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Shipley Hot Spring Historic and Current Discharge, and Evidence for Impact to Flow Due to Groundwater Pumping in Diamond Valley, Eureka County, Nevada

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September 11, 2013

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Background

This report provides a summary of data, references, observations and interpretations that support my professional hydrogeologic opinion that drawdown from long-term regional groundwater pumping in Diamond Valley is impacting flow of Shipley Hot Spring and has caused the cessation of discharge from Indian Camp Spring, both situated on the Sadler Ranch. Water rights for these spring sources are on file with the Nevada Division of Water Resources (NDWR) as proofs of appropriation V03289 and V03290.

Sadler Ranch LLC has filed applications 81719 and 81720 to appropriate underground water and application 82268 to change the point of diversion of a spring water right in order to mitigation the losses of spring flow and continue agriculture and ranching. Subject to issuance of permits, wells are planned to be pumped to sustain agriculture at levels similar to historic operations.

Historic and Current Shipley Hot Spring Discharge

From 1965 to 1994, the USGS made measurements of Shipley Hot Spring discharge. Discharge measurements were discontinued in the mid-1990s, but were resumed by hydrologists working for General Moly / Eureka Moly in 2008. Prior to the mid-1960s, spring discharge is reported over a wide range, between 8 to 15 cubic feet per second (cfs). Based on the information summarized below, the historic Shipley Hot Spring discharge prior to any groundwater development (pre-1940s) averaged about 11 to 12 cfs, consistent with the rate reported in Stearns, Stearns, and Waring (1937).

Discharge in mid-1960 to early 1990s ranged between approximately 6 to 8 cfs, and is interpreted to have already been affected by the drilling and use of artesian flowing wells to the north and south. The artesian wells were primarily drilled in the time frame of the 1940s to 1960.

Shipley Hot Spring discharge from the mid-1990s to present shows a declining trend, which in the summer of 2013 has been less than 2 cfs. The present-day declining trend is the result of the regional expansion of a basin-scale cone-of-depression resulting from extensive agricultural pumping in the southern portion of Diamond Valley.

Summer-time 2013 discharge measurements from Shipley Hot Spring are at period-of-record lows, ranging between 0.7 to 1.9 cfs.   Based on the current trend of decline, Shipley Hot Spring will cease to produce outflow within the next 2 to 6 years.

The following are notes on the reported discharge of Shipley Hot Spring from 1912 to 2013.

1. Shipley Hot Spring(s) has been historically known as Big Shipley Spring and Sadler Hot Spring. Discharge is warm, reported between 103 to 106^{o}F (Garside and Schilling, 1979).

2. U.S. Geological Survey (USGS) topographic mapping (Bailey Pass, Nevada Quadrangle, 1986 edition, compiled from 1982 aerial photography) labels a spring about ¼ south of the Shipley Hot Spring pond as Shipley Hot Spring. This is not the main geothermal spring. The main Shipley Hot Spring is located at the pond, and includes a number of submerged orifices and discharges along the western bank of the pond. The topo map labeled spring is presently dry.

3. In November 1912, State Engineer H.M. Payne made a visual estimate of flow from Shipley Hot Spring at, "*about 8 second feet or a little more*."   Discharge from Shipley Hot Spring could not be accurately measured when Payne visited the spring because the dam had recently breached and, "*flow was not being confined to any one channel*."

4. Court proceedings in 1913 and 1917 between Romano and Sadler, and Eccles and Sadler, respectively, made determinations of 1/3 of the Shipley Hot Spring discharge being allocated to the parties other than Sadler, quantifying 1/3 of the flow as 5 cfs.   These court rulings suggest that the total discharge was 15 cfs.

5. Alfred Sadler in 1931 correspondence regarding a ranch inventory states that "*the springs supply 13 second feet of water, which runs in the reservoirs and ditches*" (within the Sadler vs. Sadler, 1947 litigation, U.S. Court of Appeals 9th Circuit No. 11715)

6. The U.S. Geological Survey (USGS) reported Shipley Hot Spring discharge at approximately 11.1 cfs (5000 gallons per minute – gpm) in the publication *Thermal Springs of the United States*, by Stearns, Stearns, and Waring (1937).

7. Floyd Slagowski who worked on the Sadler Ranch from 1937 to 1940 reported that Shipley Hot Spring discharge was "*about 12 second feet*" (McCracken, 1993).

8. Thomas E. Eakin, hydrologist with the with the USGS, noted in September 1961 field notes, "*report Shipley Hot Springs discharge about 12.5 cfs*."

9. In Eakin (1962), Ground-Water Appraisal of Diamond Valley, there includes a photo of Shipley Hot Spring on the inside report cover, with the note of "*Shipley Hot Springs discharge is reported to be about 15 cfs*." The photo caption differs from his Eakin's field notes of September 1961.

10. Mifflin (1968) reports Shipley Hot Spring discharge at 15 cfs (no source cited, but suspected to be from Eakin, 1962).

11. Harrill (1968) reports three Shipley Hot Spring discharge measurements ranging between 6.2 to 7.2 cfs. The measurements were made in September 1965 (7.2 cfs), and April and November 1966 (7.0 cfs and 6.2 cfs, respectively).

12. Arteaga and others (1995) report Shipley Hot Spring discharge measurements for the time frame of 1965 to 1990, ranging from 5.2 to 8.2 cfs.

13. USGS measurements of Shipley Hot Spring discharge are currently published on the National Water Information System (NWIS) database for the time period of 1965 to 1994, and range from 4.4 to 8.3 cfs (Figure 1).

14. Shipley Hot Spring discharge measurements have been made by consulting hydrologists to General Moly – Eureka Moly from 2008 to 2013, and range from 1.6 to 3.6 cfs (Figure 1).

15. Shipley Hot Spring discharge in August of 2013 was measured by Interflow Hydrology at between 0.7 to 1.2 cfs from the primary northern diversion channel. Discharge from the Shipley Hot Spring pond may differ depending on whether the northern or southern diversions are being used, how measurements are made, and how the pond level and diversion outflows are being managed. Diversion from the southern outlet was observed at 1.9 cfs early in September 2013 (Parshall Flume, standard rating curve).

16. Potentiometric head currently driving spring discharge into the pond is only about 0.5 feet above average pond level, and about 1.1 feet above the pond outlet elevations, based on the potentiometric head in the adjacent "production" well (Interflow, 2013).

17. Seasonal variance in spring discharge is present in the measurement period of 2009 to 2013, and indicates that summer discharge (July-September) are on average 25% lower than winter and spring discharge (January-April). The frequency of spring discharge measurements prior to 2009 is insufficient to assess seasonal variances for the previous period of record. The seasonal spring discharge variance could be a response to seasonal pumping cycles for agriculture.

18. No water-year climate effects associated with spring discharge can be defined, i.e., a wet or dry water-year does not correlate with above or below average spring discharge (Figure 2).

19. Linear regression of the discharge measurements between May 2008 to August 2013 indicates that Shipley Hot Spring Discharge is declining at a rate that projects to a cessation of flow in approximately 6 years (2019) (Figure 3).

