Golden Valley Aquifer Recharge Assessment

Golden Valley Subbasin, Nevada

Prepared for

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Acronyms and Abbreviations

af	acre-feet
af/yr	acre-feet per year
ET	evapotranspiration
ft/d	feet per day
ft/yr	feet per year
ft^2/d	square feet per day
GMS	Groundwater Modeling System by Aquaveo, Inc.
gpd	gallons per day
gpd/ft	gallons per day per foot
gpm	gallons per minute
GVMW	Golden Valley Monitoring Well
in/d	inches per day
K	hydraulic conductivity
NDWR	Nevada Department of Water Resources
NOAA	National Oceanic and Atmospheric Administration
Terraphase	Terraphase Engineering Inc.
USEPA	United States Environmental Protection Agency
Water Recharge Program	Golden Valley Artificial Ground Water Recharge Program

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Signatures

All geologic information, conclusions, and recommendations in this document have been prepared under the responsible charge of a Professional Geologist.

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All engineering information, conclusions, and recommendations in this document have been prepared under the responsible charge of a Nevada Professional Engineer.

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1 Introduction

Washoe County initiated the Golden Valley Artificial Groundwater Recharge Program (Recharge Program) in the mid-1990s to address declining groundwater levels and water quality issues in the Golden Valley basin. The aquifer is relied upon by many Golden Valley residents as their water source for domestic wells. Potable imported water was injected from 1993 through 1997, was suspended until 2002 to secure funding, and operated until 2016, at which time it was suspended due to rising water levels in parts of the subbasin that led to flooding of septic systems and basements. As groundwater continued to rise in certain areas, water levels declined at other locations within the basin and approximately 58 users had to deepen their wells since 1993.

The Recharge Program was supported by a broad technical evaluation of the basin in the 1980s and early 1990s. The technical data was sufficient to convince stakeholders to invest in construction and operation of the aquifer recharge program. Part of the initial investigation into the feasibility of aquifer recharge was the development of a groundwater flow model. Other components included an analysis of surface water availability, the economic feasibility of the project, and the chemistry of the basin groundwater and proposed infiltration water.

A number of groundwater flow models have been created for Golden Valley and the greater Lemmon Valley hydrographic basin, of which Golden Valley is part of. These include a combined model for Lemmon Valley and Golden Valley, most recently updated in 2019 (Pohll 2019), and an individual model for Golden Valley, last updated in 2017 (Pohll 2017). The 2017 model predicted water levels would decline on the order of 2.5 to 3.3 feet per year (ft/yr) when the Recharge Program ceased injection of imported water, but water levels continued to rise at most locations within Golden Valley, up to more than 25 feet at some locations.

This report presents an Aquifer Recharge Assessment, performed on behalf of Washoe County, to evaluate whether continued use of an aquifer recharge program would be beneficial to domestic well users in Golden Valley. The evaluation included a focus on examining the extent to which basin conditions used to originally justify aquifer recharge have changed over the last several decades by developing a detailed conceptual model, using the conceptual model findings to revise and re-calibrate the 2017 model, and predictive modeling under select scenarios to inform decisions for aquifer recharge in the future.

2 Conceptual Model

Figure 1 presents the location of Golden Valley, which is a subbasin in the Eastern Lemmon Valley Hydrographic Basin (092B) as designated by the Nevada Department of Water Resources (NDWR). Numerous geologic investigations, recharge studies and water resource evaluations have been conducted for the greater Lemmon Valley (Rush and Glancy 1967; Maxey and Eakin 1949; Harrill 1973; Cochran et al 1984) that have described the geologic units, mapped fault locations, and groundwater conditions (sources and sinks of water, groundwater flow rates and directions, and aquifer yield).

This conceptual model focuses on hydrogeologic conditions in Golden Valley using information obtained from regional geologic reports, the NDWR online well log database, water level data collected from 60 domestic wells and three monitoring wells, regional municipal extraction records for wells located near the Golden Valley basin boundary, injection well data from the Washoe County Golden Valley Aquifer Recharge Program, and groundwater modeling work performed by the Truckee Meadows Water Authority for the greater Lemmon Valley area (Pohll 2019) and the Golden Valley subbasin (Pohll 2017). Based on the available data, Terraphase Engineering Inc. (Terraphase) developed groundwater elevation maps, hydrographs, and a water budget for years 1991 through 2001.

2.1 Geology

Golden Valley is located in the Basin and Range physiographic province, which includes numerous northwest-to northeast-trending ranges and broad intervening basins. Extensive faulting is mapped along the hills between Golden Valley and Truckee Meadows to the south, and along the eastern flank of Golden Valley, between Golden Valley and Sun Valley (Bonham and Bingler 1973; Cochran et al. 1984). The northern, eastern, and southern sides of Golden Valley are hills of Mesozoic granodiorite and quartz monzonite (Cochran et al. 1984). The southeastern corner of Golden Valley contains Tertiary andesite, rhyolite, other volcanics and the Hartford Hill metavolcanics (Bonham and Bingler 1973). The monzonite and volcanics outcrop at the edges of the basin and are highly weathered and fractured (Barry 1985).

Attachment A includes two geologic maps of the Reno area (Bonham and Bingler 1973 and Cordy 1985) which include the Golden Valley subbasin. Attachment A also includes an image made from the two maps to display the entire Golden Valley geology. The deuterically altered granodiorite (symbol Mzdg on the geologic map) is often described in well logs as “green granite” with the deuteric alteration accounting for increased porosity and permeability compared to “hard rock”. The deeply weathered quartz monzonite (symbol Mzqm on the geologic map) is exposed at the resource pit at the east end of the Valley. The Hartford Hill metavolcanics exposed in the southeast portion of GV are highly resistant to erosion, are only weakly fractured, and have very low permeabilities. Hydrothermal alternation has altered plagioclase to clay minerals. As such, specially engineered (e.g., mound system) septic systems were required to support homes in this area. The Hartford Hill volcanics are described in well logs as “yellow, white, purple clays”; the expansive character of these volcanics is addressed in Bell et al. 1986.

The basin floor is composed of medium to coarse sand, decomposed granite gravels, and thin clay lenses (Barry 1985; Cochran et al. 1984), likely colluvium from the surrounding hillside. An alluvial fan extends from Peavine Mountain to the north and northeast and abuts valley fill deposits in Golden Valley (Barry 1985).

In the western Lemmon Valley hydrographic subbasin, unconsolidated materials include layers of coarse-grained sediments interbedded with fine-grained sediments deposited in a series of pluvial lakes. Lake Lemmon, the youngest pluvial lake in Lemmon Valley, had a high stand of 4980 feet above mean sea level as evidenced by deposits and shoreline features (Soeller, 1978). Swan and Silver Lakes are ephemeral playa remnants of Lake Lemmon. Lake Lemmon was contemporaneous with, but not topographically connected to pluvial Lake Lahontan (Morrison, 1964). Similarly, in eastern Golden Valley the sediments include layers and lenses of clay-rich sediments that may have been deposited in isolated small pluvial lakes within the valley (personal communication with Elaine Hanford). The clay-rich lenses and layers are characterized by low permeability and tend to inhibit movement of groundwater.

Terraphase reviewed approximately 100 domestic, monitoring, and municipal well logs obtained from the online NDWR well log database, and lithologic logs for Golden Valley monitoring wells (GVMW3, GVMW-4, and GVMW-5) and injection wells (GVI-1, GVI-3, GVI-4, and GVI-5). The well logs were used to identify the basin fill thickness, the depth to the bedrock-fill interface, and fractured intervals. Five geologic cross-sections were constructed. Figure 3 shows the cross-section locations, along with the location of known or inferred faults from geologic studies and observations of water level differences (Horton et al. 2017; Pohll 2019; Pohll 2019). The faults appear to be reverse west-dipping normal faults (Cochran et al. 1984).

Figures 4 through 8 present the cross-sections. Recorded lithology was simplified and designated as sand/gravel, clay, decomposed granite, granite, decomposed andesite, andesite, or rhyolite. As noted above, granites and volcanics outcrop at the basin margins except for the south and southwest (Peavine area), where borings record thick intervals of decomposed granite (Section D'D', Figure 6) or clays (Section B'B', Figure 4). Static water levels from borings in the Peavine area indicate the alluvium there may not be saturated; the depth of these borings indicates water-bearing zones were not found until fractured rock was encountered.

The cross-sections show that fracture intervals identified over various depth intervals (from less than 5 feet to over 100 feet) were recorded on most well logs within the granite and andesite. The logs do not identify fracture aperture or orientation. In general, water-bearing zones were recorded coincident with fractures in bedrock. Well logs show that some static water levels were found in the overlying sediments, suggesting confined conditions in bedrock fractures. Barry (1985) notes that a deeper flow system originating from upper elevations on Peavine Mountain may move through connected fractures into Golden Valley, and that upward flow gradients observed within the basin may suggest influence from a more localized fracture flow system originating from exposed decomposed and fractured granites in the surrounding uplands. The logs presented on the cross-sections are consistent with this conceptualization. Furthermore, in the central portions of the basin, the lithology appears to consist of relatively thick sequences of clay in some areas, which would impede infiltration of precipitation and subsequent downward flow. However, many locations show relatively thick intervals of sands, gravels, and decomposed granites overlying fractured rock intervals. Many of these domestic wells are installed in the bedrock, suggesting the basin fill materials may not yield as much water as the fractured rock.

Attachment B includes a partial compilation of well log lithology, fracture intervals, screened intervals and static water levels developed by Elaine Hanford of the Golden Valley Property Owners Association.

2.2 Hydrogeology

2.2.1 Regional Hydrogeologic Conditions

The Golden Valley hydrographic subbasin boundary is shown on Figure 2. The basin is defined by groundwater divides located along the topographic highlands to the east, north, and northwest. The basin boundary to the south is a southeast-northwest trending boundary along Highway 395, separating Golden Valley from the Black Springs and Peavine Mountain areas. Groundwater from runoff and infiltration in the northeastern portion of Peavine Mountain is a source of groundwater inflow to Golden Valley and is herein referred to as the “Peavine inflow boundary”. To the west, the basin boundary is defined along the granitic bedrock outcrops that separate Golden Valley from West Lemmon Valley and a canyon across Lemmon Valley Drive through which surface water runoff intermittently collects and flows in the Golden Valley Wash. This canyon is also the only outlet for groundwater to flow from Golden Valley into Lemmon Valley and is herein referred to as the “Lemmon Valley outflow boundary”.

The climate in Lemmon Valley is similar to that of other valleys in western Nevada at comparable altitudes. Precipitation is controlled largely by topography. Winter precipitation generally falls as snow from regional storms, whereas summer precipitation is localized as thunderstorms of short duration and commonly of high intensity (Harrill 1973). Figure 9 presents total annual precipitation at the Reno Airport from 1991 through 2021, located approximately 8 miles southeast of Golden Valley, using data downloaded from the National Oceanic and Atmospheric Administration (NOAA) National Weather Service website (https://www.weather.gov/wrh). Although precipitation data does exist for the Stead Airport gauge, located closer to Golden Valley (approximately 3 miles west), that period of record is significantly shorter than the Reno Airport (36 years versus 84 years) with only 12 years without missing data. As such, the Reno Airport data was evaluated and used to scale recharge rates assigned in the model to represent how each year differs from the average (see Section 3.4). Figure 9 includes a horizontal line that represents the long-term average precipitation at the Reno Airport gauge (7.34 inches; based on records from 1937 through mid-2022). Over the assessment period of 1991 through 2021, above-average wet years occurred between 1995 through 1998, 2004 and 2005, 2009 and 2010, and 2015 through 2019, and 2021. Figure 9 also includes a line representing the precipitation scaling factor, which is the percent difference of the precipitation that year as compared to the long-term average. These scaling factors were used to adjust the model simulated recharge, discussed in detail in Section 3.4.1.

Basin fill and underlying fractured or deuterically altered granitic rocks are both considered as groundwater reserves with the ability to yield sufficient quantities of water to wells for domestic purposes. Municipal water supply wells exist throughout Lemmon Valley, but not within Golden Valley. Municipal wells located in the Peavine area upgradient of Golden Valley adjacent to the Golden Valley hydrographic boundary include CMOR1, CMOR2, and SKY (Figure 2). In addition, municipal well LVP3 is located approximately 2000 feet downgradient of the Lemmon Valley outflow boundary (Figure 2). Combined, the three wells in the Peavine area extracted approximately 42 acre-feet per year (af/yr) in the 1970s, approximately 103 to 126 af/yr from 1980 to 2001, and approximately 32 af/yr since 2002. The reduction in pumping in 2002 through the present is due to an increase in the use of imported water (Pohll 2019). These wells extract groundwater from the fractured bedrock and intercept water that would otherwise flow into Golden Valley. The historical pumping rates indicate that at least 126 af/yr can flow through this boundary, which is higher than estimated in previous studies (Harrill 1973; Barry 1985; Pohll 2017). Multiple domestic wells also exist in this area and contribute to the interception of groundwater flow from the Peavine Mountains.

Municipal well LVP3 extracted up to approximately 140 af/yr through the 1970s, and remained relatively constant through the 1980s and early 2000s, at rates ranging from approximately 50 to 100 af/yr. By 2003, rates significantly decreased to approximately 32 af/yr and continued to decline until the end of 2005, when production at this well was suspended, also due to the increased use of imported water in Lemmon Valley. Historically, higher rates of extraction from this well induced a relatively steep gradient through the Lemmon Valley outflow boundary (Harrill 1973). Harrill reports that because of the high degree of structural deformation, granitic rocks in some areas of Lemmon Valley produce high volumes of water, and states that "public supply well 20/19-4ddac, just downgradient from where Golden Valley drains to the Central Area, was drilled to a depth of 296 feet in bedrock and reportedly produces 440 gallons per minute [gpm] from 'hard rock with fractures'". The well referenced is coincident with the location of well LVP3. Conversion of 440 gpm to af/yr yields approximately 710 af/yr. It is unknown if this is a sustainable rate but does indicate that groundwater in bedrock could flow through the Lemmon Valley outflow at relatively higher rates than previously assumed.

The NDWR well log database has 501 domestic well records for Golden Valley with verifiable locations. Modeling by Pohll (2017) included wells on each parcel existing prior to construction of developments that are served by municipal water sources. The total number of parcels identified was 556. Domestic well use is discussed in more detail in Section 2.3.

2.2.2 Hydraulic Properties

Transmissivity and hydraulic conductivity values obtained from specific capacity tests at wells located throughout the greater Lemmon Valley hydrographic basin are reported in Harrill (1973). Although only two wells in the report are located in Golden Valley, the bedrock geology in both the East and West Lemmon Valley hydrographic basins is similar; therefore, all values reported can be considered representative of conditions in Golden Valley. Table 1 presents a summary of the calculated hydraulic conductivity (K) values reported in Harrill. The K values calculated for the valley fill (alluvium, colluvium) range from 1.6 to 48 feet per day (ft/d), with an average and geometric mean of 16 and 10 ft/d, respectively. The K values calculated for bedrock, including granite and fractured rhyolite, range from 0.32 to 20 ft/d, with an arithmetic and geometric mean of 5.5 and 2.7 ft/d, respectively. The ranges of K values for valley fill and bedrock overlap. The range in values indicates heterogeneity in the fill materials, and variability in fracture characteristics (aperture and interconnectedness) in bedrock.

Terraphase reviewed injection and recovery test data from 2003 provided by Washoe County for injection well GVI-3. Using Theis's recovery method (Kruseman and Ridder 1990), the calculated transmissivity is approximately 446 square feet per day (ft^2/d). Well GVI-3 was originally installed to a depth of 250 feet and screened across 70 feet of granitic sand and 45 feet of granite bedrock but was deepened to a total depth of 450 feet, suggesting that relatively little flow occurred in the original screen interval. Dividing the calculated transmissivity by the total screen interval of 315 feet yields a hydraulic conductivity value of 1.4 ft/d. This value is within the range of values presented in Harrill (1973), and similar to values obtained using domestic well yield and drawdown data described below.

The well log information for 146 wells in Golden Valley downloaded from the NDWR database includes well yield and total drawdown obtained from well production testing after well installation. This information was used to calculate the specific capacity of each well, which is a measure of how much drawdown occurs in a well for a specified pumping rate (Driscoll 1986):

$$SC = \frac{Q}{s}$$

Where:

SC = specific capacity, gpm/foot

Q = pumping rate, gpm

S = drawdown, feet

Specific capacity can be used to estimate transmissivity (T) of the perforated interval tested using the following relationship (Driscoll 1986):

$$T\ (unconfined\ aquifer) = 1500 * SC$$

$$T\ (confined\ aquifer) = 2000 * SC$$

These equations include conversion factors such that the units of transmissivity using these calculations are gallons per day per foot (gpd/ft). Hydraulic conductivity is calculated by dividing the transmissivity by the perforated interval of the test well. Appendix C includes the calculations of transmissivity and hydraulic conductivity from the 146 well records obtained from the NDWR database. The equation for confined conditions was used in the analysis because it is assumed, based on the total well depths and review of the lithologic logs, that most of these wells were installed in bedrock (see Appendix B). Calculated hydraulic conductivity values range over three orders of magnitude (0.01 to 33 ft/d), which is not an uncommon range for a given material type; however, it is not known if these wells are installed in unconsolidated materials or bedrock or both, which could explain the variation. Values greater than 6.68 ft/d were suggested as outliers on a box plot and removed from additional evaluation. The arithmetic and geometric mean values of the remaining 132 data points are 1.8 and 1.1 ft/d, respectively. The calculated upper- and lower-95 percent confidence intervals around the geometric mean are 1.4 and 0.9 ft/d, respectively. These values fall within the lower end of the range of values reported for bedrock (Harrill 1973).

There are limitations with using specific capacity data to obtain hydraulic properties, because several factors affect the drawdown observed during these tests, including well inefficiency, duration of the test, and variability in pumping rates during testing. Additionally, the equation used to calculate transmissivity from specific capacity data may not be an exact solution. However, calculation of hydraulic properties using this method is a standard and acceptable practice. The calculated values of hydraulic conductivity were used in calculations of groundwater discharge and velocity and were used to update the bedrock hydraulic conductivity distribution of the numerical model, as discussed in Section 3.2.

2.2.3 Groundwater Elevations and Flow Directions

Groundwater elevation contours under natural conditions (i.e., prior to groundwater development) and in spring 1971 in the greater Lemmon Valley area are presented on Figures 7 and 12 in NDWR Bulletin

42 (Harrill 1973). Excerpts of these figures that focus on Golden Valley are presented together in this report on Figure 10 (Panels 10a and 10b) and include inferred groundwater flow direction arrows based on the contour distribution. As shown on Panel 10a, under natural conditions, groundwater generally flows into Golden Valley from the topographic highlands/bedrock outcrops in the east and from the south via the Peavine Inflow Boundary. Groundwater flows from these areas and exits the basin through the Lemmon Valley outflow boundary. As shown on Panel 10b, by 1971, groundwater elevations in the Peavine area and downgradient of the Lemmon Valley outflow were significantly lowered due to municipal groundwater extraction. At this time, municipal wells in the Peavine area intercepted groundwater that would otherwise have flowed into Golden Valley. Also at this time, municipal pumping in the Lemmon Valley canyon significantly steepened the groundwater elevation surface, which increased groundwater velocity through the canyon and may have induced greater flow out of the basin.

A historical groundwater elevation database for 60 domestic and 3 monitoring wells obtained from Washoe County was used to evaluate spatial and temporal trends in groundwater elevations, flow directions, and hydraulic gradients. Well locations are shown on Figure 11. Most wells are screened in either fill and bedrock or bedrock and therefore, the analysis of groundwater elevations, flow directions, and temporal trends represent a composite of the two units. Groundwater elevation maps (Figures 12 through 15) were prepared for select time periods that bracket specific years of interest based on climate and the Aquifer Recharge Program operation:

- Year 1991 – the approximate year a monitoring program began, and prior to initiation of the Aquifer Recharge Program.
- Summer 2005 – the Aquifer Recharge Program was in operation and above-average precipitation conditions were observed.
- Summer 2015 – one year prior to suspension of the Aquifer Recharge Program and the beginning of significant above-average precipitation occurring in years 2015-2019.
- March 2021 – the most recent water level data at the time of this assessment.

In 1991 (Figure 12), static water levels from wells installed in 1991 were included in the contouring due to the sparsity of available data in 1991, when the monitoring program began. In general, water levels in 1991 are approximately 10 feet lower than in the 1970s as compared to Figure 10.

As shown on all groundwater elevation contour maps, steeper hydraulic gradients exist in the northeast and east, and a flattened, lower hydraulic gradient exists through the central portion of the basin. Over time, as water levels have risen throughout the basin, the overall hydraulic gradient has become relatively consistent throughout the basin, as shown on the March 2021 groundwater elevation contour map (Figure 15).

A groundwater mound was observed in the central part of the basin known as the “Gun Streets” area in 2005 and 2015 (Figures 13 and 14). Water level measurements at the Benedict well began in 2002 and show an elevated water level here as compared to upgradient wells. The higher water levels observed here are likely a function of several factors, including the presence of the mapped fault, observed bedrock high, and relatively thin interval of basin fill in this area, which lowers the transmissivity of the basin fill, limiting the amount of water that can flow through the area. Cross-section E-E’ (Figure 8) shows the location of the fault and the resulting bedrock high in this area. The cross-section also shows the groundwater elevation surfaces in Summer 2005 and May 2021, which depict the existence of the mound in 2005, and how gradients have flattened out as water levels rose through time. Additionally, the Gun Streets area is located in the lowest topographic area of the basin, where surface water runoff collects and flows through Golden Valley wash, which may contribute to elevated water levels in this area.

Some groundwater elevations at wells located in the same area of the basin are substantially different from others. This is fairly common in bedrock groundwater systems due to the variable nature of fractured bedrock networks. Different zones of fractures may or may not be in hydraulic communication with each other due to faults or the distribution and orientation of discrete fractures and fracture networks. This is especially observed in the northwestern area of the basin, where wells with similar depths and perforated intervals have substantially different water levels (for example, the Hedrick and Moser wells; Figure 13), and in the east where substantially lower groundwater levels relative to surrounding areas were observed in the Johnson, Shoensky, and Walsh wells in 1991 and 2005 (Figure 13). However, as noted above, some of these variations have diminished as groundwater elevations increased throughout the basin.

2.2.4 Calculation of Groundwater Discharge and Velocity

Groundwater discharge (volumetric flow rate) for the fill and bedrock materials at the Peavine inflow boundary and the Lemmon Valley outflow boundary were calculated for natural, pre-development conditions. Groundwater discharge is calculated using Darcy's Law:

$$Q = \mathrm{K} * \mathrm{i} * \mathrm{A}$$

where:

- Q = groundwater discharge (volume per time)
- K = hydraulic conductivity (length per time)
- I = hydraulic gradient (length per length)
- A = vertical cross-sectional area perpendicular to the dominant flow direction (length squared)

Table 2 presents a summary of the calculated groundwater discharge rates for the fill and bedrock units at each boundary. The hydraulic conductivity values used to calculate groundwater discharge for the basin fill are the arithmetic and geometric mean of the values presented in Table 1, and the values used for the bedrock include the arithmetic mean, geometric mean, and the upper and lower confidence intervals presented in Appendix C. The hydraulic gradients for both boundaries were obtained from the natural conditions groundwater elevation map (Figure 10a). The saturated thickness at each boundary was calculated using groundwater elevations from Figure 10a and average bottom elevation of each unit at each boundary based on interpolation of the top of bedrock (for the fill) and the bottom of the numerical model (discussed in more detail in Section 3.1). The fill is not saturated in the vicinity of the Peavine inflow boundary; therefore, no calculation of discharge in the fill at this boundary was performed. The width of the Peavine inflow boundary is bounded by the groundwater divide noted on Figure 2. The width of the Lemmon Valley outflow boundary for fill and bedrock were measured as the width of the canyon at the location shown on Figure 2.

Calculated groundwater discharge in bedrock at the Peavine Inflow Boundary ranges from 156 to 311 af/yr. Calculated groundwater discharge through the fill material at the Lemmon Valley outflow boundary ranges from 87 to 128 af/yr. Calculated groundwater discharge in bedrock at the Lemmon Valley outflow boundary ranges from 87 to 173 af/yr. The summation of groundwater discharge through the Lemmon Valley outflow boundary, considering the fill and bedrock, ranges from 169 to 302 af/yr.

Groundwater velocity is calculated as:

$$V = \frac{\mathrm{K} * \mathrm{i}}{n}$$

where:

V = groundwater velocity (length per time)

K = hydraulic conductivity (length per time)

i = hydraulic gradient (length per length)

n = porosity (volume per volume)

Table 3 presents the calculated groundwater velocities and travel times across the entire length of the basin for fill and bedrock. Hydraulic conductivity values used for the fill include the arithmetic mean and geometric mean (15.5 and 9.9 ft/d, respectively). Hydraulic conductivity values used for the bedrock include the arithmetic mean and the 95% lower confidence interval of the geometric mean (1.8 and 0.9 ft/d, respectively). The hydraulic gradient across the basin from Figure 10a was used in the calculation for both fill and bedrock. Two values of porosity considered representative of the fill and fractured bedrock were used. Calculated groundwater velocity ranges from 181 to 849 feet per year (ft/y) for the fill, with associated travel times across the basin of 13 to 59 years. Calculated groundwater velocity ranges from 22 to 181 ft/y for the bedrock, with associated travel times across the basin of 59 to 491 years.

2.2.5 Temporal Trends in Groundwater Elevations

Groundwater elevation hydrographs for select wells at different locations in the Golden Valley basin were prepared to assess the magnitude of, and rate of change in, groundwater elevations in different parts of the basin, and to correlate these changes to the natural and anthropogenic conditions quantified in the water budget in Section 2.3.

A hydrograph for the three Golden Valley monitoring wells (GVMW3, GVMW4, and GVMW5) located along the axis of the basin is presented on Figure 16. These wells have been monitored at least monthly from 1991 through the present. Several trends are discernable from the hydrograph:

- Seasonal water level fluctuations each year of approximately 5 to 7 feet in response to seasonal climatic variations (wet/dry seasons).
- A downward trend of approximately 10 feet from 1991 through 1995, likely due to multiple below-average precipitation years since the mid-1980s.
- Relatively rapid water level increase of approximately 20 to 25 feet from 1995 through 1997, likely in response to above-average precipitation in 1995 and 1996; as precipitation returned to average

or below-average conditions, water levels were on a downward trend until 2004, but did not decrease to pre-wet period levels.

- A long-term upward trend from 2005 through 2016, resulting in approximately 30 to 40 feet of water level rise at a rate of approximately 2 to 3 feet per year. This is likely due to changes in municipal pumping in the Peavine and Lemmon Valley outflow areas as discussed above.
- Relatively rapid water level increase of approximately 10 to 15 feet in 2016, with continued increases at a lower rate through 2020, likely in response to multiple above-average precipitation years from 2015 through 2019.
- A downward trend of approximately 5 to 10 feet from 2020 through the present.

Figure 17 presents hydrographs for the Benedict well (located in the Gun Streets area near a bedrock fault) and the Long well (located downgradient of Benedict near the Lemmon Valley outflow boundary). An overall upward trend of approximately 30 feet has occurred at these locations since 2002. Greater seasonal fluctuations are observed at the Long well (approximately 20 feet) as compared to the Benedict well (5 to 10 feet). This could be due to the proximity of the Long well to Golden Valley Wash, which would indicate the bedrock is in hydraulic communication with the overlying fill, or it could be due to differences in the fracture network that each well is screened in.

Figure 18 presents hydrographs for the Ariaz and Cohen wells, located in the northwestern portion of the basin. Groundwater elevation trends in these wells include apparent seasonal fluctuations of up to 20 feet or more throughout the period of measurement, which are more apparent for the time period with more frequent measurements. The hydrographs indicate these wells also appear to respond to above-average wet years observed in 2004-2005 and in 2015 – 2019. An overall groundwater elevation increase of approximately 50 to 60 feet has occurred in these wells since the early 2000s.

Figure 19 presents hydrographs for the McNinch well (located 1160 feet downgradient of injection well GVI-3) and the Chaves well (located approximately 1,500 feet downgradient of injection well GVI-4). The McNinch and Chaves wells generally show trends similar to the Golden Valley Monitoring Wells (GVMWs), such as the response to above-average wet years and an overall increase in groundwater elevation of approximately 50 feet in the Chaves well since the early 2000s, but a more subdued response at the McNinch well of approximately 20 feet during the same time period. It is not discernable if the McNinch well responds significantly to injection at GVI-3, which has injected approximately six percent of the total injected water in the basin (see water budget discussion in Section 2.3).

Figure 20 presents hydrographs for the Biggie and Mayo wells, located in the southeastern portion of the basin. These wells show similar trends to other wells in the basin, with approximately 75 to 100 feet of water level increase since the mid-2000s.

In summary, water levels throughout the basin respond to periods with multiple above-average precipitation (specifically 1995 through 1998 and 2015 through 2019) and at most locations have consistently risen since the early to mid-2000s. Decreasing water levels observed at many locations after the 2015-2019 above-average wet period appear to have declined to levels consistent with the long-term increasing trend observed since the mid-2000s.

2.3 Water Budget

A 31-year (1991 – 2021) annual water budget for Golden Valley was developed to quantify the volume of groundwater flowing into and out of the basin each year and to provide a basis for evaluating changes in water levels observed over time. The water budget provides an understanding of historical conditions and can be used to evaluate how future changes in land use and climate may affect the water resources of the basin and is therefore a valuable water management tool. Additionally, the calculated water budget serves as the basis for updating the boundary conditions assigned to the numerical groundwater flow model.

Under natural conditions, water enters the basin through infiltration of precipitation (areal recharge) and groundwater inflow from the Peavine boundary and exits the basin through the Lemmon Valley outflow boundary. Anthropogenic effects on the water budget include the addition of water from the Aquifer Recharge Program, irrigation of the North Valleys High School fields and development landscaping, and removal of water from domestic wells and the Golden Valley Park well. These components of the water budget are shown on Figure 21 and are discussed in detail below.

2.3.1 Inflows

2.3.1.1 Aquifer Recharge Program Injection

The Aquifer Recharge Program includes four injection wells. Wells GVI-1, GVI-3, and GVI-4 are located along the eastern edge of the basin; well GVI-5 is located on the northwestern edge of the basin (Figure 20). A well named GVI-2 was originally installed next to GVI-4 but was replaced by GVI-4 in 1992. Measured injection rates for each well are presented in Table 4. Water was injected in 1993 through 1997, was suspended until 2003, and ceased operation in early 2016.

Well GVI-1 is screened in the fill (described as cemented quartz sand) and well GVI-4 is screened in the bottom 20 feet of fill (described as quartz-rich granitic sand) and in 230 feet of bedrock. As stated previously, well GVI-3 was originally installed to a depth of 250 feet and screened across 70 feet of granitic sand and 45 feet of granite bedrock but was deepened to a total depth of 450 feet, suggesting that limited flow occurred in the original screen interval. Well GVI-5 is screened in bedrock, characterized as having major fracturing in some intervals.

Table 4 presents the total volume of water injected into each well; the total volume of water injected each year in all wells; and the percentage of the total injected water at each well. Approximately 85 percent of the total water volume was injected in wells GVI-1 and GVI-4. The total volume of water injected over the 31-year period was 1,077 af.

2.3.1.2 High School Irrigation

North Valleys High School, built in 2001, has irrigated the sport fields and some surrounding grassy areas. The aerial extent of irrigation can be observed in historical aerial photos. Water usage records in af/yr were provided by the school for years 2004 through 2021, with records for 2004 covering only a portion of the year. The volume of water each year was adjusted by the average evapotranspiration (ET) rate for turf grass of 3.6 feet per year (ft/yr; Pohll 2017) to calculate the volume of irrigated water that would recharge groundwater. The adjustment was made by summing the total area of irrigated fields and grass areas, multiplying the area by the ET rate, and subtracting that volume (60 af/yr) from the reported water usage each year. For years 2001 to 2003, when water usage data were not available, and year 2004, with only a partial year reported, the recharge to groundwater was assigned as the average from 2005 through 2020. Table 5 presents the reported water usage and adjusted rates for groundwater recharge. Rates of groundwater recharge range from zero (representing years where the irrigation was less than 60 af) to 27.5 af in 2008. The cumulative volume of irrigation water recharged to groundwater over the 31-year period is 199 af.

