrump Valley). Should sufficient funding become available for the installation of deep monitoring wells, locations that should be considered would be at Twelvemile Spring, ARHS-01 north of Shoshone, and in the Death Valley Junction/Eagle Mountain area (possibly adjacent to ARHS-08).

Geochemical Sampling of New Piezometers/Monitoring Wells

Water samples should be collected from new groundwater wells and analyzed for a specific suite of constituents, including field parameters, general chemistry, anions, cations, a comprehensive suite of trace metals, and selected stable and non-stable (e.g. radiocarbon and tritium) isotopes.

Low-levels Metals Analysis

Although metals analysis has been conducted at springs in the Middle Amargosa Valley Groundwater Basin, many of the metals are not detectable at standard laboratory detection limits. Metals suites can be quite informative to understand the relationship between waters, so this would entail specialized analysis to obtain metals concentration information at lower detection limits than typically conducted.

Measure additional $^3\text{He}/^4\text{He}$ ratios.

Collect additional $^3\text{He}/^4\text{He}$ ratios between Ash Meadows NWR and Tecopa area to provide a continuum of ratios with downgradient distance and would facilitate the development of a groundwater age model.

Analysis of Salts in Discharge Areas

Conduct an analysis of salts in discharge areas to identify elements in discharge areas that may be introduced into spring waters at specific discharge points and their solubilities that may alter the chemical makeup of waters. This would provide comparative data to spring water containing high concentrations of total dissolved solids to determine if this is a viable mechanism to explain spring water compositions.

Geophysical Investigations

Geophysical surveys should be completed in the vicinity of Tecopa to evaluate faulting in the vicinity of the thermal springs. Additional surveys north of ARHS-01 to evaluate the geologic connectivity between the northern portion of the basin and the area south of Eagle Mountain. This would also help inform our understanding of monitoring results in that area.

Installation of Four Precipitation Stations

Install precipitation stations to evaluate areal and elevation variations in precipitation in the area (for greater understanding of the water budget of the area and to provide information useful in distributing recharge in the numerical groundwater flow model) and to refine our understanding of recharge sources and the effects of precipitation events on groundwater-level fluctuations, four precipitation stations should be installed at the following locations:

- The south flank of Eagle Mountain;
- Twelvemile Spring;
- Dumont Road;
- Horsethief Spring (in the Kingston Range).

Precipitation samples could be collected from these stations (particularly the Kingston Range station) to evaluate recharge sources. These precipitation stations would also provide key data for any future investigations on effects of climate change on the Amargosa River and its feeder springs. These locations (along with the existing station in Tecopa) provide good areal coverage and span a wide elevation range (from approximately 200 ft msl to 4,600 ft msl).

At this time, it is planned that data downloading would be accomplished during quarterly events as part of hydrologic monitoring. It is anticipated that NOAA-II precipitation gages would be installed, manually serviced, and fitted with data loggers and flash memory data collection modules. The stations would be able to account for snow water content which would be of particular importance at the Kingston Range location (Horsethief Spring area).

4.2.1 Monitoring / River Monitoring Alternative

Monitoring forms the basis for any water management activities in that it is impossible to manage any resource without a basis for what that resource comprises. The recommendations provided below contain provisions for both automated monitoring techniques and regular field monitoring. In desert areas where river channel or spring conditions can radically change as the result of one summer thunderstorm, having regular field observations taking place is key to not only monitor the resource, but to assure that automated data collection devices are working correctly (and to perform maintenance) and that physical conditions on the ground have not changed to the extent that automated data collection is compromised (e.g. river changing course and stream gage station no longer accurately measuring flow).

As described in earlier, flow along the Amargosa River will be extremely sensitive to changes in groundwater level. Generally, water rises to the surface of the river channel where constrictions are encountered forcing water to the surface. Groundwater monitoring will therefore be an essential component to river management. Additionally, infestation of non-native vegetation such as tamarisk will also have a negative effect on river flow and spring flow where it is present at spring discharge points. Visual monitoring of vegetation, particularly for the presence of tamarisks or other water-using, non-native vegetation will be a key component of river management.

Roux makes the following monitoring recommendations:

- Spring Discharge, Water Level, and Precipitation Monitoring - Flow discharge and groundwater elevation measurements should continue and be collected three times per year consistent with the current schedule, from the existing suite of springs and wells being monitored in addition to new wells.
- Groundwater level measurements should continue to be collected with pressure transducer/data logger installations at all existing (currently in place) and future monitoring wells.
- Visual Monitoring – Photographic and video (where applicable) documentation should be collected from specific locations to identify noticeable changes in the spring and river environments. This will assist in identification of tamarisk or other non-native vegetation encroachment that could affect river and spring flows, as well as the areal extent of phreatophytes. Additionally, periodic cross-checking with aerial imagery should be conducted to identify changes to areas not specific to monitoring sites.
- Groundwater Usage – Monitoring existing and proposed groundwater usage throughout the basin both in Nevada and California will be a key monitoring component protective of the WSR.

4.2.2 Groundwater Modeling

The DV3 model is the primary tool that will be used by the Nevada State Engineer to evaluate groundwater applications within the Nevada portion of the Amargosa Basin. As part of the current scope of work, Roux is updating a portion of the DV3 model coinciding with the area of the AWSR. During Roux's work evaluating proposed minerals withdrawal in the area of Ash Meadows NWR, several aspects of the DV3 model relating to transmissivity zonation and other characteristics, particularly considering existing well logs in the area, were identified (Roux, 2024; Appendix K). Further, the DV3 model does not simulate conditions in the Sarcobatus Flat Hydrographic Basin, which is problematic in that a large potential extraction of groundwater may straddle the basin divide between the Sarcobatus Flat and Oasis Valley Hydrographic Basins. Further updating and refinement of the DV3 model in those areas are needed to meet the needs of future groundwater analyses affecting the Amargosa River Basin.

5. References

The following references are those listed in this report. For a more comprehensive compilation of references for the Middle Amargosa Basin, please see Appendix L.

- Anderson, K.E., 1993. Ground Water Handbook. 1st edition, National Ground Water Association. 401 p.
- Belcher, W.R., ed., 2004. Death Valley Regional Ground-Water Flow System, Nevada and California – Hydrogeologic Framework and Transient Ground-Water Flow Model. U.S. Geological Survey Scientific Investigations Report 2004-5205.
- Belcher, W.R., Sweetkind, D.S., Hopkins, C.B., and Poff, M.E., 2019, Hydrogeology of Lower Amargosa Valley and groundwater discharge to the Amargosa Wild and Scenic River, Inyo and San Bernardino Counties, California, and adjacent areas in Nye and Clark Counties, Nevada: U.S. Geological Survey Scientific Investigations Report 2018–5151, 131 p., 1 pl., <https://doi.org/10.3133/sir20185151>.
- Brogan, G.E., Kellogg, K.S., Slemmons, D.B., and Terhune, C.L., 1991. Late Quaternary Faulting along the Death Valley – Furnace Creek Fault System, California and Nevada. U.S. Geological Survey Bulletin 1991.
- Buqo, Thomas, 2004. Nye County Water Resources Plan. August.
- Cal-Adapt, 2025. California Climate Change website. <https://cal-adapt.org/>
- Calclim, 2025. California Climate Data Archive. <https://calclim.dri.edu/>
- California Department of Water Resources, 2003 – California’s Groundwater – Update. Department of Water Resources Bulletin No. 118.
- California Division of Mines, 1954. Geology of Southern California. California Division of Mines Bulletin 170.
- Classen, H.C., 1986. Late Wisconsin paleohydrology of the west-central Amargosa Valley, Nevada, USA. Chem. Geol., 58, p. 311-323.
- Davis, S.N., and DeWiest, R.J.M., 1966. Hydrogeology. Wiley & Sons, New York. 463 pp.
- Davisson, M.L., Smith, D.K., Keneally, J., Rose, T.P., 1999, Isotope hydrology of southern Nevada groundwater: stable isotopes and radiocarbon. Water Resources Research 35, 279-294.
- Desert Research Institute, 2016. Modeling Assessment of Pahrump Valley, Nevada. December.
- Faunt, C.C., D’Agnese, F., and O’Brien, G.M., 2004. Hydrology. In Chapter D of (Belcher, 2004).
- Gordon, Nancy B., T.A. McMahon, B.L. Finlayson, C.J. Gippel, and R.J. Nathan. 2004. *Stream Hydrology: An Introduction for Ecologists*, Second Edition. Wiley, Hoboken. 429p.
- Halford, K., 2015. Letter to U.S. Department of Energy re: transition to new Death Valley regional flow system model. December 18.
- Halford, K.J., and Jackson, T.R., 2020, Groundwater characterization and effects of pumping in the Death Valley regional groundwater flow system, Nevada, and California, with special reference to Devils Hole: U.S. Geological Survey Professional Paper 1863, 178 p., <https://doi.org/10.3133/pp1863>

- Hershler, R., and Sada, D.W. 1987. Springsnails (Gastropoda: Hydrobiidae) of Ash Meadows, Amargosa Basin, California-Nevada. *Proceedings of the Biological Society of Washington* 100:776-843.
- Hurst, R.W., 2012, A Multiple Isotopic Investigation of the Amargosa River: Inyo-San Bernardino Counties, CA and Nye County, NV. 25 pp.
- Johnson-Wright, Inc., 2012. Additional Hydrologic Investigations and Data Collection Results for Amargosa River Hydrologic Study. Technical Memorandum prepared for The Nature Conservancy. June 22.
- Johnson-Wright, Inc., 2013. Tecopa Safe Drinking Water and Fire Water Supply Feasibility Study. November 12.
- Laczniak, R., G. DeMeo, S. Reiner, J. Smith, W. E. Nylund, 1999. Estimates of ground-water discharge as determined from measurements of evapotranspiration, Ash Meadows area, Nye County, Nevada. U.S. Geological Survey Water Resources Investigation Report 99-4079.
- Laczniak, R.J., Smith, J.L., Elliott, P.E., DeMeo, G.A., and Chatigney, M.A., 2001. Ground-water Discharge Determined from Estimates of Evapotranspiration, Death Valley Regional Flow System, Nevada and California. U.S. Geological Survey Water-Resources Investigation Report 01-4195.
- Larsen D, GH Swihart, Y Xiao, 2001, Hydrochemistry and isotope composition of springs in the Tecopa basin, southeastern California, USA. *Chem. Geol.*, 179, 17-35.
- Mendenhall, W.C., 1909. Some Desert Watering Places in southeastern California and southwestern Nevada. U.S. Geological Survey Water-Supply Paper 224. 98p.
- Nevada Department of Water Resources, 2025. Pumping Data. <https://water.nv.gov/index.php/data/water-use-inventories>
- Partner Engineering & Science, 2020. 2020 Amargosa State of the Basin Report, Amargosa River Basin Inyo and San Bernardino Counties, California. February 4.
- Pavelko, M.T., and Damar, N.A., 2023, Groundwater discharge by evapotranspiration from the Amargosa Wild and Scenic River and contributing areas, Inyo and San Bernardino Counties, California: U.S. Geological Survey Scientific Investigations Report 2023–5106, 44 p., <https://doi.org/10.3133/sir20235106>.
- Planert, M. and Williams, J.S., 1995. Ground Water Atlas of the United States, Segment 1, California Nevada. U.S. Geological Survey Hydrologic Investigations Atlas 730-B.
- Roux Associates, Inc., 2022. Applications of Death Valley 3 Groundwater Model for Understanding Area Flow System Components, County of Inyo – Yucca Mountain. Technical Memorandum, May 24.
- Roux Associates, Inc. 2024. Technical Memorandum: Hydrologic Review related to Future Groundwater Extraction for Mining Purposes near Ash Meadows National Wildlife Refuge, Nye County, Nevada. June 5.
- Roux Associates, Inc., 2025. Technical Memorandum: Beatty Area Groundwater Applications. June 19.
- Sada, D.W. and K.F. Pohlman. 2006. U.S. National Park Service Mojave Inventory and Monitoring Network spring survey protocols: Level I, 19 November 2003. Desert Research Institute, Inc., Reno. Available at <http://water.nv.gov/hearings/past/dry/browseable/exhibits%5CUSFWS/Exhibit%20595%20Sada%20and%20Pohlmann%202006.pdf>.

- San Juan, C.A., Belcher, W.R., Lacznia, R.J., and Putnam, H.M., 2010, Hydrologic components for model development, in Belcher, W.R., and Sweetkind, D.S., eds., Death Valley regional groundwater flow system, Nevada and California—Hydrogeologic framework and transient groundwater flow model: U.S. Geological Survey Professional Paper 1711, p. 95–132.
- Serpico, Phil, 2013. Tonopah & Tidewater Railroad: The Nevada Short Line. Omni Publications, Palmdale, California. 296 pp.
- Sky Island Alliance, 2012. Springs Inventory and Assessment Training Manual. Version 2.0. Tucson, Arizona.
- Source Group (SGI). 2011 State of the Basin Report; Amargosa River Basin – Inyo and San Bernardino Counties, California & Nye County, Nevada. April 29.
- Spitz, Karlheinz and Joanna Moreno, 1996. *A Practical Guide to Groundwater and Solute Transport Modeling*. Wiley, New York. 461 p.
- Sweetkind, D.S., Belcher, W.R., Faunt, C.C., and Potter, C.J., 2004. Geology and Hydrology. In Death Valley regional ground-water flow system, Nevada and California – hydrogeologic framework and transient groundwater flow model. U.S. Geological Survey Scientific Investigations Report 2004-5205.
- Thomas, J.M., Welch, A.H., Dettinger, M.D., 1996. Geochemistry and isotope hydrology of representative aquifers in the Great Basin region, Nevada, Utah and adjacent states. U.S. Geological Survey Professional Paper 1409-C, 100 pp.
- Thomas, J.M., Benedict Jr., F.C., Rose, T.P., Hershey, R.L., Paces, J.B., Peterman, Z.E., Farnham, I.M., Johannsen, K.H., Singh, A.K., Stetzenbach, K.J., Hudson, G.B., Kenneally, J.M., Eaton, G.F., and Smith, D.K., 2003a. Geochemical and Isotopic Interpretations of Groundwater Flow in Oasis Valley Flow System, Southern Nevada. Department of Energy, Nevada operations office, DOE/NV/11508-56. Publ. No. 45190, 113 pp.
- Thomas, J.M., Hudson, G.B., Stute, M., Clark, J.F., 2003b. Noble gas loss may indicate groundwater flow across flow barriers in southern Nevada. *Environ. Geol.*, 43, p. 568-579.
- Thompson, D. G., 1929. The Mohave Desert Region, California: A Geographic, Geological and Hydrological Reconnaissance. U.S. Geological Survey Water-Supply Paper 578. 759 pp.
- U.S. Geological Survey, 2017. USGS National Water Information System Database. Streamflow records for Amargosa River at Highway 127 near Nevada State Line, Inyo County, California; Amargosa River at Tecopa, California; Amargosa River at Dumont Dunes, San Bernardino County, California.
- U.S. Geological Survey, 2025. Amargosa River Monitoring Data. <https://waterdata.usgs.gov>
- U.S. Geological Survey, 2026. Borehole Discharge Data. <https://waterdata.usgs.gov>
- Walker, G.E., and Eakin, T.E., 1963. Geology and ground water of Amargosa Desert, Nevada-California. State of Nevada Department of Conservation and Natural Resources Ground-Water Reconnaissance Series Report 14.
- Waring, G. A., 1915. Springs of California. U.S. Geological Survey Water-Supply Paper 338.
- Winograd, I.J. and W. Thordarson, 1975. Hydrogeologic and hydrochemical framework, southcentral Great Basin, Nevada and California, with special reference to the Nevada Test Site, USGS Prof. Pap. 712-C, 126 pp.

Workman, J.B., Menges, C.M., Page, W.R., Taylor, E.M., Ekren, E.B., Rowley, P.D., et.al., 2002. Geologic Map of the Death Valley ground-water model area, Nevada and California. U.S. Geological Survey Miscellaneous Field Studies MF-2381.

Zdon, Andy & Associates, 2014. 2014 State of the Basin Report: Amargosa Basin, Inyo and San Bernardino Counties, California and Nye County, Nevada. June 28.

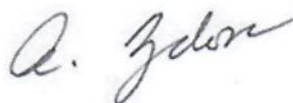
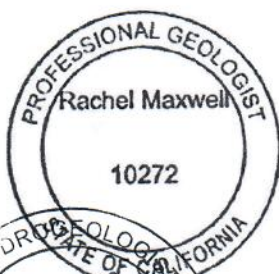
Zdon, Andy, M.L. Davisson and A.H. Love, 2015. Testing the Established Hydrogeologic Model of Source Water to the Amargosa River Basin, Inyo and San Bernardino Counties, California. Environmental Forensics, Volume 16, Number 4. Pages 344-355.