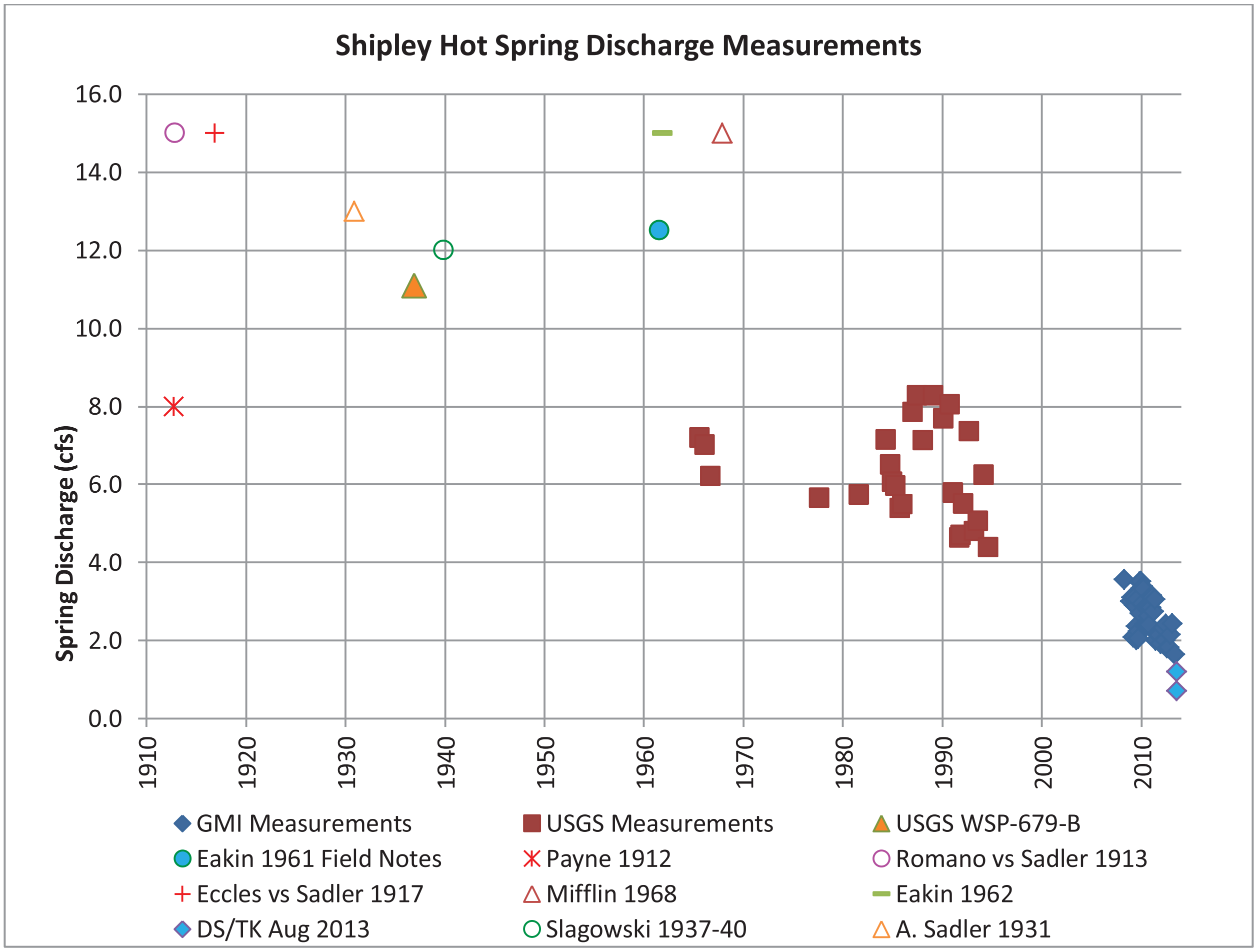


Figure 1 – Shipley Hot Spring Discharge Measurements and Reported Discharge, 1912 to 2013

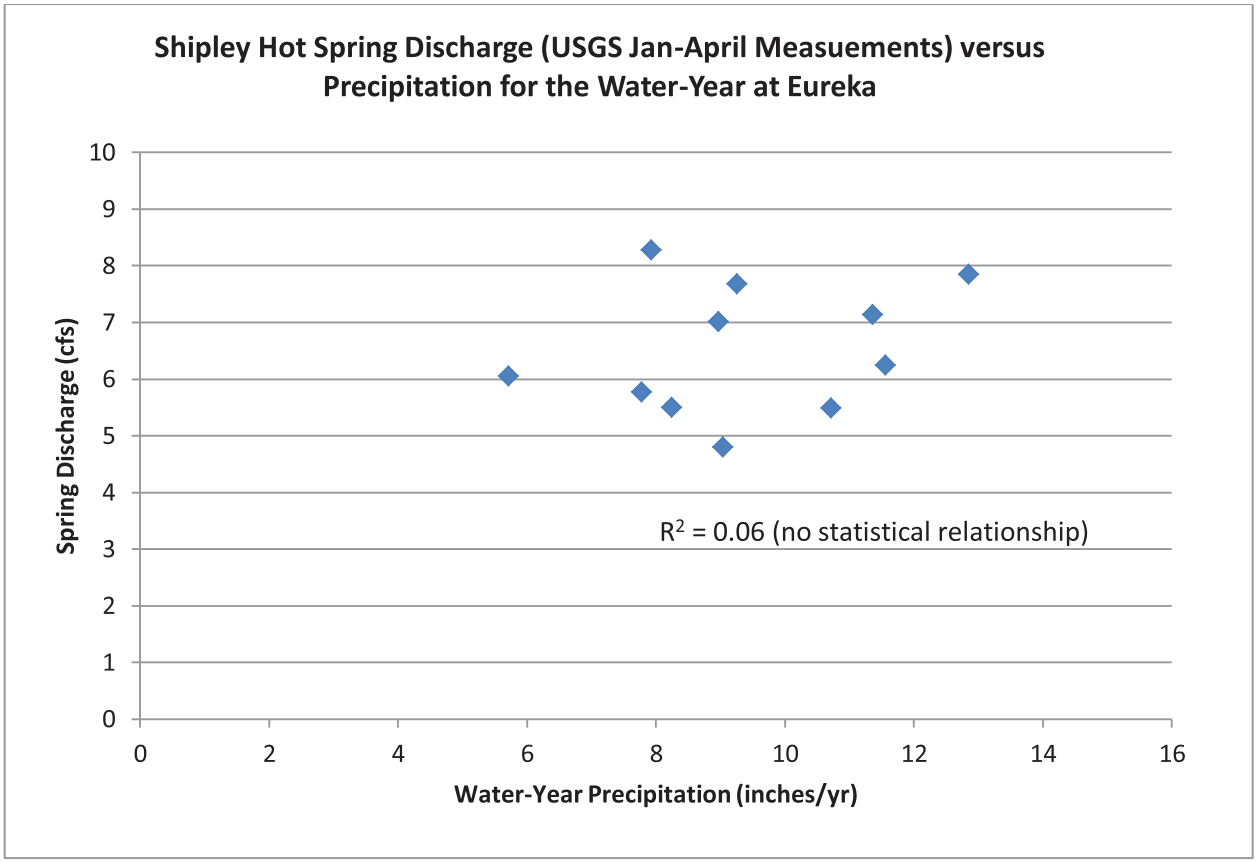


Figure 2 – Water-year Precipitation Recorded at the Eureka vs. Shipley Hot Spring Discharge Measurements (USGS data, 1965-1994 January to April measurements)