2.3.1.3 Development Landscaping

Since 2002, new housing developments have been constructed in the southern and southwestern portions of Golden Valley (Figure 21). Prior to 2002, residential development was in accordance with low density suburban zoning with lot sizes of approximately 1 acre or larger. The more recent developments have been constructed in accordance with medium density suburban zoning with smaller lot sizes on the order of approximately one-quarter acre.

As Golden Valley has become more developed, residential landscaping contributed a de minimis amount of recharge to groundwater. Development households are connected to the municipal water system; therefore, any watering associated with landscaping cannot be accounted for in adjustments to domestic well water usage (discussed below in Section 2.3). Water usage records for development households are not available; recharge to groundwater from landscaping was estimated as follows:

- Divided the development areas into polygons based on the apparent date of construction from aerial photos and approximated the average lawn size of visible lawns in each area; polygons are shown on Figure 21.
- Used turf grass ET rate in Lemmon Valley as an analogue for lawn ET in Golden Valley (3.6 ft/yr). Assumed an average resident overwaters by 20%, which equates to 0.72 ft/yr.
- Multiplied the excess watering value by the average lawn size and number of lawns visible in each development to calculate the total recharge to groundwater from watering.

Table 6 presents the total calculated recharge to groundwater from all developments for years 2002 through 2021 and the cumulative volume of recharge of 76 af, or 5.6 percent of the total anthropogenic recharge. The recharge rates increase slightly over time as additional developments have been constructed.

Table 7 presents the total annual and cumulative inflow to the basin from all anthropogenic sources (Aquifer Recharge Program, high school irrigation, and development landscaping). Annual additions of water when all three components contributed water range from approximately 24 to 99 af/yr. The total recharge from these three components over the 31-year period is 1,352 af.

2.3.1.4 Areal Recharge

Recharge in Golden Valley occurs as infiltration from precipitation on the topographic highs where bedrock is exposed, which contributes water to the fracture flow system, and to a lesser extent, to the unconsolidated basin fill (where present).

Recharge in Lemmon Valley and Golden Valley has been evaluated by several practitioners (Harrill 1973; Cochran et al. 1984, 1986, 1989; Epstein et al. 2010; Garner 2022). Additionally, recharge rates determined from calibration of groundwater flow models of the Lemmon Valley basin (both east and west hydrographic basins; Pohll 2019) and of Golden Valley subbasin (Pohll 2017) are available.

Cochran et al. (1984) developed a groundwater budget for the Golden Valley area using a Maxey-Eakin type analysis and estimated natural recharge at approximately 120 af/yr. They questioned the applicability of the Maxey-Eakin method over such a small area and decided a more representative annual recharge of 50 af/yr was more appropriate (Pohll 2017).

The study by Epstein et al. (2010) evaluated three methods for calculating recharge in Nevada's desert basins. The methodology was applied to the Golden Valley area to estimate groundwater recharge for the Golden Valley groundwater model (Pohll 2017). The results indicated a mean value of 115 af/yr and a 95 percent confidence interval of 68 – 172 af/yr. However, to achieve a reasonable transient calibration, the Pohl 2017 steady-state natural conditions model used a rate of 50 af/yr.

The Garner study assigned recharge in the East and West Lemmon Valley basins as part of a coupled watershed-lake hydrologic model of playa lakes in Lemmon Valley using rates from Harrill (1973). Figures from Garner (2022) present the spatial distribution of assigned and calibrated groundwater recharge rates, with the Golden Valley area reported at a range of $3x10^{-3}$ to $8x10^{-3}$ inches per day (in/d); multiplying these rates by the area of the Golden Valley basin yields a recharge rate of approximately 21 to 56 af/yr.

Table 8 presents annual recharge rates for 1991 through 2021 based on the minimum, mean, and maximum averages from Pohll (68, 115, and 174 af/yr of average recharge; 2017). Each of these assumed average rates of recharge were adjusted based on annual precipitation scaling factors to account for variations in precipitation. The precipitation scaling factor is calculated as the total annual precipitation divided by the long-term average annual precipitation of 7.34 inches. The scaling factors are shown on Figure 9 and are included on Table 8. Cumulative recharge using the range of values calculated by Pohll (2017) over the 31-year period ranges from approximately 2,119 to 5,361 af.

Table 8 also includes recharge rates calculated using information from Barry (1985). Figure 2 in Barry (1985) presents an isohyetal map of Golden Valley that delineates zones of precipitation rates as a function of topography; this map is included as Figure 22 in this report. Barry calculated approximately 2,300 af/yr of precipitation over the entire basin based on this map. Using this value of total precipitation with the Epstein recharge rates calculated by Pohll (68 to 172 af/yr), recharge to groundwater would range from approximately 3 percent (if recharge were 68 af/yr) to 7.5 percent (if recharge were 172 af/yr) of the total precipitation. Table 9 presents the calculation of total recharge to Golden Valley using the precipitation rates from the isohyetal map and assuming 7.5 percent recharges groundwater. The calculation uses the average precipitation in each isohyetal zone multiplied by 7.5

percent to obtain the recharge rate for each zone. Recharge rates were multiplied by the total area of each zone to obtain the volume of recharge for each zone. The total recharge calculated with this approach is 205 af/yr and was adjusted each year with the precipitation scaling factors shown on Table 8. The cumulative recharge rate over the 31-year period using this approach is 6,400 af.

2.3.1.5 Peavine Inflow

Annual groundwater flow through the Peavine inflow boundary was calculated using the range in natural groundwater discharge presented on Table 3 and was adjusted based on municipal pumping from Peavine area wells.

The calculated natural conditions discharge rates were adjusted by subtracting Peavine area annual municipal well pumping rates for wells CMOR1, CMOR2, and SKY (Figure 2) used in the Lemmon Valley groundwater flow model (Pohll 2019). This adjustment was made because the municipal wells intercept groundwater that would otherwise flow into Golden Valley.

Table 10 presents the annual Peavine municipal pumping rates and the Peavine Inflow rates adjusted for this pumping. Cumulative inflow from Peavine over the 31-year period ranges from 2,921 af to 7,726 af.

As noted earlier, the significant decline in Peavine pumping in 2002 through the present is due to an increase in the volume of imported water used to meet the needs of residents in Lemmon Valley.

2.3.2 Outflows

2.3.2.1 Domestic Wells

The NDWR well log database has 501 domestic well records for Golden Valley. Based on an evaluation of household water use in nearby Spanish Springs and on detailed measurements of septic flows in the same area, domestic well pumping rates are on the order of 0.9 af/yr. Assuming a net return flow to groundwater from septic systems of 0.2 af/yr, the net withdrawal is on the order of 0.7 af/yr (Pohll 2016; Rosen and Kropf 2006). In the 2017 update to the Golden Valley model, net domestic well pumping was adjusted during calibration to 0.07 af/yr per well (Pohll 2017). In the 2019 Lemmon Valley model update, which includes Golden Valley, a net domestic pumping rate of 0.2 af/yr was used for Golden Valley wells (Pohll 2019).

The United States Environmental Protection Agency (USEPA) reports that the average American family uses approximately 300 gallons per day (gpd), which equates to 0.34 af/yr, and that roughly 70 percent of this use is indoors (0.24 af/yr). Assuming the domestic well users of Golden Valley do not significantly landscape their properties, total domestic use could be on the order of 0.24 af/yr. Assuming 22 percent of return flow through septic systems (based on the Spanish Springs study) reduces the net withdrawal rate to 0.18 af/yr.

Table 11 presents the net domestic withdrawal each year assuming a rate of 0.18 af/yr per well. Well logs from the NDWR database were sorted by installation date to calculate net withdrawal from domestic wells over the 31-year period. Most wells were installed prior to the start of the 30-year water budget (approximately 432; see Table 11). The 2017 Golden Valley model (Pohll 2017) simulated domestic wells on each parcel according to build date, with a total number of 556 wells. The difference between the number of parcels and NDWR database records (501 wells) could be due to some well logs not being uploaded to the database, or the logs were not available to NDWR staff. As such, the calculation of total net domestic withdrawal each year includes 55 more wells than are in the NDWR database. The total net domestic withdrawal calculated over the 31-year period is 2,941 af.

Figure 23 presents map of the mapped domestic wells and additional parcels with wells color-coded by the decade in which the wells or parcels were built.

2.3.2.2 Golden Valley Park Well

The Golden Valley Park Well (see Figure 2) has been used to water the park fields since it was installed in 1980. The reported water usage from 2011 through 2021 ranges from zero (during above-average precipitation years) to 4.94 af/yr. The 2017 model-assigned net pumping rate of 4.1 af/yr was used in the calculated water budget because it includes an adjustment for an assumed ET rate. The cumulative volume extracted over the 31-year period is 127 af.

2.3.2.3 Lemmon Valley Outflow

The range in calculated groundwater discharge through the Lemmon Valley outflow boundary under natural conditions was presented in Table 2. Because this outflow boundary is the only way groundwater exits the basin, other than from domestic wells or the Golden Valley Park Well, the flow through this boundary will be a function of the difference between the water entering the basin, the net well withdrawals, and the storage properties and capacity of the basin fill and bedrock. As such, the simulated volume of water exiting the basin through this boundary in the groundwater flow model will reflect these influences; this is discussed in more detail in Section 4. For the purposes of the calculated water budget, consistent with the selected Peavine inflow rates and areal recharge rates, the maximum calculated total discharge for fill plus bedrock of 302 af/yr is used. The cumulative outflow for the 31-year period is calculated at 9,362 af.

2.3.3 Annual Water Budget

Table 12 presents a compilation of the calculated annual water budget inflows and outflows from 1991 through 2021. The annual volumes included in the table for recharge, Peavine inflow, and Lemmon Valley outflow are the maximum rates for each presented on Tables 9, 10, and 2, respectively. Table 12 includes the cumulative volume of each component and the percentage of the total that it represents. Over 90 percent of water entering the basin is from natural processes (precipitation recharge and Peavine inflow); injected water represents 7 percent of the total inflow to the basin, and the combined high school irrigation and development landscaping represents less than 2 percent of the total water entering the basin over the 31-year period. For outflows, the net domestic withdrawals represent approximately 24 percent of the total outflow, with approximately 75 percent exiting through the Lemmon Valley outflow boundary and 1 percent net withdrawal by the Golden Valley Park well.

The total inflow minus the total outflow each year represents a change in groundwater storage. When more water enters the basin than exits, there is a surplus of water, and when more water exits the basin than enters, there is a deficit. There is a surplus of water in the system during most years, which makes sense given the increasing trend in groundwater elevations throughout the basin since the early to mid-2000s. Overall, the cumulative total inflow (15,479 af) is greater than the cumulative total outflow (12,430 af) by approximately 3,049 af. Although a deficit occurs during some years throughout the assessment period, the graph of the cumulative annual inflow minus outflow (Figure 24) demonstrates that, on a cumulative basis, there is a water surplus, except for a small deficit of water from 1991 through 1994.

3 Groundwater Flow Model Update

The information obtained from the Conceptual Model was used to update the existing Golden Valley groundwater flow model (Pohll 2017). The model updates include conversion of the model domain from the metric system to the imperial system, refinement of the bedrock unit from one to three layers, revisions to the fill-bedrock interface and bedrock hydraulic conductivity based on information from the NDWR database, and updates to the model boundary conditions (assigned inflows and outflows) based on the calculated water budget.

As with the previous Golden Valley models, the model was developed using the graphical user interface software program Groundwater Modeling System (GMS) by Aquaveo, Inc., and the MODFLOW-2005 code (Harbaugh 2005) was used to simulate groundwater flow. MODFLOW is a widely accepted, industry-standard groundwater flow code that has been validated by numerous sources.

3.1 Model Domain

The model domain includes the area defined by the boundary of the Golden Valley Aquifer Recharge Program (Figure 2). The model grid horizontal discretization was refined slightly and consists of 195,236 grid cells, each with an area of 50 by 50 feet. The model was updated to include additional bedrock layers to better accommodate the intervals over which the injection wells are screened and to accommodate the depth of the deepest wells in the basin. The updated model consists of four layers:

- Layer 1: Basin Fill – defined by the topographic surface obtained from digital elevation data and the top of bedrock surface; thickness varies throughout the basin (from less than one foot to more than 150 feet) but is thickest in the south and central portions of the basin (approximately 50 to 100 feet thick).
- Layer 2: Bedrock – defined by variable bedrock elevations from an updated interpolation of the bedrock surface, with the bottom elevation calculated as 85 feet below the bedrock surface (i.e., a constant thickness of 85 feet).
- Layer 3: Bedrock – a constant thickness of 275 feet, selected to best represent depths of injection and domestic wells.
- Layer 4: Bedrock – a constant thickness of 225 feet, based on the deepest borings in the basin obtained from the NDWR database.

The interface between the basin fill and bedrock was previously defined using bedrock elevation data from 75 well logs, including the Golden Valley monitoring and injection wells. An additional 140 well logs obtained from the NDWR database were merged with that data set and an updated top of bedrock surface was created (Figure 25). In general, the interface between the basin fill and bedrock occurs at greater depth within the central portion of the basin (approximately 150 feet deep), with the exception of the Gun Streets area, which is elevated due to faulting in this area.

3.2 Temporal Discretization

Two steady-state models were developed to calibrate the hydraulic conductivity distribution, conduct an initial evaluation of the influence of model boundary conditions, and provide a simulated head distribution for the initial conditions in the transient model. The two steady-state scenarios are:

- Natural Conditions: Flow conditions in Golden Valley in the absence of domestic well withdrawals, and natural groundwater discharge at the Peavine inflow boundary without the influence of regional municipal pumping.
- 1991 Conditions: Recharge at 70 percent of normal (see Table 8), natural conditions Peavine inflow adjusted for regional municipal pumping, and domestic well withdrawal based on the number of wells installed by 1991 (adjusted for the additional 55 parcels).

The transient model simulates the groundwater flow budget from 1991 through 2021 and includes two stress periods per year: one representing a wet season from November through April, and one representing a dry season from May through October. Based on review of monthly historical precipitation data, approximately 70 percent of precipitation occurs during the wet season, and 30 percent occurs during the dry season. To be consistent with these typical climatic conditions, the model stress periods simulate conditions from May through October and November through April.

3.3 Hydraulic Properties

The hydraulic conductivity values obtained from the specific capacity calculations and the well recovery analysis from injection well GVI-3 included in Appendix C were used to re-define the bedrock hydraulic conductivity values in the numerical model. The values were adjusted using a standard trial-and-error approach during the steady-state and transient calibrations to provide a better fit to observed groundwater elevations. Figure 26 presents the calibrated hydraulic conductivity distribution. Most of the changes during calibration included decreasing values in the east to reflect steeper hydraulic gradients observed in this area. The calibrated hydraulic conductivity distribution of lower values to the north and east and higher values in the central and western portion of the basin are somewhat consistent with the previous model, however, the hydraulic conductivity values are two to three orders of magnitude greater.

Hydraulic conductivity of the deeper bedrock layer (model layer 4) was initially assigned a value an order of magnitude lower than the interpolated values to represent deeper, less weathered and fractured bedrock. The values were adjusted during calibration to a single value of 0.01 ft/d throughout the layer.

The hydraulic conductivity for the basin fill was also adjusted during the steady-state calibration process using the range of values presented in Table 1 (Harrill 1973). The calibrated value is 6 ft/d.

Vertical anisotropy (the ratio of horizontal to vertical hydraulic conductivity) was modified during calibration from a value of 3 to a value of 10.

Storage coefficients are required for the transient model. The specific yield values for the basin fill and bedrock from the 2017 model were unchanged from the assigned values of 0.02 and 0.001, respectively because they are within range of values for these material types. A specific storage of $1x10^{-6}$, as specified in the Pohll 2019 Lemmon Valley model, was assigned to both the fill and bedrock because it is within range of values considered representative of these materials (Domenico and Mifflin 1965).

3.4 Model Boundary Conditions

The following sections describe how the conceptual model and water budget were used to define the model boundary conditions. These features are identical to the water budget components shown on Figure 21, except for areal recharge zones, which are shown on Figure 27.

3.4.1 Areal Recharge

For the Natural Conditions simulation, the calculated average recharge rate of 205 af/yr was allocated over the basin into four zones consistent with the Barry (1985) isohyetal map and the recharge rates (in ft/d) presented in Table 9.

For the 1991 Conditions simulation, the scaled recharge of 144 af/yr (Table 8) was allocated to the four zones based on the percent contribution of each zone to the total recharge presented in Table 9.

Recharge rates for the transient simulation were assigned by allocating the annual adjusted recharge into a wet season (from November through April) and dry season (from May through October). The total annual adjusted recharge was allocated to the wet and dry seasons each year according to the amount of precipitation that occurred during each six-month period. On average, the allocation was approximately 70 percent during the wet season and approximately 30 percent during the dry season.

As the transient calibration progressed, the zones were further delineated and are shown on Figure 27. With each adjustment to the zones, recharge rates were re-calculated to ensure the total volume assigned each year remained consistent with the water budget.

The adjusted recharge zones from the calibrated transient model were incorporated into the Natural Conditions and 1991 Conditions simulations to ensure the changes did not adversely affect the calibration of these simulations.

3.4.2 Peavine Inflow

Consistent with the previous model, the Peavine Inflow boundary was simulated as a specified flow boundary; however, the values were adjusted each year in the transient simulation as presented on Table 10 to represent the changes in flow across this boundary as a function of municipal pumping. The boundary is shown on Figure 21 and was assigned to model layers 2 and 3 only, because the basin fill materials in this area do not appear to be saturated (based on observations of static water levels in borings and the Pohll 2017 model results), and the deeper bedrock (layer 4) represents more competent bedrock where flow would be minimal. Based on results of the steady-state calibration (discussed below), the mid-range of the calculated Peavine inflow rates from Table 10 were assigned and modified during the transient calibration to better match water level trends.

3.4.3 Injection Wells

As with the 2017 model, the Aquifer Recharge Program injection wells were simulated using the MODFLOW well package and were assigned to model layers consistent with their screened intervals. Reported injection volumes at each well as presented on Table 4 were used and were assigned as a constant rate injected throughout the year. MODFLOW allocates the injected water to each layer according to the layer transmissivity. Injection well GVI-1 is simulated in fill and bedrock (layers 1 and 2), injection well GVI-3 is simulated in bedrock (layers 2 and 3), injection well GVI-4 is simulated in fill and bedrock (layers 1 through 3), and injection well GVI-5 is simulated in bedrock (layer 3).

3.4.4 High School Irrigation

The annual recharge from irrigation of the high school fields and lawn areas was updated with values derived from water usage records obtained from the high school and were adjusted for ET, as described in Section 2.3.1.2. This recharge was simulated with the recharge package. The total annual recharge volumes presented on Table 5 were allocated to each polygon shown on Figure 21, based on its percentage to the total area irrigated. Rates for each polygon were further allocated to wet and dry seasons, assuming more watering occurs during the dry season.

3.4.5 Development Landscaping

Development landscaping recharge was not included in the 2017 model. This component of the water budget was simulated with the recharge package. Each development polygon is shown on Figure 21; the rate of recharge to groundwater for each polygon is as described in Section 2.3.1.3. Each polygon was adjusted for wet and dry seasons assuming more watering occurs during the dry season.

3.4.6 Lemmon Valley Outflow

The Lemmon Valley outflow boundary was updated from a constant head boundary to a time-varying constant head boundary. The head, or groundwater elevation, is set by the user as a constant value that can change with each stress period. The values assigned for each stress period were determined based on an extrapolation of groundwater elevation contours presented on Figures 12 through 15, and by extrapolating groundwater elevations from the Long well, which is the closest well to this boundary.

3.4.7 Domestic Wells

As stated in Section 2.3.2, 501 domestic well records for Golden Valley were found in the NDWR database, but it is likely that an additional 55 parcels have a domestic well. The 55 additional parcels were not added to the model but were instead represented by increasing the withdrawal rate at each of the 501 wells to account for the difference and preserve the calculated water budget. This adjustment does not have a great impact on model results due to the relatively low withdrawal rates. During calibration of the 1991 Conditions model, this adjusted rate (0.18 af/yr per well) was determined to be too high and was lowered by 37 percent to 0.115 af/yr per well.

3.4.8 Golden Valley Park Well

The Golden Valley Park well was assigned to model layers 2 and 3 based on the perforated interval. Rates presented on Table 12 were assigned to dry periods only, when it is likely the well would be used for watering.

3.4.9 Faults

The faults shown on Figure 3 were simulated using the horizontal flow barrier package, which simulates the reduced flow between model grid cells based on a specified conductance value. The conductance values assigned to simulated faults in the 2017 model were used.

4 Model Calibration and Simulation Results

4.1 Steady State

As stated in Section 3.2, two steady-state simulations were performed (Natural Conditions and 1991 Conditions) to calibrate the hydraulic conductivity distribution, conduct an initial evaluation of the influence of model boundary conditions, and to provide a simulated head distribution for the initial conditions in the transient model. The simulated water budgets for these scenarios were defined in Section 3.2 and are presented in Table 13.

Figures 28 and 29 present the simulated groundwater elevations for the basin fill (layer 1) and upper bedrock (layer 2), respectively, under the Natural Conditions scenario. Some areas of the basin fill are not completely saturated; this is consistent with the 2017 model results and is due to the simulated water level falling below the assigned layer 1 bottom elevation. A comparison of the simulated water levels in both units with the natural conditions groundwater elevation map in Harrill 1973 (Figure 10a of this report) indicates a good match between simulated and observed conditions.

Figures 30 and 31 present the simulated groundwater elevations for the basin fill (layer 1) and upper bedrock (layer 2), respectively, under the 1991 Conditions scenario. A comparison of the simulated water levels in both units with the 1991 groundwater elevation contour map (Figure 12) indicates a reasonable match between simulated and observed. Although the contours do not line up perfectly, the hydraulic gradient across the basin, the flow directions, and the simulated groundwater elevations at the available monitoring points provide a reasonable fit. Figures 30 and 31 also include the well locations used to construct Figure 12. Simulated versus observed groundwater elevations at these locations and the goodness-of-fit calibration statistics using these wells (mean error, absolute mean error, and root mean squared error) are presented in Table 14. In general, a good fit is obtained if the errors are within 10 percent of the total groundwater elevation change across the model domain (Anderson et al. 2015). The errors presented in Table 14 are reasonable given that during most years the variability in groundwater elevation across the basin is approximately 100 feet. Figure 32 presents a scatter plot of observed versus simulated groundwater elevations. Most points on Figure 32 fall within an error of plus or minus 10 percent. The steady-state model is considered reasonably calibrated given the match between simulated and observed groundwater elevations and hydraulic gradient across the basin, and the error statistics (Anderson et al. 2015).

4.2 Transient

As discussed in Sections 3.2, 3.3, and 3.4, the hydraulic conductivity and boundary inflows (areal recharge and Peavine inflow) were modified manually using standard trial-and-error techniques during steady-state and transient simulations.

The goals of the transient calibration included preservation of the water budget within calculated ranges for areal recharge and Peavine inflow, ensuring the calculated outflows through the Lemmon Valley outflow boundary were within reasonable range, and providing the best match possible to water level hydrographs for the GVMWs and domestic wells in the monitoring program.

Table 15 presents the simulated annual water budget. Due to the delineation of each year into a wet and dry season, the model simulation begins in May 1991 and ends in May 2022, resulting in differences between the calculated and simulated budgets on a year-to-year basis. Additionally, there are differences between the calculated and simulated results because the initial part of the transient simulation includes the 1991 steady state condition but is only simulated for six months. This results in minor differences that are not considered errors.

The simulated water budget will also differ from the calculated budget because the transient model simulates changes in storage, and these components are added to the total inflow and outflow water budget terms. A comparison between the calculated and simulated budgets indicates the cumulative volume for areal recharge differs by approximately 168 af (a 2.6 percent difference), and the simulated cumulative Peavine inflow is consistent with the mid-range calculated values presented in Table 10. The simulated outflow through the Lemmon Valley outflow boundary is a function of the simulated differences between inflows, well withdrawals, and change in storage; simulated values are within reasonable ranges calculated at the boundary, as presented in Table 3.

Figure 33 presents the simulated cumulative inflow minus cumulative outflow. Comparison to the calculated budget indicates the overall trends are similar, except that the model does not simulate the slight deficit in the early 1990s, and more differences are observed due to calculation of storage terms and variation in simulated outflow through the Lemmon Valley outflow boundary. However, the overall cumulative difference between inflows and outflows for the 31-year period are reasonably consistent, with the simulated value of 2,728 af representing approximately 89 percent of the calculated budget.

Appendix D includes hydrographs with simulated and observed groundwater elevations at 52 domestic monitoring wells (see well locations on Figure 11), the three GVMWs, and the Golden Valley Park well. In general, the model simulates the observed trends reasonably well, including a response to significant wet periods (1995 – 1997 and 2015 – 2019) and the consistent increase in groundwater level from 2005 through 2021. The best fit to these trends and to the magnitude of groundwater elevations occurs in the central portion of the basin (represented by wells Long, Benedict, GVMW3, GVMW4, GVMW5, Dresbach, Adams, Chaves, Knoles, Walsh, Priano). Greater differences between observed and simulated groundwater elevations exist closer to the basin edges, but within each of these areas, trends in groundwater elevations are reasonably consistent. For example (see well locations on Figure 11):

- In the northwestern area, the model over-simulates groundwater elevations on both sides of the simulated fault. However, the Ariaz well provides a somewhat reasonable fit to the observed trends and magnitudes.
- In the east and northeast, the model under-simulates groundwater elevations at the Donshick, Freeman, Thomas, Larkin wells and others, but reasonably matches at nearby wells Dresbach, McNinch, Pendill, Adams, Chaves, and others.
- In the southeast, the model under-simulates groundwater elevations at the Garner well but provides a reasonable match at the Mayo and Mentzer wells.

Matching the magnitude of groundwater elevations and trends at every well in the basin is challenging due to the high degree of variability in fractured bedrock systems, and how MODFLOW, a porous media model, can represent these systems. A review of observed groundwater elevations in all wells used in the study indicates that there is no consistent difference in groundwater elevations based on depth or perforated interval, with some similarly screened wells showing large differences in groundwater elevations, and wells screened over significantly different depths (sometimes up to 100 feet) displaying similar or almost identical water levels. These conditions are likely due to the variable nature of flow within fracture systems, which is a function of individual fracture apertures, orientations, and interconnectedness, which cannot be quantified because fracture details are not provided in the DWR boring logs.

An important aspect of the updated model is that it effectively simulates the observed increasing trend in groundwater elevations throughout the basin that has occurred even after the suspension of the Aquifer Recharge Program. The model simulates this condition because the areal recharge and Peavine inflow boundaries have been assigned in such a way as to simulate the increase in groundwater elevations throughout the basin. The calculated and simulated volumes of water required to match the observed surplus in groundwater storage is much greater than what was added through the combined volume of injected water, high-school irrigation, and development landscaping.

During the steady state and transient calibration, it was determined that the model is most sensitive to the hydraulic conductivity, the assigned rates and distribution of areal recharge, and the rate of change in flow across the Peavine inflow boundary. As with any model, uncertainty in parameter selections and the nature of the inverse solution (inverse in that unknown parameters are adjusted to match observed water levels) leads to model non-uniqueness, where a similar result may be obtained for different values of hydraulic conductivity and recharge. Care was taken to reduce the uncertainty and non-uniqueness by basing the model inputs on a water budget that reasonably represents changing conditions in the basin, and by incorporating hydraulic conductivity values obtained from the 132 specific-capacity tests. While it is true that uncertainty and non-uniqueness exist in the updated model, lower values of recharge would require much lower values of hydraulic conductivity to match observed water levels. Likewise, significant reductions in Peavine inflow would be required and would not lead to a model that can simulate the observed surplus in groundwater storage.

Overall, the model provides a reasonable match to groundwater elevations, trends, and hydraulic gradients, and is therefore considered a useful tool for predicting changes in flow conditions due to changes in natural and anthropogenic influences.

5 Predictive Simulations

Predictive simulations were performed to evaluate the time frame over which groundwater elevations may return to conditions where injection of imported water may be beneficial to the domestic well users of Golden Valley.

Water levels in the basin will decline from reductions in areal recharge, reductions in Peavine inflow, or an increase in domestic withdrawals. If domestic usage remains consistent with current conditions, and the Peavine inflow boundary is no longer influenced by regional municipal pumping, it is likely the only conditions that will significantly lower water levels in the basin are long-term average or drought conditions.

Multiple predictive scenarios were performed to evaluate how water levels in the basin may respond to future climatic conditions that would manifest as changes in recharge from precipitation infiltration and changes in Peavine boundary inflows.

Additional residential developments (31 plots at Golden Mesa South and 115 plots at Golden Mesa North; to be constructed in accordance with low density suburban zoning with lot sizes of approximately 1 acre) are planned for an area in the central portion of the basin and are shown on Figure 34. These developments will be tied into the municipal water and sewer systems. To include these areas in the predictive simulations, landscaping at these plots was assumed to occur in stages over a 5-year period. Recharge from landscaping at these plots was calculated using the same approach as for the existing residential developments. Assumptions made with respect to the 5-year staging should be re-evaluated once construction is complete.

For other anthropogenic sources of recharge, future landscaping at the existing developments was assumed to remain consistent with the values calculated for 2021. Future irrigation of the high-school fields was assigned the average rate based on the available records.

Two scenarios for domestic well use were considered: 1) current use continues at the same rate as 2021, and 2) domestic well users abandon their wells and tie into the municipal water system beginning in 2025. This second scenario is not likely but was considered in order to evaluate higher water level conditions that would occur if domestic well use was suspended.

Four scenarios for areal recharge were considered: 1) all future recharge occurs at the average rate from 2022 through 2051 (205 af/yr), 2) all future recharge occurs as the average of all the below-average years (153 af/yr) from 2022 through 2051 (i.e., a long-term drought condition), 3) all future recharge occurs as the average of the above-average years (272 af/yr) for 2022 through 2051 (i.e., long-term above average, wet conditions), and 4) future recharge is identical to the previous 30 years (i.e., conditions consistent with historical trends from 1991 - 2021).

Future Peavine inflows were adjusted to account for changes in groundwater flow associated with the changing recharge conditions. One scenario assumes regional municipal pumping is resumed and intercepts groundwater that would otherwise flow into Golden Valley. This scenario is not likely; however, it provides an upper bound on how groundwater levels could decline under these conditions.

Table 16 presents a summary of the predictive scenarios, which are as follows:

- **Scenario 1a:** Average recharge (205 af/yr), Peavine inflow specified as the average rate from 2005 – 2021 (average conditions without the influence of municipal pumping), current net domestic withdrawals.
- **Scenario 1b:** As per Scenario 1a, but with domestic use suspended in 2025.
- **Scenario 2a:** The average below-average recharge (153 af/yr), Peavine inflow reduced consistent with the reduction in recharge (approximately 25 percent), current net domestic withdrawals.
- **Scenario 2b:** As per Scenario 2a with domestic use suspended in 2025.
- **Scenario 3a:** The average below-average recharge (153 af/yr), Peavine inflow reduced to simulate minimum inflow that occurred with historical high municipal well pumping, current net domestic withdrawals.
- **Scenario 3b:** As per Scenario 3a with domestic use suspended in 2025.
- **Scenario 4:** The average above-average recharge (272 af/yr), Peavine inflow at the most recent (2021) simulated rate, current net domestic withdrawals.
- **Scenario 5:** Recharge rates consistent with the previous 30 years represented by the water budget, Peavine inflow at the most recent (2021) simulated rate, current net domestic withdrawals.

Figures 35 through 38 present results for the predictive scenarios for well GVMW4 (Figure 35), representative of the central basin; the Ariaz well (Figure 36), representative of the northwest; the Mayo well (Figure 37), representative of southeast; and the McNinch well (Figure 38), representative of the northeast.

At all locations, predicted groundwater elevations are highest in Scenario 4, where above-average recharge conditions are simulated. Additionally, predicted groundwater elevations in Scenario 5, where the 30-year water budget for recharge was repeated remain relatively high as compared to other scenarios.

Results for Scenario 1b, which simulates average climatic conditions with domestic use suspended in 2025, indicate water levels would remain consistent with current conditions through 2050. For this same scenario with current domestic use continued (Scenario 1a), current water levels decline over time by approximately 10 to 15 feet but remain elevated as compared to the early 1990s.