Respectfully submitted,

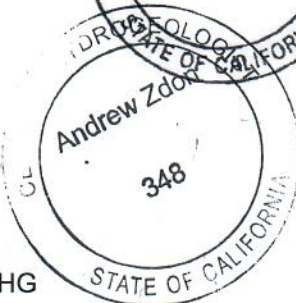
ROUX ASSOCIATES, INC.



Rachel Maxwell, PG
Senior Scientist I



Andy Zdon, PG, CEG, CHG
Technical Director



1. Amargosa River Basin Spring List
2. Depth to Water Measurements
3. Mean Annual Flow – Amargosa River
4. Summary of Pumping – Amargosa Valley
5. Summary of Pumping – Pahrump Valley

Table 1. Amargosa River Basin Spring List
Middle Amargosa Valley Groundwater Basin, Inyo County, California

Spring Name	Date	Latitude	Longitude	Elevation	Flow (gpm)	Temp (°C)	pH	EC (µS)	TDS (mg/L)	Salinity (ppm)	D.O. (mg/L)	δD	δ18O	3H	13C
7J Colson Main Pond Spring	1/17/2021	37.07374	-116.69172	3,978	<1	16.9	8.06	702	351	--	5.94	-112.7	-14.36	--	--
7J Cottonwood Warm Spring	1/17/2021	37.07394	-116.69113	3,951	1.5	28.1	8.16	710	355	--	3.02	-113.7	-14.55	--	--
7J Cottonwood Warm Spring	10/18/2021	37.07394	-116.69113	3,951	--	28.3	7.83	730	370	--	3.13	--	--	--	--
7J Cottonwood Warm Spring	2/18/2022	37.07394	-116.69113	3,951	<1	27.3	8.04	680	320	--	--	-112.7	-14.54	--	--
7J Northwest Colson Pond Mound	1/17/2021	37.07479	-116.69298	3,963	--	10.5	7.33	904	452	--	1.16	-111.5	-14.24	--	--
7J Southeast Corner Pond	1/17/2021	37.03431	-116.70902	3,835	--	15.6	7.56	815	408	--	2.22	-113.2	-14.41	--	--
7J Speckled Dace Spring	1/17/2021	37.04109	-116.71231	3,845	117	16.6	7.90	856	430	--	5.27	-112.6	-14.25	--	--
7J Speckled Dace Spring	2/18/2022	37.04109	-116.71231	3,845	~30	16.6	8.01	880	440	--	--	-109.1	-13.97	--	--
7J Stone House Spring	1/17/2021	37.03824	-116.71249	3,823	--	15.6	7.83	891	446	--	3.13	-112.4	-14.49	--	--
7J Stone House Spring	2/18/2022	37.03824	-116.71249	3,823	<1	14.7	7.71	910	450	--	--	-111.9	-14.48	--	--
Amargosa Cyn Spring 2	1/12/2011	--	--	--	--	15.3	8.16	1,271	826	--	8.69	--	--	--	--
Amargosa Cyn Spring 3	1/12/2011	35.82701	-116.21942	1,262	30	16.7	--	1,698	1,104	--	9.68	--	--	--	--
Amargosa Cyn Spring 3	4/25/2011	35.82701	-116.21942	1,262	--	21.1	8.51	1,506	979	--	9.51	--	--	--	--
Amargosa Cyn Spring 3	9/21/2011	35.82701	-116.21942	1,262	16	25.79	8.37	1,597	1,035	--	8.57	--	--	--	--
Amargosa Cyn Spring 3	5/6/2014	35.82701	-116.21942	1,262	9	20.9	8.26	1,741	--	--	8.9	--	--	--	--
Amargosa Cyn Spring 3	10/23/2018	35.82701	-116.21942	1,262	10	23.7	8.55	1,616	808	--	9.24	--	--	--	-4.1
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	1/12/2011	35.83473	-116.22274	1,372	25	26.1	8.34	915	915	--	8.07	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	4/25/2011	35.83473	-116.22274	1,372	--	26.3	8.13	1,240	809	--	8.63	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	5/11/2011	35.83473	-116.22274	1,372	7.7	--	--	--	--	--	--	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	9/21/2011	35.83473	-116.22274	1,372	7.7	28.2	8.16	1,347	876	--	7.32	-94	-12.9	0.7	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	12/22/2011	35.83473	-116.22274	1,372	8.1	26.2	8.33	1,273	828	--	7.34	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	5/1/2012	35.83473	-116.22274	1,372	9.1	26.1	8.60	1,220	795	--	9.93	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	1/26/2013	35.83473	-116.22274	1,372	7	26.4	8.31	1,537	999	--	9.42	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	4/19/2013	35.83473	-116.22274	1,372	7.9	26.6	7.86	1,333	867	--	8.4	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	5/6/2014	35.83473	-116.22274	1,372	7	26.4	8.50	1,683	820	--	7.04	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	12/6/2014	35.83473	-116.22274	1,372	20	27.2	8.21	1,326	663	--	--	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	12/8/2015	35.83473	-116.22274	1,372	3.6	26.5	8.18	1,268	634	--	2.3	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	6/4/2016	35.83473	-116.22274	1,372	12	26.9	8.10	1,320	662	--	--	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	9/14/2016	35.83473	-116.22274	1,372	--	28.9	8.19	1,175	588	--	--	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	4/9/2017	35.83473	-116.22274	1,372	9	24.7	8.53	1,331	670	--	--	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	1/17/2018	35.83473	-116.22274	1,372	>20	25.4	8.57	1,133	568	--	2.59	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	10/23/2018	35.83473	-116.22274	1,372	12.5	26.9	8.40	1,333	666	--	7.94	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	10/17/2021	35.83473	-116.22274	1,372	--	26.8	8.07	1,330	680	--	8.77	--	--	--	--
Amargosa Cyn Spring 4 (aka Sawgrass Spring)	10/29/2025	35.83476	-116.22273	1,334	10	27.3	8.29	--	--	--	--	--	--	--	--
Amargosa Cyn Spring 5	1/12/2011	35.83602	-116.22243	1,372	--	18.9	7.81	1,445	939	--	4.4	--	--	--	--
Amargosa Cyn Spring 5	5/6/2014	35.83602	-116.22243	1,372	9	20.4	8.49	1,647	--	--	8.32	--	--	--	--
Amargosa River Spring	--	36.91316	-116.75721	3,322	--	--	--	--	--	--	--	--	--	--	--
Amargosa Spring	10/13/2021	35.6348	-116.2753	492	<1	23.4	7.54	7,480	3,730	--	7.36	-79.9	-9.58	--	--
Amargosa Spring	4/22/2025	35.634838	-116.275073	540	<1	22.6	7.87	2,603	1,302	--	--	--	--	--	--
Amargosa Spring	10/28/2025	35.634838	-116.275073	540	<1	24.7	7.47	6,930	3,470	--	--	--	--	--	--
Amargosa Spring	1/14/2026	35.634838	-116.275073	540	<1	20.3	8.29	2,826	1,417	--	--	--	--	--	--
Bailey's Hot Spring	3/14/1962	36.9764	-116.7222	3,597	--	36.1	--	--	--	--	--	--	--	--	--
Beatty Narrows (Amargosa River)	1/20/2021	36.88264	-116.75141	3,193	--	10.2	7.72	1,335	668	--	12.2	-107.6	-13.79	--	--
Beck Spring	11/19/2010	35.783358	-115.923027	4,450	2.5	17.9	7.14	467	351	--	3.97	--	--	--	--
Borax Spring	1/12/2011	35.88804	-116.25789	1,340	6.8	30.5	9.91	3,019	1,963	--	0.61	-100	-13.3	<0.9	--
Borax Spring	5/5/2011	35.88804	-116.25789	1,340	6.9	--	--	--	--	--	--	--	--	--	--
Borax Spring	9/21/2011	35.88804	-116.25789	1,340	5.9	30.5	10.14	2,981	1,938	--	1.71	--	--	--	--
Borax Spring	4/30/2012	35.88804	-116.25789	1,340	5.7	30.5	10.31	2,740	1,781	--	3.2	--	--	--	--
Borax Spring	1/28/2013	35.88804	-116.25789	1,340	5.8	30	10.08	3,451	2,242	--	0.99	--	--	--	--
Borax Spring	4/18/2013	35.88804	-116.25789	1,340	6.1	30.4	9.45	2,985	1,940	--	0.49	--	--	--	--
Borax Spring	5/12/2014	35.88804	-116.25789	1,340	8.1	29.9	10.02	3,525	--	--	0.27	--	--	--	--
Borax Spring	12/5/2014	35.88804	-116.25789	1,340	7	24.7	9.74	2,969	1,476	--	--	--	--	--	--
Borax Spring	12/8/2015	35.88804	-116.25789	1,340	9.4	26.5	9.71	2,756	1,372	1,448	0.74	--	--	--	--
Borax Spring	9/15/2016	35.88804	-116.25789	1,340	8.6	32.5	9.66	2,590	1,296	--	--	--	--	--	--
Borax Spring	1/10/2017	35.88804	-116.25789	1,340	7.7	29.8	9.68	3,001	1,496	--	0.18	--	--	--	--
Borax Spring	4/11/2017	35.88804	-116.25789	1,340	7.5	30.3	9.81	2,949	1,470	--	0.11	--	--	--	--
Borax Spring	1/17/2018	35.88804	-116.25789	1,340	10.5	29.8	9.88	2,568	1,282	--	0.05	--	--	--	--
Borax Spring	4/27/2018	35.88804	-116.25789	1,340	9	30	9.95	2,560	1,279	--	0.12	--	--	--	--
Borax Spring	4/23/2019	35.88804	-116.25789	1,340	11.2	30.8	9.68	2,713	1,355	--	0.08	--	--	--	--
Borax Spring	10/1/2019	35.88804	-116.25789	1,340	17.6	30.8	9.82	2,745	1,368	--	0.18	--	--	--	--
Borax Spring	4/30/2020	35.88804	-116.25789	1,340	5	30.1	9.74	2,758	1,381	--	--	--	--	--	--
Borax Spring	10/11/2020	35.88804	-116.25789	1,340	6.5	30.1	9.67	2,792	1,396	--	0.56	--	--	--	--
Borax Spring	4/13/2021	35.88804	-116.25789	1,340	12.7	31.1	9.72	2,900	1,450	--	0.11	--	--	--	--
Borax Spring	4/13/2021	35.88804	-116.25789	1,340	12	30.4	9.48	2,910	1,450	--	0	--	--	--	--
Borax Spring	4/13/2021	35.88804	-116.25789	1,340	10.9	30.8	9.91	2,567	1,283	--	--	--	--	--	--
Borax Spring	4/13/2021	35.88804	-116.25789	1,340	11.9	28.3	9.76	2,617	1,324	--	--	-104.8	-13.27	--	-2.3
Borax Spring	4/29/2023	35.88804	-116.25789	1,340	11.77	30.3	9.74	2,548	1,274	--	--	--	--	--	--
Borax Spring	4/21/2025	35.88804	-116.25789	1,342	9.6	30.6	10.10	2,652	1,327	--	--	--	--	--	--
Borax Spring	10/28/2025	35.88804	-116.25789	1,342	9.6	30.4	9.82	3,630	1,810	--	--	--	--	--	--
Borax Spring	1/12/2026	35.88804	-116.25789	1,342	12	30	9.82	3,650	1,820	--	--	--	--	--	--
Borehole	11/11/2010	35.8862	-116.23439	1,340	20	47.8	8.62	4,156	2,704	--	2.28	-95	-12.9	<1.1	--
Borehole	5/2/2011	35.8862	-116.23439	1,340	20	44	8.71	4,176	2,711	--	1.95	--	--	--	--
Borehole	9/21/2011	35.8862	-116.23439	1,340	26.2	47.5	8.68	4,202	2,731	--	1.31	--	--	--	--
Borehole	4/30/2012	35.8862	-116.23439	1,340	90	47.7	8.93	3,890	2,529	--	0.16	--	--	--	--
Borehole	1/25/2013	35.8862	-116.23439	1,340	105	46.9	8.85	4,852	3,157	--	1.62	--	--	--	--

Table 1. Amargosa River Basin Spring List

[illegible]

Table 1. Amargosa River Basin Spring List
Middle Amargosa Valley Groundwater Basin, Inyo County, California