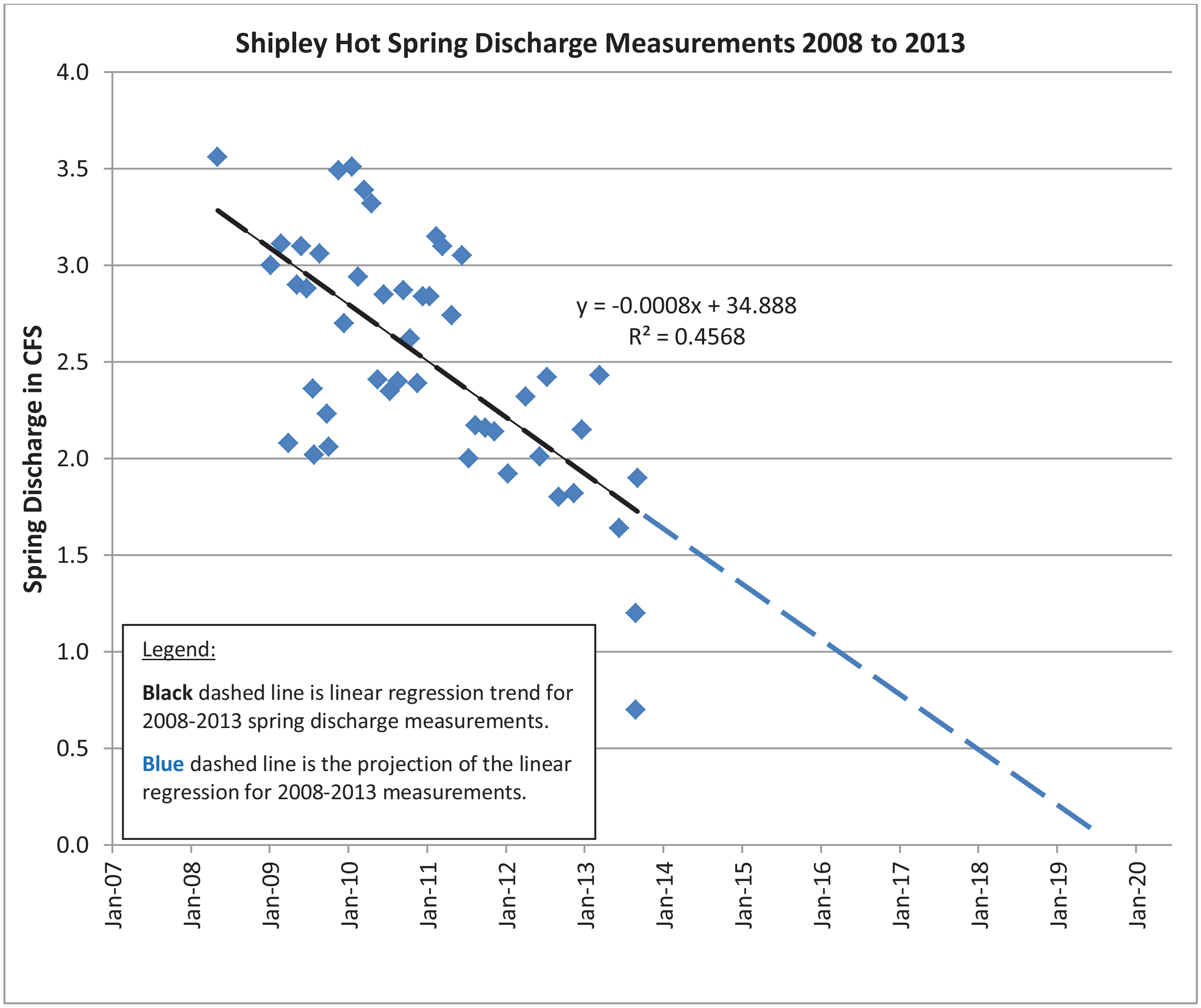


Figure 3 – Shipley Hot Spring Discharge Measurements, 2008 to 2013

Indian Camp Spring Discharge

Indian Camp Spring is located approximately ¾-mile south of Shipley Hot Spring. The spring was historically developed to irrigate about 73.9 acres as reported in proof of appropriation V03290. 1953 photography of the spring illustrates that the spring was actually comprised of over a dozen springs and seeps emanating along a spring-line (probably a fault scarp). Eakin in September 1961 observed that the spring had been developed via a north-south trench cut parallel to contour and was producing an estimated flow of 1.5 to 2 cfs (USGS field notes at Carson City). Harrill (1968) reports discharge from Indian Camp Spring as 0.66 cfs in December 1965, and 0.82 cfs in April 1966 (Table 9, 24/52-26d "Unnamed"). Discharge is believed to have been warm, about 80^{o}F, similar in temperature to Sulphur Spring to the south and Siri Ranch Spring (Eva Spring) to the north.

Artesian wells drilled south of the spring in the 1940s to 1960 probably had some initial impact, latter followed by regional drawdown sourced from the southern portion of Diamond Valley. Indian Spring appears in aerial photography to have produced flow until the late 1980s or early 1990s (appears dry in 1994).

An excavation in the spring source area to thirteen (13) feet in depth in September 2013 did not encounter water. A cistern excavated near the spring (Plate 1), believed to have been built in the 1980s in an effort to sustain a source of water, has a current depth to groundwater of approximately 8 feet (groundwater encountered at the very base of the cistern). Given the information available today regarding the extent and magnitude of regional drawdown caused by southern Diamond Valley agriculture, as detailed in following sections of this report, it is probable that flowing artesian wells in use for farming along the western side of the playa may have had some initial influence on spring discharge (1940s to early 1960s). During this period (1950s), a trench was cut to better collect flow from Indian Camp Spring. The spring then produced discharge until the impacts of regional drawdown from agriculture in southern Diamond captured spring discharge in late 1980s to early 1990s time-frame.

Examination of the Cause of Shipley Hot Spring Discharge Decline

Regional effects of large-scale and decadal pumping in southern Diamond Valley are pronounced, and exasperated by over-appropriation of the basin. Water level data, and regional evidence of cessation of spring flows, indicate that drawdown stemming from the southern agricultural area has systematically spread northward, capturing spring discharge all along the southern edge of the playa, drying Tule marshes, large meadows, and peat bogs, and lowering water levels at springs and ranches along both the eastern and western sides of the playa. As springs and artesian wells dried up along the western side of the playa, some ranches drilled new wells or pumped prior flowing wells to replace their lost water sources (Bailey Ranch, Romano Ranch, and Siri Ranch). Ranches on the east side of the basin did not drill and pump wells, and there is currently no agriculture (Thompson Ranch, Cox Ranch, Willow Ranch, and Rock Ranch).

Shipley Hot Spring stands out as the last remaining flowing spring in central Diamond Valley, in an area that once contained abundant springs.

An overview of groundwater development and pumping in Diamond Valley is presented below.

Initial Affects to Shipley Hot Spring Discharge from Flowing Artesian Wells

In the 1940s, several artesian wells were drilled on the Romano Ranch, approximately 4.5 miles south of the Shipley Hot Spring. Eakin (1962) reported that several artesian wells were drilling in about 1943, with initial discharge of 600 gpm, diminishing to about 200 gpm. Artesian flows measured by the USGS in October 1947 totaled 250 gpm from three wells owned by Florio (Romano Ranch) (USGS fieldwork notes in Carson City). Five well logs filed in 1948 and 1949 for A.C. Florio (Romano Ranch) indicate artesian well discharge from five wells ranging from 0.5 to 1.5 cfs, and totaling 4 cfs (NDWR Well Logs 509, 625, 626, 627, and 1037; note 1.5 cfm on well log 1037 assumed to be cfs). Artesian flows reported on well logs probably diminished after of a period of time. In November of 1965, the USGS measured a total combined discharge from 13 artesian wells on the Romano Ranch at 521 gpm, equal to 840 acre-feet per year (Harrill, 1968; and USGS fieldwork notes in Carson City).

Harrill (1968) reported a total of seventeen flowing wells on the western side of central-northern Diamond Valley, including the Romano Ranch wells. One flowing well is reported on the northern portion of the Sadler Ranch ("Middle Well", see Plate 1) drilled in 1960 (Well Log 5526). This well had a reported flow of 400 gpm and pressure head of 14 feet on the driller's well log. Reported flow by Harrill (1968) had decreased to 100 gpm in 1965. One flowing well is reported in Harrill (1968) on the Brown Ranch (24/53 – 6BDAB). The driller's well log (Well Log 5527) indicates the well drilled in 1960 with a reported flow of 400 gpm. Reported flow by Harrill (1968) in 1965 was 200 gpm. Besides these wells, two artesian wells are also reported in Harrill (1968) at the Flynn Ranch, 10 miles north of Shipley Hot Spring.