At all locations, the remaining scenarios (1a, 2a, 2b, 3a, and 3b) indicate it would take approximately 20 to 30 years for water levels to equilibrate with the simulated conditions.

At all locations, the greatest water level declines occur with long-term below average recharge and a return to higher historical municipal pumping rates in the Peavine area (scenarios 2a and 3a). Although future climatic conditions are unknown, it is likely unrealistic to assume below-average recharge or above-average recharge would occur consistently over a 30-year period. Regarding flow at the Peavine boundary, the current plan is to continue to rely more heavily on the use of imported water to service residents of the greater Lemmon Valley and, as such, there are no plans to return to higher groundwater withdrawals (personal communication with G. Pohll, June 28, 2022). These two factors indicate that scenario 3a and 3b are unlikely, and that water levels in the basin will equilibrate to higher levels than those observed in the 1980s and early 1990s.

Scenarios where domestic well users abandon their wells and tie into the municipal water system are also unlikely to occur. However, these scenarios were included to conservatively evaluate higher water level conditions that may continue to exacerbate basement flooding and other issues observed in the Gun Streets area. Future modeling and analysis will continue to revisit these scenarios.

Based on this analysis, we do not anticipate groundwater levels to decrease back to levels observed in the 1980s and 1990s, most notably because of the use of imported water to the greater Lemmon Valley area. The less conservative scenarios show high water levels, similar to those observed during the last 20 years, extending out to the year 2050.

6 Conclusions and Recommendations

The following conclusions can be made from the assessment:

- An overall surplus in groundwater storage has occurred since the 1990s. This surplus is a result of a decline in regional municipal extraction allowing for greater inflow from the Peavine area, combined with areal recharge and anthropogenic sources of water that are greater than the net domestic withdrawals and outflow through the Lemmon Valley outflow boundary.
- The total volume of water added to the system since 1991 from anthropogenic sources (injection, irrigation, and landscaping) of approximately 1,352 af is 9 to 11 percent of the calculated and simulated volumes of water added to the basin, respectively (a total of 15,479 af from the calculated water budget [Table 12], and a total of 14,280 af calculated from the simulated water budget [Table 15]).
- Groundwater elevation trends indicate that water levels respond most to multiple periods of above-average wet years (1995 through 1997 and 2015 through 2019) and have been on an overall increasing trend since approximately 2005, coincident with large reductions in regional municipal pumping in the Peavine inflow and Lemmon Valley outflow areas.
- It is likely that water levels will stabilize as a new equilibrium condition with Peavine inflow and Lemmon Valley outflow is reached.

- Shallow groundwater elevations in the Gun Streets area are likely a function of several factors, including the presence of the mapped fault, observed bedrock high, and relatively thin interval of basin fill in this area, which lowers the transmissivity of the basin fill, limiting the amount of water that can flow through the area. Additionally, this location is the lowest topography of the basin, and may be impacted by surface water runoff that may flow through Golden Valley wash.
- Results of predictive simulations indicate that water levels may not decline to levels observed in the 1990s unless long-term drought conditions occur and higher rates of extraction at regional municipal pumping wells are resumed. This scenario is not likely.
- It is unlikely that groundwater recharge will be needed in the basin through the year 2050, unless there are major changes in rainfall and water extraction rates.

The following recommendations regarding the Aquifer Recharge Program are as follows:

- Retain the injection well system infrastructure and maintain the water rights in the event that water levels decline over the long-term to levels observed in the 1980s and early 1990s.
- Ensure a system is in place to track whether regional municipal pumping in the Peavine area or downgradient of the Lemmon Valley outflow boundary is resumed, which would trigger a re-evaluation of water need for the basin.
- Add selected existing domestic or monitoring wells in the Black Springs area to the monitoring program to evaluate flow conditions in this area.
- Consider optimization of the monitoring program network and monitoring frequency to reduce monitoring costs.
- As climatic and/or water usage conditions change, consider an update of the numerical model every five years.
- As the Golden Mesa developments are constructed, it may be useful to conduct a detailed evaluation of localized recharge losses through land development as well as recharge contributions through water collection systems. Likewise, potential impacts from other surface water features in Golden Valley could be evaluated at that time.

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Tables

Table 1
Summary of Hydraulic Conductivity Values from Harrill 1973
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

Material Description	Hydraulic Conductivity (gpd/ft^2)	Hydraulic Conductivity (ft/d)
Valley Fill		
sand	155	21
sand	360	48
sand	52	7.0
sand	45	6.0
sand	47	6.3
sand, gravel, rock	52	7.0
sand	120	16
sand, minor gravel	290	39
sand, minor gravel	25	3.3
sand, minor gravel	21	2.8
sand, gravel	12	1.6
sand, some gravel, clay	160	21
sand	170	23
	Minimum	**1.6**
	Maximum	**48.1**
	Arithmetic Mean:	**15.5**
	Geometric Mean:	**9.9**
Bedrock		
granite	150	20
granite	17	2.2
fractured rhyolite	22	2.9
fractured rhyolite	42	5.6
fractured rhyolite	12	1.6
granite	2	0.32
	Minimum	**0.32**
	Maximum	**20.1**
	Arithmetic Mean:	**5.5**
	Geometric Mean:	**2.7**

Notes:
gpd/ft^2 = gallons per day per square foot
ft/d = feet per day

Table 2
Calculation of Groundwater Discharge, Natural Conditions: Peavine Inflow and Lemmon Valley Outflow
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

			Peavine Inflow					Lemmon Valley Outflow				
				Cross Sectional Area		Discharge			Cross Sectional Area		Discharge	
		Hydraulic Conductivity (ft/d)	Hydraulic Gradient[1] (ft/ft)	Saturated Thickness[2] (ft)	Width[4] (ft)	(ft3/d)	(af/yr)	Hydraulic Gradient[2] (ft/ft)	Saturated Thickness[3] (ft)	Width[4] (ft)	(ft3/d)	(af/yr)
Fill	Mean	15.5	Not Applicable; Fill not saturated in Peavine Area					0.0152	100	650	15,314	**128**
	Geometric Mean	9.9						0.0152	100	650	9,781	**82**
Bedrock	Mean	1.8	0.0072	560	5117	37,137	**311**	0.0152	510	1480	20,651	**173**
	UCL	1.4	0.0072	560	5117	28,884	**242**	0.0152	510	1479	16,051	**135**
	Geometric Mean	1.1	0.0072	560	5117	22,695	**190**	0.0152	510	1480	12,620	**106**
	LCL	0.9	0.0072	560	5117	18,569	**156**	0.0152	510	1480	10,326	**87**
								Total discharge through fill and bedrock, minimum:				**169**
								Total discharge through fill and bedrock, maximum:				**302**

ft/d = feet per day
ft/ft = feet per foot
ft = feet
ft3/d = cubic feet per day
af/yr = acre-feet per year
UCL = 95 percent upper confidence interval
LCL = 95 percent lower confidence interval

Notes:

[1] Hydraulic gradients at each boundary were calculated using Harrill 1973 Figure 7, "Approximate water-level contours for natural conditions", presented as Figure 10a in this report.

[2] Saturated thickness for each unit is based on groundwater elevation contours from Figure 10a and an average bottom elevation of each unit at each boundary obtained from interpolation of the top of bedrock surface (for the fill) and the bottom of the numerical model (for bedrock).

[3] The width for the Peavine cross section was determined from inferred flowlines perpendicular to groundwater elevation contours presented on Figure 10a, and the width for the Lemmon Valley Outflow cross section is the width of the canyon mouth presented on the same figure. The width of the fill unit is narrower than the bedrock width.

Table 3
Calculation of Groundwater Velocity and Travel Time Across the Golden Valley Basin
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

		Hydraulic Conductivity[1] (ft/d)	Hydraulic Gradient[2] (ft/ft)	Porosity	Velocity (ft/yr)	Travel Time Across Basin (yr)	Porosity	Velocity (ft/yr)	Travel Time Across Basin (yr)
Basin Fill	Mean	15.5	0.006	0.1	283	38	0.3	849	13
	Geometric Mean	9.9	0.006		181	59		542	20
Bedrock	Mean	1.8	0.006		60	178		181	59
	LCL	0.9	0.006		22	491		66	164

ft/d = feet per day
ft/ft = feet per foot
ft/yr = feet per year
yr = year
LCL = 95 percent lower confidence interval

Notes:

[1] Hydraulic conductivity of the Basin Fill is the arithmetic mean and geometric mean of the values obtained from Harrill 1973 and presented in Table 1 of this report. Hydraulic conductivity of the Bedrock includes the arithmetic mean and 95% lower confidence interval calculated from specific capacity data presented in Attachment C.

[2] Hydraulic gradient was calculated across the entire basin length (approximately 10,850 feet) using Figure 10a in this report.

Table 4
Reported Injection Volumes
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

Year	Volume of Water Injected per Well (af)					Total Volume of Water Injected per Year (af)
	GVI-1	GVI-2	GVI-3	GVI-4	GVI-5	
1991	0.0	--	--	--	--	0.0
1992	0.0	--	--	--	--	0.0
1993	17.44	8.17	0.86	--	--	26.5
1994	3.20	1.95	--	--	--	5.2
1995	23.97	7.48	1.06	11.81	--	44.3
1996	17.75	--	4.26	40.88	--	62.9
1997	11.86	--	2.38	35.94	--	50.2
1998	0.00	--	0.00	13.98	--	14.0
1999	0.00	--	0.00	0.00	--	0.0
2000	0.00	--	0.00	0.00	--	0.0
2001	0.00	--	0.00	0.00	--	0.0
2002	2.83	--	0.00	9.96	--	12.8
2003	11.51	--	5.00	36.84	10.36	63.7
2004	18.06	--	5.51	43.07	7.99	74.6
2005	17.62	--	6.41	41.94	6.58	72.6
2006	17.29	--	5.96	38.84	6.14	68.2
2007	18.22	--	5.52	39.02	5.60	68.4
2008	18.20	--	4.95	35.80	4.68	63.6
2009	15.15	--	3.96	29.57	3.58	52.3
2010	15.84	--	4.09	31.86	3.51	55.3
2011	9.134	--	2.017	20.02	5.027	36.2
2012	17.977	--	3.815	35.471	8.449	65.7
2013	30.067	--	3.75	40.221	6.706	80.7
2014	25.59	--	2.91	34.84	5.36	68.7
2015	26.08	--	3.24	36.85	5.05	71.2
2016	6.88	--	0.93	10.56	1.49	19.9
2017	--	--	--	--	--	0.0
2018	--	--	--	--	--	0.0
2019	--	--	--	--	--	0.0
2020	--	--	--	--	--	0.0
2021	--	--	--	--	--	0.0
Cumulative:	**325**	**18**	**67**	**587**	**81**	**1,077**
Percent of Total:	**30%**	**2%**	**6%**	**55%**	**7%**	**100%**

Notes:
af = acre-feet

Table 5
Calculation of Recharge to Groundwater from North Valleys High School Irrigation
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

Year	Reported Water Usage (af)	Recharge to Groundwater[1] (af)
2001	--	9.5
2002	--	9.5
2003	--	9.5
2004	--	9.5
2005	85.12	25.1
2006	75.06	15.1
2007	80.89	20.9
2008	87.5	27.5
2009	71.69	11.7
2010	69.42	9.4
2011	56.88	0.0
2012	70.86	10.9
2013	64.9	4.9
2014	67.83	7.8
2015	58.44	0.0
2016	71.02	11.0
2017	57.94	0.0
2018	59.76	0.0
2019	56.65	0.0
2020	76.9	16.9
2021	20.7	0.0
Cumulative:	**1,132**	**199**

Notes:

af = acre-feet

[1] Recharge to groundwater calculated by subtracting the total volume lost to evapotranspiration (60 af/yr). Note that years 2001 through 2004 are assigned the average rate of recharge to groundwater from 2005 through 2021.

Table 6
Calculated Recharge to Groundwater from Development Landscaping
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

Year	Calculated Recharge to Groundwater (af)
2002	1.8
2003	1.8
2004	1.8
2005	1.8
2006	2.4
2007	2.4
2008	2.4
2009	2.6
2010	2.6
2011	2.6
2012	4.9
2013	4.9
2014	4.9
2015	5.5
2016	5.5
2017	5.5
2018	5.5
2019	5.5
2020	5.5
2021	6.4
Cumulative:	**76**

Notes:
af = acre-feet

Table 7

Calculated Annual Inflow from Anthropogenic Sources, 1991 - 2021

Golden Valley Aquifer Recharge Assessment

Golden Valley Subbasin, Washoe County, Nevada

Year	**Inflows (af)**			
	Injection	High School Irrigation	Development Landscaping	Total Anthropogenic Recharge
1991	--	--	--	0.0
1992	--	--	--	0.0
1993	26.5	--	--	26.5
1994	5.2	--	--	5.2
1995	44.3	--	--	44.3
1996	62.9	--	--	62.9
1997	50.2	--	--	50.2
1998	14.0	--	--	14.0
1999	--	--	--	0.0
2000	--	--	--	0.0
2001	--	9.5	--	9.5
2002	12.8	9.5	1.8	24.1
2003	63.7	9.5	1.8	75.0
2004	74.6	9.5	1.8	85.9
2005	72.6	25.1	1.8	99.4
2006	68.2	15.1	2.4	85.7
2007	68.4	20.9	2.4	91.6
2008	63.6	27.5	2.4	93.5
2009	52.3	11.7	2.6	66.5
2010	55.3	9.4	2.6	67.3
2011	36.2	0.0	2.6	38.8
2012	65.7	10.9	4.9	81.5
2013	80.7	4.9	4.9	90.5
2014	68.7	7.8	4.9	81.4
2015	71.2	0.0	5.5	76.7
2016	19.9	11.0	5.5	36.4
2017	--	0.0	5.5	5.5
2018	--	0.0	5.5	5.5
2019	--	0.0	5.5	5.5
2020	--	16.9	5.5	22.4
2021	--	0.0	6.4	6.4
Cumulative:	**1,077**	**199**	**76**	**1,352**

Notes:

af = acre-feet

Table 8

Calculation of Annual Precipitation Scaling Factors and Groundwater Recharge Rates

Golden Valley Aquifer Recharge Assessment

Golden Valley Subbasin, Washoe County, Nevada

Year	Total Precipitation[1] (in)	Precipitation Scaling Factor[2]	Recharge Based on Pohll 2017[3]:			Recharge Based on Barry Isohyetal and Pohll Maximum[4] (af/yr)
			Minimum (af/yr)	Mean (af/yr)	Maximum (af/yr)	
1991	5.15	70.2%	47.7	80.7	120.7	144.1
1992	5.36	73.0%	49.7	84.0	125.6	150.0
1993	6.58	89.6%	61.0	103.1	154.2	184.1
1994	5.20	70.8%	48.2	81.5	121.9	145.5
1995	12.56	171.1%	116.4	196.8	294.3	351.4
1996	12.21	166.3%	113.1	191.3	286.1	341.6
1997	7.75	105.6%	71.8	121.4	181.6	216.8
1998	12.03	163.9%	111.4	188.5	281.9	336.6
1999	4.42	60.2%	40.9	69.3	103.6	123.7
2000	5.71	77.8%	52.9	89.5	133.8	159.7
2001	4.35	59.3%	40.3	68.2	101.9	121.7
2002	7.08	96.5%	65.6	110.9	165.9	198.1
2003	4.58	62.4%	42.4	71.8	107.3	128.1
2004	9.41	128.2%	87.2	147.4	220.5	263.3
2005	9.39	127.9%	87.0	147.1	220.0	262.7
2006	7.17	97.7%	66.4	112.3	168.0	200.6
2007	3.73	50.8%	34.6	58.4	87.4	104.4
2008	6.09	83.0%	56.4	95.4	142.7	170.4
2009	8.25	112.4%	76.4	129.3	193.3	230.8
2010	9.25	126.0%	85.7	144.9	216.8	258.8
2011	4.92	67.0%	45.6	77.1	115.3	137.6
2012	5.77	78.6%	53.5	90.4	135.2	161.4
2013	4.02	54.8%	37.2	63.0	94.2	112.5
2014	4.99	68.0%	46.2	78.2	116.9	139.6
2015	8.52	116.1%	78.9	133.5	199.7	238.4
2016	9.04	123.2%	83.7	141.6	211.8	252.9
2017	13.73	187.1%	127.2	215.1	321.7	384.1
2018	9.26	126.2%	85.8	145.1	217.0	259.1
2019	11.14	151.8%	103.2	174.5	261.0	311.7
2020	2.72	37.1%	25.2	42.6	63.7	76.1
2021	8.39	114.3%	77.7	131.5	196.6	234.7
		Cumulative:	**2,119**	**3,584**	**5,361**	**6,400**

Notes:

in = inches

af/yr = acre-feet per year

[1] Data obtained from the National Oceanic and Atmospheric Administration (NOAA) National Weather Service website at the Reno Airport (https://www.weather.gov/wrh)

[2] Precipitation scaling factors calculated as a percent from the long-term average annual precipitation of 7.34 inches.

[3] The minimum, average, and maximum annual recharge rates of 68, 115, and 172 af/yr, respectively, from Pohll 2017.

[4] Recharge calculated using a combination of the Barry 1985 isohyetal map (Figure 22) and total precipitation with the Pohll 2017 maximum recharge, calculated as 205 af/yr.

Table 9
Calculation of Groundwater Recharge Using Isohyetal Zones for Golden Valley
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

Isohyetal zone[1]	Annual Precipitation Range[2] (in)	Value Used[3] (in)	Value Used (ft)	7.5% of Value[4] (ft/yr)	7.5% of Value[4] (ft/d)	Zone Area (ft2)	Rate (af/yr)	Percent of Total Recharge
4	14+	15	1.25	0.094	2.57E-04	10,746,344	23.1	11.3%
3	12-14	13	1.08	0.081	2.22E-04	45,107,913	84.1	41.0%
2	10-12	11	0.92	0.069	1.88E-04	45,211,738	71.4	34.8%
1	10-	9	0.75	0.056	1.54E-04	20,646,247	26.7	13.0%
						Total:	**205**	

Notes:
in = inches
ft = feet
ft/d = feet per day
ft^2 = square feet
af/yr = acre-feet per year

[1] Zones of precipitation shown on Figure 2 in Barry 1985.

[2] Range in precipitation for each zone shown on Figure 2 in Barry 1985.

[3] Selected value of precipitation for each zone is an assumed average.

[4] The percentage of precipitation assumed to recharge groundwater calculated from total annual precipitation over Golden Valley of 2,300 af (Barry 1985) and a recharge rate of 172 af/yr (Pohll 2017). See the report text for more details.

Table 10
Calculation of Annual Peavine Boundary Inflow Adjusted for Municipal Pumping
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

		Peavine Inflow Adjusted for Municipal Pumping[2] (af/yr)		
		Mean	**Geomean**	**LCL**
Year	**Municipal Pumping[1] (af/yr)**	**311**	**190**	**156**
1991	103	208	87	53
1992	103	208	87	53
1993	103	208	87	53
1994	103	208	87	53
1995	117	194	73	39
1996	126	185	64	30
1997	126	185	64	30
1998	126	185	64	30
1999	119	192	71	37
2000	126	185	64	30
2001	126	185	64	30
2002	32	279	158	124
2003	32	279	158	124
2004	32	279	158	124
2005	32	279	158	124
2006	32	279	158	124
2007	32	279	158	124
2008	32	279	158	124
2009	32	279	158	124
2010	32	279	158	124
2011	32	279	158	124
2012	32	279	158	124
2013	32	279	158	124
2014	32	279	158	124
2015	32	279	158	124
2016	32	279	158	124
2017	32	279	158	124
2018	32	279	158	124
2019	32	279	158	124
2020	32	279	158	124
2021	32	279	158	124
	Cumulative:	**7,726**	**3,975**	**2,921**

Notes:
af/yr = acre-feet per year

[1] Total pumping from municipal wells CMOR1, CMOR2, and SKY as reported in Pohl 2019. Well locations are shown on Figure 2.

[2] The calculated Peavine boundary inflows (mean, geomean, and LCL; see Table 2) adjusted for the Peavine area municipal pumping.

Table 11
Annual Net Domestic Well Withdrawals
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

Year	Number of Wells[1]	Net Annual Domestic Withdrawal[2] (af)
1991	432	78
1992	449	81
1993	465	84
1994	477	86
1995	489	88
1996	496	89
1997	500	90
1998	503	90
1999	507	91
2000	510	92
2001	513	92
2002	522	94
2003	531	96
2004	537	97
2005	547	98
2006	549	99
2007	550	99
2008	551	99
2009	551	99
2010	554	100
2011	554	100
2012	554	100
2013	555	100
2014	555	100
2015	556	100
2016	556	100
2017	556	100
2018	556	100
2019	556	100
2020	556	100
2021	556	100
	Cumulative:	**2,941**

Notes:
af = acre-feet

[1] The number of wells obtained from the NDWR database plus 55 additional parcels not included in the database.

[2] Net domestic withdrawal is based on 0.24 af/yr withdrawal minus 22 percent return flow for 0.18 af/y per well.

Table 12
Calculated Annual Water Budget, 1991 - 2021
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

Year	Inflows (af)							Outflows (af)				Total In Minus Out	Cumulative In Minus Out
	Injection	High School Irrigation	Development Landscaping	Total Anthropogenic Recharge	Recharge	Peavine Inflow	Total Inflow	Domestic Wells	Park Well	Lemmon Valley Outflow	Total Outflow		
1991	--	--	--	0.0	144.1	208	352	78	4.1	302	384	**-31.9**	**-32**
1992	--	--	--	0.0	150.0	208	358	81	4.1	302	387	**-29.0**	**-61**
1993	26.5	--	--	26.5	184.1	208	418	84	4.1	302	390	**28.7**	**-32**
1994	5.2	--	--	5.2	145.5	208	358	86	4.1	302	392	**-33.5**	**-66**
1995	44.3	--	--	44.3	351.4	194	590	88	4.1	302	394	**195.8**	**130**
1996	62.9	--	--	62.9	341.6	185	590	89	4.1	302	395	**194.4**	**325**
1997	50.2	--	--	50.2	216.8	185	452	90	4.1	302	396	**56.1**	**381**
1998	14.0	--	--	14.0	336.6	185	536	90	4.1	302	397	**139.2**	**520**
1999	--	--	--	0.0	123.7	192	316	91	4.1	302	397	**-81.4**	**438**
2000	--	--	--	0.0	159.7	185	345	92	4.1	302	398	**-52.9**	**385**
2001	--	9.5	--	9.5	121.7	185	316	92	4.1	302	398	**-82.1**	**303**
2002	12.8	9.5	1.8	24.1	198.1	279	501	94	4.1	302	400	**101.3**	**405**
2003	63.7	9.5	1.8	75.0	128.1	279	482	96	4.1	302	402	**80.5**	**485**
2004	74.6	9.5	1.8	85.9	263.3	279	628	97	4.1	302	403	**225.5**	**711**
2005	72.6	25.1	1.8	99.4	262.7	279	641	98	4.1	302	404	**236.8**	**948**
2006	68.2	15.1	2.4	85.7	200.6	279	565	99	4.1	302	405	**160.6**	**1,108**
2007	68.4	20.9	2.4	91.6	104.4	279	475	99	4.1	302	405	**70.1**	**1,178**
2008	63.6	27.5	2.4	93.5	170.4	279	543	99	4.1	302	405	**137.8**	**1,316**
2009	52.3	11.7	2.6	66.5	230.8	279	576	99	4.1	302	405	**171.2**	**1,487**
2010	55.3	9.4	2.6	67.3	258.8	279	605	100	4.1	302	406	**199.5**	**1,687**
2011	36.2	0.0	2.6	38.8	137.6	279	456	100	4.1	302	406	**49.7**	**1,736**
2012	65.7	10.9	4.9	81.5	161.4	279	522	100	4.1	302	406	**116.2**	**1,853**
2013	80.7	4.9	4.9	90.5	112.5	279	482	100	4.1	302	406	**76.1**	**1,929**
2014	68.7	7.8	4.9	81.4	139.6	279	500	100	4.1	302	406	**94.2**	**2,023**
2015	71.2	0.0	5.5	76.7	238.4	279	594	100	4.1	302	406	**188.0**	**2,211**
2016	19.9	11.0	5.5	36.4	252.9	279	568	100	4.1	302	406	**162.3**	**2,373**
2017	--	0.0	5.5	5.5	384.1	279	669	100	4.1	302	406	**262.6**	**2,636**
2018	--	0.0	5.5	5.5	259.1	279	544	100	4.1	302	406	**137.5**	**2,773**
2019	--	0.0	5.5	5.5	311.7	279	596	100	4.1	302	406	**190.1**	**2,963**
2020	--	16.9	5.5	22.4	76.1	279	378	100	4.1	302	406	**-28.6**	**2,935**
2021	--	0.0	6.4	6.4	234.7	279	520	100	4.1	302	406	**114.1**	**3,049**
Cumulative:	**1,077**	**199**	**76**	**1,352**	**6,400**	**7,726**	**15,479**	**2,941**	**127**	**9,362**	**12,430**	**3,049**	
Percent of Total:	**7.0%**	**1.3%**	**0.5%**	**8.7%**	**41.3%**	**49.9%**	**--**	**23.7%**	**1.0%**	**75.3%**	**--**		

Notes:

af = acre-feet

[1] The number of wells obtained from the NDWR database plus 55 additional parcels not included in the database.

[2] Net domestic withdrawal is based on 0.24 af/yr withdrawal minus 22 percent return flow for 0.18 af/y per well. See Section 2.3.2.1 for details.

Table 13

Steady State Simulated Water Budgets: Natural Conditions and 1991 Conditions

Golden Valley Aquifer Recharge Assessment

Golden Valley Subbasin, Washoe County, Nevada

	Inflow (af)	Outflow (af)
Natural Conditions		
Peavine Inflow	187	
Areal Recharge	205	
Lemmon Valley Outflow		-392
Total	**394**	**-394**
1991 Conditions		
Peavine Inflow	181	
Areal Recharge	144	
Lemmon Valley Outflow		-276
Domestic Wells		-49
Total	**325**	**-325**

Notes:

af = acre-feet

Table 14
Calibration Statistics, 1991 Conditions Simulation
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

Well Name	Observed Groundwater Elevation[1] (ft msl)	Simulated Groundwater Elevation[2] (ft msl)	Residual[3] (ft)	Absolute Value of Residual (ft)	Residual Squared (ft^2)
Adams	5058.81	5051.53	7.28	7.28	53.05
Bell	5065.86	5048.63	17.23	17.23	296.86
Biggie	5072.13	5048.42	23.71	23.71	561.98
Chavez	5048.68	5048.84	-0.16	0.16	0.03
Dresbach	5047.27	5046.65	0.62	0.62	0.38
Freeman	5088.23	5060.41	27.82	27.82	773.81
GV_Park	5025.77	5039.65	-13.88	13.88	192.67
GV3	5049.77	5046.74	3.03	3.03	9.17
GV4	5035.11	5045.49	-10.39	10.39	107.85
GV5	5035.45	5044.20	-8.76	8.76	76.68
Marshrey	5057.62	5051.44	6.18	6.18	38.20
McNinch	5083.89	5093.19	-9.30	9.30	86.45
Mentzer	5076.26	5073.69	2.57	2.57	6.59
Pendill	5072.13	5071.28	0.85	0.85	0.73
Powell_(Kaspar)	5027.02	5047.27	-20.25	20.25	410.06
Priano_(Harcinske)	5042.44	5045.55	-3.11	3.11	9.65
Steadman	5036.79	5047.99	-11.20	11.20	125.48
35993	5020.19	5029.22	-9.03	9.03	81.56
36249	5024.13	5010.42	13.72	13.72	188.21
36672	5046.18	5047.68	-1.50	1.50	2.24
37216	5052.54	5047.10	5.43	5.43	29.53
37238	5058.69	5056.44	2.25	2.25	5.08
37609	5037.36	5046.09	-8.73	8.73	76.19
37614	5036.67	5033.28	3.39	3.39	11.47
37617	5060.32	5046.86	13.46	13.46	181.26

Calibration Statistics:	
Mean Error:	1.25
Mean Absolute Error:	8.95
Root Mean Squared Error:	11.53

Notes:
ft msl = feet above mean sea level
ft = feet
ft^2 = feet squared

[1] Observed groundwater elevation measured in 1991. Note the groundwater elevation for wells with numeric names are static water levels obtained from wells installed in 1991 according to the DWR Well Database.
[2] Steady state simulated groundwater elevation at the well location.
[3] The residual is the observed minus simulated groundwater elevation. Positive values indicate the model is undersimulating and negative values indicate the model is oversimulating.

Table 15
Simulated Annual Water Budget, 1991 - 2021
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

Year[1]	Inflows (af)								Outflows (af)					Total In Minus Out	Cumulative In Minus Out
	Injection	High School Irrigation	Development Landscaping	Total Anthropogenic Recharge	Recharge	Peavine Inflow	Storage In	Total Inflow	Domestic Wells	Park Well	Lemmon Valley Outflow	Storage Out	Total Outflow		
1991	--	--	--	0.0	137.8	126.6	0.0	264	46.5	4.1	213.8	0.0	264	**0.0**	**0**
1992	--	--	--	0.0	172.3	129.9	47.5	350	48.0	4.1	206.3	3.6	262	**87.7**	**88**
1993	26.5	--	--	26.5	164.5	111.0	47.6	350	50.0	4.1	214.4	14.1	283	**66.9**	**155**
1994	5.2	--	--	5.2	190.8	118.2	65.6	380	51.5	4.1	213.9	20.9	290	**89.3**	**244**
1995	44.3	--	--	44.3	308.4	98.8	163.7	615	53.0	4.1	230.7	0.0	288	**327.5**	**571**
1996	62.9	--	--	62.9	294.1	90.4	141.3	589	54.3	4.1	247.6	0.0	306	**282.6**	**854**
1997	50.2	--	--	50.2	272.1	79.8	83.2	485	54.6	4.1	260.2	0.0	319	**166.4**	**1,020**
1998	14.0	--	--	14.0	280.4	77.0	55.6	427	55.0	4.1	271.2	14.6	345	**82.1**	**1,103**
1999	--	--	--	0.0	144.6	75.4	0.1	220	55.5	4.1	258.5	98.3	416	**-196.3**	**906**
2000	--	--	--	0.0	113.4	74.5	0.1	188	56.0	4.1	240.5	112.8	413	**-225.4**	**681**
2001	--	9.5	--	9.5	95.0	76.4	0.6	181	56.2	4.1	217.3	97.2	375	**-193.3**	**488**
2002	12.8	9.5	1.8	24.1	158.8	81.8	5.5	270	56.8	4.1	209.0	10.8	281	**-10.7**	**477**
2003	63.7	9.5	1.8	75.0	194.4	71.9	75.9	417	58.0	4.1	203.6	0.3	266	**151.2**	**628**
2004	74.6	9.5	1.8	85.9	243.6	73.4	127.4	530	58.9	4.1	212.5	0.0	276	**254.8**	**883**
2005	72.6	25.1	1.8	99.4	267.5	78.8	152.5	598	59.9	4.1	229.3	0.0	293	**305.0**	**1,188**
2006	68.2	15.1	2.4	85.7	194.4	88.9	94.3	463	60.4	4.1	244.8	34.6	344	**119.5**	**1,308**
2007	68.4	20.9	2.4	91.6	154.0	95.8	47.2	389	60.6	4.1	242.8	13.2	321	**68.0**	**1,376**
2008	63.6	27.5	2.4	93.5	153.4	106.6	46.9	401	60.9	4.1	248.6	6.9	320	**80.1**	**1,456**
2009	52.3	11.7	2.6	66.5	252.1	123.1	117.9	560	60.8	4.1	259.0	0.0	324	**235.8**	**1,691**
2010	55.3	9.4	2.6	67.3	271.8	125.0	120.8	585	60.9	4.1	278.3	0.0	343	**241.6**	**1,933**
2011	36.2	0.0	2.6	38.8	177.8	152.0	31.8	400	61.1	4.1	295.0	23.5	384	**16.6**	**1,950**
2012	65.7	10.9	4.9	81.5	110.5	155.1	6.9	354	61.3	4.1	295.5	20.8	382	**-27.7**	**1,922**
2013	80.7	4.9	4.9	90.5	151.5	168.1	43.8	454	61.2	4.1	302.4	1.4	369	**84.8**	**2,007**
2014	68.7	7.8	4.9	81.4	159.6	195.0	56.9	493	61.3	4.1	315.0	1.2	382	**111.4**	**2,118**
2015	71.2	0.0	5.5	76.7	259.1	201.7	132.9	670	61.3	4.1	339.2	0.0	405	**265.8**	**2,384**
2016	19.9	11.0	5.5	36.4	363.5	223.9	178.0	802	61.6	4.1	380.2	0.0	446	**356.0**	**2,740**
2017	--	0.0	5.5	5.5	289.9	233.1	79.3	608	61.4	4.1	409.3	25.4	500	**107.6**	**2,847**
2018	--	0.0	5.5	5.5	333.1	233.1	87.6	659	61.4	4.1	419.2	0.7	485	**173.9**	**3,021**
2019	--	0.0	5.5	5.5	225.3	233.1	37.2	501	61.4	4.1	427.8	66.5	560	**-58.8**	**2,963**
2020	--	16.9	5.5	22.4	94.7	233.7	0.0	351	61.6	4.1	407.8	122.7	596	**-245.3**	**2,717**
2021	--	0.0	6.4	6.4	199.5	233.1	3.3	442	61.4	4.1	396.0	25.8	487	**-44.9**	**2,672**
2022		0.0	0.0	0.0	139.9	115.59	27.7	283	30.4	0.00	197.4	0.0	228	**55.2**	**2,728**
Cumulative:	**1,077**	**199**	**76**	**1,352**	**6,568**	**4,281**	**2,079**	**14,280**	**1,823**	**127**	**8,887**	**715**	**11,552**	**2,728**	
Percent of Total:	**7.5%**	**1.4%**	**0.5%**	**9.5%**	**46.0%**	**30.0%**	**14.6%**	**--**	**15.8%**	**1.1%**	**76.9%**	**6.2%**	**--**		

Notes:

af = acre-feet

[1] The number of wells obtained from the NDWR database plus 55 additional parcels not included in the database.