Spring Name	Date	Latitude	Longitude	Elevation	Flow (gpm)	Temp (°C)	pH	EC (µS)	TDS (mg/L)	Salinity (ppm)	D.O. (mg/L)	δD	δ18O	3H	13C
Borehole	4/18/2013	35.8862	-116.23439	1,340	81	47.8	8.47	4,202	2,731	--	0.35	--	--	--	--
Borehole	5/10/2014	35.8862	-116.23439	1,340	--	46.3	8.71	6,215	--	--	1.1	--	--	--	--
Borehole	12/3/2014	35.8862	-116.23439	1,340	140	41.1	8.49	>4,000	>2,000	--	--	--	--	--	--
Borehole	12/6/2015	35.8862	-116.23439	1,340	USGS	36.9	8.57	3,893	1,988	2,044	2.18	--	--	--	--
Borehole	5/31/2016	35.8862	-116.23439	1,340	USGS	40	8.52	>4,000	>2,000	2,014	1.66	--	--	--	--
Borehole	9/15/2016	35.8862	-116.23439	1,340	USGS	41.3	8.60	3,582	1,794	--	--	--	--	--	--
Borehole	1/9/2017	35.8862	-116.23439	1,340	USGS	43.2	8.61	>4,000	>2,000	--	0.3	--	--	--	--
Borehole	4/10/2017	35.8862	-116.23439	1,340	USGS	42.4	8.74	>4,000	>2,000	--	1.28	--	--	--	--
Borehole	1/16/2018	35.8862	-116.23439	1,340	USGS	40.7	8.59	3,337	1,686	--	1.55	--	--	--	--
Borehole	10/22/2018	35.8862	-116.23439	1,340	USGS	43.9	8.65	>4,000	>2,000	--	1.76	--	--	--	--
Borehole	1/18/2019	35.8862	-116.23439	1,340	USGS	37.6	8.76	3,815	1,904	--	--	--	--	--	--
Borehole	4/23/2019	35.8862	-116.23439	1,340	USGS	46.1	8.41	3,903	1,975	--	0.07	--	--	--	--
Borehole	4/29/2020	35.8862	-116.23439	1,340	USGS	44.8	8.52	3,945	1,975	--	--	--	--	--	--
Borehole	10/12/2020	35.8862	-116.23439	1,340	USGS	43.1	8.56	>4,000	>2,000	--	0.09	--	--	--	--
Borehole	10/14/2021	35.8862	-116.23439	1,340	USGS	43.6	8.18	4,010	2,100	--	0.1	--	--	--	--
Borehole	10/17/2022	35.8862	-116.23439	1,340	USGS	42.8	7.12	3,662	1,835	--	--	--	--	--	--
Borehole	1/7/2023	35.8862	-116.23439	1,340	USGS	45.1	8.39	2,436	1,215	--	--	-98.1	-12.7	--	-3.7
Borehole	4/27/2023	35.8862	-116.23439	1,340	USGS	46.2	8.40	3,509	1,780	--	--	--	--	--	--
Borehole	12/12/2023	35.8862	-116.23439	1,340	USGS	40.9	8.53	>4000	>2000	--	--	--	--	--	--
Borehole	4/23/2025	35.8862	-116.23439	1,344	USGS	47.9	8.45	3,695	1,845	--	--	--	--	--	--
Borehole	10/26/2025	35.8862	-116.23439	1,344	USGS	45.6	8.51	3,964	1,982	--	--	--	--	--	--
Borehole	1/12/2026	35.8862	-116.23439	1,344	USGS	44.6	8.33	3,579	1,809	--	--	--	--	--	--
Bryan Spring	1/18/2021	36.98316	-116.75875	3,945	12	18.8	8.56	397	199	--	7.45	-94	-12.57	--	--
Bryan Spring	2/20/2022	36.98316	-116.75875	3,945	1.3	19.6	7.60	380	190	--	--	-92.9	-12.49	--	--
Burro Spring	2/20/2022	36.9915	-116.731	3,665	<1	8.5	7.36	1,260	630	--	--	-105	-13.61	--	--
Chappo Spring	11/12/2010	35.94775	-116.18944	2,016	1	24.5	7.48	696	508	--	0.92	-94	-13	<1.0	--
Chappo Spring	5/1/2011	35.94775	-116.18944	2,016	1	23.2	7.81	782	491	--	3.81	--	--	--	--
Chappo Spring	5/9/2014	35.94775	-116.18944	2,016	5	26.6	7.47	755	--	--	0.83	--	--	--	--
Chappo Spring	12/5/2014	35.94775	-116.18944	2,016	5	21.3	7.65	1,025	392	--	--	--	--	--	--
Chappo Spring	2/9/2016	35.94775	-116.18944	2,016	1	24.4	7.45	786	348	--	0.55	--	--	--	--
Chappo Spring	4/23/2019	35.94775	-116.18944	2,016	1	28.5	7.61	715	357	--	1.57	--	--	--	--
Chappo Spring	1/16/2021	35.94775	-116.18944	2,016	1	15.5	7.25	1,476	741	--	0.27	--	--	--	--
China Ranch Cyn Spring	1/13/2011	35.80335	-116.14099	1,770	20	13.9	8.50	1,215	789	--	0.34	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	11/17/2010	35.83943	-116.22397	1,298	38	23.22	7.93	1,053	685	--	7.42	-94	-12.9	1.1	--
Christian Spring (aka Am. Cyn. Spg. 1)	4/25/2011	35.83943	-116.22397	1,298	--	22.5	7.94	1,029	669	--	8.62	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	5/11/2011	35.83943	-116.22397	1,298	66.1	--	--	--	--	--	--	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	9/21/2011	35.83943	-116.22397	1,298	40.5	25.8	8.12	1,076	700	--	7.74	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	12/22/2011	35.83943	-116.22397	1,298	78	18.7	8.22	1,009	656	--	7.96	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	1/12/2012	35.83943	-116.22397	1,298	67.7	23.3	--	573	363	--	--	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	5/1/2012	35.83943	-116.22397	1,298	80.2	21	--	1,274	828	--	--	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	1/26/2013	35.83943	-116.22397	1,298	83.4	22.4	7.67	1,020	663	--	8.4	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	5/6/2014	35.83943	-116.22397	1,298	72.4	22.2	8.17	1,278	--	--	7.15	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	12/6/2014	35.83943	-116.22397	1,298	60	22.5	--	1,054	527	--	8.05	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	12/8/2015	35.83943	-116.22397	1,298	70	20	8.02	1,001	500	--	5.53	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	6/4/2016	35.83943	-116.22397	1,298	40	22.6	7.95	1,012	506	--	--	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	9/14/2016	35.83943	-116.22397	1,298	48	23.5	8.04	925	462	--	--	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	4/9/2017	35.83943	-116.22397	1,298	40	21	8.06	1,046	523	--	--	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	1/17/2018	35.83943	-116.22397	1,298	80	20.2	8.26	927	464	--	4.08	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	4/27/2018	35.83943	-116.22397	1,298	40	23.5	8.31	900	449	--	6.98	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	4/23/2019	35.83943	-116.22397	1,298	88.4	23.5	7.96	900	450	--	0.09	--	--	--	--
Christian Spring (aka Am. Cyn. Spg. 1)	4/11/2021	35.83943	-116.22397	1,298	65	22.6	8.24	1,010	510	--	14.78	--	--	--	--
Cottonrod Seep (in Shoshone Spg Complex)	2/21/2016	35.97975	-116.2726	1,598	2	16.2	8.19	1,940	971	1,088	--	--	--	--	--
Cottonrod Seep (in Shoshone Spg Complex)	4/23/2025	35.97975	-116.2726	1,598	<10	28.1	8.25	1,429	714	--	--	--	--	--	--
Cottonrod Seep (in Shoshone Spg Complex)	10/31/2025	--	--	--	--	--	--	--	--	--	--	--	--	--	--
Cottonwood Spring	2/17/2016	35.59139	-116.38649	1,647	<1	13.8	8.05	2,857	1,428	1,632	4.81	-99.3	-12.83	--	--
Cowboy Seep #1	10/23/2018	35.82038	-116.20439	1,474	ET Only	--	--	--	--	--	--	--	--	--	--
Cowboy Seep #1	4/21/2025	35.82038	-116.20439	1,474	<1	--	--	--	--	--	--	--	--	--	--
Cowboy Seep #1	10/30/2025	35.82038	-116.20439	1,474	<1	--	--	--	--	--	--	--	--	--	--
Cowboy Seep #1	1/11/2026	35.82038	-116.20439	1,474	ET Only	--	--	--	--	--	--	--	--	--	--
Cowboy Seep #2	10/23/2018	35.82097	-116.20862	1,444	<1	--	--	--	--	--	--	--	--	--	--
Cowboy Seep #2	4/21/2025	35.8207	-116.20821	1,416	ET Only	--	--	--	--	--	--	--	--	--	--
Cowboy Seep #2	10/30/2025	35.82097	-116.20862	1,444	ET Only	--	--	--	--	--	--	--	--	--	--
Cowboy Seep #2	1/11/2026	35.8207	-116.20821	1,416	ET Only	--	--	--	--	--	--	--	--	--	--
Cowboy Seep #3	10/23/2018	35.82131	-116.2096	1,399	1.5	22.1	7.78	1,893	946	--	7.65	--	--	--	--
Cowboy Seep #3	10/19/2022	35.82131	-116.2096	1,399	5	24.1	8.20	1,402	700	--	--	--	--	--	--
Cowboy Seep #3	4/21/2025	35.821501	-116.209422	1,420	20	--	--	--	--	--	--	--	--	--	--
Cowboy Seep #3	10/30/2025	35.821501	-116.209422	1,420	<10	20.7	8.24	1,714	858	--	--	--	--	--	--
Cowboy Seep #3	1/11/2026	35.82131	-116.209422	1,420	6	18.1	7.69	1,837	919	--	--	--	--	--	--
Cowboy Seep #4	10/23/2018	35.82299	-116.21081	1,396	1.5	23.4	8.19	1,521	760	--	9.11	--	--	--	--
Cowboy Seep #4	4/21/2025	35.82299	-116.21081	1,396	ET Only	--	--	--	--	--	--	--	--	--	--
Cowboy Seep #4	10/30/2025	35.82299	-116.21081	1,396	10	19.6	8.27	1,769	884	--	--	--	--	--	--
Cowboy Seep #4	1/11/2026	35.82299	-116.21081	1,396	8	16.1	8.00	1,755	878	--	--	--	--	--	--
Coyote Holes	11/19/2010	35.64095	-115.95894	2,161	ET Only	--	--	--	--	--	--	--	--	--	--
Coyote Holes	2/18/2016	35.64095	-115.95894	2,161	ET Only	--	--	--	--	--	--	--	--	--	--
Crystal Spring	3/14/1962	36.98683	-116.75395	3,904	--	20.6	--	--	--	--	--	--	--	--	--

Table 1. Amargosa River Basin Spring List
Middle Amargosa Valley Groundwater Basin, Inyo County, California

Spring Name	14C	Apparent Age (yrs) ¹	Vent Lithology	Spring Type	Monitor	Area	Land Owner/Manager
Borehole	--	--	Playa Deposits	Artesian Borehole	Johnson-Wright	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	AZI	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	AZI	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	AZI	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	AZI	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	Partner	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	Partner	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	Partner	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	Partner	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	Partner	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	Partner	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	Partner	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	Roux	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	Roux	Amargosa	BLM
Borehole	3.3 +/- 0.1	28,200	Playa Deposits	Artesian Borehole	Roux	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	Roux	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	Roux	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	Roux	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	Roux	Amargosa	BLM
Borehole	--	--	Playa Deposits	Artesian Borehole	Roux	Amargosa	BLM
Bryan Spring	--	--	Volcanic	Rheocrene	Partner	Oasis Valley, NV	BLM
Bryan Spring	--	--	Volcanic	Rheocrene	Roux	Oasis Valley, NV	BLM
Burro Spring	--	--	Volcanic	Rheocrene	Roux	Oasis Valley, NV	BLM
Chappo Spring	--	--	Carbonate	Rheocrene	Source Group (Phillip/Zdon)	Amargosa - Resting Spring	Tribal
Chappo Spring	--	--	Carbonate	Rheocrene	Source Group (Phillip/Zdon)	Amargosa - Resting Spring	Tribal
Chappo Spring	--	--	Carbonate	Rheocrene	AZI	Amargosa - Resting Spring	Tribal
Chappo Spring	--	--	Carbonate	Rheocrene	AZI	Amargosa - Resting Spring	Tribal
Chappo Spring	--	--	Carbonate	Rheocrene	AZI	Amargosa - Resting Spring	Tribal
Chappo Spring	--	--	Carbonate	Rheocrene	Partner	Amargosa - Resting Spring	Tribal
Chappo Spring	--	--	Carbonate	Rheocrene	Partner	Amargosa - Resting Spring	Tribal
China Ranch Cyn Spring	--	--	Fluvial Deposits	Rheocrene	Source Group (Phillip/Zdon)	Amargosa	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	Source Group (Phillip/Zdon)	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	Source Group (Phillip/Zdon)	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	Source Group (Phillip/Zdon)	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	Source Group (Phillip/Zdon)	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	Source Group (Phillip/Zdon)	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	Johnson-Wright	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	Johnson-Wright	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	Johnson-Wright	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	AZI	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	AZI	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	AZI	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	AZI	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	Partner	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	Partner	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	Partner	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	Partner	Amargosa - Sperry Hills	BLM
Christian Spring (aka Am. Cyn. Spg. 1)	--	--	Fluvial Deposits	Rheocrene	Partner	Amargosa - Sperry Hills	BLM
Cottonrod Seep (in Shoshone Spg Complex)	--	--	Mixed	Rheocrene	AZI	Amargosa	Private
Cottonrod Seep (in Shoshone Spg Complex)	--	--	Mixed	Rheocrene	Roux	Amargosa	Private
Cottonrod Seep (in Shoshone Spg Complex)	--	--	Mixed	Rheocrene	Roux	Amargosa	Private
Cottonwood Spring	--	--	Intrusive Igneous	Rheocrene	AZI	Amargosa - Avawatz	BLM
Cowboy Seep #1	--	--	Mixed	Hypocrene	Partner	Amargosa - Sperry Hills	BLM
Cowboy Seep #1	--	--	Mixed	Hypocrene	Roux	Amargosa - Sperry Hills	BLM
Cowboy Seep #1	--	--	Mixed	Hypocrene	Roux	Amargosa - Sperry Hills	BLM
Cowboy Seep #1	--	--	Mixed	Hypocrene	Roux	Amargosa - Sperry Hills	BLM
Cowboy Seep #2	--	--	Mixed	Hypocrene	Partner	Amargosa - Sperry Hills	BLM
Cowboy Seep #2	--	--	Mixed	Hypocrene	Roux	Amargosa - Sperry Hills	BLM
Cowboy Seep #2	--	--	Mixed	Hypocrene	Roux	Amargosa - Sperry Hills	BLM
Cowboy Seep #2	--	--	Mixed	Hypocrene	Roux	Amargosa - Sperry Hills	BLM
Cowboy Seep #3	--	--	Mixed	Rheocrene	Partner	Amargosa - Sperry Hills	BLM
Cowboy Seep #3	--	--	Mixed	Rheocrene	Roux	Amargosa - Sperry Hills	BLM
Cowboy Seep #3	--	--	Mixed	Rheocrene	Partner	Amargosa - Sperry Hills	BLM
Cowboy Seep #3	--	--	Mixed	Rheocrene	Roux	Amargosa - Sperry Hills	BLM
Cowboy Seep #4	--	--	Mixed	Rheocrene	Partner	Amargosa - Sperry Hills	BLM
Cowboy Seep #4	--	--	Mixed	Rheocrene	Roux	Amargosa - Sperry Hills	BLM
Cowboy Seep #4	--	--	Mixed	Rheocrene	Roux	Amargosa - Sperry Hills	BLM
Cowboy Seep #4	--	--	Mixed	Rheocrene	Roux	Amargosa - Sperry Hills	BLM
Coyote Holes	--	--	Alluvial	Seep	Source Group (Phillip/Zdon)	Amargosa - Kingston Range	BLM
Coyote Holes	--	--	Alluvial	Seep	AZI	Amargosa - Kingston Range	BLM
Crystal Spring	--	--	Volcanic	Rheocrene	--	Oasis Valley, NV	Private

Table 1. Amargosa River Basin Spring List
Middle Amargosa Valley Groundwater Basin, Inyo County, California