Artesian wells drilled during the time period of the mid 1940s and possibly into the 1950s on the Romano Ranch could have affected Indian Camp Spring and Shipley Hot Spring discharge prior to being measured in the 1965 and 1966 by Harrill (1968). Drawdown estimates using the Theis equation to assess the potential for affect by the mid-1960s. The following parameters were used in the Theis computations:

- confined storage coefficient of 0.003,
- transmissivity of 10,000 ft^2/day,
- and reported discharges from flowing wells on well drillers logs diminishing to those reported in Harrill (1968) and cessation of flow as reported in various documents in the 1970s-1980s.

Theis computations indicate that equilibrated drawdown affects at Shipley Hot Spring would have been experienced within approximately 3 years of continuous artesian well discharge at the Romano Ranch. The computed drawdown at Shipley Hot Spring is approximately 4 feet. A higher storage coefficient would result in a lower magnitude of predicted drawdown, and slower times for drawdown to become an equilibrated condition. For example, a storage coefficient of 0.007 produces an equilibrated drawdown effect at the spring of 3 feet in approximately 5 years.

The two artesian wells drilled in 1960 to the north of Shipley Hot Spring, one on the Sadler Ranch (Middle Well) and one on the Brown Ranch (N24/E53 - 6BDAB) also may have created water level drawdown and spring discharge reduction by the 1965 and 1966 measurements made by Harrill (1968). Estimated drawdown at Shipley Hot Spring from the Middle Well is 2 feet, with a time to equilibration of drawdown of approximately 1 year, using a storage coefficient of 0.003. Estimated drawdown at Shipley Hot Springs from the Brown Ranch well is 1 foot, and equilibrates to this level of drawdown within approximately 3 years, using a storage coefficient of 0.003.

The predicted drawdown from these flowing artesian wells indicates that about 5 to 6 feet of drawdown may have been experienced at Shipley Hot Spring by the time discharge measurements began in the mid-1960s. The historic artesian head driving flow at Shipley Hot Spring source is not known. But assuming the artesian head may have been greater than the 14 feet of head as reported on the 1960 Middle Well log (5526), then perhaps the spring originally had around 16 to 18 feet of pressure head.

The predicted head reduction due to artesian well discharge would then equal about 1/3 of the total head, resulting in a similar level of reduction of discharge from Shipley Hot Spring by the time measurements began in the mid-1960s.

As regional drawdown effects from pumped wells encroached from the south, the flowing artesian wells eventually ceased to flow and were no longer affecting Shipley Hot Spring or Indian Camp Spring. The artesian well influences were effectively replaced by regional pumping influences. In some cases, continued pumping from the formerly artesian wells simply perpetuated the original aquifer stress, with regional pumping influences becoming additional.

Diamond Valley Over-Appropriation of Groundwater

The perennial yield of Diamond Valley is estimated at 30,000 acre-feet per year (af/yr). A portion of the perennial yield supports spring discharge with historic agricultural water uses, such as Shipley Hot Spring and Indian Camp Spring. Diamond Valley is significantly over-appropriated, and pumping has been greater than the defined perennial yield for the basin for over four (4) decades. Approximately 131,000 af/yr of underground water right are currently permitted, with consumptive use by agriculture estimated at 60,000 to 65,000 af/yr.

The following are notes regarding the appropriation and development of groundwater in Diamond Valley.

1. In 1951, the first groundwater appropriation for irrigation was issued in Diamond Valley, but the level of groundwater appropriation and use remained low throughout the 1950s. NDWR (2009) reports 1,180 and 1,854 af/yr of groundwater use for irrigation in 1957 and 1958, respectively.

2. T. E. Eakin (1962) presents a groundwater perennial yield estimate for Diamond Valley of 23,000 af/yr.

3. In concert with a large amount of Desert Land Entry (DLE) filings made in the late 1950s, the State Engineer issues over 100,000 af/yr of underground water rights in the early 1960s (Figure 4). Adjusted for supplemental duties, the total of new appropriations was approximately 90,000 af/yr (NDWR, 2009). The typical success rate for DLE filings was low, and the State Engineer expected similar in Diamond Valley (Shamberger, 1967).

4. In 1960 to 1964, there was a large spike in the drilling of irrigation wells in Diamond Valley in support of the DLE development (Figure 5).

5. Harrill (1968) presents an updated perennial yield estimate of 30,000 af/yr, after accounting for subsurface inflow from the Garden Valley portion of Pine Valley. This perennial yield estimate is the currently relied upon value by the NDWR.

6. Pumping history and totals based on annual crop inventory data by NDWR, time periods 1966-1969, and 1975 to present, and Arteaga and others (1995), indicate that irrigation pumping peaked in the mid-1980s at approximately 125,000 af/yr (assuming 4 ft per year total duty pumped), with a crop consumptive use estimate of 80,000 to 85,000 af/yr (Figure 6). Electricity became available to agriculture (pumps) in the early 1970s, and resulted in an increase in large-scale pumping (Arteaga and others, 1995).

7. From the 1990s to present, pumped quantities for irrigation have stabilized at approximately 100,000 af/yr pumped, with estimated crop consumptive use at 60,000 to 65,000 af/yr, based on NDWR Net Irrigation Water Requirement values (Figure 6).

8. Pumping and consumptive use of groundwater by agriculture has exceeded the perennial yield since 1970, without consideration of municipal and mining uses of groundwater in the basin, and without any allocation of a portion of perennial yield to springs that have historically been used for agriculture. The total consumptive use of pumped groundwater that has occurred over the perennial yield since 1970 is approximately 1.6 million acre-feet (Figure 7).

9. Current (August, 2013) groundwater appropriations in Diamond Valley total 131,380 acre-feet per year, after supplemental duty adjustments, of which approximately 95% are for irrigation uses (NDWR records).