[2] Net domestic withdrawal is based on 0.24 af/yr withdrawal minus 22 percent return flow for 0.18 af/y per well. See Section 2.3.2.1 for details.

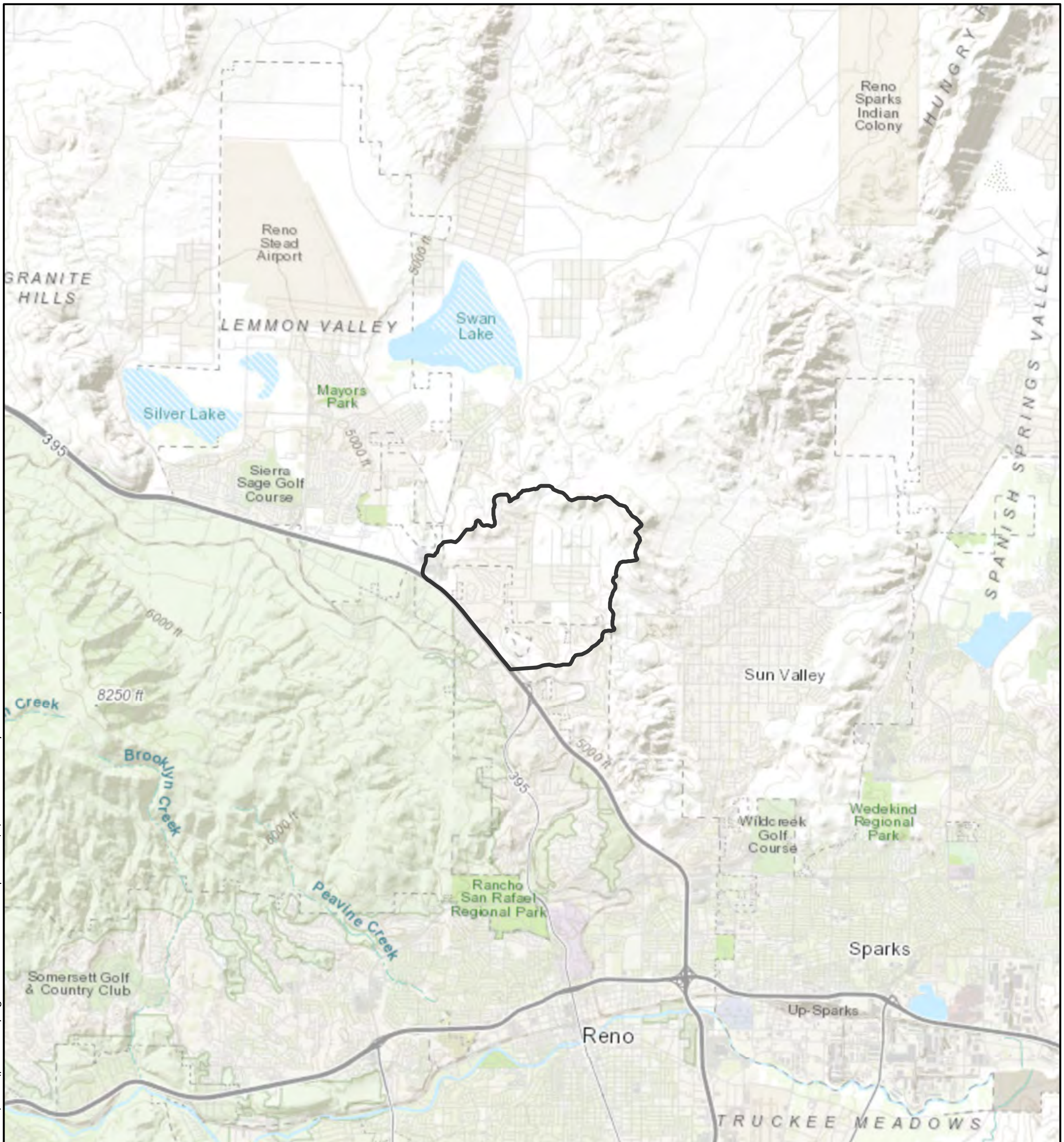
Table 16
Summary of Predictive Simulations
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

	Description		
Predictive Scenario	**Recharge**	**Peavine**	**Domestic**
Scenario 1a	Average = 205 af/yr	Average rate from 2005 - 2021	Current
Scenario 1b			None
Scenario 2a	Below Average Average = 153 af/yr	Average rate reduced by ~ 25% [1]	Current
Scenario 2b			None
Scenario 3a	Below Average Average = 153 af/yr	Lowest rate due to highest municipal	Current
Scenario 3b			None
Scenario 4	Above Average Average = 272 af/yr	Current	Current
Scenario 5	30-Year Repeat (1991 - 2021)	Current	Current

af/yr = acre-feet per year

Note:
[1] Reduction is consistent with the reduction in recharge as compared to Scenario 1 (153/205 = 0.75).

Figures



0 5,000 10,000 15,000 20,000 Feet

1 inch = 10,000 feet

N

Legend

Aquifer Recharge Program Boundary

Base Map: ESRI World Topographic Map
(data providers include HERE, Garmin, USGS, et al.)

SAFETY FIRST

terraphase engineering

CLIENT:	Washoe County Engineering and Capital Projects
PROJECT:	Golden Valley Aquifer Recharge Assessment - Golden Valley, NV
PROJECT NUMBER:	N022.001.001

Golden Valley Basin Location Map

FIGURE 1

File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\(20221207) Figure 1 - Site Location Map.mxd 12/7/2022 Created by: Resource Coordinate System: NAD 1983 StatePlane Nevada West FIPS 2703 Feet

Aerial Imagery Source: Nearmap, June 1st, 2022

0 850 1,700 3,400 Feet

1 inch = 1,700 feet

N

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CLIENT: Washoe County Engineering and Capital Projects

PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV

PROJECT NUMBER: N022.001.001

Golden Valley Aquifer Recharge Program Boundary

FIGURE 2

File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\(20221207) Figure 2 - Aquifer Boundary.mxd 12/8/2022 Created by: Resource Coordinate System: NAD 1983 StatePlane Nevada West FIPS 2703 Feet

File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\F2_Geologic Cross-Section Location Map.mxd 12/8/2022 Created by: Resource Coordinate System: NAD 1983 StatePlane Nevada West FIPS 2703 Feet

Aerial Imagery Source: Nearmap, June 1st, 2022

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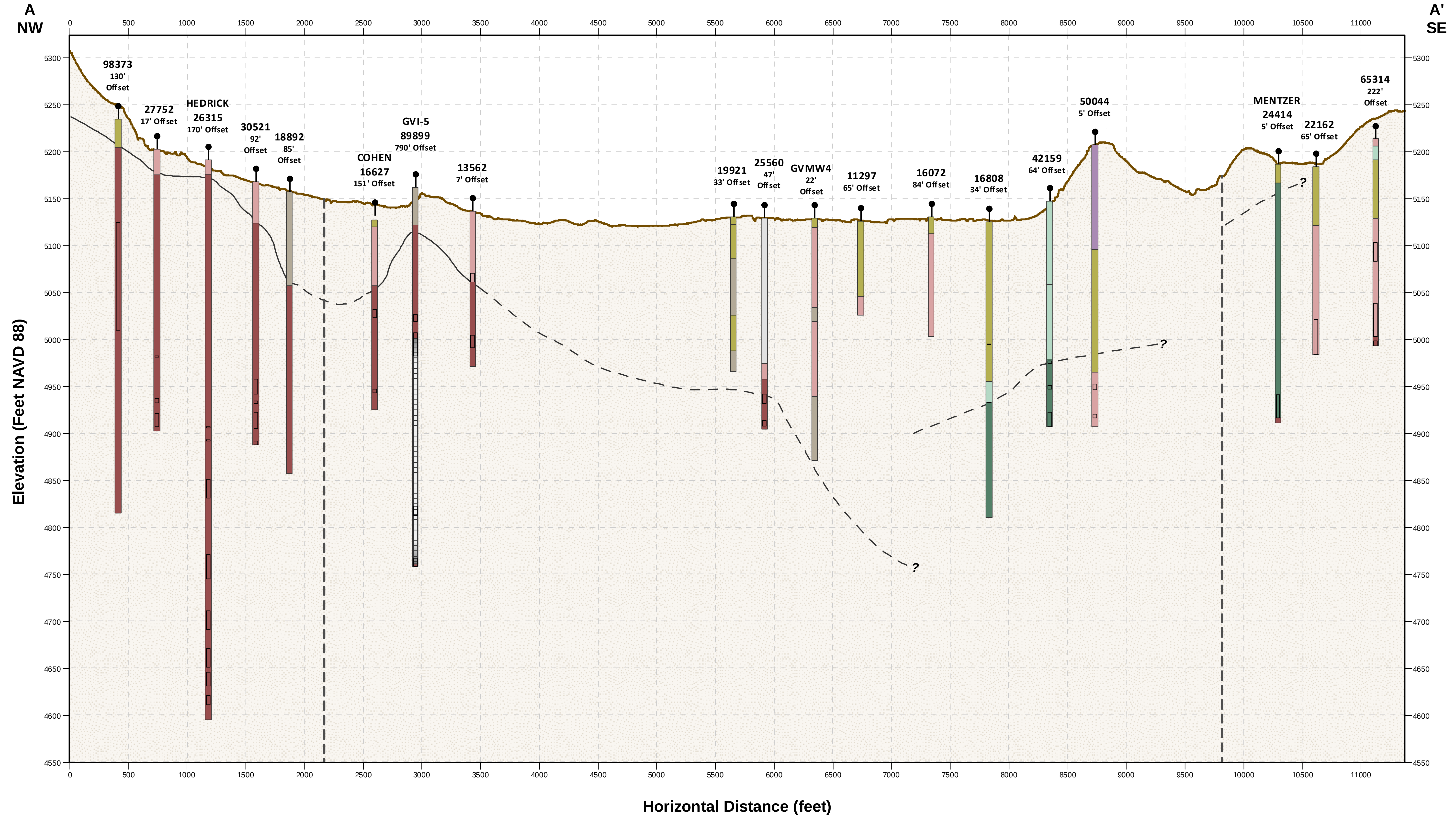
CLIENT: Washoe County Engineering and Capital Projects

PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV

PROJECT NUMBER: N022.001.002

Geologic Cross Section Location Map

FIGURE 3



Legend

- Well Screen
- Fractures Noted in Boring

Boring Lithology

- Andesite
- Decomposed Andesite
- Clay
- Granite
- Decomposed Granite
- Rhyolite
- Sand/Gravel
- Blank
- Fault
- Top Of Rock - Dashed Where Inferred

0 400 800 1,600 Feet

Vertical Exaggeration = 8X

1 inch = 800 feet

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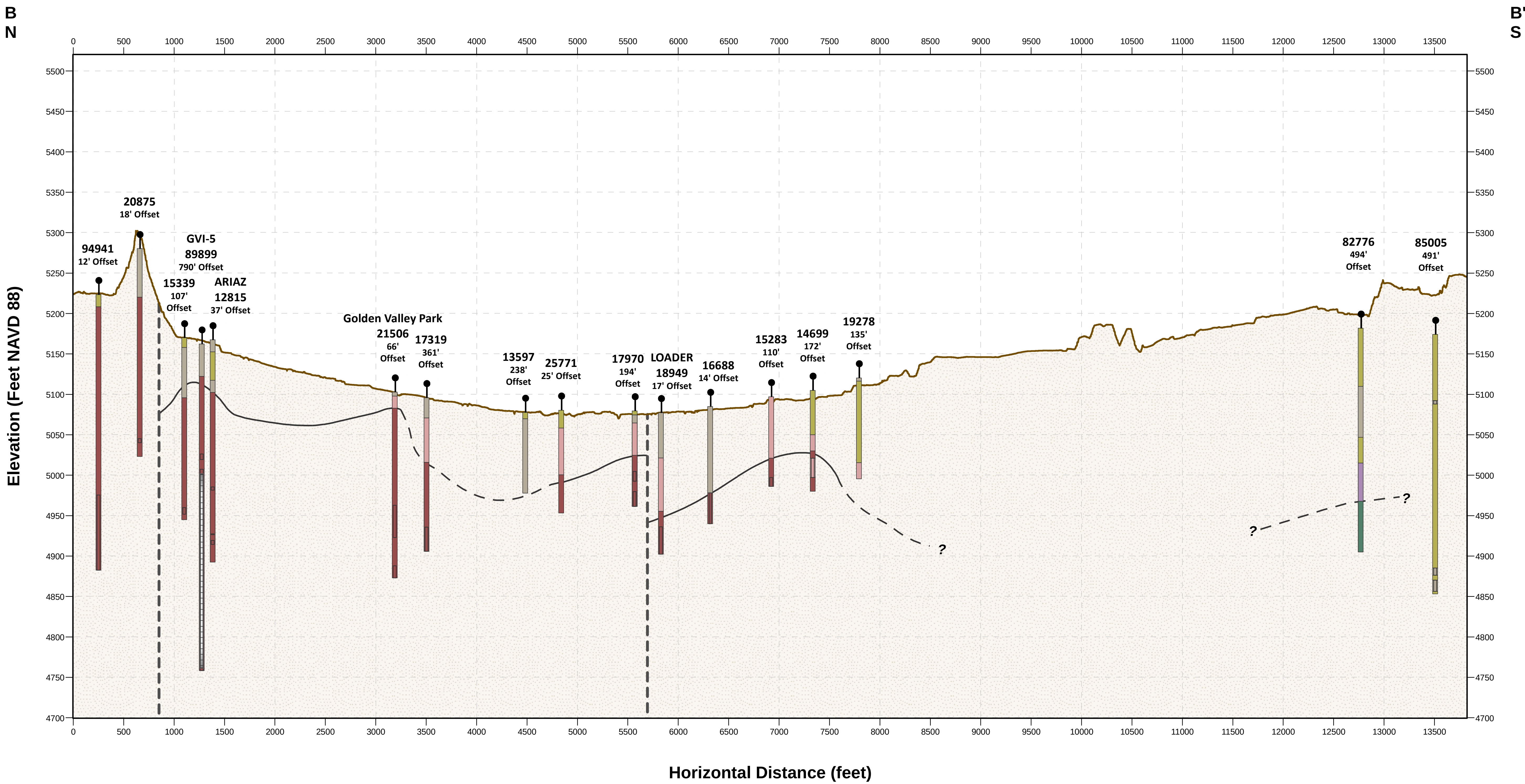
CLIENT:	Washoe County Engineering and Capital Projects
PROJECT:	Golden Valley Aquifer Recharge Assessment Golden Valley, NV
PROJECT NUMBER:	N022.001.001

Cross Section A-A'

FIGURE 4

File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\F3_Geologic Cross-Section A-A'.mxd 2/24/2023 Created by: BKO Checked by: TR



Legend

Fractures Noted in Boring

Well Screen

Boring Lithology

- Andesite
- Clay
- Granite
- Decomposed Granite
- Rhyolite
- Sand/Gravel
- Fault
- Top Of Rock - Dashed Where Inferred

0 500 1,000 2,000 Feet

Vertical Exaggeration = 8X

1 inch = 1,000 feet

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CLIENT: Washoe County Engineering and Capital Projects

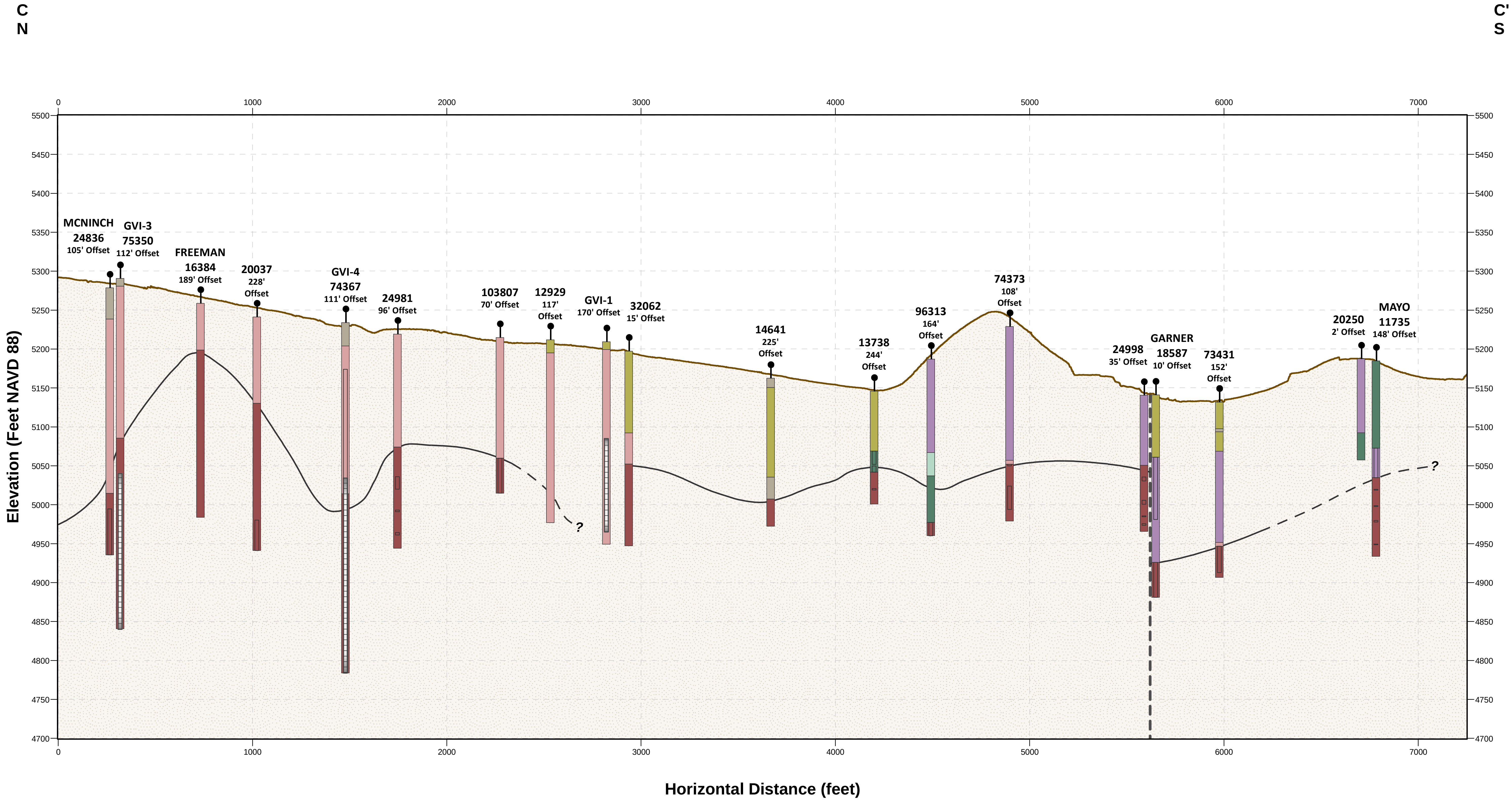
PROJECT: Golden Valley Aquifer Recharge Assessment Golden Valley, NV

PROJECT NUMBER: N022.001.001

Cross Section B-B'

FIGURE 5

File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\F4_Geologic Cross-Section B-B'.mxd 12/7/2022 Created by: BKO Checked by: DM Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet



File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\F5_Geologic Cross-Section C-C'.mxd 12/7/2022 Created by: BKO Checked by: DM Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet

Legend

- Fractures Noted in Boring
- Well Screen

Boring Lithology

- Andesite
- Decomposed Andesite
- Clay
- Granite
- Decomposed Granite
- Rhyolite
- Sand/Gravel
- Fault
- Top Of Rock - Dashed Where Inferred

0 250 500 1,000 Feet

Vertical Exaggeration = 4X

1 inch = 500 feet

SAFETY FIRST

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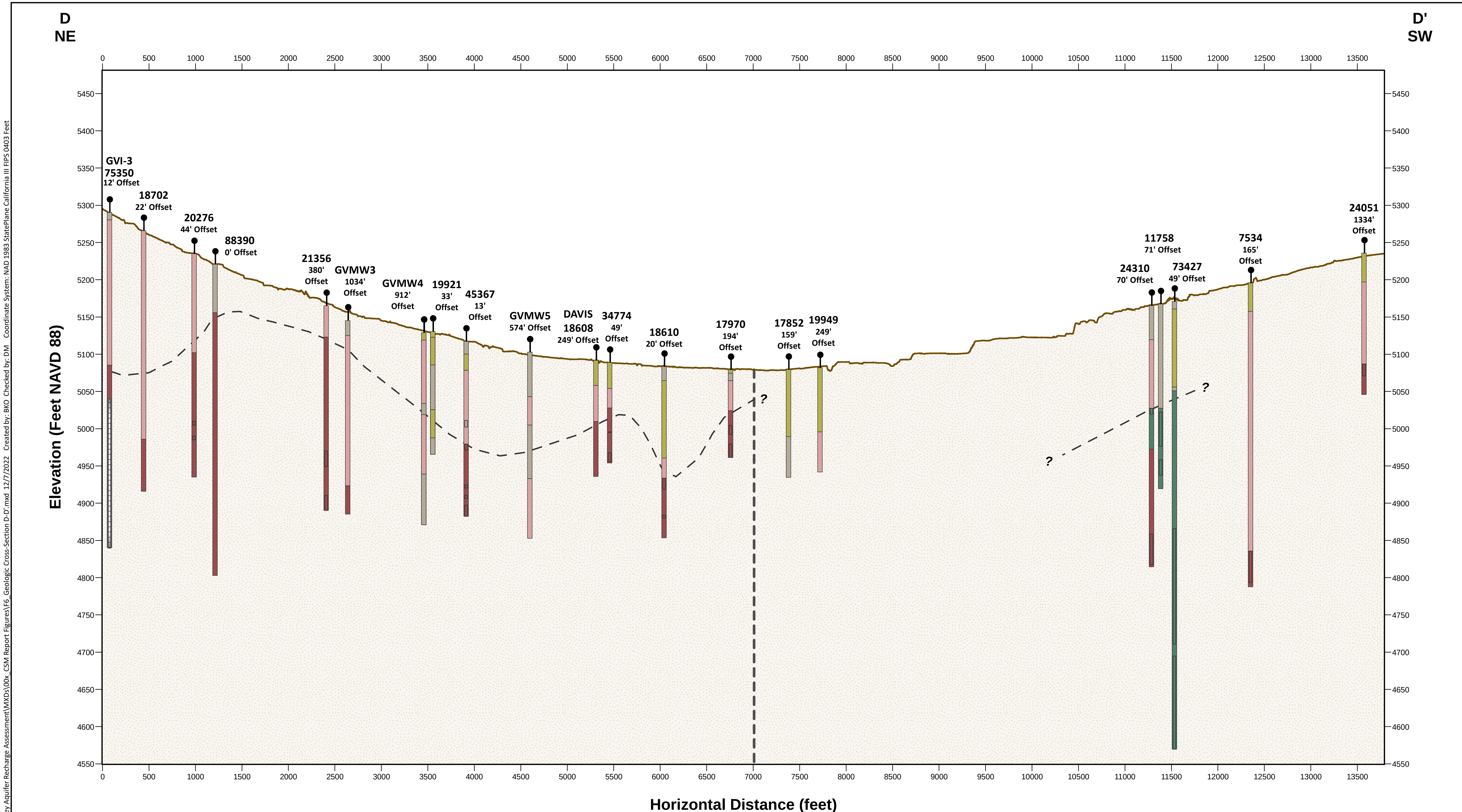
CLIENT:	Washoe County Engineering and Capital Projects
PROJECT:	Golden Valley Aquifer Recharge Assessment Golden Valley, NV
PROJECT NUMBER:	N022.001.001

Cross Section C-C'

FIGURE 6



Legend

Fractures Noted in Boring
Well Screen

Boring Lithology

Andesite
Clay
Granite
Decomposed Granite
Sand/Gravel
Fault
Top Of Rock - Dashed Where Inferred

0 500 1,000 2,000 Feet

Vertical Exaggeration = 8X

1 inch = 1,000 feet

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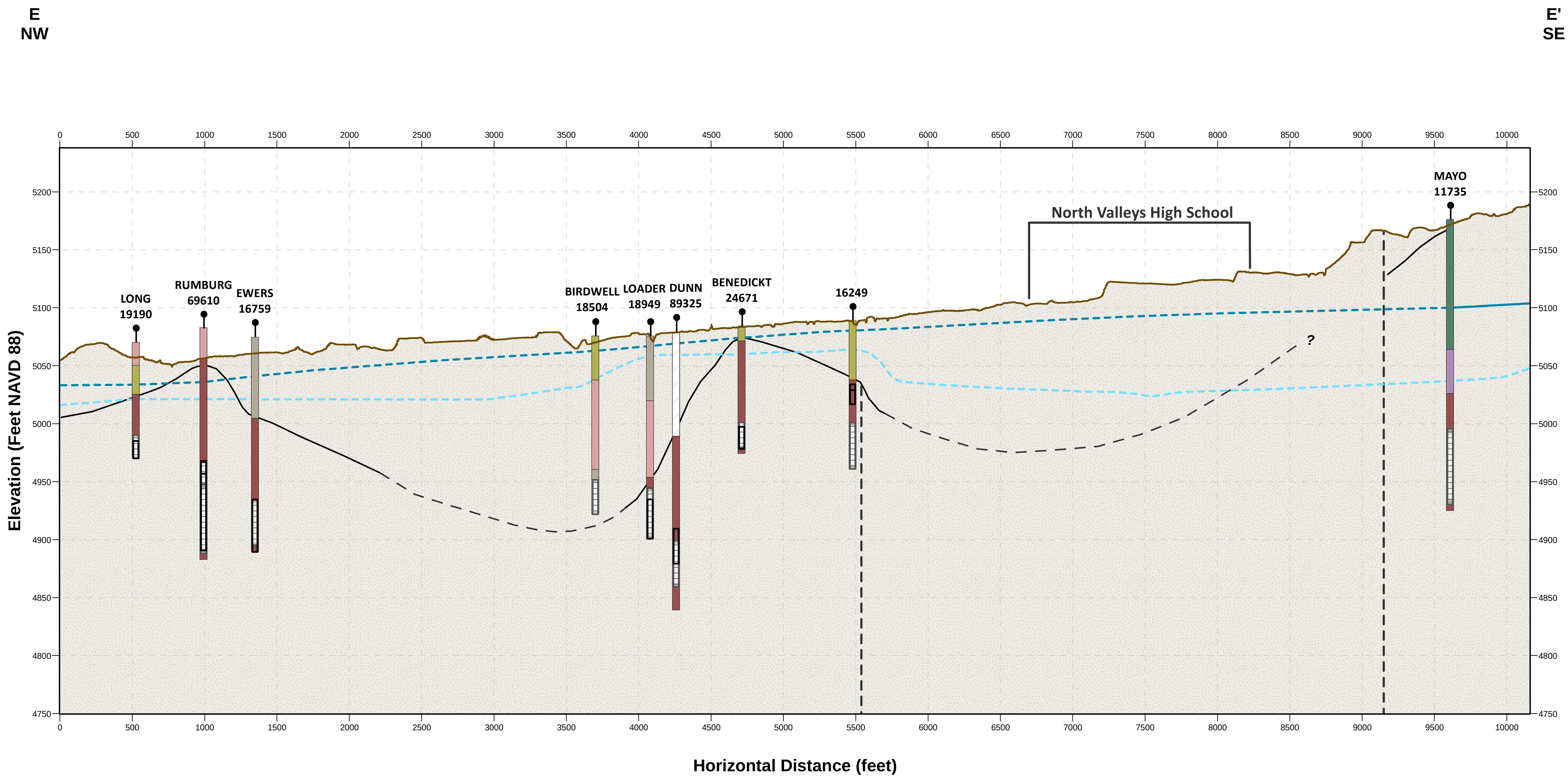
CLIENT:	Washoe County Engineering and Capital Projects
PROJECT:	Golden Valley Aquifer Recharge Assessment Golden Valley, NV
PROJECT NUMBER:	N022.001.001

Cross Section D-D'

FIGURE 7



Legend

- Well Screen
- Fractures Noted in Boring
- March 2021 Water Level Contours
- Summer 2005 Water Level Contours
- Top of Rock - Dashed Where Inferred
- Fault

Boring Lithology

- Andesite
- Clay
- Granite
- Decomposed Granite
- Rhyolite
- Sand/Gravel
- Blank

0 350 700 1,400 Feet

Vertical Exaggeration = 8X

1 inch = 700 feet

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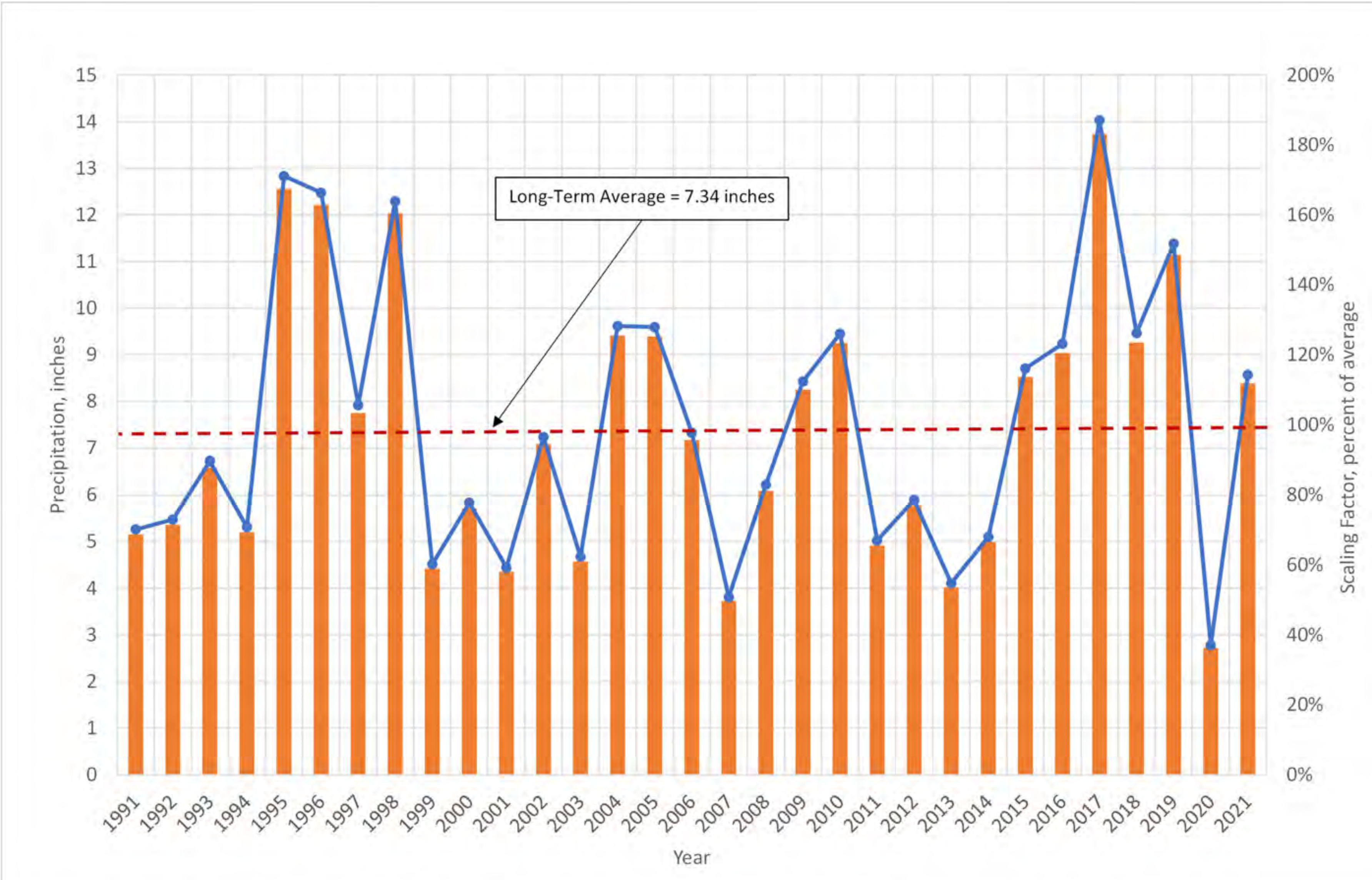
CLIENT:	Washoe County Engineering and Capital Projects
PROJECT:	Golden Valley Aquifer Recharge Assessment Golden Valley, NV
PROJECT NUMBER:	N022.001.001

Cross Section E-E'

FIGURE 8

File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\F7_Geologic Cross-Section E-E'.mxd 12/8/2022 Created by: BKO Checked by: DM Coordinate System: NAD 1983 StatePlane Nevada West FIPS 2703 Feet



Notes:
Long-term average annual precipitation = 7.34 inches (1937 through 2022).