Spring Name	Date	Latitude	Longitude	Elevation	Flow (gpm)	Temp (°C)	pH	EC (µS)	TDS (mg/L)	Salinity (ppm)	D.O. (mg/L)	δD	δ18O	3H	13C
Crystal Spring	11/19/2010	35.79503	-115.96176	3,877	5	21.1	7.45	632	411	--	--	-82	-14.16	0.9	--
Crystal Spring	4/26/2011	35.79503	-115.96176	3,877	13.5	21.2	7.52	610	397	--	--	--	--	--	--
Crystal Spring	9/22/2011	35.79503	-115.96176	3,877	9.5	21.4	7.29	637	414	--	--	--	--	--	--
Crystal Spring	12/22/2011	35.79503	-115.96176	3,877	8.3	21.3	7.45	607	395	--	--	--	--	--	--
Crystal Spring	4/30/2012	35.79503	-115.96176	3,877	5.9	21.2	7.61	586	381	--	--	--	--	--	--
Crystal Spring	1/25/2013	35.79503	-115.96176	3,877	6.8	20.9	7.43	732	476	--	--	--	--	--	--
Crystal Spring	4/21/2013	35.79503	-115.96176	3,877	5.4	21.2	6.93	638	415	--	--	--	--	--	--
Crystal Spring	5/4/2014	35.79503	-115.96176	3,877	4.3	21.2	7.43	880	--	--	--	--	--	--	--
Crystal Spring	12/7/2014	35.79503	-115.96176	3,877	5	20.1	7.48	644	322	--	--	--	--	--	--
Crystal Spring	12/8/2015	35.79503	-115.96176	3,877	2	20.1	7.50	629	315	--	--	--	--	--	--
Crystal Spring	5/31/2016	35.79503	-115.96176	3,877	5	22.8	7.46	635	318	--	--	--	--	--	--
Crystal Spring	9/15/2016	35.79503	-115.96176	3,877	1.5	21.7	7.63	620	309	--	--	--	--	--	--
Crystal Spring	1/8/2017	35.79503	-115.96176	3,877	2	20.5	7.37	703	352	--	--	--	--	--	--
Crystal Spring	4/11/2017	35.79503	-115.96176	3,877	5	21.2	7.60	656	329	271	--	--	--	--	--
Crystal Spring	1/15/2018	35.79503	-115.96176	3,877	8	21.2	7.61	612	306	--	--	--	--	--	--
Crystal Spring	4/26/2018	35.79503	-115.96176	3,877	8	23.9	7.62	588	298	--	--	--	--	--	--
Crystal Spring	10/22/2018	35.79503	-115.96176	3,877	10	21.6	7.41	663	332	--	--	--	--	--	-7
Crystal Spring	1/9/2019	35.79503	-115.96176	3,877	5	20.5	7.88	599	295	--	--	--	--	--	--
Crystal Spring	4/22/2019	35.79503	-115.96176	3,877	10	21.3	7.56	598	299	--	--	--	--	--	--
Crystal Spring	10/6/2019	35.79503	-115.96176	3,877	1.9	21.2	6.81	594	297	--	--	--	--	--	--
Crystal Spring	4/30/2020	35.79503	-115.96176	3,877	6	21.7	7.61	590	224	--	--	--	--	--	--
Crystal Spring	1/16/2021	35.79503	-115.96176	3,877	4	21.1	7.45	680	340	--	5.69	--	--	--	--
Crystal Spring	1/18/2021	36.98683	-116.75395	3,904	5	20.4	8.10	491	246	--	4.67	-92.7	-12.46	--	--
Crystal Spring	10/12/2021	35.79503	-115.96176	3,877	3	--	--	--	--	--	--	--	--	--	--
Crystal Spring	10/14/2021	35.79503	-115.96176	3,877	4	21.7	7.27	640	320	--	4.12	--	--	--	--
Crystal Spring	2/21/2022	36.98683	-116.75395	3,904	--	18	7.27	440	220	--	--	-92.3	-12.39	--	--
Crystal Spring	10/18/2022	35.79503	-115.96176	3,877	5	22.9	7.12	553	227	--	--	--	--	--	--
Crystal Spring	1/6/2023	35.79503	-115.96176	3,877	3	19.4	7.52	604	302	--	--	--	--	--	--
Crystal Spring	4/28/2023	35.79503	-115.96176	3,877	15-20	24.2	7.44	578	283	--	--	--	--	--	--
Crystal Spring	12/11/2023	35.79503	-115.96176	3,877	5	20.7	7.33	613	305	--	--	--	--	--	--
Crystal Spring	4/20/2025	35.79503	-115.96176	3,877	10	22.4	7.86	455	227	--	--	--	--	--	--
Crystal Spring	10/27/2025	35.79503	-115.96176	3,877	10	22.5	8.00	622	311	--	--	--	--	--	--
Crystal Spring	1/13/2026	35.79503	-115.96176	3,877	5	21.1	7.53	619	309	--	--	--	--	--	--
Denning Spring	2010	35.58727	-116.46915	1,921	ET Only	--	--	--	--	--	--	--	--	--	--
Denning Spring	2/17/2016	35.58727	-116.46915	1,921	ET Only	--	--	--	--	--	--	--	--	--	--
Dodge City Spring	5/10/2014	35.88018	-116.22955	1,399	>20	23	8.79	4,141	--	2,795	8.2	-95.3	-12.04	--	--
Dodge City Spring	12/3/2014	35.88018	-116.22955	1,399	20	23.7	8.63	3,832	1,914	--	--	--	--	--	--
Dodge City Spring	12/6/2015	35.88018	-116.22955	1,399	8	23	8.60	3,564	1,780	1,924	6.6	--	--	--	--
Dodge City Spring	5/31/2016	35.88018	-116.22955	1,399	8	24	8.65	3,955	1,983	--	4.36	--	--	--	--
Dodge City Spring	1/9/2017	35.88018	-116.22955	1,399	5	22.4	8.60	3,725	1,862	1,907	2.55	--	--	--	--
Dodge City Spring	4/10/2017	35.88018	-116.22955	1,399	8	23.2	8.67	>4,000	>2,000	2,226	10.8	--	--	--	--
Dodge City Spring	1/6/2018	35.88018	-116.22955	1,399	6	21	8.83	3,499	1,749	--	3.49	--	--	--	--
Dodge City Spring	4/27/2018	35.88018	-116.22955	1,399	10	23.5	8.79	3,234	1,617	--	10.28	--	--	--	--
Dodge City Spring	10/22/2018	35.88018	-116.22955	1,399	5	26	8.60	3,793	1,897	--	2.03	--	--	--	--
Dodge City Spring	1/8/2019	35.88018	-116.22955	1,399	10	23.2	8.78	3,333	1,667	--	--	--	--	--	--
Dodge City Spring	4/23/2019	35.88018	-116.22955	1,399	5	23.2	8.67	3,418	1,709	--	0.38	--	--	--	--
Dodge City Spring	10/1/2019	35.88018	-116.22955	1,399	7.6	26.3	8.75	3,459	1,730	--	2.09	--	--	--	--
Dodge City Spring	4/29/2020	35.88018	-116.22955	1,399	15	24.3	8.57	2,880	1,441	--	--	--	--	--	--
Dodge City Spring	10/12/2020	35.88018	-116.22955	1,399	9	26	8.36	3,317	1,661	--	14.64	--	--	--	--
Dodge City Spring	1/15/2021	35.88018	-116.22955	1,399	--	22.7	8.46	3,275	1,640	--	--	--	--	--	--
Dodge City Spring	4/13/2021	35.88018	-116.22955	1,399	20	23.5	8.94	3,560	1,780	--	12.36	--	--	--	--
Dodge City Spring	10/14/2021	35.88018	-116.22955	1,399	>10	25.6	8.44	3,530	1,770	--	--	--	--	--	--
Dodge City Spring	10/17/2022	35.88018	-116.22955	1,399	5	26.7	8.82	3,037	1,518	--	--	--	--	--	--
Dodge City Spring	1/7/2023	35.88018	-116.22955	1,399	10	22.9	8.66	3,163	1,581	--	--	--	--	--	--
Dodge City Spring	4/27/2023	35.88018	-116.22955	1,399	10	23.8	8.70	3,153	1,571	--	--	--	--	--	--
Dodge City Spring	12/12/2023	35.88018	-116.22955	1,399	8	22.8	8.71	3,431	1,712	--	--	--	--	--	--
Dodge City Spring	4/23/2025	35.88018	-116.22955	1,399	20	23.6	8.75	3,511	1,747	--	--	--	--	--	--
Dodge City Spring	10/26/2025	35.88018	-116.22955	1,399	10	25.7	8.81	3,656	1,828	--	--	--	--	--	--
Dodge City Spring	1/12/2026	35.88018	-116.22955	1,399	20	22.5	8.74	3,794	1,897	--	--	--	--	--	--
East Tecopa Seep	12/6/2015	35.8669	-116.2226	1,423	<1	12.9	7.84	1,888	937	--	--	-95.9	-12.66	--	--
East Tecopa Seep	6/4/2016	35.8669	-116.2226	1,423	<1	29.6	7.92	1,744	871	--	2.21	--	--	--	--
Gold Bar Spring	--	36.9966	-116.85705	4,241	--	--	--	--	--	--	--	--	--	--	--
Goldenrod Seep 1	2/21/2016	35.97987	-116.27299	1,598	5	19.3	7.79	1,408	704	1,015	1.56	-94.2	-12.25	--	--
Goldenrod Seep 2	2/21/2016	35.97984	-116.27313	1,598	1	18.7	7.85	1,569	787	899	0.25	--	--	--	--
Goldenrod Seep 3	2/20/2016	35.97997	-116.27264	1,598	10	18.4	8.01	1,552	777	1,121	1.35	--	--	--	--
Goldenrod Seep 4	2/21/2016	35.97986	-116.27268	1,598	5	20.1	7.59	2,193	1,094	1,420	0.75	-94.7	-12.37	--	--
Goldenrod Seep 4	1/7/2023	35.97986	-116.27268	1,598	3	24.3	6.99	1,933	971	--	--	--	--	--	--
Goss Spgs - Barn Spring	1/18/2021	36.99589	-116.71528	3,698	12	25	7.96	882	463	--	--	-111	-14.52	--	--
Goss Spgs - North Spring	1/18/2021	36.99912	-116.70801	3,833	20	21.3	7.95	625	315	--	--	112.6	14.5	--	--
Goss Spgs - South Spring	1/18/2021	36.9931	-116.70513	3,810	--	8.7	8.63	653	327	--	10.18	-110.3	-13.95	--	--
Goss Spgs - Willow Spring	1/18/2021	36.99892	-116.70887	3,797	4	12.4	8.68	685	343	--	7.11	104.6	12.74	--	--
Grimshaw Well	4/27/2018	35.88814	-116.24062	1,343	<1	21.9	9.55	>4,000	>2,000	--	0.23	--	--	--	--
Historic Spring	2/21/2016	35.98044	-116.27367	1,605	13	32.4	7.48	1,398	698	754	1.42	-96.1	-12.54	--	--
Historic Spring	6/4/2016	35.98044	-116.27367	1,605	15	32.9	7.53	1,567	784	--	2.3	--	--	--	--
Historic Spring	9/18/2016	35.98044	-116.27367	1,605	20	31.7	7.19	1,594	797	--	--	--	--	--	--

Table 1. Amargosa River Basin Spring List
Middle Amargosa Valley Groundwater Basin, Inyo County, California

[illegible]

Table 1. Amargosa River Basin Spring List
Middle Amargosa Valley Groundwater Basin, Inyo County, California

Spring Name	Date	Latitude	Longitude	Elevation	Flow (gpm)	Temp (°C)	pH	EC (µS)	TDS (mg/L)	Salinity (ppm)	D.O. (mg/L)	δD	δ18O	3H	13C
Historic Spring	1/10/2017	35.98044	-116.27367	1,605	12	31.6	7.44	1,597	799	724	2.99	--	--	--	--
Historic Spring	4/11/2017	35.98044	-116.27367	1,605	17	32.9	7.47	1,564	783	753	0.64	--	--	--	--
Historic Spring	1/17/2018	35.98044	-116.27367	1,605	8.2	32.3	7.48	1,365	683	--	1.65	--	--	--	--
Historic Spring	4/27/2018	35.98044	-116.27367	1,605	17	31.8	7.56	1,483	742	--	5.37	--	--	--	--
Historic Spring	1/8/2019	35.98044	-116.27367	1,605	20	31.3	7.64	1,483	740	--	--	--	--	--	--
Historic Spring	4/23/2019	35.98044	-116.27367	1,605	21.8	31.9	7.48	1,431	715	--	4.25	--	--	--	--
Historic Spring	4/30/2020	35.98044	-116.27367	1,605	20	32	7.77	1,487	741	--	--	--	--	--	--
Historic Spring	10/8/2020	35.98044	-116.27367	1,605	--	32.7	7.27	1,470	736	--	5.44	--	--	--	--
Historic Spring	10/14/2021	35.98044	-116.27367	1,605	6.7	31.7	7.31	1,610	800	--	4.25	--	--	--	--
Historic Spring	1/7/2023	35.98044	-116.27367	1,605	33.9	30.4	6.99	1,408	701	--	--	--	--	--	--
Historic Spring	4/28/2023	35.98056	-116.27384	1,615	37.15	33	7.51	1,352	676	--	--	--	--	--	--
Historic Spring	12/12/2023	35.98056	-116.27384	1,615	20	30.5	6.93	1,530	763	--	--	--	--	--	--
Historic Spring	4/23/2025	35.98056	-116.27384	1,615	12	31.6	7.63	1,481	740	--	--	--	--	--	--
Historic Spring	10/31/2025	35.98056	-116.27384	1,615	11	30.4	7.42	1,602	807	--	--	--	--	--	--
Historic Spring	1/10/2026	35.98056	-116.27384	1,615	65	32.2	7.30	1,470	734	--	--	--	--	--	--
Hog Farm Well (Slough Spring)	5/5/2014	36.28748	-116.37854	2,017	2.5	21.6	8.74	1,627	880	--	0.14	--	--	--	--
Homestead Spring	1/9/2017	35.85437	-116.22075	1,401	<1	19.4	8.25	1,959	980	--	3.88	--	--	--	--
Horsethief Spring	11/19/2010	35.77294	-115.88824	4,600	5	16	6.94	444	288	--	--	--	--	--	--
Horsethief Spring	4/26/2011	35.77294	-115.88824	4,600	10.1	15.3	7.37	436	284	--	--	--	--	--	--
Horsethief Spring	9/22/2011	35.77294	-115.88824	4,600	7.9	17.6	7.04	473	308	--	--	--	--	--	--
Horsethief Spring	12/22/2011	35.77294	-115.88824	4,600	8	17.3	6.96	441	287	--	--	--	--	--	--
Horsethief Spring	4/30/2012	35.77294	-115.88824	4,600	8.8	16.7	7.20	429	279	--	--	--	--	--	--
Horsethief Spring	1/25/2013	35.77294	-115.88824	4,600	--	16.7	6.70	540	351	--	--	--	--	--	--
Horsethief Spring	4/21/2013	35.77294	-115.88824	4,600	--	16.6	6.47	500	326	--	--	--	--	--	--
Horsethief Spring	5/4/2014	35.77294	-115.88824	4,600	10	16.8	6.95	484	--	--	--	--	--	--	--
Horsethief Spring	12/7/2014	35.77294	-115.88824	4,600	7	12.8	7.19	1,186	594	--	--	--	--	--	--
Horsethief Spring	12/8/2015	35.77294	-115.88824	4,600	1	17.3	7.05	480	240	--	--	--	--	--	--
Horsethief Spring	5/31/2016	35.77294	-115.88824	4,600	3	21.1	7.07	501	252	--	--	--	--	--	--
Horsethief Spring	9/15/2016	35.77294	-115.88824	4,600	1	18.5	7.56	439	221	--	--	--	--	--	--
Horsethief Spring	1/8/2017	35.77294	-115.88824	4,600	1	12.3	7.08	528	260	--	--	--	--	--	--
Horsethief Spring	4/11/2017	35.77294	-115.88824	4,600	7.5	17.7	7.27	494	249	213	--	--	--	--	--
Horsethief Spring	1/15/2018	35.77294	-115.88824	4,600	2	12.3	7.14	444	222	--	--	--	--	--	--
Horsethief Spring	4/26/2018	35.77294	-115.88824	4,600	--	--	--	--	--	--	--	--	--	--	--
Horsethief Spring	10/22/2018	35.77294	-115.88824	4,600	5	17.6	7.10	508	254	--	--	--	--	--	--
Horsethief Spring	4/22/2019	35.77294	-115.88824	4,600	11.5	17.6	7.35	462	231	--	--	--	--	--	--
Horsethief Spring	10/6/2019	35.77294	-115.88824	4,600	13.5	17.7	6.81	473	236	--	--	--	--	--	--
Horsethief Spring	4/30/2020	35.77294	-115.88824	4,600	20	18.5	7.36	444	222	--	--	--	--	--	--
Horsethief Spring	10/12/2020	35.77294	-115.88824	4,600	8	18.1	7.03	--	--	--	2.54	--	--	--	--
Horsethief Spring	4/16/2021	35.77294	-115.88824	4,600	11.3	17.7	7.06	482	240	--	3.42	--	--	--	--
Horsethief Spring	10/14/2021	35.77294	-115.88824	4,600	<1	17.2	6.90	480	240	--	3.35	--	--	--	--
Horsethief Spring	10/18/2022	35.77294	-115.88824	4,600	1	20	7.26	415	208	--	--	--	--	--	--
Horsethief Spring	4/28/2023	35.77294	-115.88824	4,600	30	19.9	7.10	435	219	--	--	--	--	--	--
Horsethief Spring	4/20/2025	35.77294	-115.88824	4,600	15	19.2	7.96	450	225	--	--	--	--	--	--
Horsethief Spring	10/27/2025	35.77294	-115.88824	4,600	5-10	18.8	7.58	474	237	--	--	--	--	--	--
Horsethief Spring	1/13/2026	35.77294	-115.88824	4,600	4	17.7	7.39	476	238	--	--	--	--	--	--
Hot Springs	--	36.97635	-116.72223	3,597	--	--	--	--	--	--	--	--	--	--	--
Ibex Hills Spring	1/11/2026	35.916505	-116.386008	2,534	3	12.9	8.35	550	275	--	--	--	--	--	--
Kingston Spring	2010	35.62071	-115.96389	2,272	<1	16.1	7.23	1,524	1,194	--	--	--	--	--	--
Kingston Spring	2/18/2016	35.62071	-115.96389	2,272	<1	16.9	9.17	1,601	802	964	--	--	--	--	--
Kingston Spring	9/18/2016	35.62071	-115.96389	2,272	ET Only	--	--	--	--	--	--	--	--	--	--
Kingston Spring	4/29/2018	35.62071	-115.96389	2,272	<1	18.7	7.39	1,760	891	--	--	--	--	--	--
Kristin's Well	4/29/2023	35.846911	-116.211169	1,414	>100	28.1	7.70	823	412	--	--	-97.9	-13.18	--	--
Lower Indian Spring	1/18/2021	36.94501	-116.796514	4,047	>3	18.9	8.39	334	167	--	--	-96.3	-12.96	--	--
Lower Indian Spring	2/19/2022	36.94501	-116.796514	4,047	2.2	17.3	7.48	320	160	--	--	-96.7	-12.93	--	--
Middle Indian Spring	2/19/2022	36.9495	-116.8006	4,150	1	15.2	8.48	300	150	--	--	-97	-12.95	--	--
Mud Spring	2/19/2022	36.996	-116.8563	4,255	<1	16.2	7.72	450	220	--	--	-92.9	-12.33	--	--
North Mud Spring	2/19/2022	37.0216	-116.8284	4,277	0.5	16.2	8.15	390	190	--	--	-99.1	-13.11	--	--
Old Mormon Spring	2/18/16	35.51538	-116.25577	2,079	ET Only	--	--	--	--	--	--	--	--	--	--
One Palm Seep	12/7/2015	35.86019	-116.22212	1,432	ET Only	--	--	--	--	--	--	--	--	--	--
One Palm Seep	4/27/2018	35.86019	-116.22212	1,432	ET Only	--	--	--	--	--	--	--	--	--	--
One Palm Seep	10/22/2018	35.86019	-116.22212	1,432	ET Only	--	--	--	--	--	--	--	--	--	--
One Palm Seep	12/12/2023	35.86019	-116.22212	1,432	ET Only	--	--	--	--	--	--	--	--	--	--
One Palm Seep	4/23/2025	35.86019	-116.22212	1,432	ET Only	--	--	--	--	--	--	--	--	--	--
One Palm Seep	10/26/2025	35.86019	-116.22212	1,432	ET Only	--	--	--	--	--	--	--	--	--	--
One Palm Seep	1/12/2026	35.86019	-116.22212	1,432	ET Only	--	--	--	--	--	--	--	--	--	--
Owl Hole Spring	10/15/1917	35.63943	-116.64758	1,943	<1	--	--	--	1,804	--	--	--	--	--	--
Owl Hole Spring	6/15/1953	35.63943	-116.64758	1,943	<1	--	--	--	1,540	--	--	--	--	--	--
Owl Hole Spring	2/11/1967	35.63943	-116.64758	1,943	<1	14	8.50	3,060	1,960	--	--	--	--	--	--
Owl Hole Spring	11/2010	35.63943	-116.64758	1,943	<1	17	6.86	3,472	2,664	--	0.29	--	--	--	--
Owl Hole Spring	5/11/2014	35.63943	-116.64758	1,943	<1	13.7	7.49	--	--	--	1.06	--	--	--	--
Owl Hole Spring	2/17/2016	35.63943	-116.64758	1,943	<1	14.4	7.00	3,357	1,681	1,850	0.51	-90.8	-9.86	--	--
Owl Hole Spring	4/27/2018	35.63943	-116.64758	1,943	<1	25.3	8.34	2,845	1,427	--	10.41	--	--	--	--
Parker Ranch - TNC #1 Spring	6/2/2016	36.96725	-116.72338	3,594	<1	30.6	7.48	1,214	608	--	--	--	--	--	--
Parker Ranch - TNC #1 Spring	1/19/2021	36.96725	-116.72338	3,594	--	21.8	7.15	1,685	854	--	0.48	--	--	--	--
Parker Ranch - TNC #2 Spring	6/2/2016	36.96751	-116.72362	3,594	--	--	--	--	--	--	--	--	--	--	--