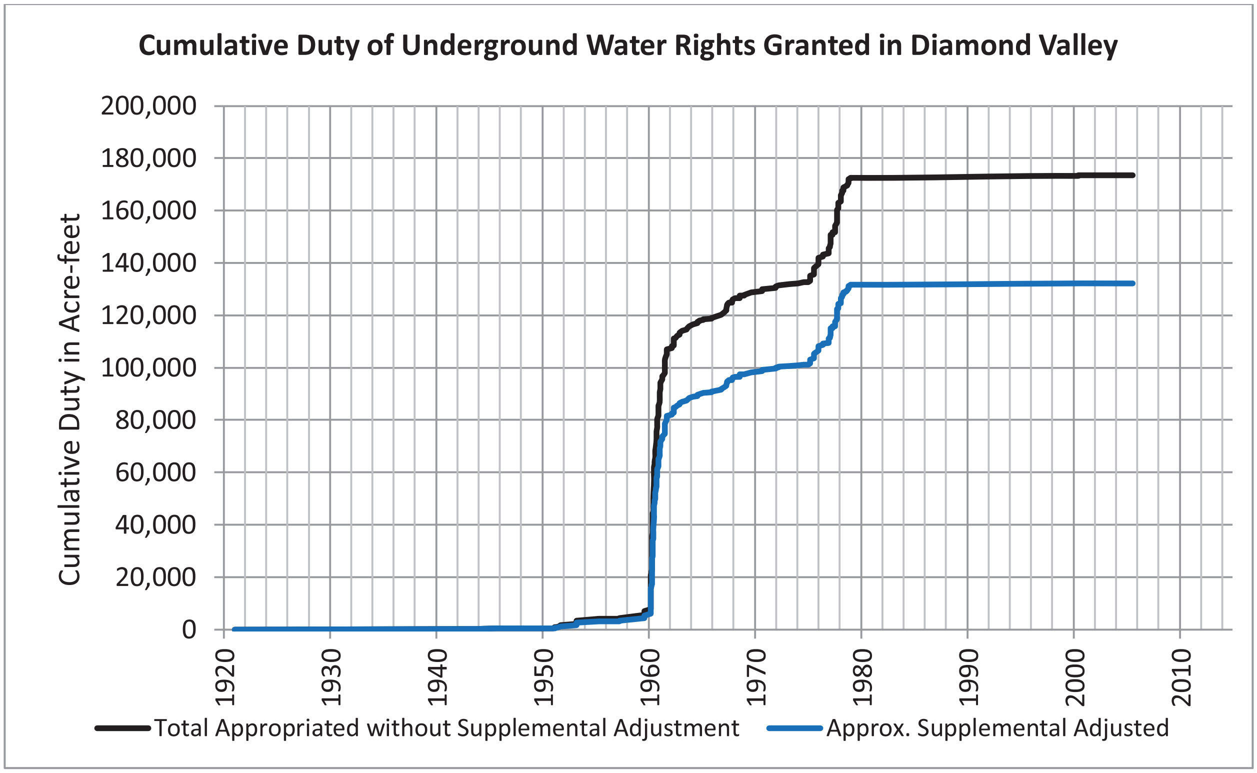


Figure 4 – Underground Water Rights Issued (permitted – active) in Diamond Valley (NDWR records), Scaled for Supplemental Duties

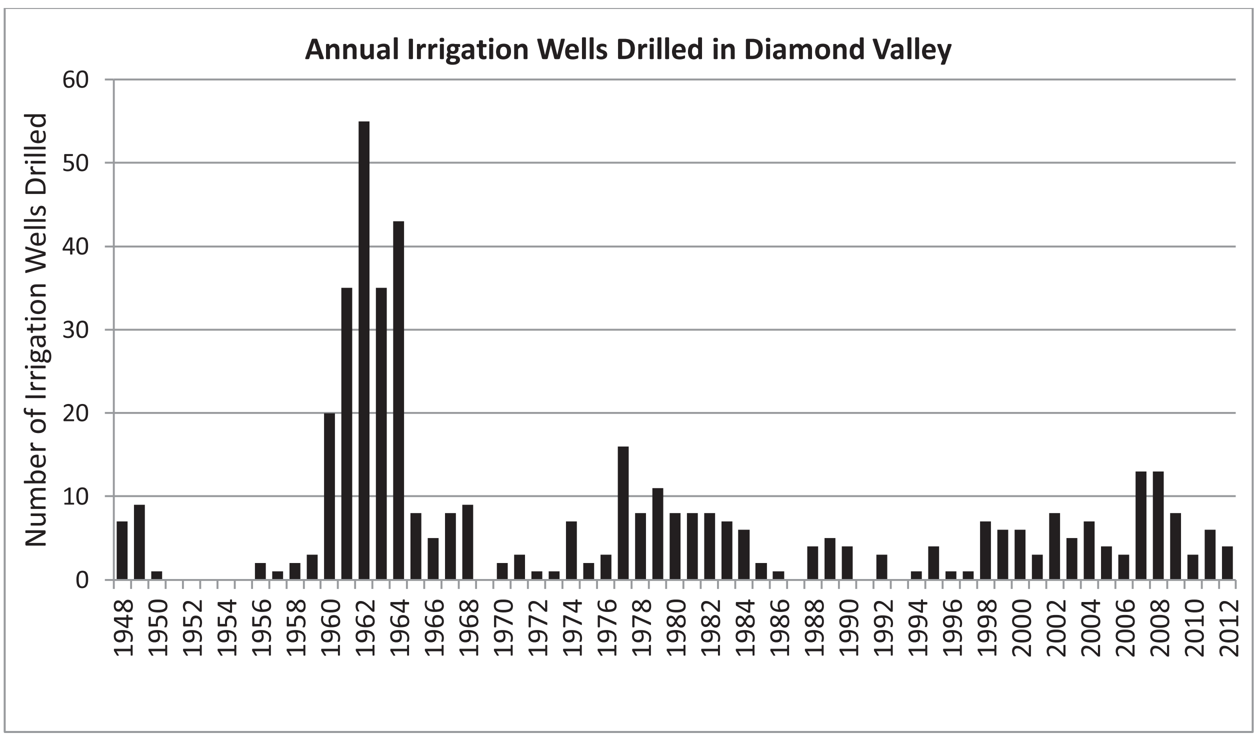


Figure 5 – Irrigation Wells Drilled in Diamond Valley (NDWR records)

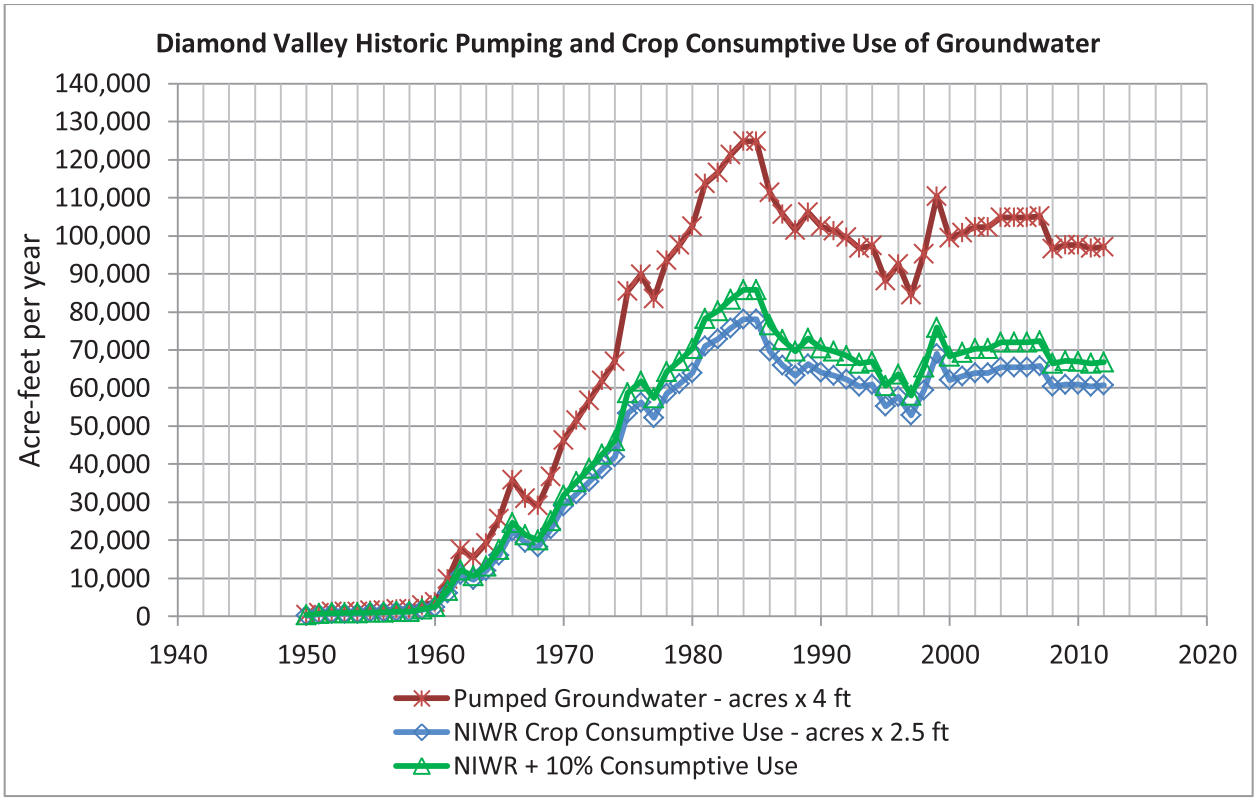


Figure 6 – Estimated Total Irrigation Pumping in Diamond Valley and Crop Consumptive Use of Groundwater (Based on NDWR Crop Inventory Data and NDWR Net Irrigation Water Requirement)