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CLIENT: Washoe County Engineering and Capital Projects

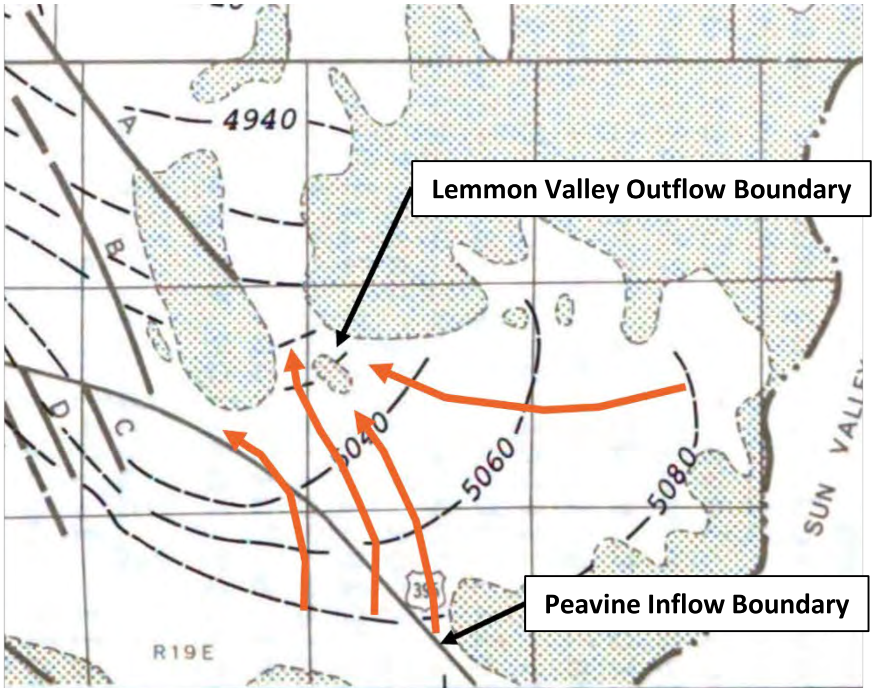
PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV

PROJECT NUMBER: N022.001.001

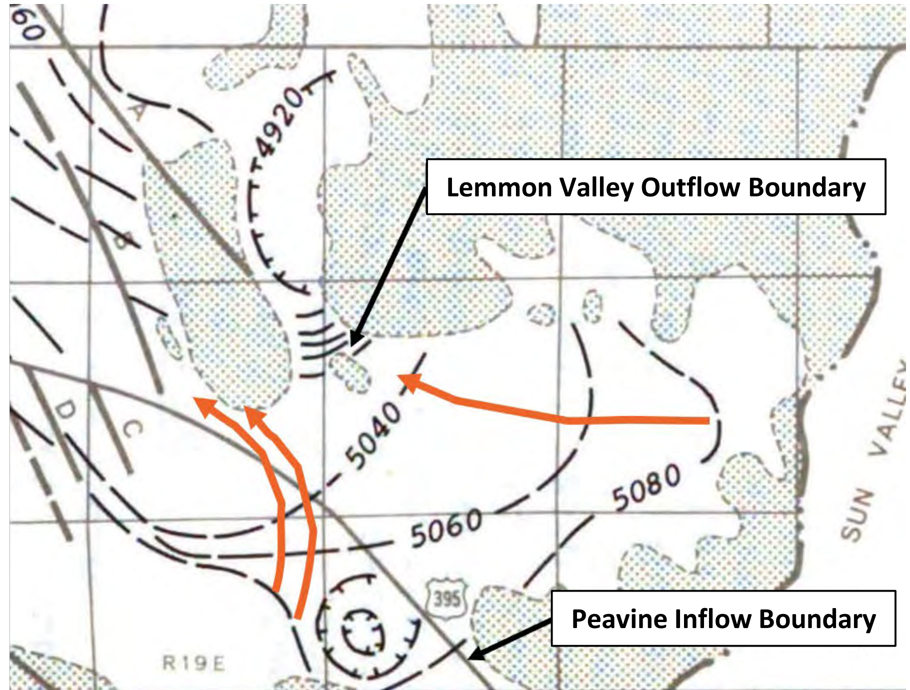
Annual Precipitation
Reno Airport
1991 - 2021

FIGURE 9

File: N:\GIS\Utilities\ArcMap Templates\Precipitation.mxd 11/18/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet



Natural Conditions
Panel 10a



Spring 1971
Panel 10b

Legend

Flow Line

Note: Images adapted from Harrill 1973. Panel 10a shows groundwater elevation contours under natural conditions (no domestic or municipal pumping). Panel 10b shows the influence of municipal pumping in the Black Springs/Peavine area and in the Lemmon Valley outflow canyon.

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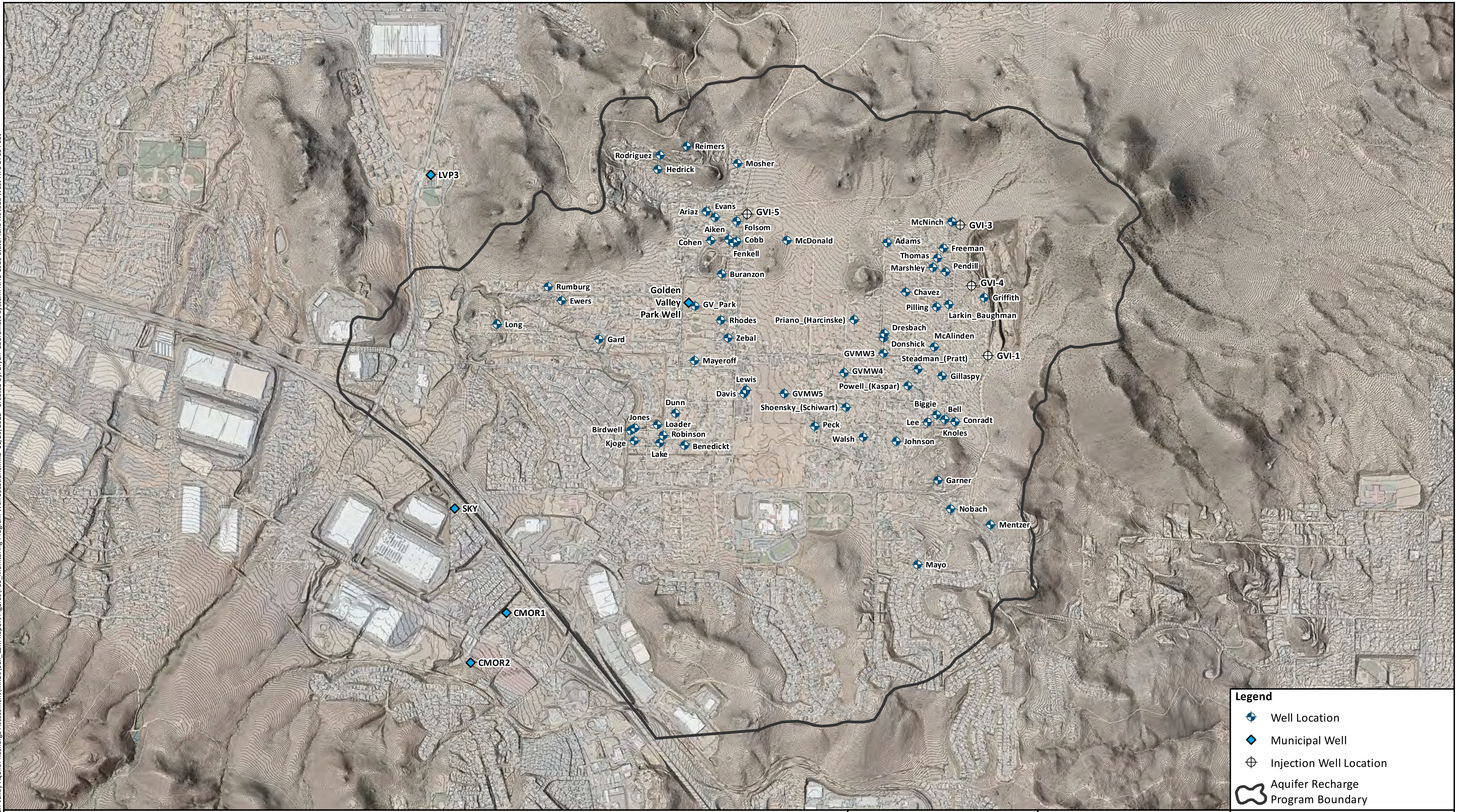
CLIENT: Washoe County Engineering and Capital Projects

PROJECT: Golden Valley Aquifer Recharge Assessment – Golden Valley, NV

PROJECT NUMBER: N022.001.002

Comparison of Groundwater Elevations and Flow: Natural Conditions and Spring 1971

FIGURE 10



File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\F10_Monitoring Program Well Locations.mxd 11/29/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane Nevada West FIPS 2703 Feet

Aerial Imagery Source: Nearmap, June 1st, 2022

0 850 1,700 3,400 Feet

1 inch = 1,700 feet

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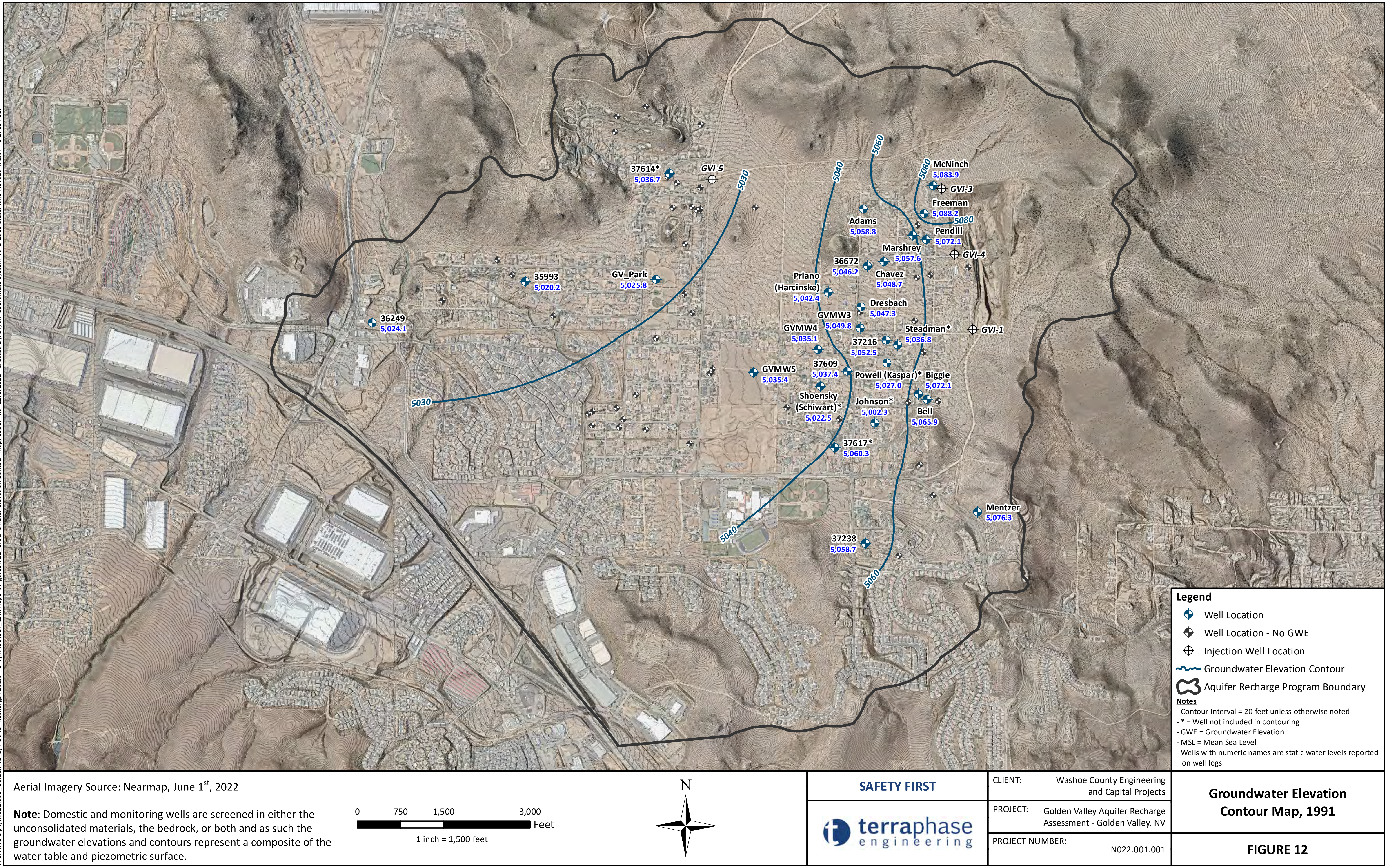
CLIENT:	Washoe County Engineering and Capital Projects
PROJECT:	Golden Valley Aquifer Recharge Assessment - Golden Valley, NV
PROJECT NUMBER:	N022.001.001

Monitoring Program Well Locations

FIGURE 11



File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\F11_Groundwater Elevation Contour Map, 1991.mxd 12/6/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane Nevada West FIPS 2703 Feet

Aerial Imagery Source: Nearmap, June 1st, 2022

Note: Domestic and monitoring wells are screened in either the unconsolidated materials, the bedrock, or both and as such the groundwater elevations and contours represent a composite of the water table and piezometric surface.

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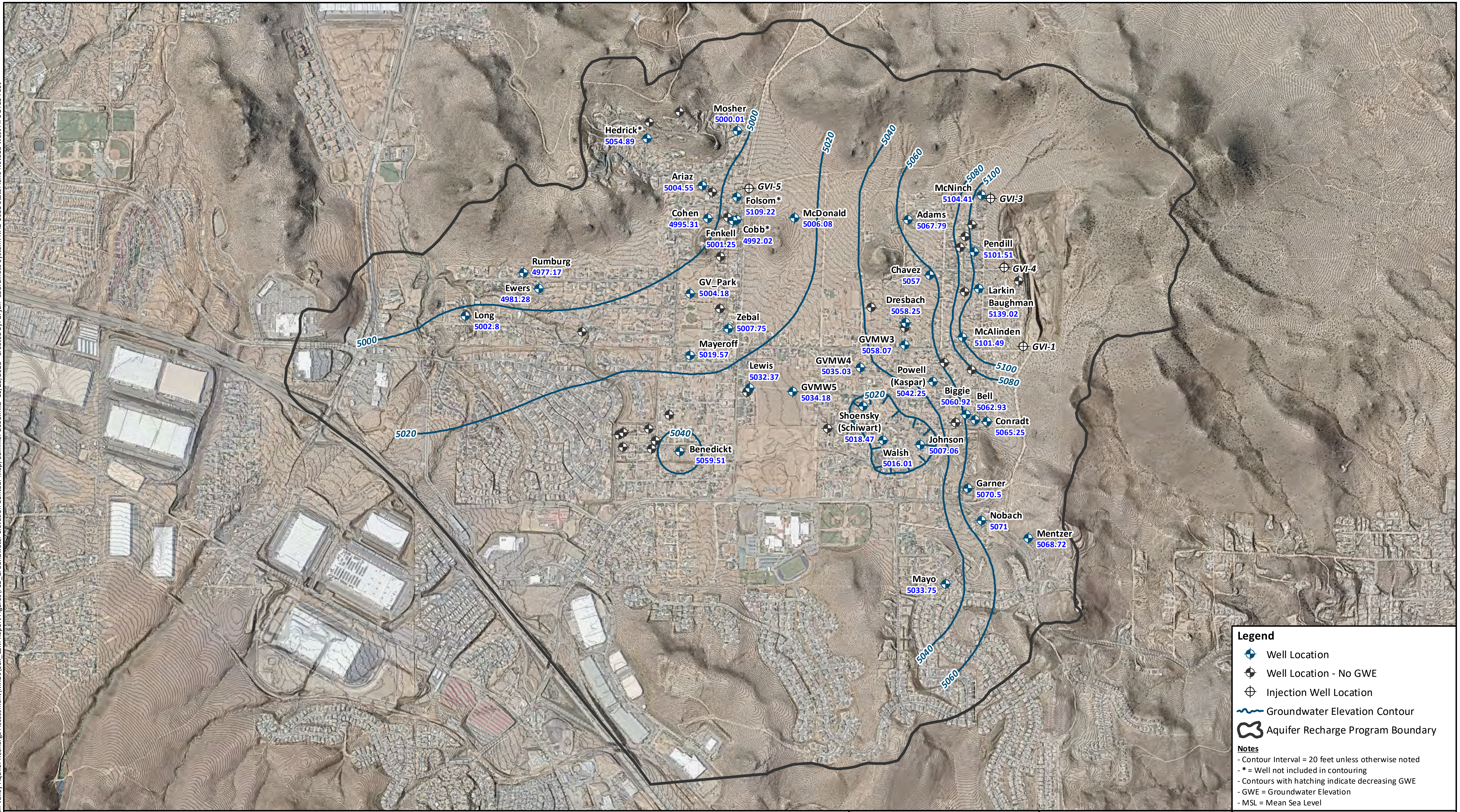
CLIENT:	Washoe County Engineering and Capital Projects
PROJECT:	Golden Valley Aquifer Recharge Assessment - Golden Valley, NV
PROJECT NUMBER:	N022.001.001

Groundwater Elevation Contour Map, 1991

FIGURE 12



File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\F12_Groundwater Elevation Contour Map, Summer 2005.mxd 11/28/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane Nevada West FIPS 2703 Feet

Aerial Imagery Source: Nearmap, June 1st, 2022

Note: Domestic and monitoring wells are screened in either the unconsolidated materials, the bedrock, or both and as such the groundwater elevations and contours represent a composite of the water table and piezometric surface.

0 750 1,500 3,000 Feet

1 inch = 1,500 feet

N

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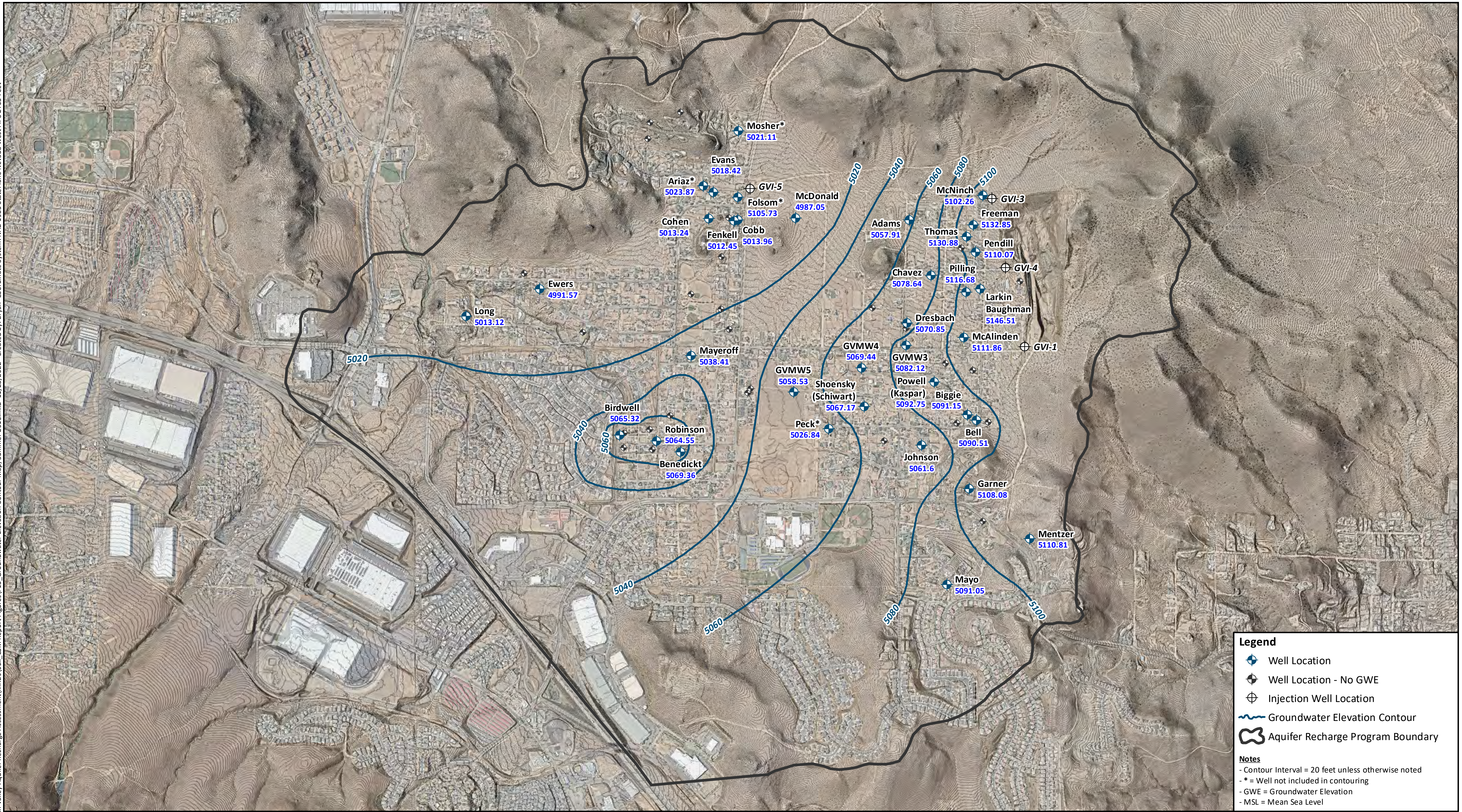
CLIENT: Washoe County Engineering and Capital Projects

PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV

PROJECT NUMBER: N022.001.001

Groundwater Elevation Contour Map, Summer 2005

FIGURE 13



File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\F13_Groundwater Elevation Contour Map, Summer 2015.mxd 11/28/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane Nevada West FIPS 2703 Feet

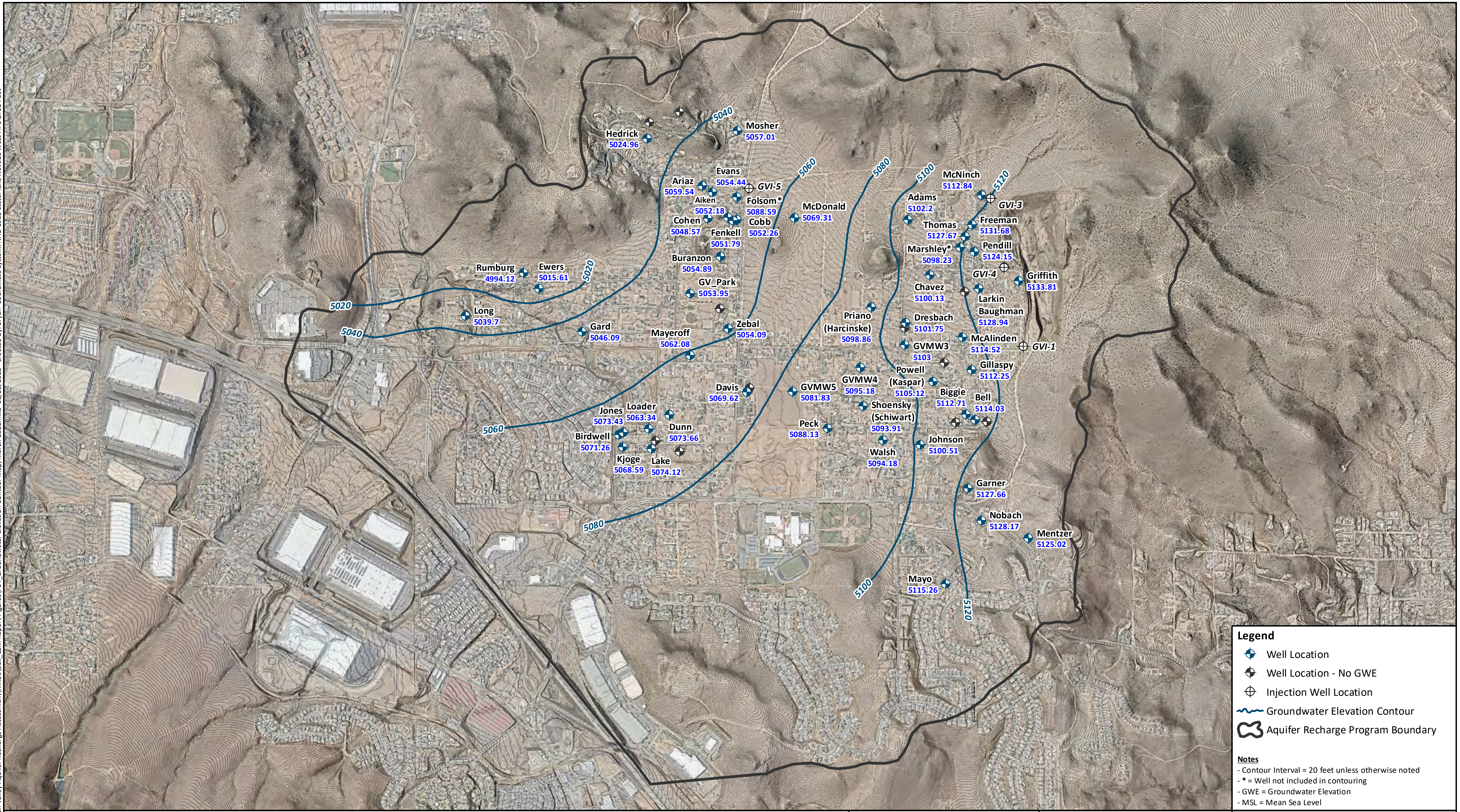
Aerial Imagery Source: Nearmap, June 1st, 2022

Note: Domestic and monitoring wells are screened in either the unconsolidated materials, the bedrock, or both and as such the groundwater elevations and contours represent a composite of the water table and piezometric surface.

SAFETY FIRST	CLIENT: Washoe County Engineering and Capital Projects
terraphase engineering	PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV
	PROJECT NUMBER: N022.001.001

Groundwater Elevation Contour Map, Summer 2015

FIGURE 14



File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\F14_Groundwater Elevation Contour Map, March 2021.mxd 11/28/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane Nevada West FIPS 2703 Feet

Aerial Imagery Source: Nearmap, June 1st, 2022

Note: Domestic and monitoring wells are screened in either the unconsolidated materials, the bedrock, or both and as such the groundwater elevations and contours represent a composite of the water table and piezometric surface.