Table 1. Amargosa River Basin Spring List
Middle Amargosa Valley Groundwater Basin, Inyo County, California

Spring Name	14C	Apparent Age (yrs) ¹	Vent Lithology	Spring Type	Monitor	Area	Land Owner/Manager
Historic Spring	--	--	Mixed	Rheocene	Partner	Amargosa	Private
Historic Spring	--	--	Mixed	Rheocene	Partner	Amargosa	Private
Historic Spring	--	--	Mixed	Rheocene	Partner	Amargosa	Private
Historic Spring	--	--	Mixed	Rheocene	Partner	Amargosa	Private
Historic Spring	--	--	Mixed	Rheocene	Partner	Amargosa	Private
Historic Spring	--	--	Mixed	Rheocene	Partner	Amargosa	Private
Historic Spring	--	--	Mixed	Rheocene	Partner	Amargosa	Private
Historic Spring	--	--	Mixed	Rheocene	Partner	Amargosa	Private
Historic Spring	--	--	Mixed	Rheocene	Roux	Amargosa	Private
Historic Spring	--	--	Mixed	Rheocene	Roux	Amargosa	Private
Historic Spring	--	--	Carbonate - Volcanic - mixed	Rheocene	Roux	Amargosa	Private
Historic Spring	--	--	Carbonate - Volcanic - mixed	Rheocene	Roux	Amargosa	Private
Historic Spring	--	--	Carbonate - Volcanic - mixed	Rheocene	Roux	Amargosa	Private
Historic Spring	--	--	Carbonate - Volcanic - mixed	Rheocene	Roux	Amargosa	Private
Historic Spring	--	--	Carbonate - Volcanic - mixed	Rheocene	Roux	Amargosa	Private
Hog Farm Well (Slough Spring)	--	--	Mixed	Artesian Well	AZI	Amargosa	Private
Homestead Spring	--	--	Mixed	Rheocene	Partner	Amargosa	Private
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Source Group (Phillip/Zdon)	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Source Group (Phillip/Zdon)	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Source Group (Phillip/Zdon)	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Johnson-Wright	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Johnson-Wright	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Johnson-Wright	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Johnson-Wright	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	AZI	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	AZI	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	AZI	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	AZI	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	AZI	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Partner	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Partner	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Partner	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Partner	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Partner	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Partner	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Partner	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Partner	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Partner	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Partner	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Partner	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Partner	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Roux	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Roux	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Roux	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Roux	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Roux	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Roux	Amargosa - Kingston Range	BLM
Horsethief Spring	--	--	Intrusive Igneous	Rheocene	Roux	Amargosa - Kingston Range	BLM
Hot Springs	--	--	Volcanic	--	--	Oasis Valley, NV	Private
Ibex Hills Spring	--	--	--	--	Roux	Amargosa	BLM
Kingston Spring	--	--	Carbonate	Helocene	Source Group (Phillip/Zdon)	Amargosa - Kingston Range	BLM
Kingston Spring	--	--	Carbonate	Helocene	AZI	Amargosa - Kingston Range	BLM
Kingston Spring	--	--	Carbonate	Helocene	AZI	Amargosa - Kingston Range	BLM
Kingston Spring	--	--	Carbonate	Helocene	Partner	Amargosa - Kingston Range	BLM
Kristin's Well	--	--	Playa Deposits	Artesian Well	Roux	Amargosa	Private
Lower Indian Spring	--	--	Volcanic	Modified	Partner	Oasis Valley, NV	BLM
Lower Indian Spring	--	--	Volcanic	Modified	Roux	Oasis Valley, NV	BLM
Middle Indian Spring	--	--	--	Rheocene	Roux	Oasis Valley, NV	BLM
Mud Spring	--	--	--	Rheocene	Roux	Oasis Valley, NV	BLM
North Mud Spring	--	--	--	Rheocene	Roux	Oasis Valley, NV	BLM
Old Mormon Spring	--	--	Granitic	Seep	AZI	Amargosa	BLM
One Palm Seep	--	--	Faulted - Playa Deposits	Seep	AZI	Amargosa	BLM
One Palm Seep	--	--	Faulted - Playa Deposits	Seep	Partner	Amargosa	BLM
One Palm Seep	--	--	Faulted - Playa Deposits	Seep	Partner	Amargosa	BLM
One Palm Seep	--	--	Faulted - Playa Deposits	Seep	Partner	Amargosa	BLM
One Palm Seep	--	--	Faulted - Playa Deposits	Seep	Roux	Amargosa	BLM
One Palm Seep	--	--	Faulted - Playa Deposits	Seep	Roux	Amargosa	BLM
One Palm Seep	--	--	Faulted - Playa Deposits	Seep	Roux	Amargosa	BLM
Owl Hole Spring	--	--	Alluvial	Depression spring	USGS	Amargosa - Owlshead Mountains	NPS
Owl Hole Spring	--	--	Alluvial	Depression spring	USGS	Amargosa - Owlshead Mountains	NPS
Owl Hole Spring	--	--	Alluvial	Depression spring	USGS	Amargosa - Owlshead Mountains	NPS
Owl Hole Spring	--	--	Alluvial	Depression spring	Source Group (Phillip/Zdon)	Amargosa - Owlshead Mountains	NPS
Owl Hole Spring	--	--	Alluvial	Depression spring	AZI	Amargosa - Owlshead Mountains	NPS
Owl Hole Spring	--	--	Alluvial	Depression spring	AZI	Amargosa - Owlshead Mountains	NPS
Owl Hole Spring	--	--	Alluvial	Depression spring	Partner	Amargosa - Owlshead Mountains	NPS
Parker Ranch - TNC #1 Spring	--	--	Alluvial	Helocene	AZI	Oasis Valley, NV	TNC
Parker Ranch - TNC #1 Spring	--	--	Alluvial	Helocene	Partner	Oasis Valley, NV	TNC
Parker Ranch - TNC #2 Spring	--	--	Alluvial	Helocene	AZI	Oasis Valley, NV	TNC

Table 1. Amargosa River Basin Spring List
Middle Amargosa Valley Groundwater Basin, Inyo County, California

Spring Name	Date	Latitude	Longitude	Elevation	Flow (gpm)	Temp (°C)	pH	EC (µS)	TDS (mg/L)	Salinity (ppm)	D.O. (mg/L)	δD	δ18O	3H	13C
Parker Ranch Spring	6/2/2016	36.9648	-116.72412	3,603	45	29.7	7.43	1,232	618	--	--	--	--	--	--
Parker Ranch Spring	1/19/2021	36.9648	-116.72412	3,603	--	21.8	7.15	1,685	854	--	0.48	--	--	--	--
Phragmites Seep	2/21/2016	35.97634	-116.2747	1,581	<1	10.5	8.44	2,639	1,319	1,483	10.1	-94	-12.31	--	--
Phragmites Seep	6/4/2016	35.97634	-116.2747	1,581	ET Only	--	--	--	--	--	--	--	--	--	--
Phragmites Seep	9/18/2016	35.97634	-116.2747	1,581	ET Only	--	--	--	--	--	--	--	--	--	--
Phragmites Seep	10/11/2020	35.97634	-116.2747	1,581	ET Only	--	--	--	--	--	--	--	--	--	--
Phragmites Seep	10/21/2022	35.97634	-116.2747	1,581	ET Only	--	--	--	--	--	--	--	--	--	--
Phragmites Seep	10/31/2025	35.97554	-116.27582	1,649	ET Only	--	--	--	--	--	--	--	--	--	--
Phragmites Seep	1/10/2026	35.97554	-116.27582	1,649	<1	--	7.45	>4000	>2000	--	--	--	--	--	--
Quail Spring	--	35.63369	-116.86746	4,122	--	--	--	--	--	--	--	--	--	--	--
Rabbithole Spring	1/14/2011	35.71302	-116.05174	2,120	ET Only	--	--	--	--	--	--	--	--	--	--
Red Trail Seep	2/21/2016	35.98158	-116.26932	1,585	<1	15.2	8.63	3,291	1,646	1,945	2.71	-95	-12.23	--	--
Red Trail Seep	6/4/2016	35.98158	-116.26932	1,585	<1	20.5	7.77	3,717	1,860	--	5.6	--	--	--	--
Red Trail Seep	9/18/2016	35.98158	-116.26932	1,585	<1	15.9	7.82	3,563	1,792	--	--	--	--	--	--
Red Trail Seep	1/10/2017	35.98158	-116.26932	1,585	<1	17.3	8.37	3,445	1,735	1,771	5.81	--	--	--	--
Red Trail Seep	10/10/2020	35.98158	-116.26932	1,585	<1	--	--	--	--	--	--	--	--	--	--
Red Trail Seep	10/21/2022	35.98158	-116.26932	1,585	ET Only	--	--	--	--	--	--	--	--	--	--
Red Trail Seep	10/31/2025	35.98158	-116.26932	1,585	<1	--	--	--	--	--	--	--	--	--	--
Red Trail Seep	1/10/2026	35.98158	-116.26932	1,585	<1	13.9	7.94	3,191	1,595	--	--	--	--	--	--
Resting Spring	1/23/2011	35.8772	-116.15694	1,767	150	26.84	8.36	923	600	--	5.62	-96	-13.2	<1.0	--
Revert Spring at TNC	6/2/2016	36.91551	-116.75311	3,890	311	28.7	8.48	573	287	--	--	-108.6	-14.16	--	--
Revert Spring at TNC	1/18/2021	36.91551	-116.75311	3,890	175	19.6	8.43	583	292	--	--	-109.1	-14.15	--	--
Riley Spring	12/6/15	35.95215	-116.2662	1,503	ET Only	--	--	--	--	--	--	--	--	--	--
Roberts Field Spring	1/18/2021	37.01973	-116.73422	3,717	--	7.8	8.67	2,798	1,407	--	11.81	-97.4	-12.12	--	--
Salt Spring	1/14/1918	35.62614	-116.28089	526	--	--	--	--	5,390	--	--	-81	-9.6	1	--
Salt Spring	4/21/1954	35.62614	-116.28089	526	--	--	8.00	9,010	5,800	--	--	--	--	--	--
Salt Spring	5/19/1955	35.62614	-116.28089	526	--	27	7.60	9,520	6,440	--	--	--	--	--	--
Salt Spring	9/26/1955	35.62614	-116.28089	526	--	23	7.80	9,800	7,300	--	--	--	--	--	--
Salt Spring	5/22/1956	35.62614	-116.28089	526	--	28	8.30	9,520	--	--	--	--	--	--	--
Salt Spring	11/14/1956	35.62614	-116.28089	526	--	17	7.90	11,800	8,540	--	--	--	--	--	--
Salt Spring	5/9/1957	35.62614	-116.28089	526	--	20	7.70	8,900	--	--	--	--	--	--	--
Salt Spring	5/19/1958	35.62614	-116.28089	526	--	22	7.90	9,630	--	--	--	--	--	--	--
Salt Spring	5/12/1959	35.62614	-116.28089	526	--	31	7.90	10,100	6,500	--	--	--	--	--	--
Salt Spring	5/13/1960	35.62614	-116.28089	526	--	28	7.80	12,500	8,210	--	--	--	--	--	--
Salt Spring	3/25/1963	35.62614	-116.28089	526	--	23	8.10	12,000	8,000	--	--	--	--	--	--
Salt Spring	5/4/1964	35.62614	-116.28089	526	--	25	8.20	12,400	8,020	--	--	--	--	--	--
Salt Spring	4/25/1967	35.62614	-116.28089	526	--	19	7.70	10,100	6,700	--	--	--	--	--	--
Salt Spring	11/5/2010	35.62614	-116.28089	526	1	20.5	7.94	6,514	4,235	--	0.74	--	--	--	--
Salt Spring	5/10/2011	35.62614	-116.28089	526	1	19.5	7.70	8,944	5,814	--	5.79	--	--	--	--
Salt Spring	5/11/2014	35.62614	-116.28089	526	5	26.3	8.30	10,690	--	5,900	8.34	--	--	--	--
Salt Spring	12/5/2015	35.62614	-116.28089	526	5	10.4	8.21	>4,000	>2,000	7,096	13.61	--	--	--	--
Salt Spring	5/31/2016	35.62614	-116.28089	526	<1	24	8.04	>4,000	>2,000	6,978	5.18	--	--	--	--
Salt Spring	9/18/2016	35.62614	-116.28089	526	ET Only	--	--	--	--	--	--	--	--	--	--
Salt Spring	1/10/2017	35.62614	-116.28089	526	5	11.1	7.96	>4,000	>2,000	6,783	11.96	--	--	--	--
Salt Spring	4/10/2017	35.62614	-116.28089	526	<1	13.4	8.16	>4,000	>2,000	5,130	7.1	--	--	--	--
Salt Spring	1/15/2018	35.62614	-116.28089	526	10	13.2	7.96	>4,000	>2,000	--	10.41	--	--	--	--
Salt Spring	4/27/2018	35.62614	-116.28089	526	<1	--	--	--	--	--	--	--	--	--	--
Salt Spring	10/17/2018	35.62614	-116.28089	526	ET Only	--	--	--	--	--	--	--	--	--	--
Salt Spring	1/8/2019	35.62614	-116.28089	526	10	14	7.08	>4,000	>2,000	--	--	--	--	--	--
Salt Spring	4/23/2019	35.62614	-116.28089	526	<1	18	7.57	>4,000	>2,000	--	4.45	--	--	--	--
Salt Spring	4/23/2020	35.62614	-116.28089	526	10	20.1	7.76	>4,000	>2,000	--	--	--	--	--	--
Salt Spring	10/8/2020	35.62614	-116.28089	526	<1	--	--	--	--	--	--	--	--	--	--
Salt Spring	1/14/2021	35.62614	-116.28089	526	15	14.6	7.55	>4,000	>2,000	--	16.8	--	--	--	--
Salt Spring	4/10/2021	35.62614	-116.28089	526	5	24	7.87	10,630	5,310	--	2.48	--	--	--	--
Salt Spring	10/13/2021	35.62614	-116.28089	526	<1	16.1	7.41	15,350	7,670	--	4.58	--	--	--	--
Salt Spring	10/16/2022	35.62614	-116.28089	526	<1	22	7.12	>4,000	>2,000	--	--	--	--	--	--
Salt Spring	1/8/2023	35.62614	-116.28089	526	20	12.4	7.34	13,060	6,600	--	--	--	--	--	--
Salt Spring	4/26/2023	35.62614	-116.28089	526	7	21.2	7.90	10,570	5,270	--	--	--	--	--	--
Salt Spring	4/22/2025	35.624011	-116.276422	530	<10	19.1	7.70	6,040	3,020	--	--	--	--	--	--
Salt Spring	10/28/2025	35.624011	-116.276422	530	>10	15.6	7.53	8,320	4,160	--	--	--	--	--	--
Salt Spring	1/14/2026	35.62413	-116.27811	520	40	19.3	8.74	4,150	2,070	--	--	--	--	--	--
Scofield Spring	5/31/2016	35.8735	-116.12078	2,051	ET Only	--	--	--	--	--	--	--	--	--	--
Scofield Spring	1/10/2017	35.8735	-116.12078	2,051	<1	15.6	7.43	1,417	708	740	4.37	--	--	--	--
Scofield Spring	10/21/2018	35.8735	-116.12078	2,051	<1	22.5	7.29	1,051	528	--	0.61	--	--	--	--
Scofield Spring	4/22/2019	35.8735	-116.12078	2,051	<1	21.4	7.36	992	494	--	0.57	--	--	<0.81	-11.6
Scofield Spring	10/17/2021	35.8735	-116.12078	2,051	<1	21.7	7.06	1,050	520	--	2.9	--	--	<0.82	-10.6
Scofield Spring	4/23/2025	35.8735	-116.12078	2,034	ET Only	--	--	--	--	--	--	--	--	--	--
Scofield Spring	10/29/2025	35.8735	-116.12078	2,034	ET Only	--	--	--	--	--	--	--	--	--	--
Scofield Spring	1/13/2026	35.8735	-116.12078	2,034	ET Only	--	--	--	--	--	--	--	--	--	--
Seep Spring	--	36.9882	-116.7532	3,890	--	--	--	--	--	--	--	--	--	--	--
Sheep Creek Spring	10/16/1917	35.58858	-116.36027	1,703	--	--	--	--	860	--	--	-88.1	-11.9	<0.8	--
Sheep Creek Spring	10/1919	35.58858	-116.36027	1,703	--	22	--	--	--	--	--	--	--	--	--
Sheep Creek Spring	3/11/1953	35.58858	-116.36027	1,703	--	--	--	--	860	--	--	--	--	--	--
Sheep Creek Spring	2/10/1967	35.58858	-116.36027	1,703	--	20	7.90	1,130	801	--	--	--	--	--	--
Sheep Creek Spring	11/5/2010	35.58858	-116.36027	1,703	5	23.1	9.02	614	400	--	8.57	--	--	--	--