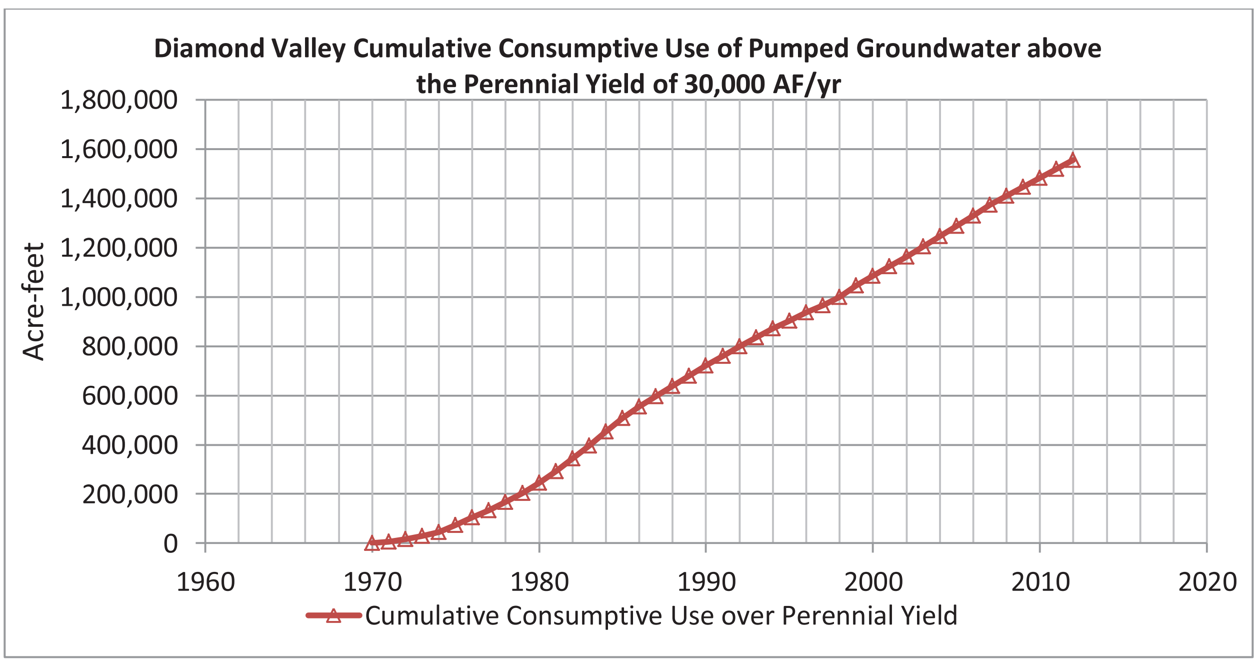


Figure 7 – Cumulative Consumption of Groundwater by Agriculture in Diamond Valley above the Perennial Yield of 30,000 acre-feet per year.

Diamond Valley Regional Pumping Drawdown and Capture of Spring Discharge

The development and progression of pumping drawdown has continued through present day to expand to the north and to cause declining water levels throughout southern and central Diamond Valley, all within the influence of the pumping center in southern Diamond Valley. The effects of progressive drawdown are clearly evident. All springs in central Diamond Valley and along the western side of the playa south of the Brown Ranch, except Shipley Hot Spring, have ceased to flow. This totals over 100 mapped springs as located on USGS topographic maps (Plate 1, spring locations from the USGS National Hydrography Dataset).

Water level records along the western side of the playa, south of Shipley Hot Spring show long-term trends of water level drawdown ranging between 12 to 35 feet. Water level drawdown at Shipley Hot Spring is estimated to be at least 10 feet, as shown in Plate 1. Estimated drawdown values on Plate 1 are considered minimum values, and do not take into account pressure heads on springs and artesian wells greater than 2 feet above land surface (a typical height of well casing above land surface). In reality, pressure heads were probably greater in pre-development conditions.

Discharge from Shipley Hot Spring, while still present, has been progressively declining, and is well below historic levels (currently at about 10 to 15% of historic flow rates). Discharge in August 2013 was between 0.7 to 1.2 cfs.

Regional pumping drawdown has likely extended as far north as the Brown Ranch on the west side of Diamond Valley, and to the Rock Ranch on the east side of Diamond Valley (Plate 1).

The following data and observations support my interpretations.

1. Regional groundwater drawdown in response to pumping in southern Diamond Valley is well documented by historic measurements of water levels by the USGS and NDWR, and as interpreted and reported in Harrill (1968), Harrill (1982), Arteaga and others (1995), Tumbusch and Plume (2006), NDWR (2009), and Knochenmus and others (2011).

2. Spring observations and water level data indicate that the drawdown effects from regional pumping in southern Diamond Valley have extended north to near the southern edge of the playa, and further north along the eastern and western margins of the valley, between the mountain front and the playa edge. Springs which have ceased to flow include:
    a. Thompson Spring, Birch Spring, Willow Ranch and Rock Ranch springs along the east margin of valley (Plate 1),
    b. Over sixty (60) unnamed springs on the southern edge of the playa, as mapped by the USGS on 7.5-minute topographic maps (Plate 1),
    c. Tule Dam Spring, Sulphur Spring, springs on the Romano Ranch, Bailey Ranch Spring, Indian Camp Spring, James White Spring, and Eva Spring, all on the western side of the valley.

3. In 1982, Tule Dam Spring and Sulphur Spring (6.5 to 7 miles south of Shipley Hot Spring), and Birch Spring (Diamond Spring in Harrill 1982, 1 mile north of Thompson Ranch Springs) were all noted to be dry by Harrill (1982). Sulphur Spring was reported in Stearns, Stearns, and Waring (1937) to have a discharge of approximately 20 gpm, with a warm water temperature (74^{o}F). Harrill reported a flow in 1965 of 40 gpm. Tule Dam Spring is reported by Harrill to discharge 54 gpm. Tule Dam spring and Sulphur spring are observed in historic photography, and mapped on topo maps, as supporting marsh conditions, with braided discharge channels. Today, these areas exhibit extensive areas of dried organic peat soils. Similar conditions are observed at Indian Camp Spring, the spring area ¼-mile south of Shipley Hot Spring, and other areas where formerly wet meadow and Tule conditions existed.

4. Harrill (1968, p. 30) reported: "*Eventually, a gradual decrease of spring discharge in the North Diamond subarea should occur in response to pumping in the South Diamond subarea as sufficient water is removed from storage to induce subsurface flow from the spring areas toward the well field*." Harrill's prediction has proved to be correct.

5. Harrill (1968, p. 60) concludes that "*In time, discharge from springs may have to be supplemented or replaced by pumping from wells*."

6. Thompson Spring was reported be declining in the 1970s, and was the subject of review by the State Engineer in the early 1980s. The last known flow measurement from Thompson Spring made by the USGS was in 1990, at approximately 0.1 cfs. Depth to groundwater at the Thompson Spring is approximately 8 feet below the former spring discharge elevation (measurements by Interflow Hydrology and Cordilleran Hydrology, August 2013).

7. Drawdown interpretations based on available water level and spring data are shown in Plate 1, and are considered conservative for the western and eastern margins of the valley, based on a conservative assumption for artesian head for springs and wells being near land surface or the tops of well casings. Data considered in this interpretation includes water level measurements for the period of time from the 1960s to 2013. Based on water level data, over 100 feet of water level drawdown exists in the southern agricultural area, and sustained rates of drawdown range between 1 to 3 feet per year. The cone-of-depression created by pumping extends for many miles north of that agricultural area, and the level of drawdown decreases systematically with greater distance from the pumping center. The cone-of-depression however is extending more aggressively up the outer edges of the valley, between the mountain front and playa, where higher permeability basin-fill materials are present.