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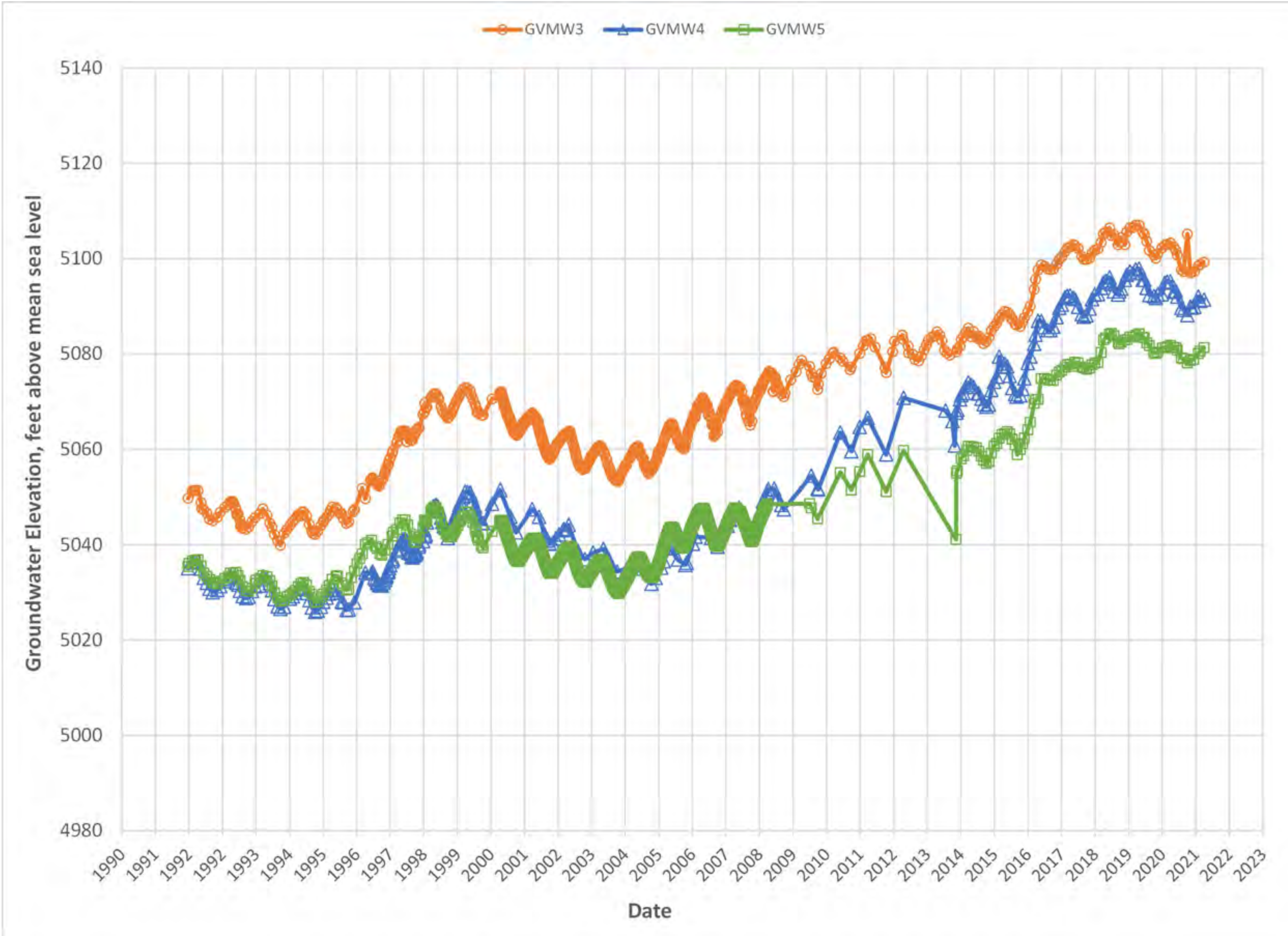
CLIENT:	Washoe County Engineering and Capital Projects
PROJECT:	Golden Valley Aquifer Recharge Assessment - Golden Valley, NV
PROJECT NUMBER:	N022.001.001

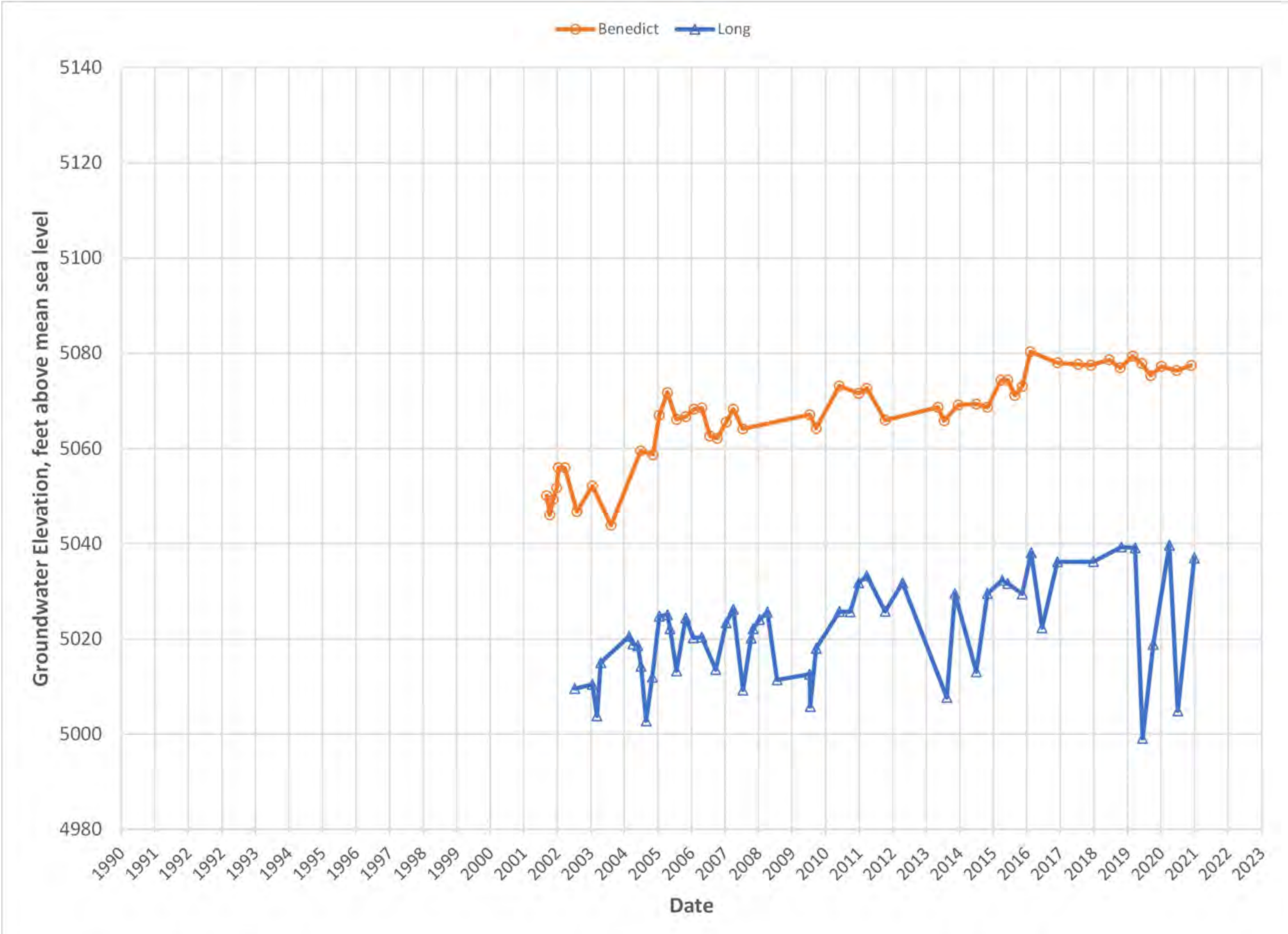
Groundwater Elevation Contour Map, March 2021

FIGURE 15



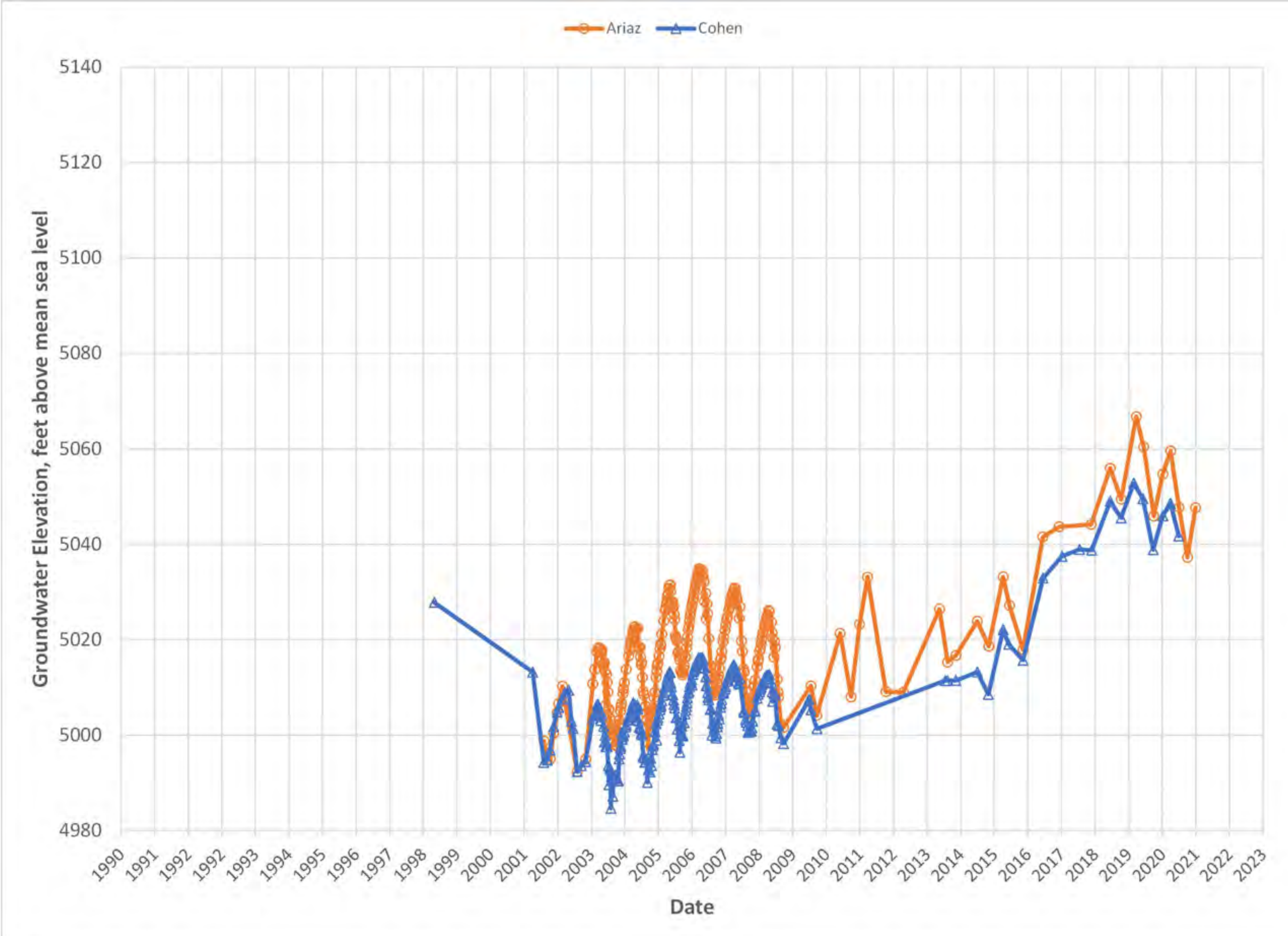
SAFETY FIRST	CLIENT: Washoe County Engineering and Capital Projects		**Groundwater Elevation Hydrograph: Golden Valley Monitoring Wells**
terraphase engineering	PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV		
	PROJECT NUMBER: N022.001.001		**FIGURE 16**

File: N:\GIS\Utilities\ArcMap Templates\Template_8_11_landscape.mxd 11/18/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet



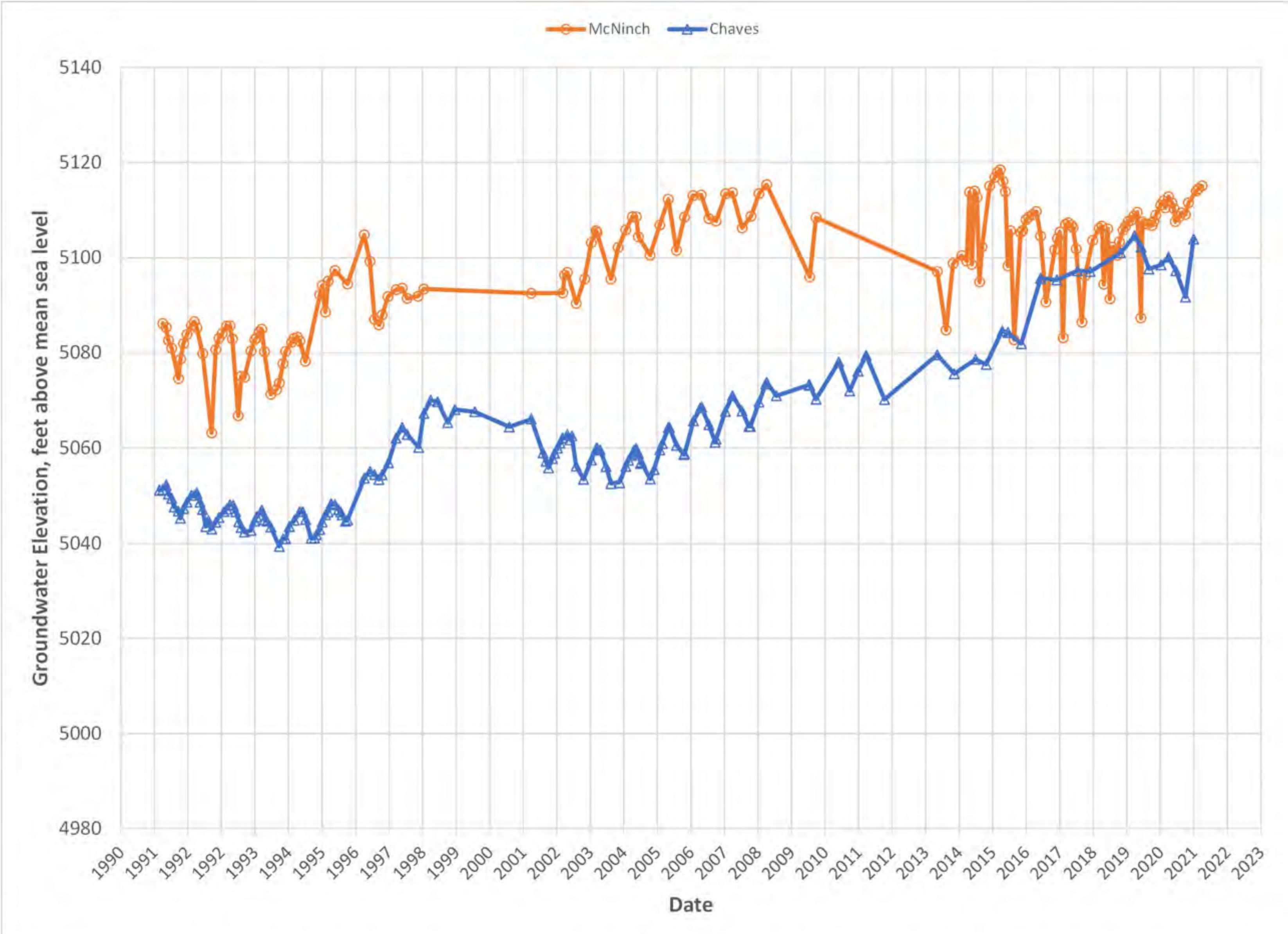
File: N:\GIS\Utilities\ArcMap Templates\Template_8_11_landscape.mxd 11/18/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet

SAFETY FIRST	CLIENT: Washoe County Engineering and Capital Projects	**Groundwater Elevation Hydrograph: Benedict and Long Wells**	
terraphase engineering	PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV		
	PROJECT NUMBER: N022.001.001	**FIGURE 17**	



SAFETY FIRST	CLIENT: Washoe County Engineering and Capital Projects	Groundwater Elevation Hydrograph: Ariaz and Cohen Wells
terraphase engineering	PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV	
	PROJECT NUMBER: N022.001.001	FIGURE 18

File: N:\GIS\Utilities\ArcMap Templates\Template_8_11_landscape.mxd 11/18/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet



SAFETY FIRST

terraphase engineering

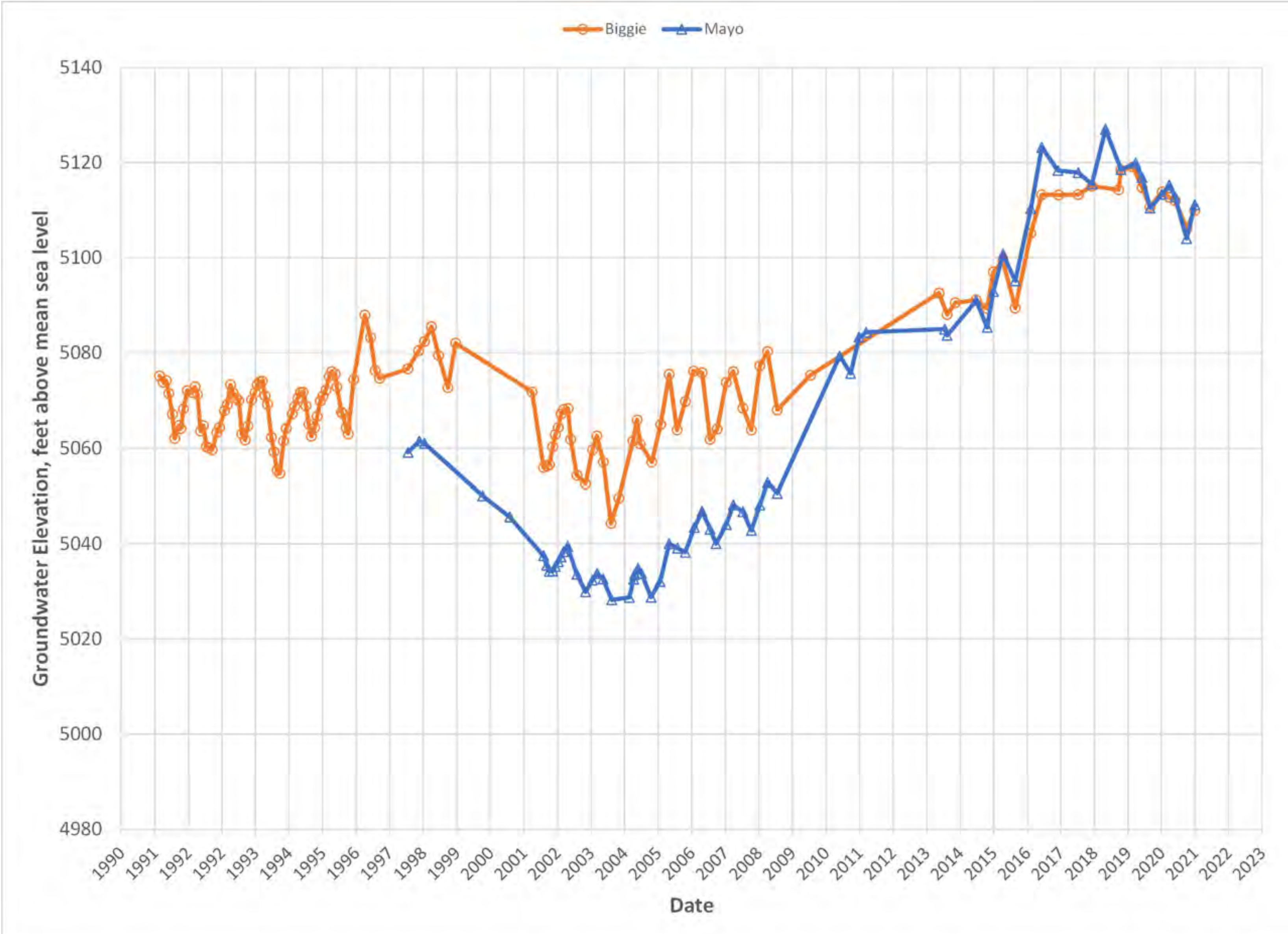
CLIENT: Washoe County Engineering and Capital Projects

PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV

PROJECT NUMBER: N022.001.001

Groundwater Elevation Hydrograph: McNinch and Chaves Wells

FIGURE 19



File: N:\GIS\Utilities\ArcMap Templates\Template_8_11_landscape.mxd 11/18/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet

SAFETY FIRST

terraphase engineering

CLIENT:	Washoe County Engineering and Capital Projects
PROJECT:	Golden Valley Aquifer Recharge Assessment - Golden Valley, NV
PROJECT NUMBER:	N022.001.001

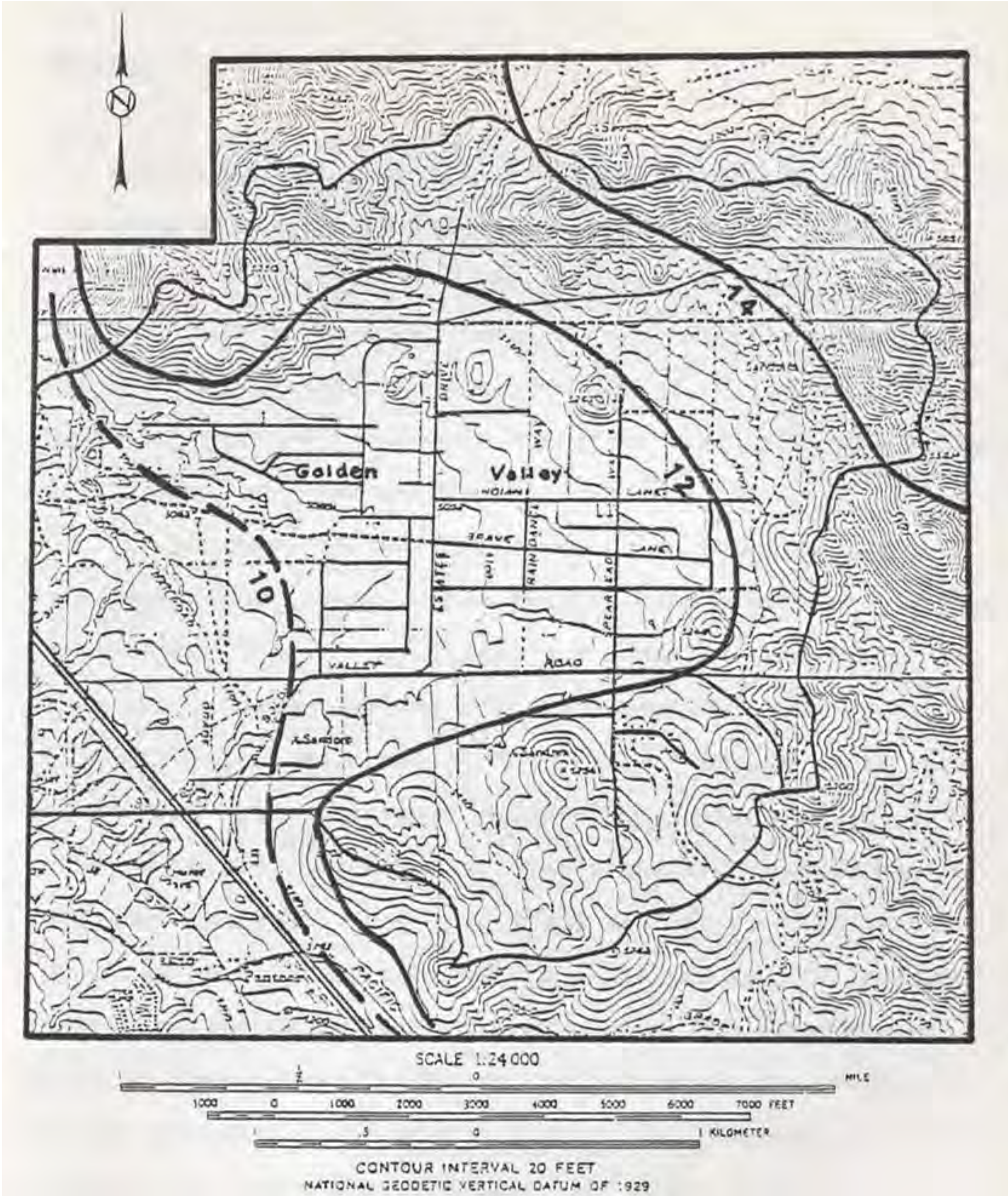
Groundwater Elevation Hydrograph: Biggie and Mayo Wells

FIGURE 20

Aerial Imagery Source: Nearmap, June 1st, 2022

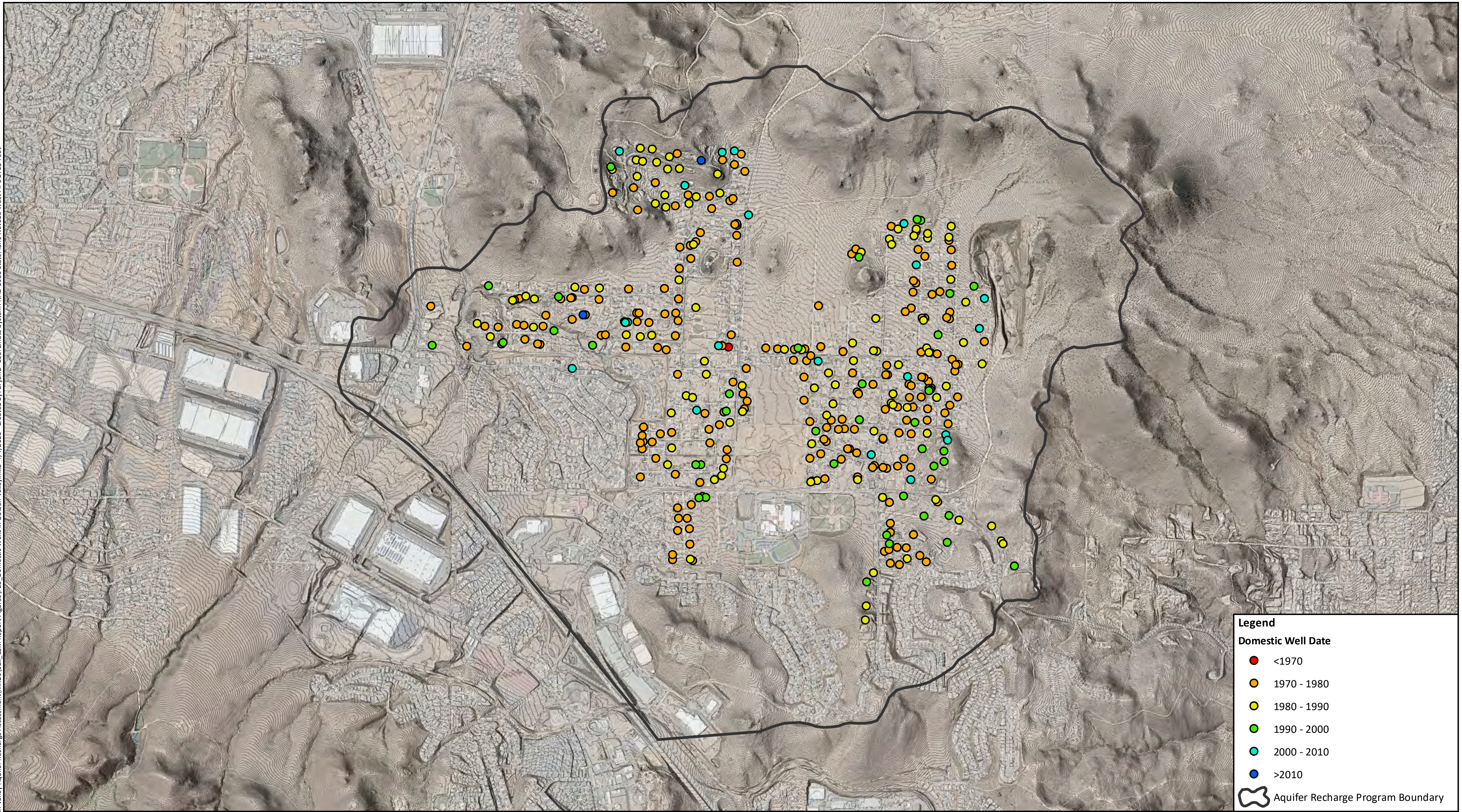
SAFETY FIRST	CLIENT: Washoe County Engineering and Capital Projects		Water Budget Components
terraphase engineering	PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV		
	PROJECT NUMBER:	N022.001.001	FIGURE 21

File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\F16_Water Budget Components.mxd 11/29/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane Nevada West FIPS 2703 Feet



Note: Isohyetal map presented in Barry 1985. The values shown are inches of precipitation in each zone.

SAFETY FIRST	CLIENT: Washoe County Engineering and Capital Projects	**Isohyetal Map of Golden Valley**
terraphase engineering	PROJECT: Golden Valley Aquifer Recharge Assessment – Golden Valley, NV	
	PROJECT NUMBER: N022.001.002	**FIGURE 22**



Aerial Imagery Source: Nearmap, June 1st, 2022

0 850 1,700 3,400 Feet

1 inch = 1,700 feet

N

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CLIENT: Washoe County Engineering and Capital Projects

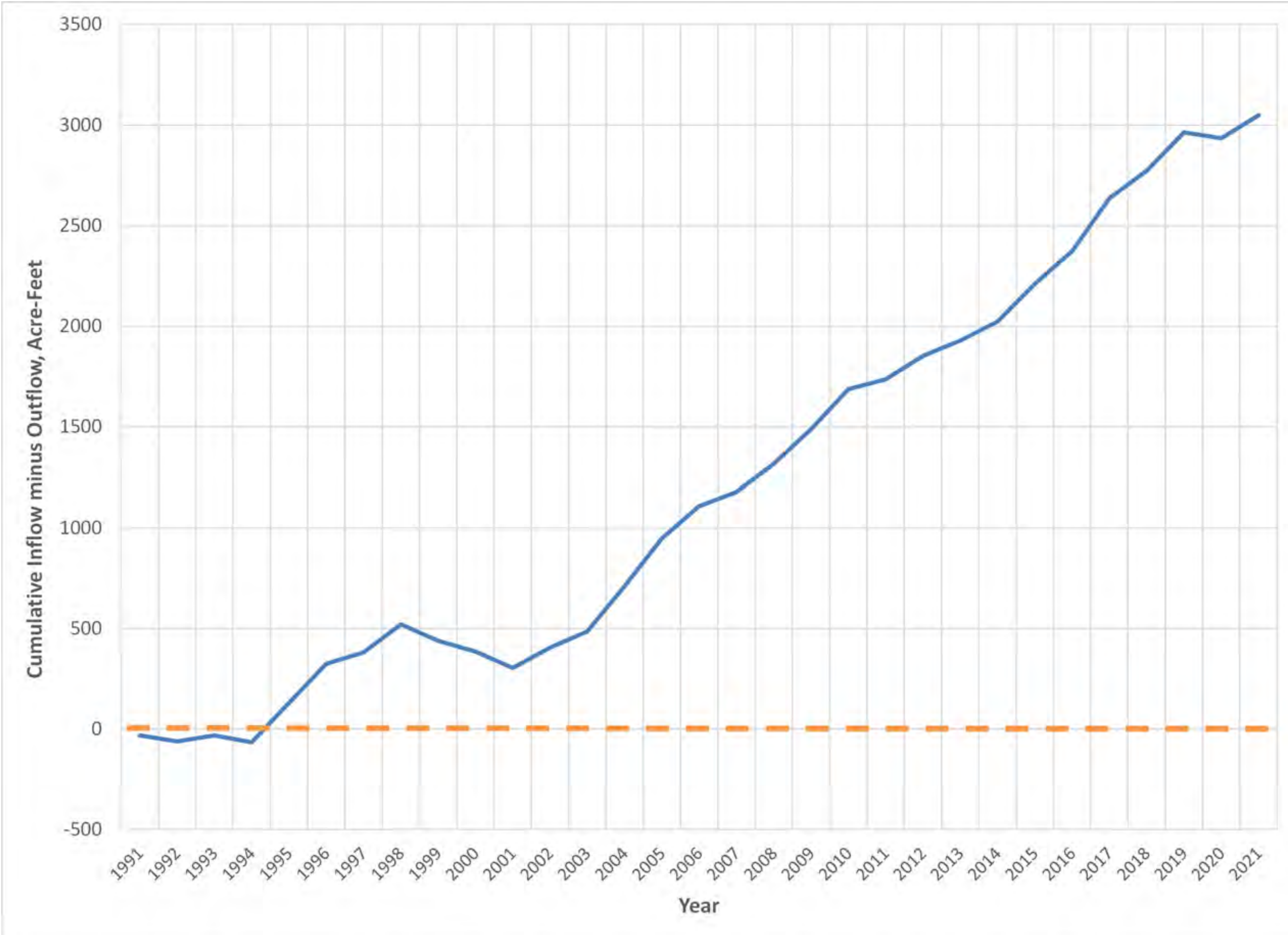
PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV

PROJECT NUMBER: N022.001.001

Domestic Wells in Golden Valley

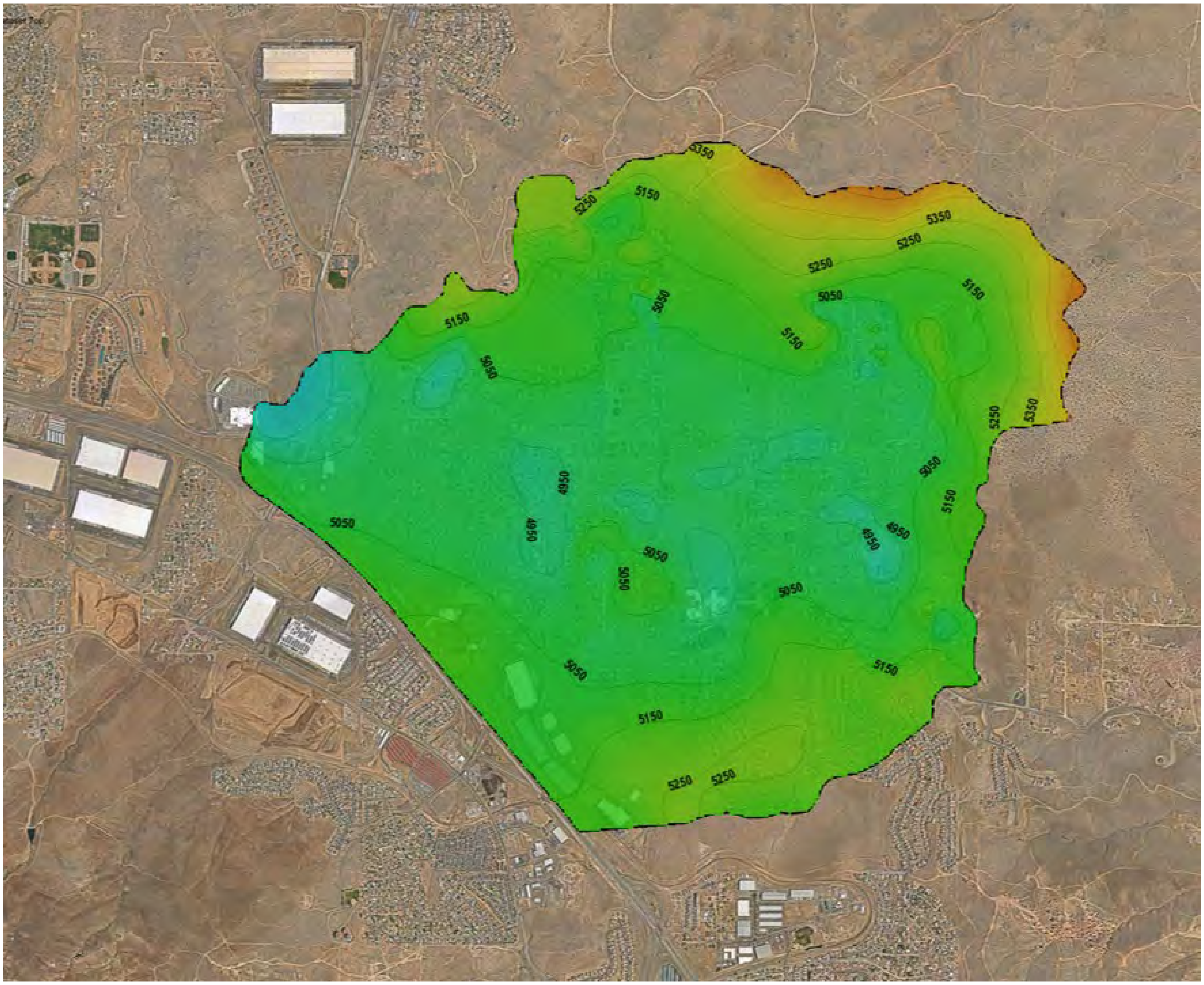
FIGURE 23

File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\F23_Domestic Wells in Golden Valley.mxd 4/4/2023 Created by: BryanO Coordinate System: NAD 1983 StatePlane Nevada West FIPS 2703 Feet