Middle Amargosa Valley Groundwater Basin, Inyo County, California

[illegible]

Table 1. Amargosa River Basin Spring List
Middle Amargosa Valley Groundwater Basin, Inyo County, California

Spring Name	Date	Latitude	Longitude	Elevation	Flow (gpm)	Temp (°C)	pH	EC (µS)	TDS (mg/L)	Salinity (ppm)	D.O. (mg/L)	δD	δ18O	3H	13C
Sheep Creek Spring	4/24/2011	35.58858	-116.36027	1,703	5	21.4	7.78	1,216	789	--	7.67	--	--	--	--
Sheep Creek Spring	2/17/2016	35.58858	-116.36027	1,703	15	18.6	8.09	1,083	541	589	2.45	--	--	--	--
Sheep Creek Spring	4/29/2018	35.58858	-116.36027	1,703	10	21.8	7.61	1,111	555	--	0.9	--	--	--	--
Sheep Creek Spring	10/13/2020	35.58858	-116.36027	1,703	3.5	21	8.43	1,065	522	--	--	--	--	--	--
Shoshone Spring	1/23/2011	35.98056	-116.27384	1,615	>250	33.5	7.79	1,624	1,056	--	3.75	-93	-12.6	<0.6	--
Shoshone Spring	4/27/2011	35.98056	-116.27384	1,615	>250	--	--	--	--	--	--	--	--	--	--
Shoshone Spring	5/1/2012	35.98056	-116.27384	1,615	--	33.5	7.68	1,477	960	--	6.77	--	--	--	--
Shoshone Spring	1/29/2013	35.98056	-116.27384	1,615	--	33.3	7.66	1,847	1,201	--	5.85	--	--	--	--
Shoshone Spring	5/2/2013	35.98056	-116.27384	1,615	--	33.5	7.41	1,601	1,040	--	4.5	--	--	--	--
Shoshone Spring	5/9/2014	35.98056	-116.27384	1,615	>250	32.3	7.51	2,088	--	920	2.99	--	--	--	--
Shoshone Spring	12/6/2014	35.98056	-116.27384	1,615	>250	33.7	7.26	1,566	788	--	--	--	--	--	--
Shoshone Spring	2/21/2016	35.98056	-116.27384	1,615	265	32.3	7.64	1,416	708	--	--	--	--	--	--
Shoshone Spring	10/21/2022	35.98056	-116.27384	1,615	24	31.2	7.63	1,432	716	--	--	--	--	--	--
Shoshone Spring	1/7/2023	35.98056	-116.27384	1,615	67.3	32.3	6.99	1,391	703	--	--	-96	-12.69	--	-4.3
Shoshone Spring	4/23/2025	35.98038	-116.27387	1,590	54	33.5	7.44	1,461	732	--	--	--	--	--	--
Shoshone Spring	10/31/2025	35.98038	-116.27387	1,590	37.57	33.2	7.36	1,567	783	--	--	--	--	--	--
South Yeoman Spring	1/16/2021	35.94483	-116.18761	1,926	--	--	--	--	--	--	--	--	--	--	--
Specie Spring	1/19/2021	36.86859	-116.65998	4,418	<1	11.4	7.12	721	361	--	2.58	-91.4	-12.54	--	--
Specie Spring	2/20/2022	36.86859	-116.65998	4,418	<1	13.6	7.84	910	450	--	--	-84.8	-10.67	--	--
Springdale Upper Spring	1/18/2021	37.03079	-116.75509	3,846	20	13.7	8.13	695	347	--	7.14	-101.8	-13.31	--	--
Still Spring	6/3/2016	35.95903	-116.25961	1,511	--	--	--	--	--	--	--	--	--	--	--
Stormy Spring	12/7/2015	35.85212	-116.22059	1,378	<1	7.3	7.95	2,726	1,379	1,642	2.93	-91.6	-12.06	--	--
Stump Spring	12/7/2015	35.98366	-115.8255	2,822	ET Only	--	--	--	--	--	--	--	--	--	--
Tecopa Hot Spring	12/5/2014	35.87191	-116.232145	1,415	30	40.2	7.93	3,076	1,535	1,570	1.56	-98.1	-12.93	--	--
Tecopa Hot Spring	12/7/2015	35.87191	-116.232145	1,415	30	40.3	--	3,295	1,695	--	--	--	--	--	--
Tecopa Hot Spring	12/7/2016	35.87191	-116.232145	1,415	39	41.5	8.13	3,187	1,598	1,556	0.55	--	--	--	--
Tecopa Hot Spring	1/7/2023	35.87191	-116.232145	1,415	85.7	40.9	7.98	2,816	1,418	--	--	-98.6	-12.91	--	-4.2
Tecopa Hot Spring	4/27/2023	35.87191	-116.232145	1,415	147.23	40.1	8.16	2,948	1,476	--	--	--	--	--	--
Tecopa Hot Spring	12/12/2023	35.87191	-116.232145	1,415	93	39.0	6.93	3,277	1,645	--	--	--	--	--	--
Tecopa Hot Spring	4/23/2025	35.8789	-116.23812	1,332	66.64	39.1	8.13	3,232	1,016	--	--	--	--	--	--
Tecopa Hot Spring	1/12/2026	35.8789	-116.23812	1,332	269	40.3	8.10	3,430	1,717	--	--	--	--	--	--
Tecopa Hot Spring (at TNC)	11/11/2010	35.87744	-116.23618	1,332	6	40.8	8.61	4,306	2,799	--	0.09	-91	-11.3	<0.5	--
Tecopa Hot Spring (at TNC)	9/21/2011	35.87744	-116.23618	1,332	5.1	38.9	9.18	6,400	4,100	--	--	--	--	--	--
Tecopa Hot Spring (at TNC)	4/30/2012	35.87744	-116.23618	1,332	4.9	41.2	8.96	3,525	2,311	--	--	--	--	--	--
Tecopa Hot Spring (at TNC)	1/29/2013	35.87744	-116.23618	1,332	5.4	38	8.87	5,000	3,250	--	--	--	--	--	--
Tecopa Hot Spring (at TNC)	5/10/2014	35.87744	-116.23618	1,332	7.5	40.6	8.71	2,390	--	--	--	--	--	--	--
Tecopa Hot Spring (at TNC)	12/5/2014	35.87744	-116.23618	1,332	8	39.6	8.43	>4000	>2000	--	--	--	--	--	--
Tecopa Hot Spring (at TNC)	12/7/2015	35.87744	-116.23618	1,332	6	39.4	8.43	>4000	>2000	2,126	--	--	--	--	--
Thom Spring	11/11/2010	35.85619	-116.22361	1,406	5	24.8	7.63	1,571	1,021	779	2.77	-95	-13.1	<0.9	--
Thom Spring	4/30/2012	35.85619	-116.22361	1,406	2	24.9	6.79	1,478	960	--	3.66	--	--	--	--
Thom Spring	1/28/2013	35.85619	-116.22361	1,406	2.5	28.6	7.73	1,819	1,182	--	2.8	--	--	--	--
Thom Spring	4/30/2013	35.85619	-116.22361	1,406	2.5	27.9	7.20	1,601	1,040	--	1.83	--	--	--	--
Thom Spring	5/5/2014	35.85619	-116.22361	1,406	5	27.7	7.63	1,965	--	--	1.4	--	--	--	--
Thom Spring	12/3/2014	35.85619	-116.22361	1,406	1	28.5	7.43	1,572	787	--	--	--	--	--	--
Thom Spring	12/7/2015	35.85619	-116.22361	1,406	<1	16.2	7.75	1,630	814	779	6.14	--	--	--	--
Thom Spring	5/31/2016	35.85619	-116.22361	1,406	<1	24.8	7.57	1,672	829	--	--	--	--	--	--
Thom Spring	9/15/2016	35.85619	-116.22361	1,406	1	25.9	7.64	1,382	691	--	--	--	--	--	--
Thom Spring	1/9/2017	35.85619	-116.22361	1,406	<1	23	7.70	1,876	965	765	2.21	--	--	--	--
Thom Spring	4/10/2017	35.85619	-116.22361	1,406	<1	25.2	7.75	1,588	796	776	3.36	--	--	--	--
Thom Spring	1/16/2018	35.85619	-116.22361	1,406	<1	17	8.06	1,425	712	--	6.76	--	--	--	--
Thom Spring	4/27/2018	35.85619	-116.22361	1,406	<1	27.9	7.68	1,347	676	--	1.31	--	--	--	--
Thom Spring	10/22/2018	35.85619	-116.22361	1,406	<1	21.5	7.94	1,617	809	--	2.46	--	--	--	--
Thom Spring	1/8/2019	35.85619	-116.22361	1,406	<1	27.5	7.68	1,351	676	--	--	--	--	--	--
Thom Spring	4/22/2019	35.85619	-116.22361	1,406	<1	27.1	8.08	1,458	728	--	3.42	--	--	--	--
Thom Spring	9/30/2019	35.85619	-116.22361	1,406	<1	17	8.44	1,362	679	--	1.82	--	--	--	--
Thom Spring	4/29/2020	35.85619	-116.22361	1,406	<1	--	--	--	--	--	--	--	--	--	--
Thom Spring	10/12/2020	35.85619	-116.22361	1,406	<1	--	--	--	--	--	--	--	--	--	--
Thom Spring	1/15/2021	35.85619	-116.22361	1,406	<1	--	--	--	--	--	--	--	--	--	--
Thom Spring	4/11/2021	35.85619	-116.22361	1,406	<1	--	--	--	--	--	--	--	--	--	--
Thom Spring	10/14/2021	35.85619	-116.22361	1,406	<1	11.6	8.39	1,570	780	--	7.75	--	--	--	--
Thom Spring	10/17/2022	35.85619	-116.22361	1,406	ET Only	--	--	--	--	--	--	--	--	--	--
Thom Spring	1/7/2023	35.85619	-116.22361	1,406	ET Only	--	--	--	--	--	--	--	--	--	--
Thom Spring	4/27/2023	35.85619	-116.22361	1,406	ET Only	--	--	--	--	--	--	--	--	--	--
Thom Spring	12/12/2023	35.85619	-116.22361	1,408	ET Only	11.2	8.83	2,034	1,017	--	--	--	--	--	--
Thom Spring	4/23/2025	35.85619	-116.22361	1,408	ET Only	--	--	--	--	--	--	--	--	--	--
Thom Spring	10/26/2025	35.85619	-116.22361	1,408	ET Only	--	--	--	--	--	--	--	--	--	--
Thom Spring	1/12/2026	35.85619	-116.22361	1,408	ET Only	--	--	--	--	--	--	--	--	--	--
Torrance Ranch - Atwood Spg	1/17/2021	37.00488	-116.7246	3,665	80	16.8	8.03	1,216	609	--	7.85	-108.7	-13.97	--	--
Torrance Ranch - Boardwalk Spg	6/2/2016	37.00402	-116.72407	3,661	16	20.9	8.07	852	424	--	5.57	--	--	--	--
Torrance Ranch - Boardwalk Spg	1/17/2021	37.00402	-116.72407	3,661	42	15.2	8.05	1,159	575	--	7.54	-108.6	-14	--	--
Torrance Ranch - Kiosk Spg	6/2/2016	37.00304	-116.74256	3,669	<1	22.3	7.89	1,289	644	--	--	--	--	--	--
Torrance Ranch - Kiosk Spg	1/17/2021	37.00304	-116.74256	3,669	ET Only	--	--	--	--	--	--	--	--	--	--
Tule Spring	11/1/2010	35.81691	-116.0554	2,326	<1	16.4	7.51	878	571	570	0.47	--	--	--	--
Tule Spring	5/9/2014	35.81691	-116.0554	2,326	<1	20	7.44	1,031	--	--	0.37	--	--	--	--
Tule Spring	2/19/2016	35.81691	-116.0554	2,326	<1	18.1	7.53	737	368	377	0.44	-96.2	-12.89	--	--

Middle Amargosa Valley Groundwater Basin, Inyo County, California

[illegible]

Table 1. Amargosa River Basin Spring List
Middle Amargosa Valley Groundwater Basin, Inyo County, California