8. Water level drawdown in the vicinity of Sulphur Spring, 7 miles south of Shipley Hot Spring, appears to be approximately 35 feet, based on the current depth to groundwater in well N23 E52 36BBDB1 (Figure 8, Plate 1).

9. Water level drawdown in the vicinity of the Romano Ranch, 4.5 miles south of Shipley Hot Spring, has been approximately 19 to 25 feet (Figure 8, Plate 1) based on wells N23 E52 11ADAA1 and N23 E52 13CDBC1, respectively. Artesian wells drilled in the late 1940s and 1950s on the Romano Ranch, located approximately 4.5 miles south of Shipley Hot Spring, have ceased to flow. Flow from these wells is reported to have begun declining in the mid-1960s, and the wells were reported to no longer flow in 1972 (NDWR records for V04476 and V04479).

10. Water level drawdown in the vicinity of the Bailey Ranch, 2.5 miles south of Shipley Hot Spring has been approximately 12 feet (Figure 8, Plate 1) based on well N23 E52 11ADAA1, and records that the well once produced artesian flow. A spring at the Bailey Ranch ("Bailey Spring") has ceased to flow, and was reported in Harrill (1968) to produce 1.14 cfs (510 gpm). A well was drilled in 1998 to replace lost spring discharge under vested claim V01104, under water right Permit 63497.

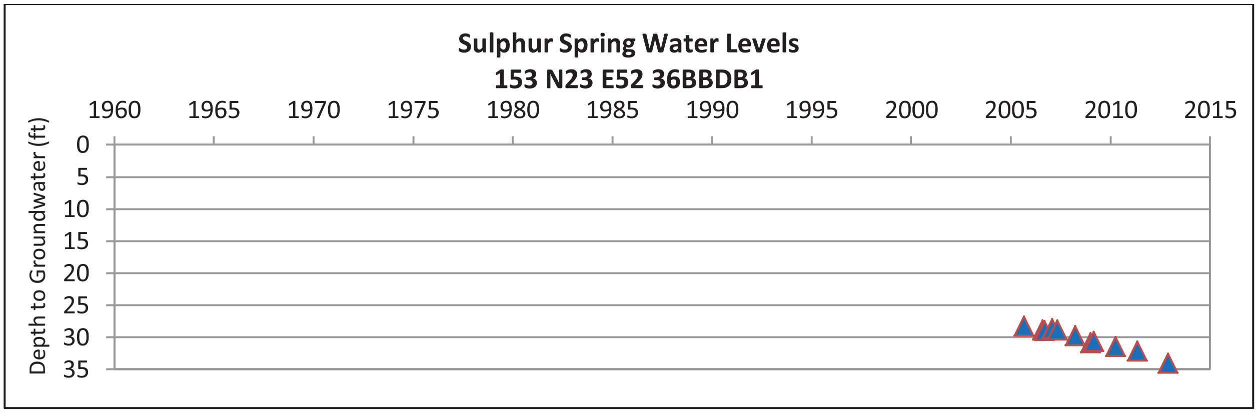
11. Indian Camp Spring, located ¾-mile south of Shipley Hot Spring is dry. This spring was reported to have a flow of 0.66 and 0.82 cfs (300 and 370 gpm) in Harrill (1968, Table 9 spring 24/52-26d). An excavation in the summer of 2013 at the spring location did not encounter groundwater to an excavation depth of 13 feet below land surface.

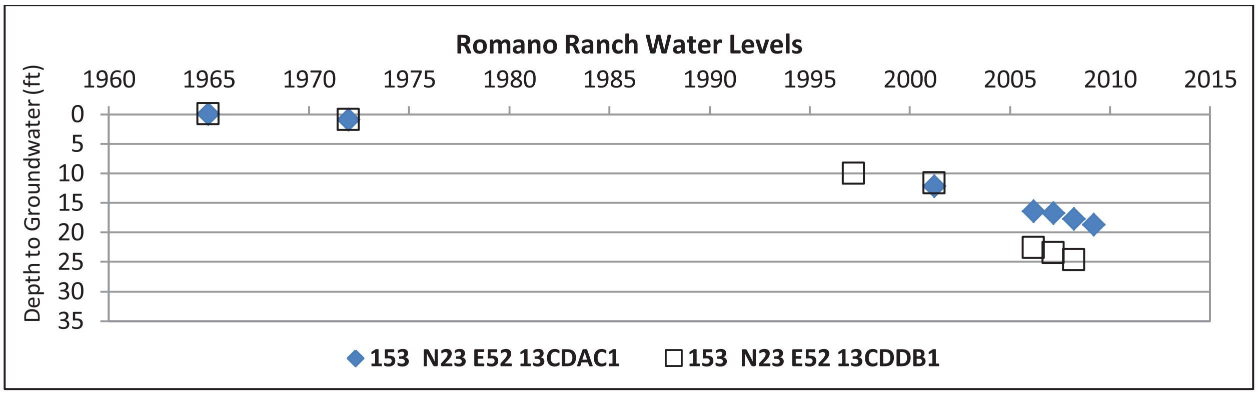
12. An excavation at the spring location ¼-mile south of Shipley Hot Spring did not encountered groundwater to a depth of excavation of 11 feet below land surface.

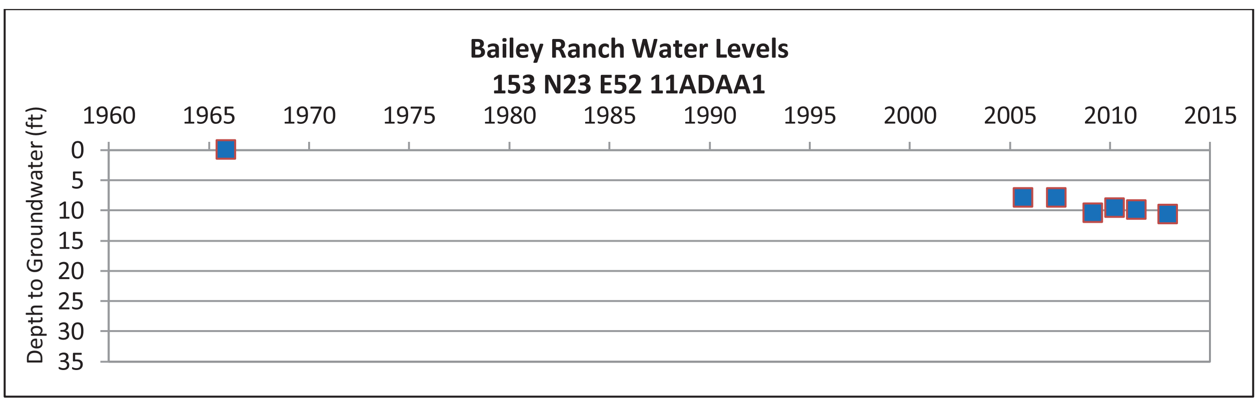
13. James White Spring located approximately 3 miles north of Shipley Hot Spring on the southern portion of the Brown Ranch is dry. The spring appears to have gone dry by 1975 based on aerial photography.

14. Eva Spring (also called Siri Ranch Spring) at the Brown Ranch, approximately 3.5 miles north of Shipley Hot Spring is dry. This spring appears to have produced flow up until the late-1990s or early 2000s, based on aerial photographs. Harrill (1968) reported a flow of 0.58 cfs (255 gpm) from Siri Spring. Vested proof of appropriation (V02658, filed in 1969) stated irrigation of 81.4 acres from the spring source with a water use of 407 acre-feet per year. Combined effects of localized pumping from a previously flowing well, and a new well drilled in 1977, along with the progression of drawdown from the southern agricultural center are interpreted to have cumulatively resulted in the cessation of flow Eva Spring.