File: N:\GIS\Utilities\ArcMap Templates\Template_8_11_landscape.mxd 11/18/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet

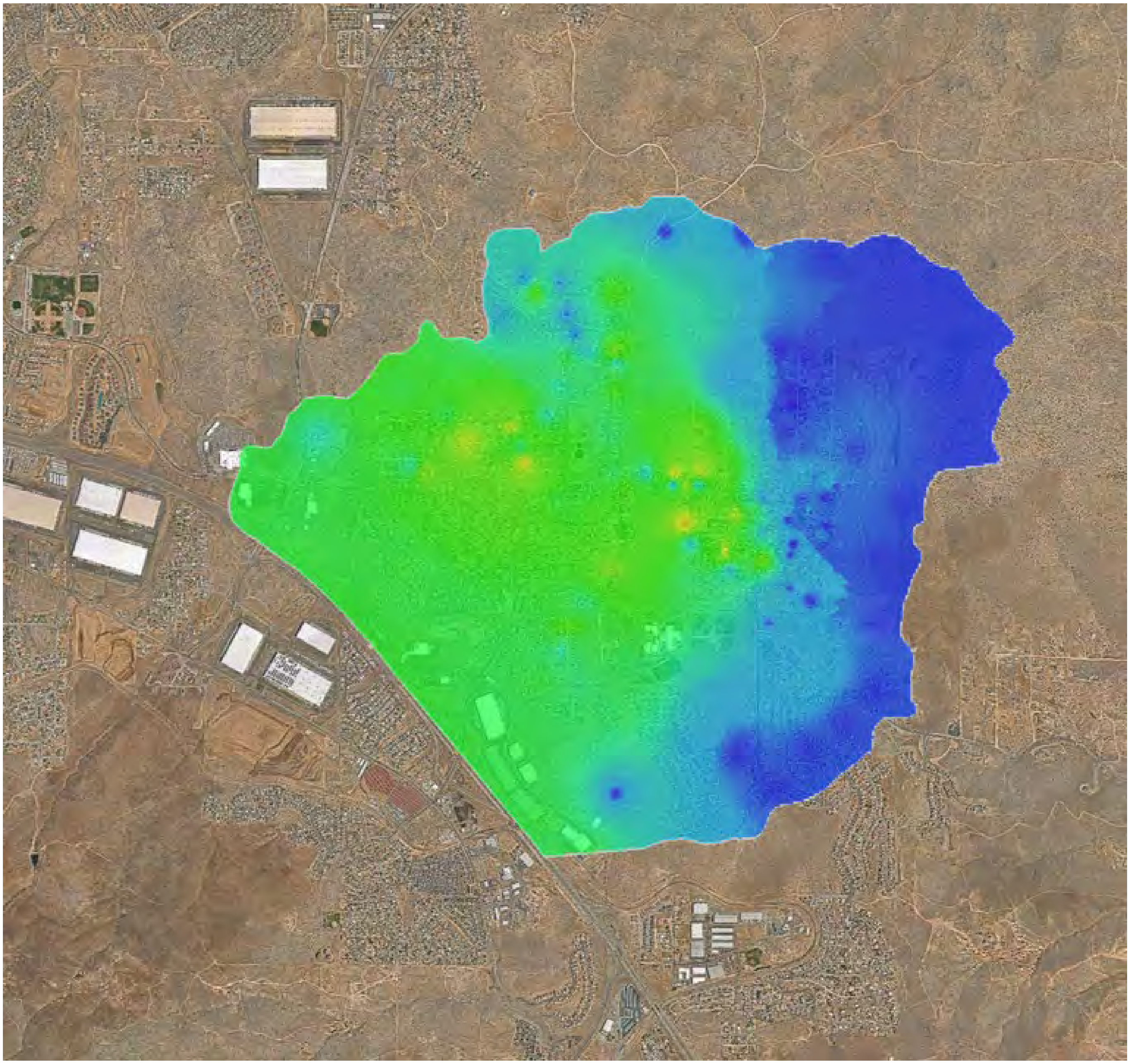
SAFETY FIRST	CLIENT: Washoe County Engineering and Capital Projects	**Calculated Cumulative Inflow Minus Outflow, 1991 - 2021**
terraphase engineering	PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV	
	PROJECT NUMBER: N022.001.001	**FIGURE 24**



Legend

5050 Interpolated top of bedrock elevation in feet above mean sea level

SAFETY FIRST	CLIENT: Washoe County Engineering and Capital Projects	**Bedrock Surface Elevation Map**
terraphase engineering	PROJECT: Golden Valley Aquifer Recharge Assessment – Golden Valley, NV	
	PROJECT NUMBER: N022.001.002	**FIGURE 25**

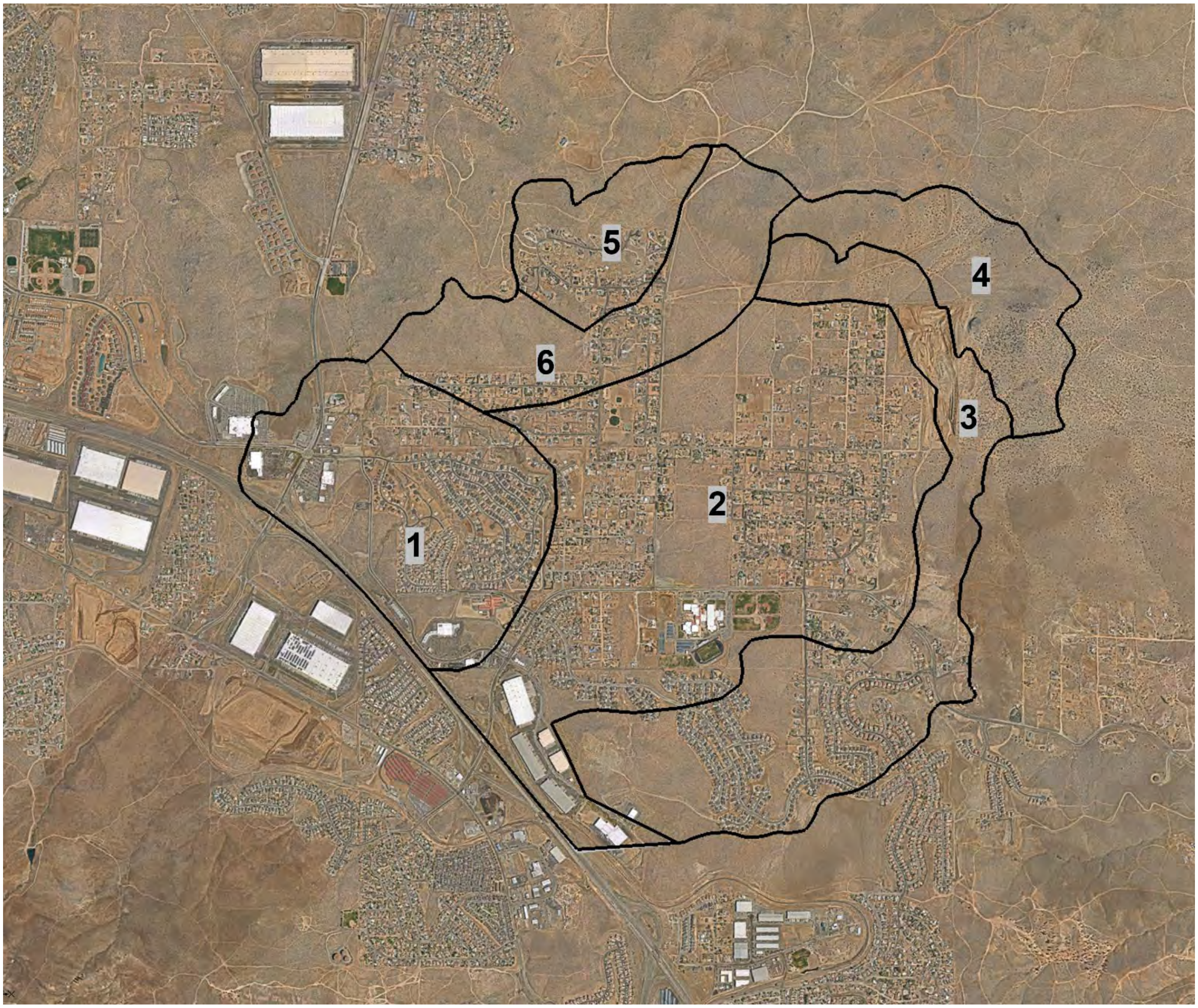


Legend

Hydraulic Conductivity, Feet per Day

- 0.01 to 0.1
- 0.1 to 1
- 1 to 3
- 3 to 5
- 5 to 6

SAFETY FIRST	CLIENT: Washoe County Engineering and Capital Projects	**Bedrock Hydraulic Conductivity Distribution Map**
terraphase engineering	PROJECT: Golden Valley Aquifer Recharge Assessment – Golden Valley, NV	
	PROJECT NUMBER: N022.001.002	**FIGURE 26**

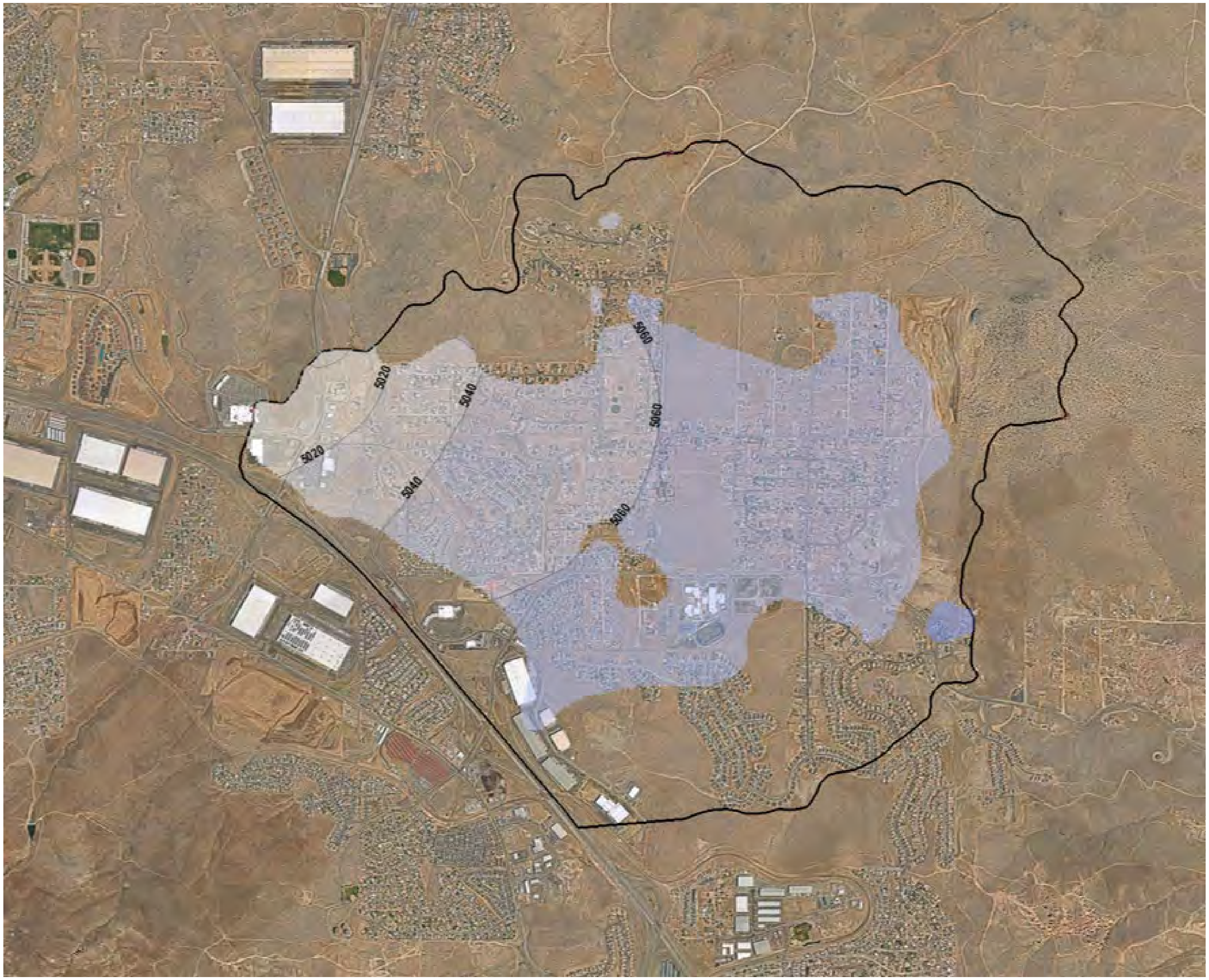


Legend

1 Recharge Zone Number

Recharge Zone Boundary

SAFETY FIRST	CLIENT: Washoe County Engineering and Capital Projects	**Model Recharge Zones**
terraphase engineering	PROJECT: Golden Valley Aquifer Recharge Assessment – Golden Valley, NV	
	PROJECT NUMBER: N022.001.002	**FIGURE 27**



Legend

5020 Simulated Groundwater Elevation Contour (feet above mean sea level

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CLIENT:	Washoe County Engineering and Capital Projects
PROJECT:	Golden Valley Aquifer Recharge Assessment – Golden Valley, NV
PROJECT NUMBER:	N022.001.002

Simulated Groundwater Elevation Map Natural Conditions, Fill, Layer 1

FIGURE 28

Legend

5020 Simulated Groundwater Elevation Contour (feet above mean sea level

SAFETY FIRST

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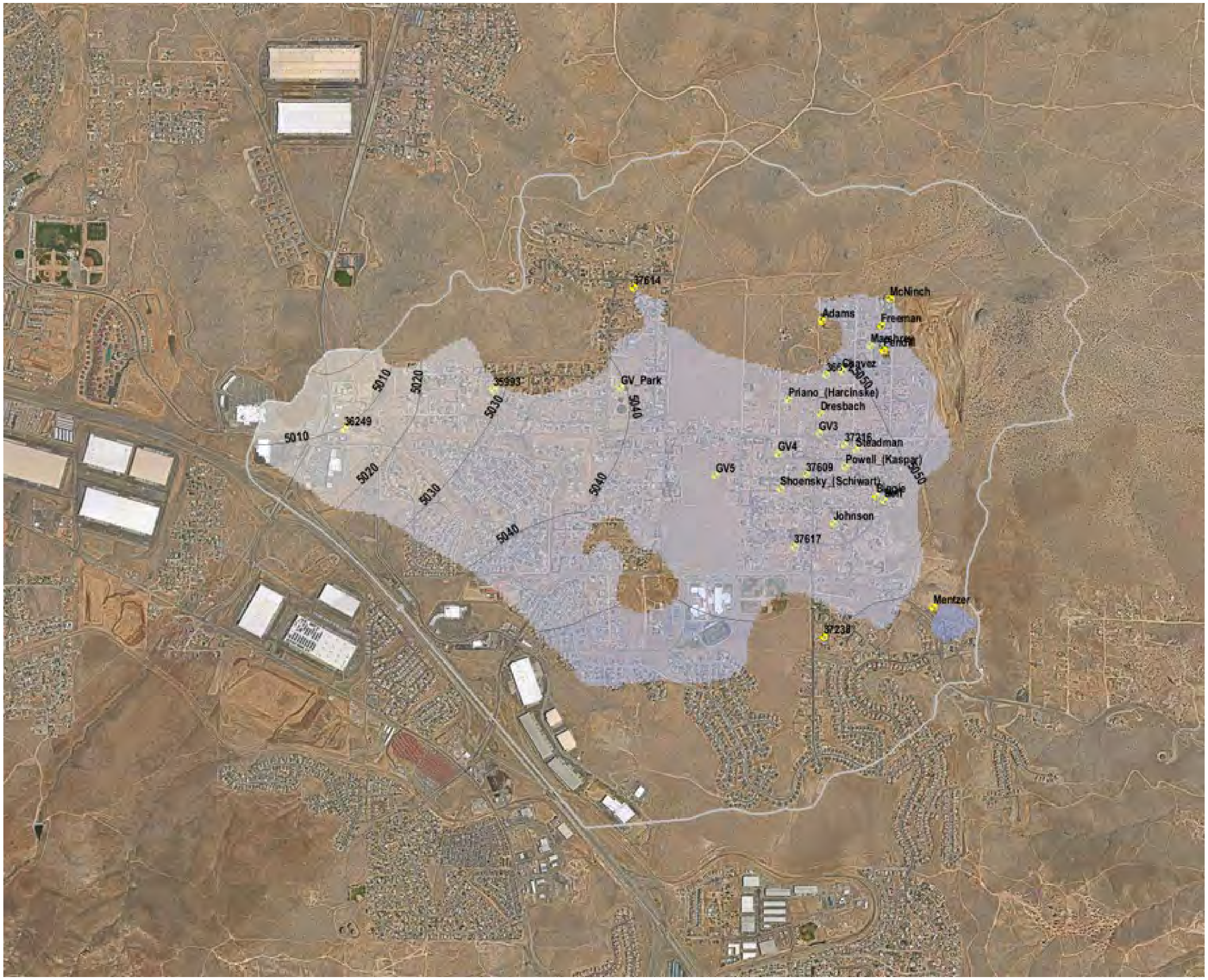
CLIENT: Washoe County Engineering and Capital Projects

PROJECT: Golden Valley Aquifer Recharge Assessment – Golden Valley, NV

PROJECT NUMBER: N022.001.002

Simulated Groundwater Elevation Map Natural Conditions, Bedrock, Layer 2

FIGURE 29



Legend

Calibration Target Location

5020 Simulated Groundwater Elevation Contour (feet above mean sea level)

SAFETY FIRST

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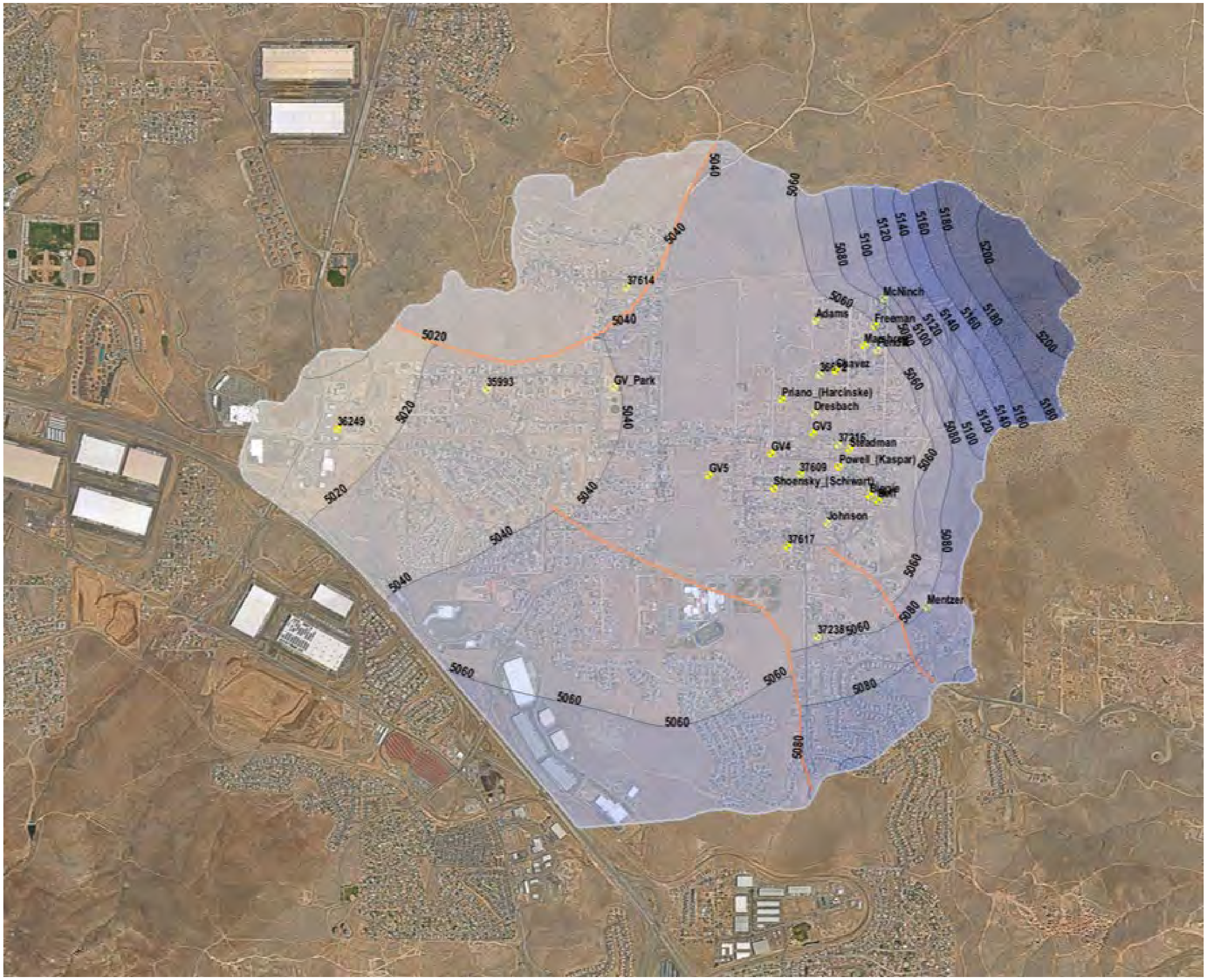
CLIENT: Washoe County Engineering and Capital Projects

PROJECT: Golden Valley Aquifer Recharge Assessment – Golden Valley, NV

PROJECT NUMBER: N022.001.002

Simulated Groundwater Elevation Map 1991 Conditions, Fill, Layer 1

FIGURE 30



Legend

Calibration Target Location

5020 — Simulated Groundwater Elevation Contour (feet above mean sea level)

SAFETY FIRST

terraphase engineering

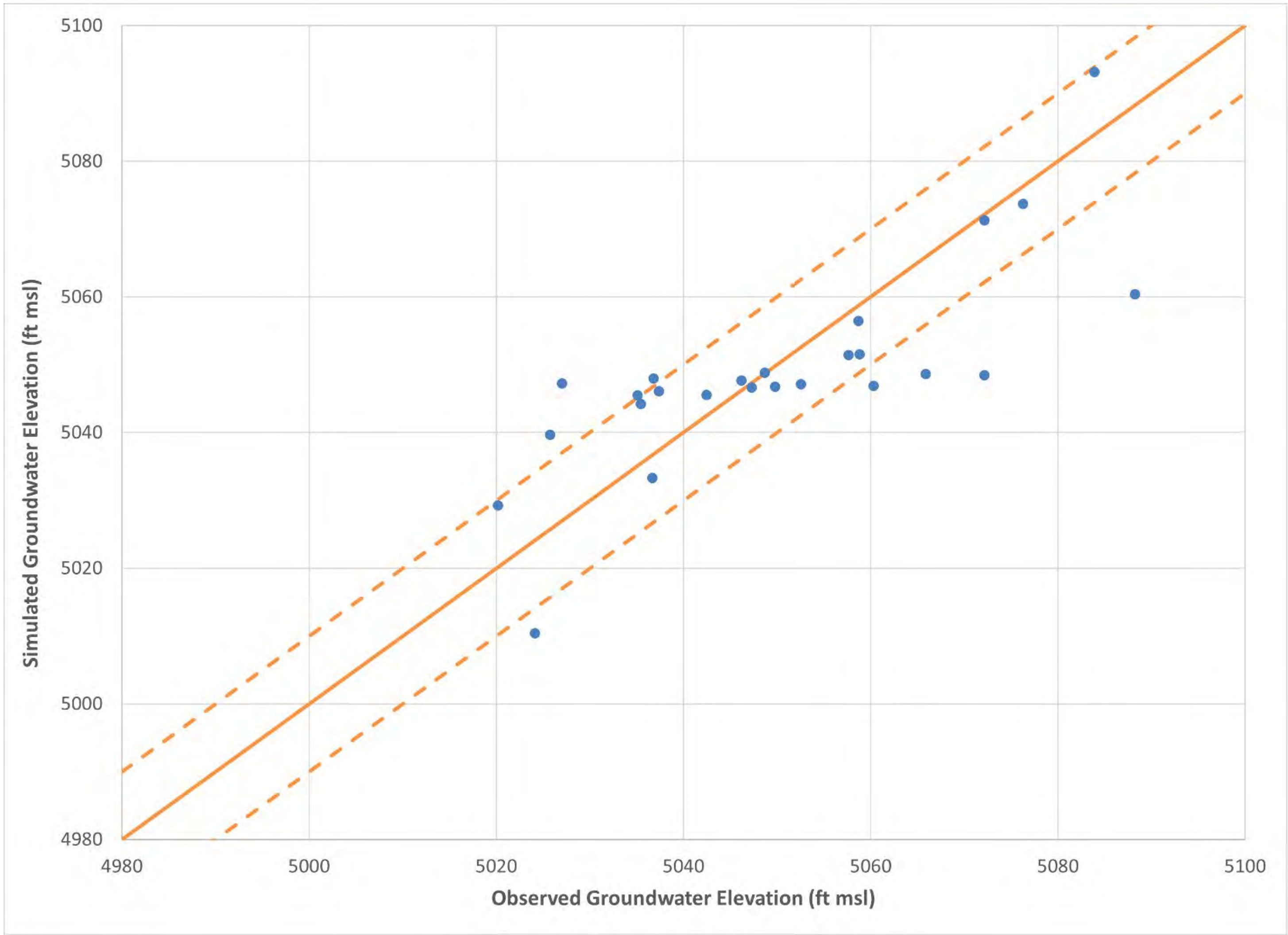
CLIENT: Washoe County Engineering and Capital Projects

PROJECT: Golden Valley Aquifer Recharge Assessment – Golden Valley, NV

PROJECT NUMBER: N022.001.002

Simulated Groundwater Elevation Map 1991 Conditions, Bedrock, Layer 2

FIGURE 31



Legend

- Calibration Target
- 1:1 Match Line
- +/- 10% Error Lines

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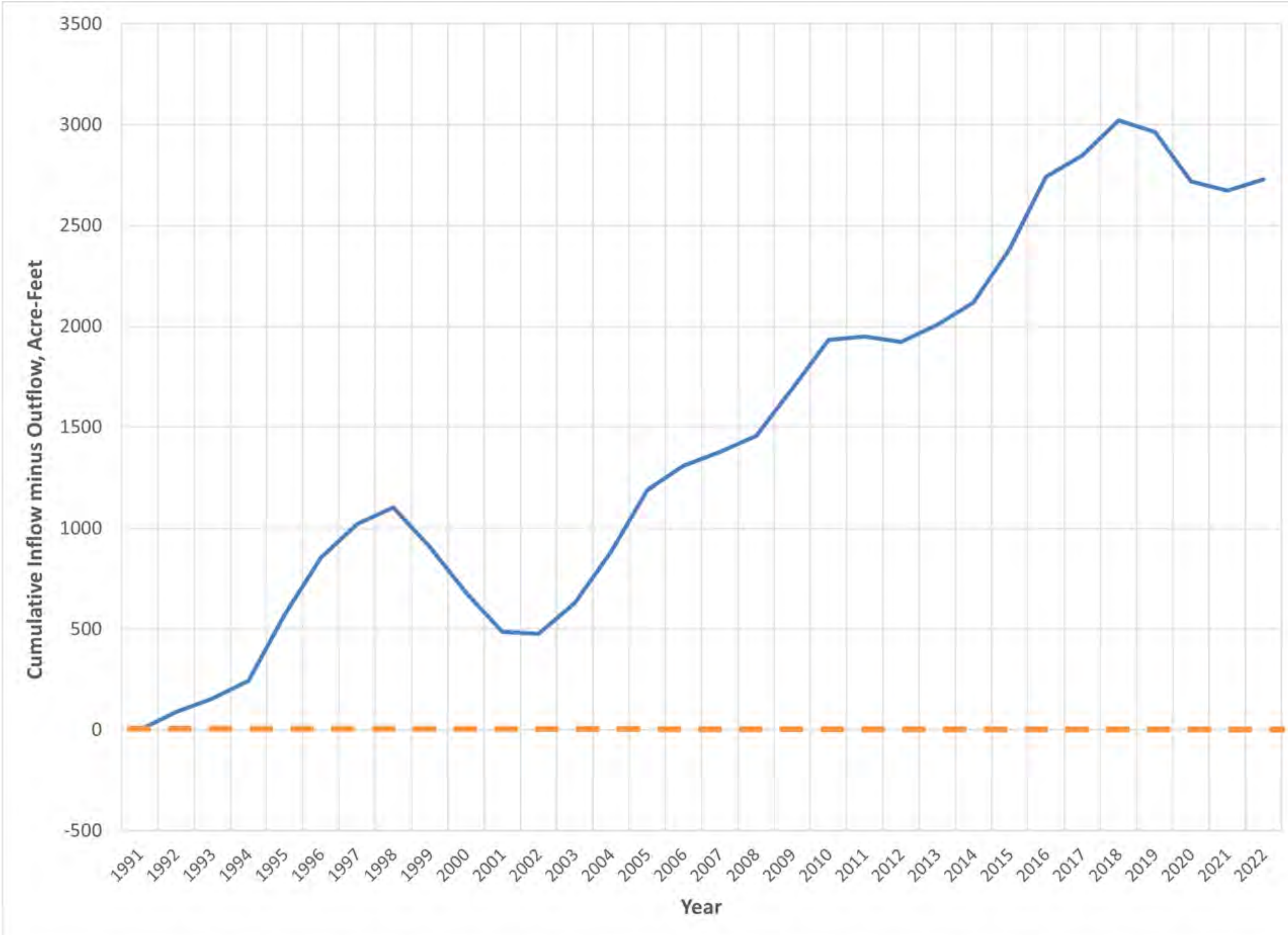
CLIENT: Washoe County Engineering and Capital Projects

PROJECT: Golden Valley Aquifer Recharge Assessment – Golden Valley, NV

PROJECT NUMBER: N022.001.002

Steady State Calibration Plot

FIGURE 32



	SAFETY FIRST	CLIENT: Washoe County Engineering and Capital Projects	**Simulated Cumulative Inflow Minus Outflow, 1991 - 2021**
	terraphase engineering	PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV	
		PROJECT NUMBER: N022.001.001	**FIGURE 33**

File: N:\GIS\Utilities\ArcMap Templates\Template_8_11_landscape.mxd 11/18/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet

Aerial Imagery Source: Nearmap, June 1st, 2022

0 850 1,700 3,400 Feet

1 inch = 1,700 feet

N

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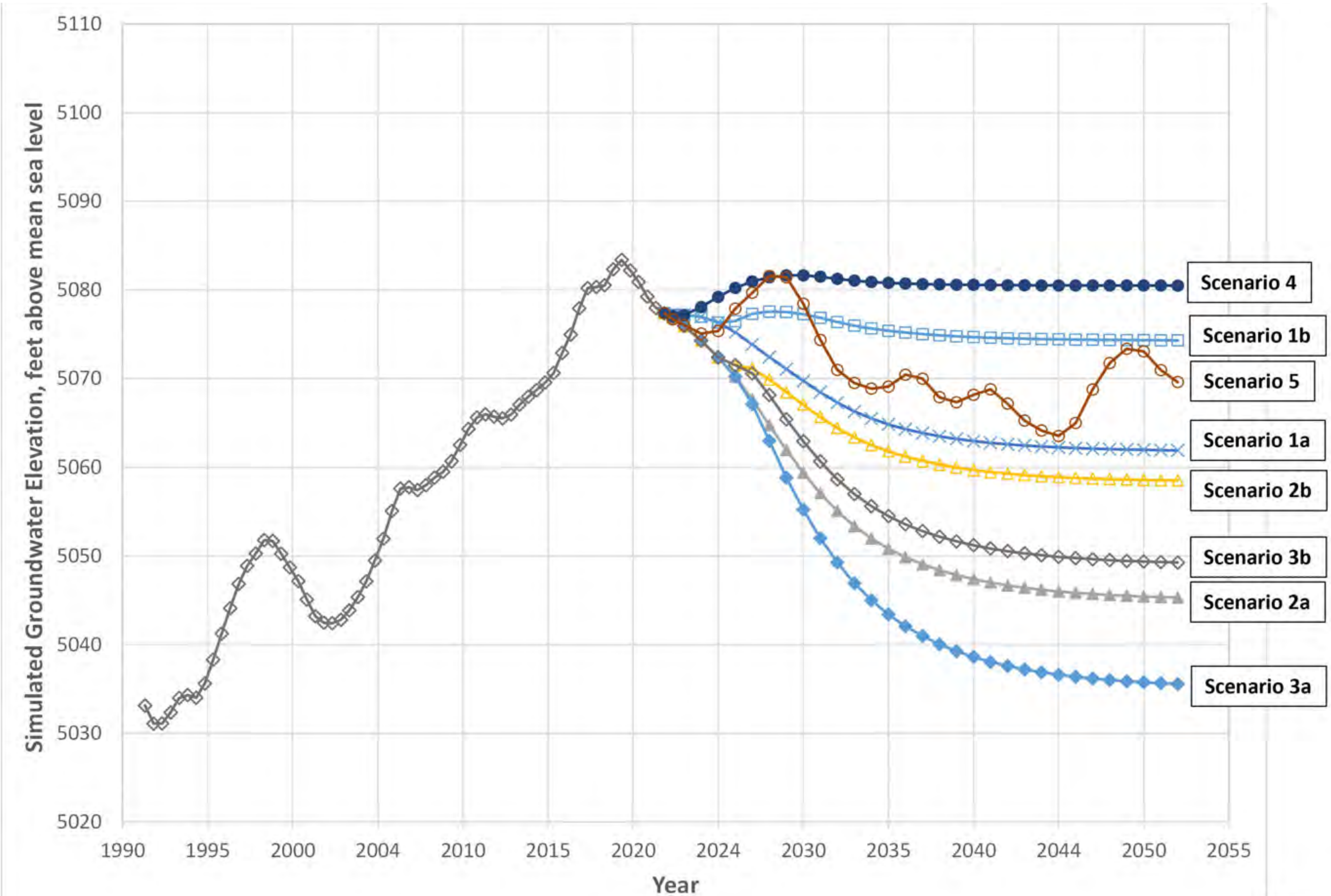
CLIENT:	Washoe County Engineering and Capital Projects
PROJECT:	Golden Valley Aquifer Recharge Assessment - Golden Valley, NV
PROJECT NUMBER:	N022.001.001

Location of Future Developments

FIGURE 34

File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\F31_Location of Future Developments.mxd 12/6/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane Nevada West FIPS 2703 Feet



File: N:\GIS\Utilities\ArcMap Templates\Template_8_11_landscape.mxd 11/18/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet

Notes:
See Section 5.0 for Predictive Scenario descriptions.