Spring Name	Date	Latitude	Longitude	Elevation	Flow (gpm)	Temp (°C)	pH	EC (µS)	TDS (mg/L)	Salinity (ppm)	D.O. (mg/L)	δD	δ18O	3H	13C
Tule Spring	5/31/2016	35.81691	-116.0554	2,326	<1	--	--	--	--	--	--	--	--	--	--
Tule Spring	9/17/2016	35.81691	-116.0554	2,326	<1	22.8	7.23	1,650	857	--	--	--	--	--	--
Tule Spring	1/8/2017	35.81691	-116.0554	2,326	<1	15.2	6.91	947	473	444	0.61	--	--	--	--
Tule Spring	4/11/2017	35.81691	-116.0554	2,326	<1	19.6	7.56	796	398	374	1.1	--	--	--	--
Tule Spring	1/5/2018	35.81691	-116.0554	2,326	<1	18.8	7.47	830	415	--	0.5	--	--	--	--
Tule Spring	4/26/2018	35.81691	-116.0554	2,326	<1	23.4	7.30	865	435	--	0.21	--	--	--	--
Tule Spring	10/18/2018	35.81691	-116.0554	2,326	<1	19.6	7.20	1,012	506	--	0	--	--	--	--
Tule Spring	1/9/2019	35.81691	-116.0554	2,326	<1	--	--	--	--	--	--	--	--	--	--
Tule Spring	4/22/2019	35.81691	-116.0554	2,326	<1	22.2	7.66	1,809	1,061	--	0	--	--	--	--
Tule Spring	9/30/2019	35.81691	-116.0554	2,326	<1	--	--	--	--	--	--	--	--	--	--
Tule Spring	4/29/2020	35.81691	-116.0554	2,326	<1	--	--	--	--	--	--	--	--	--	--
Tule Spring	10/9/2020	35.81691	-116.0554	2,326	<1	21.2	7.53	3,656	1,803	--	--	--	--	--	--
Tule Spring	1/16/2021	35.81691	-116.0554	2,326	<1	16.3	7.22	1,284	637	--	<0.01	--	--	--	--
Tule Spring	4/12/2021	35.81691	-116.0554	2,326	<1	25.2	7.84	1,080	540	--	0.4	--	--	--	--
Tule Spring	10/15/2021	35.81691	-116.0554	2,326	<1	19.1	6.73	1,890	950	--	0	--	--	--	--
Tule Spring	10/17/2022	35.81691	-116.0554	2,326	ET Only	--	--	--	--	--	--	--	--	--	--
Tule Spring	1/6/2023	35.81691	-116.0554	2,326	ET Only	--	--	--	--	--	--	--	--	--	--
Tule Spring	4/28/2023	35.81691	-116.0554	2,326	ET Only	--	--	--	--	--	--	--	--	--	--
Tule Spring	12/11/2023	35.81691	-116.0554	2,326	ET Only	--	--	--	--	--	--	--	--	--	--
Tule Spring	4/20/2025	35.81691	-116.0554	2,326	ET Only	--	--	--	--	--	--	--	--	--	--
Tule Spring	10/27/2025	35.81691	-116.0554	2,326	ET Only	--	--	--	--	--	--	--	--	--	--
Tule Spring	1/13/2026	35.81691	-116.0554	2,326	ET Only	--	--	--	--	--	--	--	--	--	--
Twelvemile Spring	11/14/2010	36.02195	-116.1553	2,208	<1	19.2	7.66	712	520	--	1.38	--	--	--	--
Twelvemile Spring	2/19/2016	36.02195	-116.1553	2,208	<1	21.9	7.57	813	411	361	3.23	-97.1	-13.13	--	--
Twelvemile Spring	6/1/2016	36.02195	-116.1553	2,208	<1	32.2	7.18	933	463	--	0.26	--	--	--	--
Twelvemile Spring	9/17/2016	36.02195	-116.1553	2,208	<1	25	7.24	907	451	--	--	--	--	--	--
Twelvemile Spring	4/11/2017	36.02195	-116.1553	2,208	<1	25.9	7.25	640	320	364	0.08	--	--	--	--
Twelvemile Spring	4/26/2018	36.02195	-116.1553	2,208	<1	25.9	7.25	640	320	364	0.08	--	--	--	--
Twelvemile Spring	10/22/2018	36.02195	-116.1553	2,208	<1	23.8	7.45	813	408	--	1.35	--	--	--	-7.2
Twelvemile Spring	4/22/2019	36.02195	-116.1553	2,208	<1	22.3	7.44	716	357	--	0.08	--	--	--	--
Twelvemile Spring	10/1/2019	36.02195	-116.1553	2,208	<1	24.8	7.36	701	354	--	0.13	--	--	--	--
Twelvemile Spring	10/12/2020	36.02195	-116.1553	2,208	<1	21.1	7.92	786	390	--	1.07	--	--	--	--
Twelvemile Spring	1/15/2021	36.02195	-116.1553	2,208	<1	20.8	7.26	1,029	513	--	1.93	--	--	--	--
Twelvemile Spring	4/12/2021	36.02195	-116.1553	2,208	<1	17.1	7.50	650	330	--	5.7	--	--	--	--
Twelvemile Spring	10/15/2021	36.02195	-116.1553	2,208	<1	20.1	7.01	900	--	--	1.41	--	--	--	--
Twelvemile Spring	10/17/2022	36.02195	-116.1553	2,208	ET Only	--	--	--	--	--	--	--	--	--	--
Twelvemile Spring	4/28/2023	36.02195	-116.1553	2,208	ET Only	--	--	--	--	--	--	--	--	--	--
Twelvemile Spring	12/11/2023	36.02195	-116.1553	2,208	ET Only	--	--	--	--	--	--	--	--	--	--
Twelvemile Spring	4/20/2025	36.02195	-116.1553	2,208	<1	17.9	7.76	911	455	--	--	--	--	--	--
Twelvemile Spring	10/27/2025	36.02195	-116.1553	2,208	<1	20.2	7.93	827	413	--	--	--	--	--	--
Upper Indian Spring	2/19/2022	36.9516	-116.805	4,229	--	--	--	--	--	--	--	--	--	--	--
Upper Wild Horse Spring	12/8/2015	35.78515	-115.99353	3,369	<1	9.8	7.59	870	435	358	--	-86.3	-11.67	--	--
Upper Wild Horse Spring	1/6/2023	35.78515	-115.99353	3,369	1	14.8	8.26	627	316	--	--	-85.3	-11.61	--	-10.4
Upper Wild Horse Spring	4/20/2025	35.785079	-115.993458	3,350	<1	26.5	8.49	745	373	--	--	--	--	--	--
Upper Wild Horse Spring	10/27/2025	35.785079	-115.993458	3,350	<10	14.5	8.53	775	386	--	--	--	--	--	--
Upper Wild Horse Spring	1/13/2026	35.785079	-115.993458	3,350	5	13.1	7.22	662	332	--	--	--	--	--	--
Ute Spring	--	36.9586	-116.72044	3,538	--	--	--	--	--	--	--	--	--	--	--
Vole Hot Spring	2/21/2016	35.85092	-116.2232	1,369	5	18.6	8.28	1,809	906	951	7.26	-96.4	-12.89	--	--
Vole Hot Spring	6/3/2016	35.85092	-116.2232	1,369	<1	23	8.50	1,853	927	--	6.61	--	--	--	--
Vole Hot Spring	9/15/2016	35.85092	-116.2232	1,369	1	23	8.54	1,640	826	--	--	--	--	--	--
Vole Hot Spring	1/9/2017	35.85092	-116.2232	1,369	<1	17.5	8.37	1,853	925	954	7.46	--	--	--	--
Vole Hot Spring	4/10/2017	35.85092	-116.2232	1,369	3	21.4	8.60	1,831	926	933	11.6	--	--	--	--
Vole Hot Spring	1/16/2018	35.85092	-116.2232	1,369	20	19.2	8.63	1,642	820	--	7.29	--	--	--	--
Vole Hot Spring	4/27/2018	35.85092	-116.2232	1,369	20	22.6	8.71	1,583	792	--	10.72	--	--	--	--
Vole Hot Spring	4/23/2019	35.85092	-116.2232	1,369	3	23.9	8.48	1,680	842	--	8.18	--	--	--	--
Vole Hot Spring	1/7/2023	35.85092	-116.2232	1,369	--	--	--	--	--	--	--	--	--	--	--
West Side Spring	5/6/2014	35.84324	-116.22879	1,301	10	18	7.98	1,322	--	770	0.71	--	--	--	--
Wild Bath Spring	11/11/2010	35.87277	-116.21932	1,411	1.7	29.9 (*)	7.90	1,642	1,067	771	4.69	-95	-13.1	<0.6	--
Wild Bath Spring	9/21/2011	35.87277	-116.21932	1,411	1.9	38 (*)	7.83	1,664	1,083	--	5.59	--	--	--	--
Wild Bath Spring	5/5/2012	35.87277	-116.21932	1,411	1.3	34.9 (*)	8.37	1,559	1,012	--	5.64	--	--	--	--
Wild Bath Spring	1/25/2013	35.87277	-116.21932	1,411	<2	36.5 (*)	7.94	1,906	1,024	--	4.52	--	--	--	--
Wild Bath Spring	5/4/2013	35.87277	-116.21932	1,411	<2	33.8 (*)	7.81	1,633	1,061	--	3.97	--	--	--	--
Wild Bath Spring	9/25/2013	35.87277	-116.21932	1,411	<2	30.8 (*)	8.07	1,403	911	--	5	--	--	--	--
Wild Bath Spring	5/10/2014	35.87277	-116.21932	1,411	5	35.5 (*)	8.20	2,249	1,215	930	3.85	--	--	--	--
Wild Bath Spring	12/3/2014	35.87277	-116.21932	1,411	2.5	38.8	7.41	1,689	848	--	--	--	--	--	--
Wild Bath Spring	12/7/2014	35.87277	-116.21932	1,411	3	39.8	--	1,613	802	--	--	--	--	--	--
Wild Bath Spring	5/31/2016	35.87277	-116.21932	1,411	1.6	40.2	7.49	1,673	834	--	0.82	--	--	--	--
Wild Bath Spring	9/15/2016	35.87277	-116.21932	1,411	1.5	42.1	7.50	1,465	732	--	--	--	--	--	--
Wild Bath Spring	1/9/2017	35.87277	-116.21932	1,411	1.5	41.1	7.38	1,658	828	768	0.65	--	--	--	--
Wild Bath Spring	4/11/2017	35.87277	-116.21932	1,411	1.5	41.7	7.46	1,635	817	767	0.36	--	--	--	--
Wild Bath Spring	1/16/2018	35.87277	-116.21932	1,411	2	41.8	7.59	1,433	721	--	1.61	--	--	--	--
Wild Bath Spring	4/23/2019	35.87277	-116.21932	1,411	1.8	42.1	7.49	1,507	756	--	2.48	--	--	--	--
Wild Bath Spring	10/1/2019	35.87277	-116.21932	1,411	1.5	41.2	7.75	1,503	751	--	0.91	--	--	--	--
Wild Bath Spring	4/29/2020	35.87277	-116.21932	1,411	2	42	7.52	1,531	760	--	--	--	--	--	--
Wild Bath Spring	4/11/2021	35.87277	-116.21932	1,411	1.6	40.8	7.56	1,640	--	--	--	--	--	--	--

Middle Amargosa Valley Groundwater Basin, Inyo County, California

Spring Name	14C	Apparent Age (yrs) [†]	Vent Lithology	Spring Type	Monitor	Area	Land Owner/Manager
Tule Spring	--	--	Faulted - Alluvial	Seep	AZI	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	AZI	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep	Roux	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep, Dry	Roux	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep, Dry	Roux	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep, Dry	Roux	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep, Dry	Roux	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep, Dry	Roux	Amargosa - Kingston Range	BLM
Tule Spring	--	--	Faulted - Alluvial	Seep, Dry	Roux	Amargosa - Kingston Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep	Source Group (Phillip/Zdon)	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep	AZI	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep	AZI	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep	AZI	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Nopah Range	BLM
Twelvemile Spring	28.0 +/- 0.1	10,500	Faulted - Alluvial	Seep	Partner	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep	Partner	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep	Roux	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep, Dry	Roux	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep, Dry	Roux	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep, Dry	Roux	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep	Roux	Amargosa - Nopah Range	BLM
Twelvemile Spring	--	--	Faulted - Alluvial	Seep	Roux	Amargosa - Nopah Range	BLM
Upper Indian Spring	--	--	--	Rheocrene	Roux	Oasis Valley, NV	BLM
Upper Wild Horse Spring	--	--	Colluvium	Hillslope	AZI	Amargosa - Kingston Range	BLM
Upper Wild Horse Spring	71.2 +/- 0.3	2,810	Colluvium	Hillslope	Roux	Amargosa - Kingston Range	BLM
Upper Wild Horse Spring	--	--	Colluvium	Hillslope	Roux	Amargosa - Kingston Range	Private (Amargosa Conservancy)
Upper Wild Horse Spring	--	--	Colluvium	Hillslope	Roux	Amargosa - Kingston Range	Private (Amargosa Conservancy)
Upper Wild Horse Spring	--	--	Colluvium	Hillslope	Roux	Amargosa - Kingston Range	Private (Amargosa Conservancy)
Ute Spring	--	--	--	--	--	Oasis Valley, NV	--
Vole Hot Spring	--	--	Silicic metasedimentary	Rheocrene	AZI	Amargosa	BLM
Vole Hot Spring	--	--	Silicic metasedimentary	Rheocrene	AZI	Amargosa	BLM
Vole Hot Spring	--	--	Silicic metasedimentary	Rheocrene	AZI	Amargosa	BLM
Vole Hot Spring	--	--	Silicic metasedimentary	Rheocrene	Partner	Amargosa	BLM
Vole Hot Spring	--	--	Silicic metasedimentary	Rheocrene	Partner	Amargosa	BLM
Vole Hot Spring	--	--	Silicic metasedimentary	Rheocrene	Partner	Amargosa	BLM
Vole Hot Spring	--	--	Silicic metasedimentary	Rheocrene	Partner	Amargosa	BLM
Vole Hot Spring	--	--	Silicic metasedimentary	Rheocrene	Partner	Amargosa	BLM
Vole Hot Spring	--	--	Silicic metasedimentary	Rheocrene	Roux	Amargosa	BLM
West Side Spring	--	--	Alluvial	Rheocrene	AZI	Amargosa	BLM
Wild Bath Spring	--	--	Playa Deposits	Modified	Source Group (Phillip/Zdon)	Amargosa	BLM
Wild Bath Spring	--	--	Playa Deposits	Modified	Source Group (Phillip/Zdon)	Amargosa	BLM
Wild Bath Spring	--	--	Playa Deposits	Modified	Johnson-Wright	Amargosa	BLM</

Table 1. Amargosa River Basin Spring List
Middle Amargosa Valley Groundwater Basin, Inyo County, California

Spring Name	Date	Latitude	Longitude	Elevation	Flow (gpm)	Temp (°C)	pH	EC (µS)	TDS (mg/L)	Salinity (ppm)	D.O. (mg/L)	δD	δ18O	3H	13C
Wild Bath Spring	10/14/2021	35.87277	-116.21932	1,411	0.8	41.8	7.13	1,630	810	--	4.16	--	--	--	--
Wild Bath Spring	4/27/2023	35.87277	-116.21932	1,411	1.58	41.6	7.40	1,415	709	--	--	--	--	--	--
Wild Bath Spring	12/12/2023	35.87277	-116.21932	1,424	1.77	42	7.37	1,583	789	--	--	--	--	--	--
Wild Bath Spring	4/23/2025	35.87277	-116.21932	1,424	1.305	41	7.51	1,528	760	--	--	--	--	--	--
Wild Bath Spring	10/26/2025	35.87277	-116.21932	1,424	--	35	7.26	2,030	1,010	--	--	--	--	--	--
Wild Horse Spring	11/19/2010	35.78804	-115.99766	3,108	1	21.4	7.81	420	293	--	--	--	--	--	--
Wild Horse Spring	4/26/2011	35.78804	-115.99766	3,108	ET Only	--	--	--	--	--	--	--	--	--	--
Wild Horse Spring	5/9/2014	35.78804	-115.99766	3,108	2.5	--	--	--	--	--	--	--	--	--	--
Wild Horse Spring	12/8/2015	35.78804	-115.99766	3,108	<1	12.6	7.67	466	233	213	--	-87.4	-11.92	--	--
Wild Horse Spring	6/3/2016	35.78804	-115.99766	3,108	<1	23.9	7.57	461	229	--	--	--	--	--	--
Wild Horse Spring	4/26/2018	35.78804	-115.99766	3,108	ET Only	--	--	--	--	--	--	--	--	--	--
Wild Horse Spring	10/22/2018	35.78804	-115.99766	3,108	<1	--	--	--	--	--	--	--	--	--	--
Wild Horse Spring	4/12/2021	35.78804	-115.99766	3,108	0.5	21.3	7.87	440	220	--	5.79	--	--	--	--
Wild Horse Spring	10/18/2022	35.78804	-115.99766	3,108	<1	24.4	7.42	699	342	--	--	--	--	--	--
Wild Horse Spring	1/6/2023	35.78804	-115.99766	3,108	<0.1	14.9	7.83	711	358	--	--	--	--	--	--
Wild Horse Spring	4/20/2025	35.78804	-115.99766	3,108	<1	20.5	7.99	450	223	--	--	--	--	--	--
Wild Horse Spring	10/27/2025	35.78804	-115.99766	3,108	ET Only	--	--	--	--	--	--	--	--	--	--
Wild Horse Spring	1/13/2026	35.78804	-115.99766	3,108	ET Only	--	--	--	--	--	--	--	--	--	--
Willow Creek Below China Ranch	10/17/2022	35.79895	-116.1951	1,211	72	22.3	7.11	887	441	--	--	--	--	--	--
Willow Creek Below China Ranch	1/6/2023	35.79895	-116.1951	1,211	--	18.6	8.24	1,271	635	--	--	--	--	--	--
Willow Creek Below China Ranch	4/27/2023	35.79895	-116.1951	1,211	125.52	20.5	8.29	1,074	537	--	--	--	--	--	--
Willow Creek Below China Ranch	12/11/2023	35.79895	-116.1951	1,211	78	19.8	8.25	1,108	562	--	--	--	--	--	--
Willow Creek Below China Ranch	4/21/2025	35.79895	-116.1951	1,211	69	22.8	8.13	1,158	580	--	--	--	--	--	--
Willow Creek Below China Ranch	10/30/2025	35.79895	-116.1951	1,211	44.88	21.9	8.46	974	486	--	--	--	--	--	--
Willow Creek Below China Ranch	1/12/2026	35.79895	-116.1951	1,211	70	20.7	8.38	1,144	572	--	--	--	--	--	--
Willow Spring 1	12/6/2014	35.80569	-116.18264	1,445	40	24	7.34	1,312	664	--	--	-95	-12.8	<0.8	--
Willow Spring 1	12/5/2015	35.80569	-116.18264	1,445	1	12.9	7.55	1,703	852	--	3.91	--	--	--	--
Willow Spring 1	5/31/2016	35.80569	-116.18264	1,445	2.5	25.2	7.25	986	491	--	2.73	--	--	--	--
Willow Spring 1	9/17/2016	35.80569	-116.18264	1,445	20	27.3	7.29	1,011	510	--	--	--	--	--	--
Willow Spring 1	1/9/2017	35.80569	-116.18264	1,445	2.5	20.6	7.64	1,631	809	--	3.87	--	--	--	--
Willow Spring 1	4/11/2017	35.80569	-116.18264	1,445	30	21.5	7.63	1,147	573	560	2.58	--	--	--	--
Willow Spring 1	1/16/2018	35.80569	-116.18264	1,445	40	21.5	7.71	1,020	515	--	2.95	--	--	--	--
Willow Spring 1	4/29/2018	35.80569	-116.18264	1,445	15	23.6	7.69	893	447	--	2.86	--	--	--	--
Willow Spring 1	4/25/2019	35.80569	-116.18264	1,445	--	22.6	7.66	1,008	504	--	5.46	--	--	--	--
Willow Spring 1	4/30/2020	35.80569	-116.18264	1,445	72	23.6	7.84	1,005	502	--	--	--	--	--	--
Willow Spring 1	4/11/2021	35.80569	-116.18264	1,445	60	23.6	7.56	1,050	530	--	10.21	--	--	--	--
Willow Spring 1	10/14/2021	35.80569	-116.18264	1,445	30	24.7	7.19	990	490	--	--	--	--	--	--
Willow Spring 1	10/17/2022	35.80569	-116.18264	1,445	11.28	22.5	7.12	899	449	--	--	--	--	--	--
Willow Spring 1	1/7/2023	35.80569	-116.18264	1,445	32.8	19.6	7.59	1,078	540	--	--	--	--	--	--
Willow Spring 1	4/27/2023	35.80569	-116.18264	1,445	42.25	26.2	6.96	915	448	--	--	--	--	--	--
Willow Spring 1	4/21/2025	35.80569	-116.18264	1,445	Variable	24.5	7.64	1,000	500	--	--	--	--	--	--
Willow Spring 1	10/30/2025	35.80569	-116.18264	1,445	14.47	25	7.59	1,055	528	--	--	--	--	--	--
Willow Spring 1	1/12/2026	35.80569	-116.18264	1,445	53	21.4	7.80	1,404	702	--	--	--	--	--	--
Willow Spring 2	12/5/2015	35.80097	-116.19438	1,236	30	22.7	7.93	972	486	484	3.52	--	--	--	--
Willow Spring 2	9/17/2016	35.80097	-116.19438	1,236	25	24.4	7.91	991	496	--	--	--	--	--	--
Willow Spring 2	1/9/2017	35.80097	-116.19438	1,236	90	20.1	7.86	1,561	780	784	5.07	--	--	--	--
Willow Spring 2	4/10/2017	35.80097	-116.19438	1,236	40	20.9	7.92	1,390	614	580	7.96	--	--	--	--
Willow Spring 2	1/16/2018	35.80097	-116.19438	1,236	80	23.4	8.08	813	407	--	2.89	--	--	--	--
Willow Spring 2	4/29/2018	35.80097	-116.19438	1,236	220	21.9	8.22	871	435	--	5.83	--	--	--	--
Willow Spring 2	4/30/2020	35.80097	-116.19438	1,236	250	22.6	7.92	1,213	607	--	--	--	--	--	--
Yerba Mansa Seep	12/6/2015	35.86925	-116.22356	1,416	ET Only	--	--	--	--	--	--	--	--	--	--