15. In total, over 100 mapped valley-floor springs on the USGS topographic maps, south in latitude of the Shipley Hot Spring, have ceased to flow in Diamond Valley and are now dry.







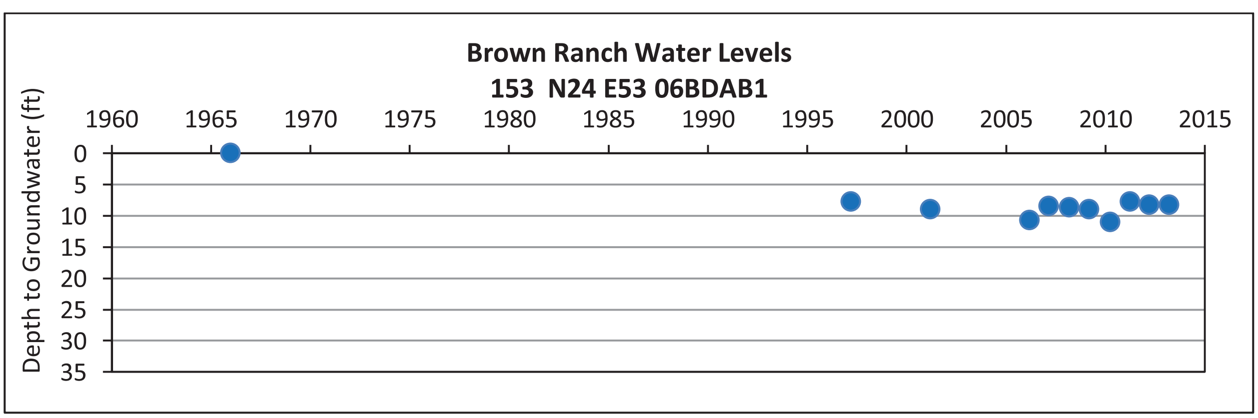


Figure 8 – Water Level Hydrographs for Wells along the Central-Western Edge of Diamond Valley

Conclusions & Professional Opinion

Historic discharge from Shipley Hot Spring is reported in the range of 8 to 15 cubic-feet per second (cfs), which is equal to 5,790 to 10,860 acre-feet, annually. The best available estimate of average pre-development Shipley Hot Spring discharge (prior to the 1940s) is approximately 11 to 12 cfs, consistent with reporting of spring discharge in Stearns, Stearns, and Waring (1937).

Flowing artesian wells initially produced a decline in Shipley Hot Spring discharge of possibly about 30 percent. The artesian wells no longer flow due to regional groundwater pumping and associated drawdown, which is now the dominant source of drawdown at Shipley Hot Spring. A transition from artesian well effects to regional pumping effects probably occurred over the time frame of the 1970s to 1990s, and by the mid-1990s, regional pumping had become the principal cause of the decline in spring discharge.

From the mid-1990s to present, Shipley Hot Spring discharge has progressively declined, and in the summer of 2013 has been at the lowest historically recorded discharge (1.6 cfs in June, and 0.7 to 1.2 cfs in August, 1.9 cfs in September). The expanding and deepening cone of depression caused by extensive pumping in the southern part of the valley is exasperated by continual annual pumping at levels above the perennial yield for the basin, which has occurred since 1970. Cumulative withdrawal of groundwater above the perennial yield totals approximately 1.6 million acre-feet, and grows by approximately 30,000 acre-feet each year under present pumping levels. As basin-wide pumping above the perennial yield continues, drawdown will continue to progress into the northern portion of Diamond Valley. At the current rate of decline of Shipley Hot Spring, flow will cease within the next 2 to 6 years.

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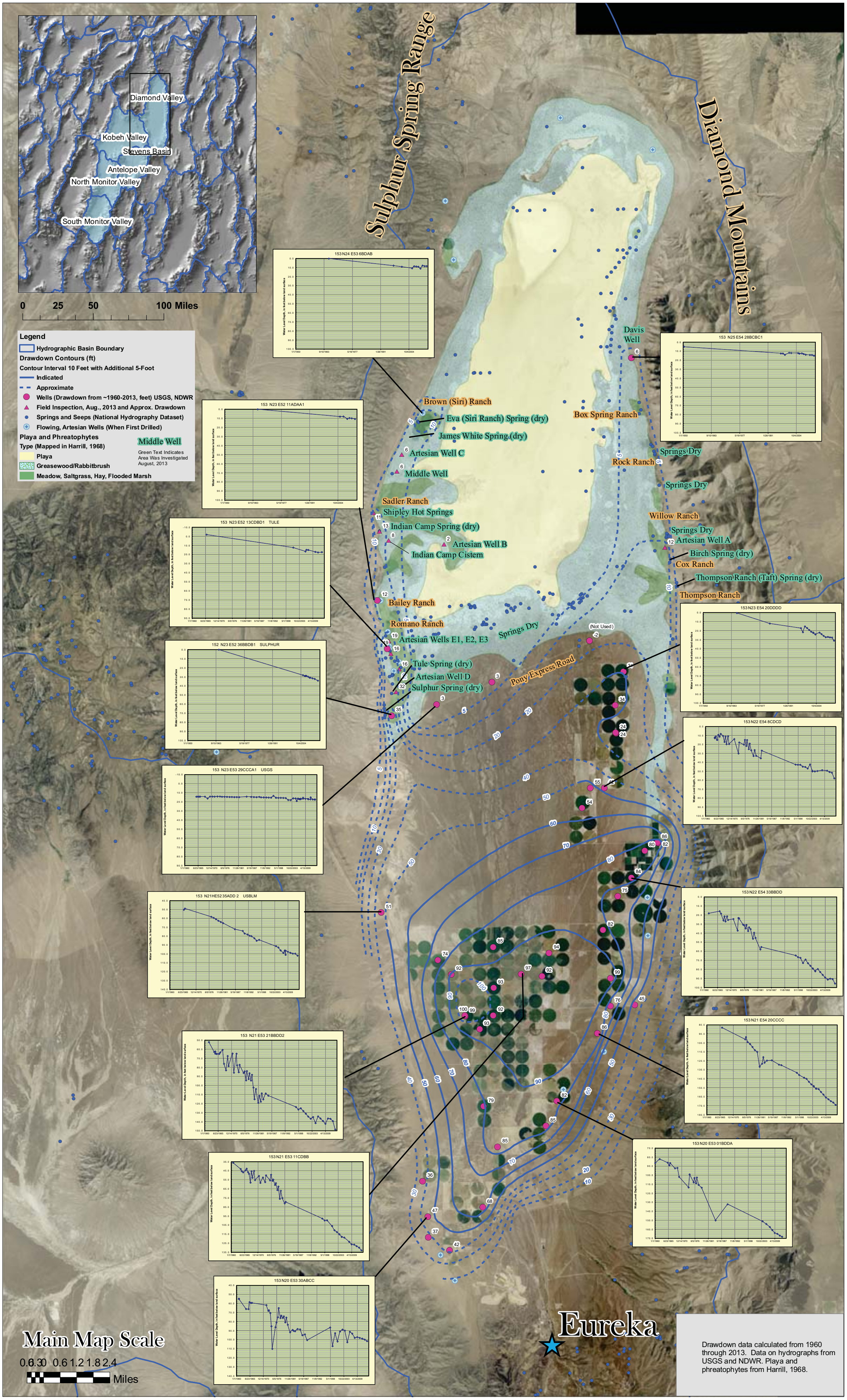

Plate 1: Drawdown in the Basin-Fill Aquifer, Diamond Valley 1960-2013