Notes
µS = microsiemens
13C = carbon-13
13C = carbon-14
¹See Love and Zdon (2018) in Appendix L
3H = tritium
D.O. = dissolved oxygen
gpm = gallons per minute
δ18O = delta oxygen-18
δD = delta duetrium
mg/L = milligrams per liter
ppm = parts per million
yrs = years

Table 1. Amargosa River Basin Spring List

[illegible]

Notes

μS = microsiemens

^{13}C = carbon-13

13C = carbon-14

¹See Love and Zdon (2018) in Appendix L

3H = tritium

D.O. = dissolved oxygen

gpm = gallons per minute

$$\delta^{18}\text{O} = \text{delta oxygen-18}$$

δD = delta deuterium

mg/L = milligrams per liter

ppm = parts per million

yrs = years

Table 2. Depth to Water Measurements
Middle Amargosa Valley Groundwater Basin, Inyo County, California

Well ID	Well Location	Date	Total Well Depth (ft bgs)	DTW	DTW From?	Top of Monument (ft above ground surface)	Top of Casing (ft above ground surface)	DTW (ft below ground surface)	Measurement Type
ARHS 01	North of Shoshone, off the 127	10/15/2021	148.00	113.04	TOM	3.28	2.63	109.76	Water level meter
ARHS 01	North of Shoshone, off the 127	10/17/2022	148.00	112.96	TOM	3.28	2.63	109.68	Water level meter
ARHS 01	North of Shoshone, off the 127	1/6/2023	148.00	113.14	TOM	3.28	2.63	109.86	Water level meter
ARHS 01	North of Shoshone, off the 127	4/27/2023	148.00	112.98	TOM	3.28	2.63	109.70	Water level meter
ARHS 01	North of Shoshone, off the 127	12/13/2023	148.00	113.09	TOM	3.28	2.63	109.81	Water level meter
ARHS 01	North of Shoshone, off the 127	4/22/2025	148.00	112.92	TOM	3.28	2.63	109.64	Water level meter
ARHS 01	North of Shoshone, off the 127	10/28/2025	148.00	113.04	TOM	3.28	2.63	109.76	Water level meter
ARHS 01	North of Shoshone, off the 127	1/28/2025	148.00	113.01	TOM	3.28	2.63	109.73	Water level meter
ARHS 02	At China Ranch Date Farm	10/15/2021	--	6.44	TOM	2.0		4.44	Water level meter
ARHS 02	At China Ranch Date Farm	10/17/2022	--	5.72	TOM	2.0		3.72	Water level meter
ARHS 02	At China Ranch Date Farm	1/7/2023	--	5.06	TOM	2.0		3.06	Water level meter
ARHS 02	At China Ranch Date Farm	4/27/2023	--	6.05	TOM	2.0		4.05	Water level meter
ARHS 02	At China Ranch Date Farm	12/11/2023	--	6.00	TOM	2.0		4.00	Water level meter
ARHS 02	At China Ranch Date Farm	4/21/2025	--	6.28	TOM	2.0		4.28	Water level meter
ARHS 02	At China Ranch Date Farm	1/12/2026	--	5.95	TOM	2.0		3.95	Water level meter
ARHS 03	At Twelvemile Spring, Chicago Valley	10/15/2021	41.50	20.35	TOM	0.55		19.80	Water level meter
ARHS 03	At Twelvemile Spring, Chicago Valley	10/18/2022	41.50	20.44	TOM	0.55		19.89	Water level meter
ARHS 03	At Twelvemile Spring, Chicago Valley	4/28/2023	41.50	20.25	TOM	0.55		19.70	Water level meter
ARHS 03	At Twelvemile Spring, Chicago Valley	12/11/2023	41.50	20.34	TOM	0.55		19.79	Water level meter
ARHS 03	At Twelvemile Spring, Chicago Valley	4/20/2025	41.50	20.47	TOM	0.55		19.92	Water level meter
ARHS 03	At Twelvemile Spring, Chicago Valley	10/27/2025	41.50	20.05	TOM	0.55		19.5	Water level meter
ARHS 03	At Twelvemile Spring, Chicago Valley	10/28/2025	41.50	20.03	TOC	0.65		19.38	Water level meter
ARHS 04	At Noonday Camp, Married Mans Camp	10/15/2021	40.00	13.75	TOM	0.5		13.25	Water level meter
ARHS 04	At Noonday Camp, Married Mans Camp	10/18/2022	40.00	13.74	TOM	0.5		13.24	Water level meter
ARHS 04	At Noonday Camp, Married Mans Camp	1/6/2023	40.00	12.98	TOM	0.5		12.48	Water level meter
ARHS 04	At Noonday Camp, Married Mans Camp	4/28/2023	40.00	12.87	TOM	0.5		12.37	Water level meter
ARHS 04	At Noonday Camp, Married Mans Camp	12/11/2023	40.00	12.72	TOM	0.5		12.22	Water level meter
ARHS 04	At Noonday Camp, Married Mans Camp	4/20/2025	40.00	12.99	TOM	0.5		12.49	Water level meter
ARHS 04	At Noonday Camp, Married Mans Camp	10/29/2025	40.00	13.63	TOM	0.5		13.13	Water level meter
ARHS 04	At Noonday Camp, Married Mans Camp	1/13/2026	40.00	12.94	TOM	0.5		12.44	Water level meter
ARHS 05	At Dumont Dunes, by Amargosa River	10/15/2021	110.00	108.70	TOM	2.53	2.65	106.17	Water level meter
ARHS 05	At Dumont Dunes, by Amargosa River	10/16/2022	110.00	108.25	TOM	2.53	2.65	105.72	Water level meter
ARHS 05	At Dumont Dunes, by Amargosa River	1/5/2023	110.00	107.52	TOM	2.53	2.65	104.99	Water level meter
ARHS 05	At Dumont Dunes, by Amargosa River	4/26/2023	110.00	107.08	TOM	2.53	2.65	104.55	Water level meter
ARHS 05	At Dumont Dunes, by Amargosa River	12/12/2023	110.00	106.53	TOM	2.53	2.65	104.00	Water level meter
ARHS 05	At Dumont Dunes, by Amargosa River	4/22/2025	110.00	103.34	TOM	2.53	2.65	100.81	Water level meter
ARHS 05	At Dumont Dunes, by Amargosa River	10/28/2025	110.00	105.01	TOC	2.53	2.65	102.36	Water level meter
ARHS 05	At Dumont Dunes, by Amargosa River	1/14/2026	110.00	104.32	TOC	2.53	2.65	101.67	Water level meter
ARHS 08	Evelyn; North of Shoshone, off the 127	10/15/2021	200.00	178.29	TOM	1.65	1.50	176.64	Water level meter
ARHS 08	Evelyn; North of Shoshone, off the 127	10/17/2022	200.00	178.17	TOM	1.65	1.50	176.52	Water level meter
ARHS 08	Evelyn; North of Shoshone, off the 127	1/6/2023	200.00	178.40	TOM	1.65	1.50	176.75	Water level meter
ARHS 08	Evelyn; North of Shoshone, off the 127	4/27/2023	200.00	178.19	TOM	1.65	1.50	176.54	Water level meter
ARHS 08	Evelyn; North of Shoshone, off the 127	12/13/2023	200.00	178.39	TOM	1.65	1.50	176.74	Water level meter
ARHS 08	Evelyn; North of Shoshone, off the 127	4/22/2025	200.00	178.24	TOM	1.65	1.50	176.59	Water level meter
ARHS 08	Evelyn; North of Shoshone, off the 127	10/28/2025	200.00	178.31	TOC	1.65	1.50	176.81	Water level meter
ARHS 08	Evelyn; North of Shoshone, off the 127	1/14/2026	200.00	178.4	TOC	1.65	1.50	176.90	Water level meter
ARHS 09	Stewart Valley	10/15/2021	80.00	56.55	TOM	2.92	2.76	53.63	Water level meter
ARHS 09	Stewart Valley	10/18/2022	80.00	56.83	TOM	2.92	2.76	53.91	Water level meter
ARHS 09	Stewart Valley	1/6/2023	80.00	56.81	TOM	2.92	2.76	53.89	Water level meter
ARHS 09	Stewart Valley	4/28/2023	80.00	57.15	TOM	2.92	2.76	54.23	Water level meter
ARHS 09	Stewart Valley	12/11/2023	80.00	57.18	TOM	2.92	2.76	54.26	Water level meter
ARHS 09	Stewart Valley	4/20/2025	80.00	57.50	TOM	2.92	2.76	54.58	Water level meter
ARHS 09	Stewart Valley	10/27/2025	80.00	57.66	TOC	2.92	2.76	54.9	Water level meter
ARHS 09	Stewart Valley	1/14/2026	80.00	57.63	TOC	2.92	2.76	54.87	Water level meter
ARHS 10	Davis Well, California Valley	10/15/2021	60.00	46.52	TOM	2.51		44.01	Water level meter
ARHS 10	Davis Well, California Valley	10/18/2022	60.00	46.90	TOM	2.51		44.39	Water level meter
ARHS 10	Davis Well, California Valley	1/6/2023	60.00	47.09	TOM	2.51		44.58	Water level meter
ARHS 10	Davis Well, California Valley	4/28/2023	60.00	47.47	TOM	2.51		44.96	Water level meter
ARHS 10	Davis Well, California Valley	12/11/2023	60.00	47.36	TOM	2.51		44.85	Water level meter
ARHS 10	Davis Well, California Valley	4/20/2025	60.00	48.87	TOM	2.51		46.36	Water level meter
ARHS 10	Davis Well, California Valley	10/27/2025	60.00	48.05	TOM	2.51		45.54	Water level meter
ARHS 10	Davis Well, California Valley	1/13/2026	60.00	47.83	TOM	2.51		45.32	Water level meter

Table 3. Mean Annual Flow - Amargosa River
Middle Amargosa Valley Groundwater Basin, Inyo County, California

Year	Discharge (cfs)				
	Station 1	Station 2	Station 3	Station 4	Station 5
2019	ND	1.07	ND	ND	ND
2020	ND	1.67	ND	ND	ND
2021	ND	0.549	ND	ND	ND
2022 ¹	ND	1.59	ND	ND	ND
2023 ^{1,2}	ND	13.7	ND	ND	ND
2024 ³	ND	16.2	ND	ND	ND

Notes:

Station 1 = USGS 10251375 Amargosa River at Dumont Dunes near Death Valley, San Bernardino County, California (Latitude 35°41'45", Longitude 116°15'02" NAD27).

Station 2 = USGS 10251300 Amargosa River at Tecopa, Inyo County, California (Latitude 35°50'45", Longitude 116°13'45" NAD27).

Station 3 = USGS 10251259 Amargosa River at Hwy 127 near Nevada State Line, Inyo County, California (Latitude 36°23'12", Longitude 116°25'22" NAD27).

Station 4 = USGS 10251218 Amargosa River at Hwy 95 below Beatty, Nevada, Nye County, Nevada (Latitude 36°52'52", Longitude 116°45'04" NAD27).

Station 5 = USGS 10251220 Amargosa River near Beatty, Nevada, Nye County, Nevada (Latitude 36°52'01.76", Longitude 116°45'37.53" NAD83).

ND = No Data

* = Data set for given year is incomplete

¹ = Data set for year is partially estimated

² = Data set for year is partially provisional and subject to revision

³ = Data approval period is provisional

For data prior to 2019, refer to the 2014 State of the Basin Report (Andy Zdon & Associates, 2014)

Table 4. Summary of Pumping - Amargosa Valley
Middle Amargosa Valley Groundwater Basin, Inyo County, California

Year	Total Pumping Usage (Acre-feet)	Irrigation (Acre-feet)	Non-irrigation (Acre-feet)
1983	10,175	9,105	1,070
1985	9,672	8,472	1,200
1986	7,238	6,553	685
1987	6,137	5,700	437
1988	4,109	2,978	1,131
1989	3,921	1,566	2,355
1990	7,807	4,953	2,854
1991	6,122	4,942	1,180
1992	8,164	5,761	2,403
1993	11,300	8,709	2,591
1994	12,595	9,977	2,618
1995	15,035	12,354	2,681
1996	13,613	11,043	2,570
1997	13,902	10,454	3,448
1998	15,376	12,040	3,336
1999	14,181	10,835	3,093
2000	12,522	9,711	2,811
2001	12,067	9,407	2,660
2002	12,421	9,576	2,845
2003	13,588	10,471	3,117
2004	13,544	10,603	2,941
2005	13,004	10,764	2,240
2006	15,988	13,124	2,864
2007	16,736	14,059	2,677
2008	17,967	12,356	5,611
2009	16,380	11,477	4,903
2010	15,393	9,898	5,495
2011	16,536	11,258	5,278
2012	17,622	13,190	4,432
2013	17,585	15,159	2,426
2014	16,321	13,324	2,997
2015	16,461	13,259	3,202
2016	15,691	12,237	3,454
2017	17,172	13,374	3,800
2018	17,352	13,676	3,676
2019	17,260	13,909	3,351
2020	16,561	13,816	2,746
2021	17,700	15,154	2,546
2022	17,963	14,940	3,023

Reference: Nevada DWR, 2025. Pumpage Inventories, Available at: <https://tools.water.nv.gov/PumpageInventoryFiles.aspx>

Table 5. Summary of Pumping - Pahrump Valley
Middle Amargosa Valley Groundwater Basin, Inyo County, California

Year	Total Pumping Usage (Acre-feet)	Irrigation (Acre-feet)	Non-irrigation (Acre-feet)
1959	25,564	25,564	0
1960	27,421	27,421	0
1961	30,087	30,087	0
1962	29,195	29,195	0
1963	31,923	31,923	0
1964	37,527	37,527	0
1965	36,514	36,514	0
1966	38,109	37,944	112
1967	41,501	41,323	177
1968	47,949	47,632	317
1969	40,893	40,505	388
1970	42,619	41,902	492
1971	37,983	36,992	990
1972	36,661	35,950	681
1973	39,390	38,562	828
1974	41,387	39,634	1,752
1975	40,746	37,819	2,928
1976	44,499	37,144	7,355
1977	42,909	37,344	4,091
1978	34,334	32,333	2,346
1980	25,000	24,100	900
1981	24,000	22,975	1,025
1982	23,182	19,807	3,375
1983	23,153	19,526	3,627
1984	24,351	20,464	3,887
1985	23,053	19,140	3,913
1986	19,408	15,424	3,984
1987	19,147	14,804	4,343
1988	19,644	14,475	5,169
1989	20,132	14,868	5,264
1990	20,853	15,374	5,479
1991	24,846	19,257	5,589
1992	23,289	16,893	6,396
1993	20,962	14,051	6,911
1994	24,905	17,067	7,838
1995	23,621	14,183	9,438
1996	26,866	16,378	10,488
1997	28,819	16,723	12,095
1998	27,522	14,818	12,704
1999	25,558	11,940	13,617
2000	22,799	7,930	14,870
2001	25,247	10,396	14,851
2002	22,499	6,803	15,696
2003	22,354	6,649	15,705
2004	22,584	6,369	16,215
2005	21,753	4,583	17,170
2006	22,124	3,506	18,618
2007	24,838	4,580	20,258
2008	24,367	4,543	19,824
2009	21,599	3,582	17,986
2010	19,609	2,885	16,711
2011	18,905	2,442	16,279
2012	19,690	3,008	16,682
2013	19,857	3,466	16,391
2014	21,065	4,473	16,592
2015	21,076	4,477	16,785
2016	21,630	4,504	17,126
2017	21,998	4,881	17,117
2018	21,270	3,426	17,844
2019	20,159	2,350	17,809
2020	18,982	1,048	17,934
2021	19,685	1,354	18,331
2022	22,508	4,002	18,506
2023	20,787	3,575	17,212

Reference: Nevada DWR, 2025. Pumpage Inventories, Available at: <https://tools.water.nv.gov/PumpageInventoryFiles.aspx>