SAFETY FIRST

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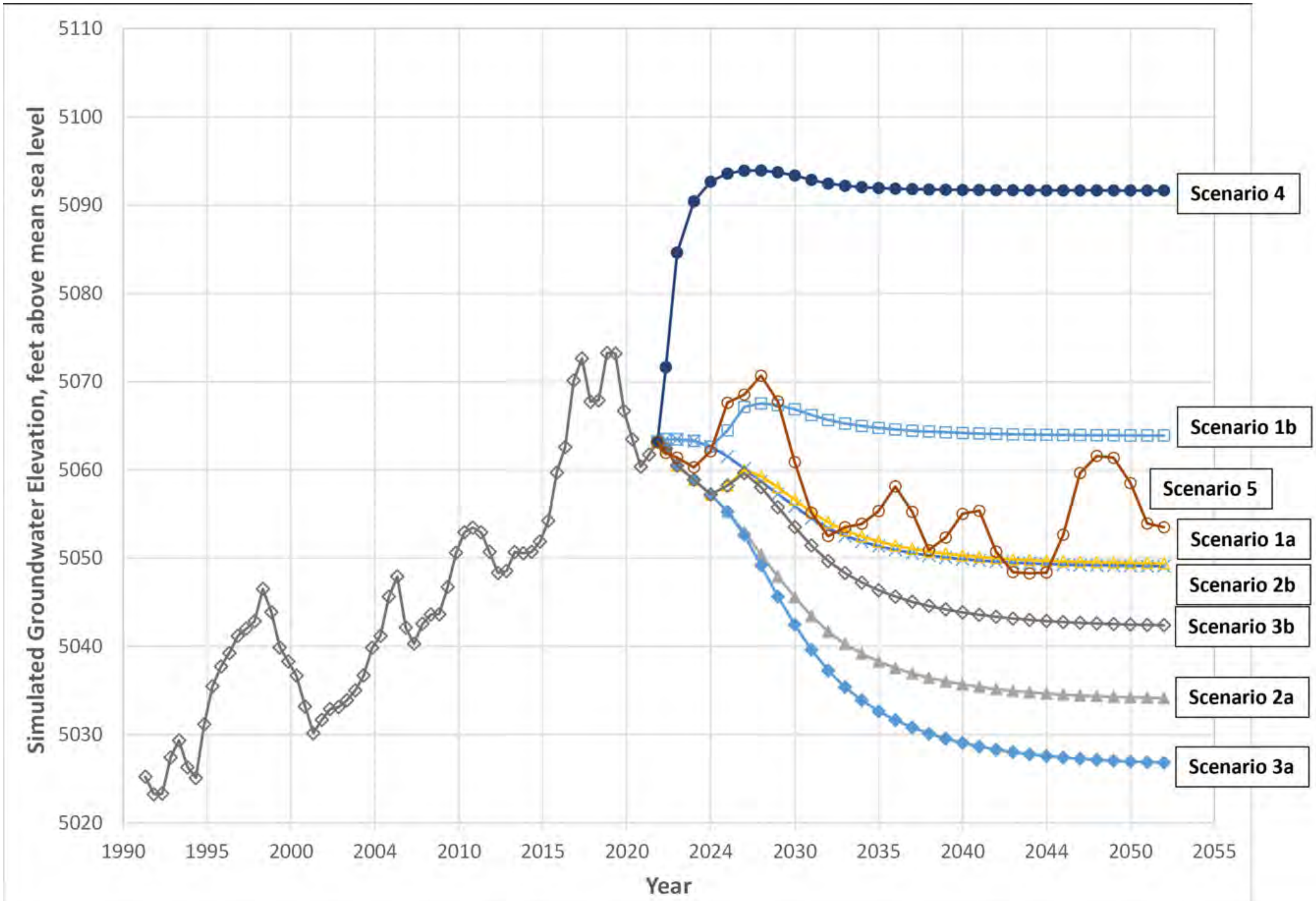
CLIENT:	Washoe County Engineering and Capital Projects
PROJECT:	Golden Valley Aquifer Recharge Assessment - Golden Valley, NV
PROJECT NUMBER:	N022.001.001

Predictive Simulation Results Well GVMW4

FIGURE 35



Notes:
See Section 5.0 for Predictive Scenario descriptions.

SAFETY FIRST

terraphase engineering

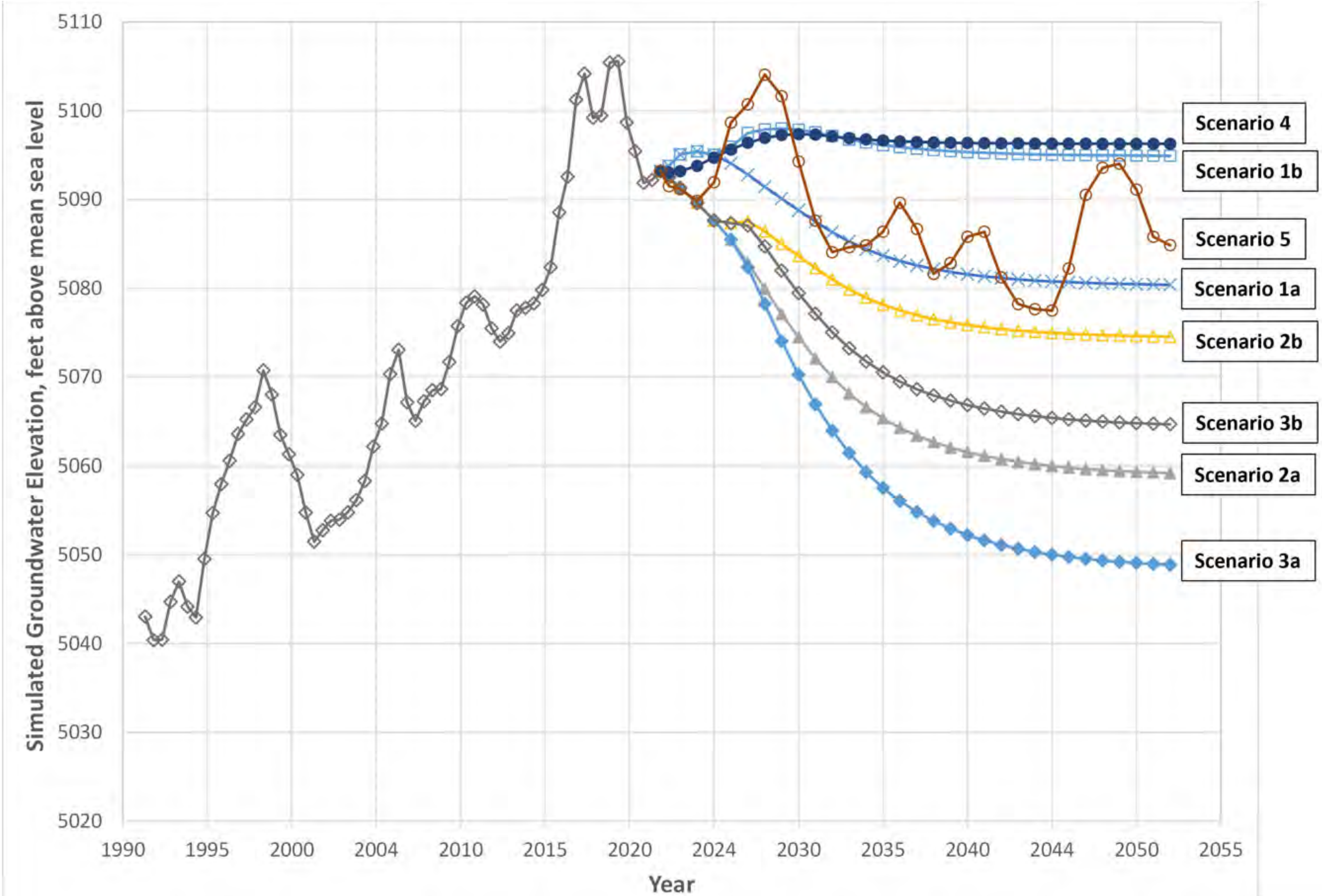
CLIENT: Washoe County Engineering and Capital Projects

PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV

PROJECT NUMBER: N022.001.001

Predictive Simulation Results
Ariaz Well

FIGURE 36



File: N:\GIS\Utilities\ArcMap Templates\Template_8_11_landscape.mxd 11/18/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet

Notes:
See Section 5.0 for Predictive Scenario descriptions.

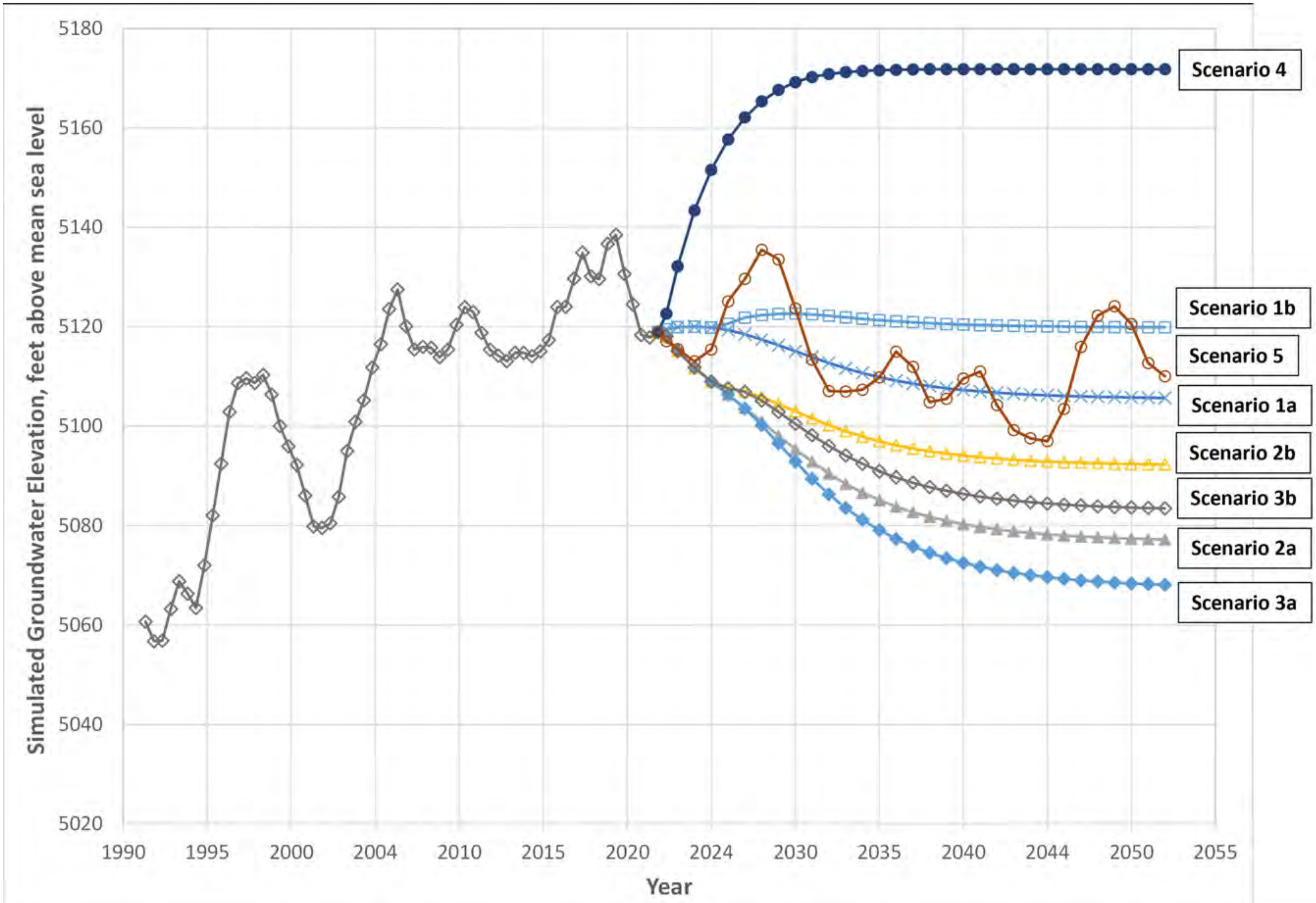
SAFETY FIRST

terraphase engineering

CLIENT:	Washoe County Engineering and Capital Projects
PROJECT:	Golden Valley Aquifer Recharge Assessment - Golden Valley, NV
PROJECT NUMBER:	N022.001.001

Predictive Simulation Results Mayo Well

FIGURE 37



File: N:\GIS\Utilities\ArcMap Templates\Template_8_11_landscape.mxd 11/18/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane California III FIPS 0403 Feet

Notes:
See Section 5.0 for Predictive Scenario descriptions.

SAFETY FIRST

terraphase engineering

CLIENT: Washoe County Engineering and Capital Projects

PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV

PROJECT NUMBER: N022.001.001

Predictive Simulation Results McNinch Well

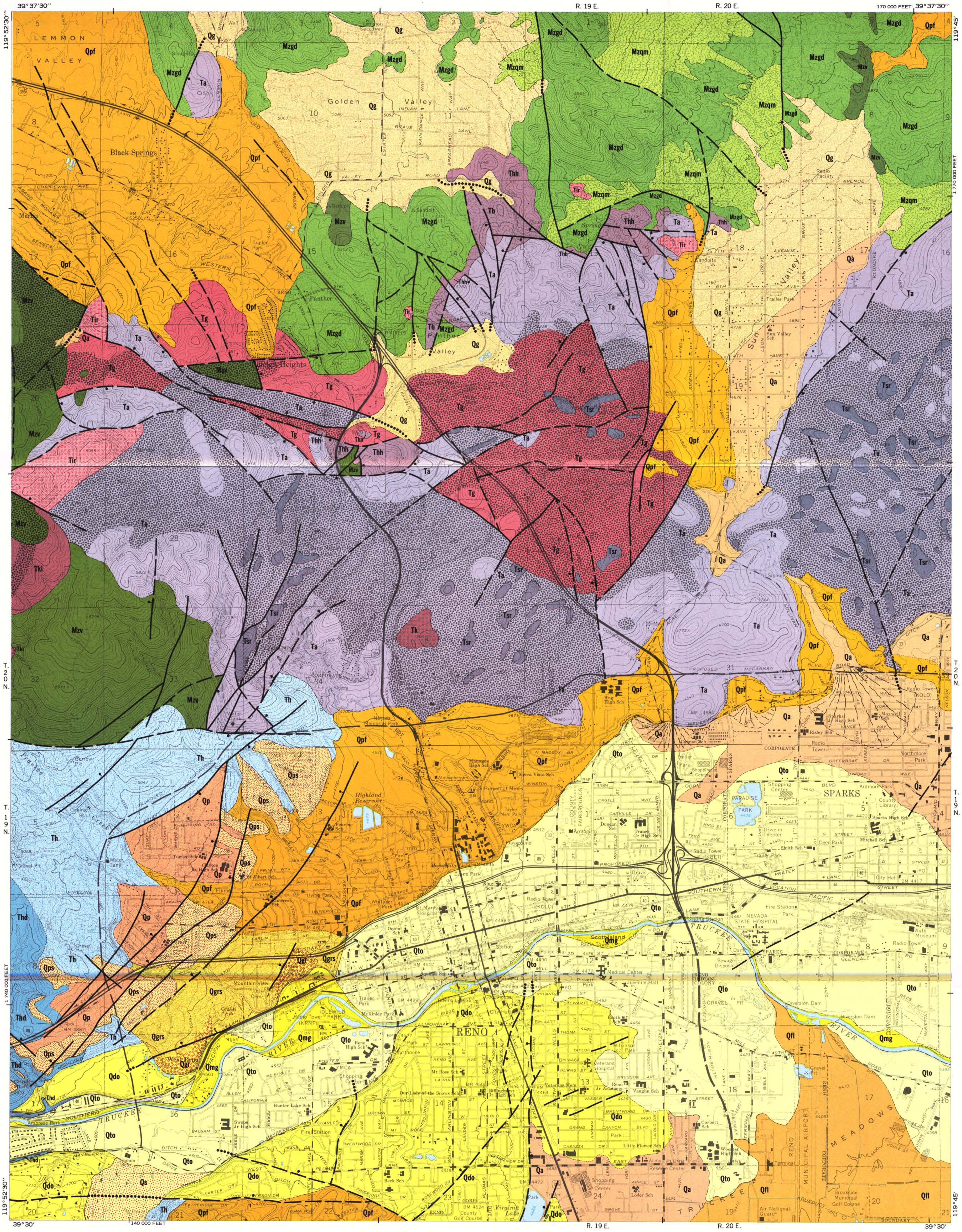
FIGURE 38

Appendix A

Geologic Maps of Reno Nevada

ENVIRONMENTAL SERIES ✧ RENO AREA

RENO FOLIO ✧ GEOLOGIC MAP



Qmg	**Mainstream Gravel** Sandy cobble gravel confined to the present Truckee River floodplain.
Qfl	**Floodplain and Lake Deposits** Thin sheet of medium- to thin-bedded clayey silt and sand. Contains discontinuous layers of silt and peat.
Qa	**Alluvium** Poorly sorted clayey to silty gravelly sand, poorly bedded to unbedded.
Qg	**Granitic Alluvium** Weathered granitic sand.
Qp	**Pediment Deposits** Thin sheets of gravelly silt and silty clay. Weakly weathered.
Qto / Qs	**Tahoe Outwash Qto:** Boulder to cobble gravel, sandy gravel, and gravely sand. Contains giant boulders. Rock clasts are rounded to subrounded and, in decreasing order of abundance, are granitic, volcanic, and metamorphic. **Qs:** Sidestream deposits.
Qdo	**Donner Lake Outwash** Deposits similar to Tahoe outwash except weathered to depths of four feet or more.
Qps	**Pediment and Stream Gravel** Thin deposits of sandy to clayey, cobble to small boulder gravel. Moderately to deeply weathered. Chalk Bluff area-contains numerous large, rounded to highly rounded cobbles and boulders of basalt and granitic rock. Peavine Creek area-contains many locally derived white to yellowish white, silicified andesite fragments.
Qgr / Qgrs	**Gravel of Reno Qgr:** Moderately well-sorted sandy cobble gravel. Slightly cemented. **Qgrs:** Weakly-bedded deposits of coarse sand containing scattered small cobbles and thin cobble layers.
Qpf	**Alluvial Fan Deposits of Peavine Mountain** Poorly sorted, pale yellowish to reddish brown, montmorillonitic, gravelly to sandy and clayey silt. White silicified andesite fragments common. Black Springs area—pale orange brown clayey and gravelly sand.

QUATERNARY

UNCONFORMITY

Th / Thd	**Sandstone of Hunter Creek Th:** Pale brown to gray brown and greenish gray, prominently bedded, interlayered siltstone, silty sandstone, and sandy conglomerate. **Thd:** White to yellowish white diatomite and diatomaceous sandstone.
Tk / Tki	**Kate Peak Formation Tk:** Gray, porphyritic, hornblende-biotite andesite flow containing phenocrysts of plagioclase, biotite, and hornblende. **Tki:** Intrusive rock lithologically similar to the flow.
Tir	**Rhyolite Plugs** Flow-banded, light gray porphyritic rhyolite. Small quartz and feldspar phenocrysts in a fine-grained matrix.
Tsr	**Silicified Rock** Silicified rock and breccia consisting almost entirely of fine-grained red-brown quartz, colored by iron-oxide. This unit is confined to areas of altered volcanic or granitic rocks.
Tg	**Granitic Stock** Hypabyssal stock composed of several intrusive phases ranging in composition from pyroxene diorite through granodiorite porphyry to pyroxene syenite. Largely altered to cream-colored iron-stained rock made up of quartz, sericite, and clay. Locally contains chlorite, epidote and potassium feldspar. Pyrite is abundant in unweathered parts of the altered rock.
Ta	**Alta Formation** Dark brown pyroxene andesite flows, flow breccia, and laharic breccia. Commonly altered to tan rock composed of quartz, sericite, and clay minerals or propylitized to gray green rock containing chlorite, calcite, albite, epidote, and clay minerals.
Tb	**Epiclastic Volcanic Breccia** Greenish white volcanic breccia composed predominently of lithic fragments derived from the erosion of rhyolitic flows and ash-flow tuff. In many areas the fragments are altered to quartz, sericite, and clay minerals.
Thh	**Hartford Hill Formation** Crystal-poor cream to buff rhyolitic ash-flow tuff with sparse crystals of quartz and feldspar in a moderately welded matrix of pumice and ash.

TERTIARY

UNCONFORMITY

Mzqm	**Quartz Monzonite** Coarse-grained, light gray plutonic rock composed of microcline, quartz, plagioclase, and moderately abundant biotite. Deeply weathered and does not normally cropout.
Mzgd	**Granodiorite** Gray hornblende-biotite granodiorite. Deuteric alteration has commonly formed actinolite and chlorite from hornblende and biotite; epidote, calcite, and sericite partially replace plagioclase. Not normally deeply weathered and usually forms numerous outcrops.
Mzv	**Peavine Sequence** Gray to gray-green metavolcanic rocks with subordinate amounts of metamorphosed epiclastic volcanic sedimentary rocks. The metavolcanic rocks include rhyolite flows and pyroclastics and dacite to andesite flows and laharic breccias. Where fresh, highly resistant to erosion and tends to form bold outcrops.

MESOZOIC

Contact Long dashes where approximately located; short dashes where indefinite; dotted where buried.

Fault Dashed where approximately located; dotted where concealed. Ball on downthown side.

Alluvial Fan

Altered Rock

This map illustrates the distribution of bedrock and surficial deposits in the Reno Quadrangle. The geologic mapping was done as a reconnaissance, thus the user should regard this map as preliminary.

By H. F. Bonham Jr. and E. C. Bingler, 1973

Quaternary geology in part from Birkeland, P. W., Correlation of Quaternary Stratigraphy of the Sierra Nevada with that of the Lake Lahontan Area in *Means of Correlation of Quaternary Successions,* Univ. of Utah, 1968.

1 INCH EQUALS 2000 FEET

0 0.5 1 MILE

0 2000 4000 FEET

0 0.5 1 KILOMETER

0 1000 METERS

CONTOUR INTERVAL 20 FEET
DOTTED LINES ARE 10-FOOT CONTOURS
DATUM IS MEAN SEA LEVEL

Topographic base from U.S. Geological Survey Reno 7½' quadrangle, 1967.

Cartography by Susan L. Nichols.

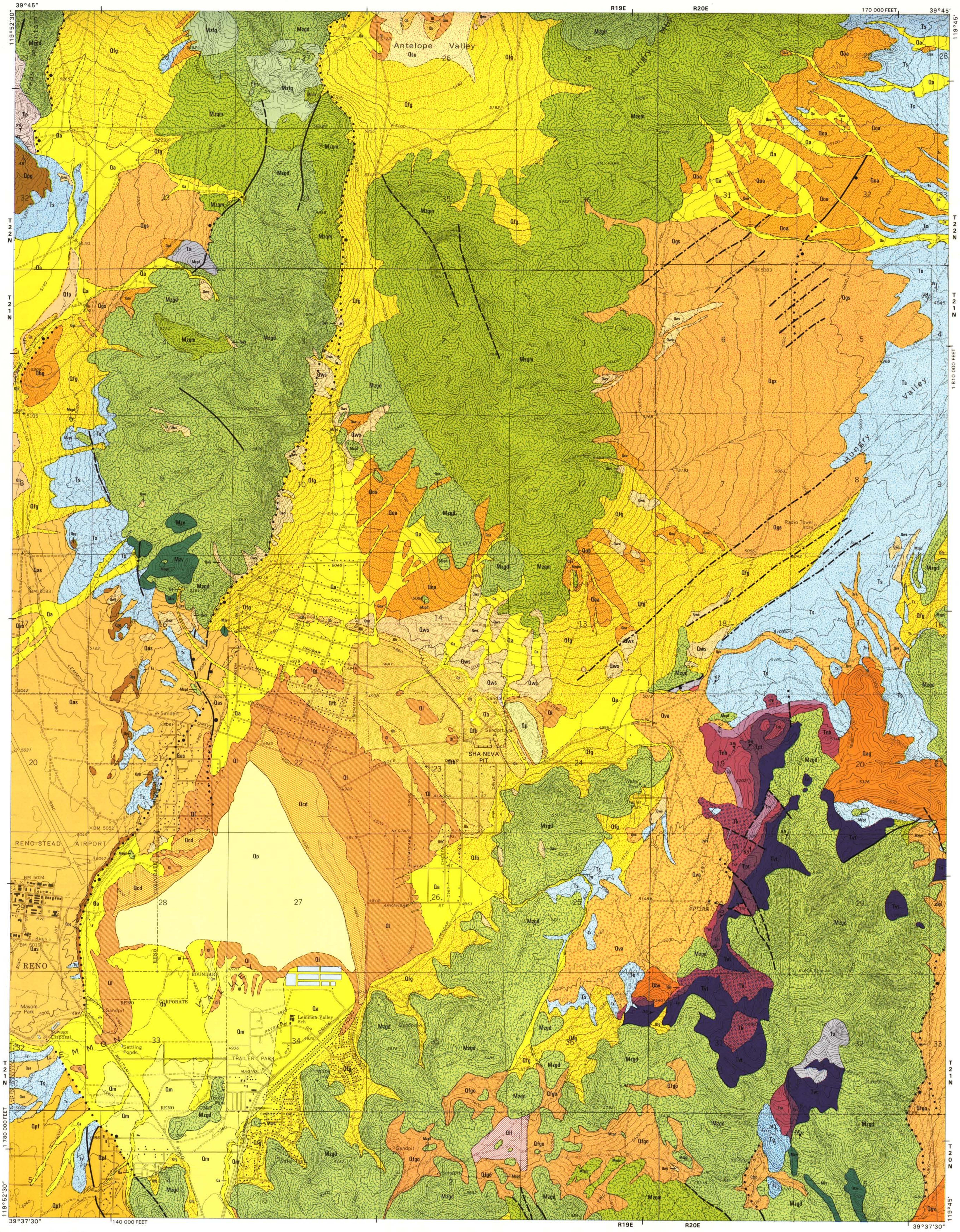
NEVADA BUREAU OF MINES AND GEOLOGY
UNIVERSITY OF NEVADA
RENO, NEVADA 89507

NEVADA BUREAU OF MINES AND GEOLOGY
RENO AREA MAP 4Cg

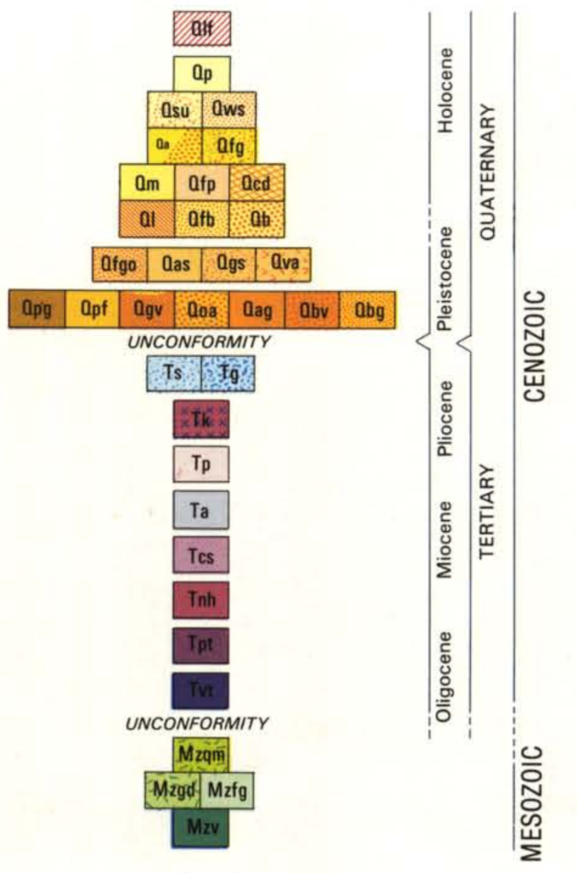
PREPARED IN COOPERATION WITH THE U.S. GEOLOGICAL SURVEY

RENO NE QUADRANGLE
GEOLOGIC MAP

RENO NE QUAD



GEOLOGY



Qlf **Landfill**

Qp **Playa deposits** Light-brown to brown, mod. well sorted slightly sandy to granular mud with interbedded fine sand and silt.

Qsu **Undifferentiated sand** Yellowish-brown to tan, mod. sorted, arkosic med. to fine sand. Composed of beach and windblown sand deposits.

Qws **Windblown sand** Yellowish- to orangish-brown, poorly to mod. well sorted, arkosic med. sand. Forms stabilized dunes and actively accumulating deposits.

Qa **Sheetwash, stream channel, and other Holocene alluvium** Gray to yellowish-brown, poorly sorted cobbly to pebbly sand and muddy sand to mod. well sorted fine to coarse sand; predominantly arkosic. Stippled pattern indicates gravelly alluvium derived from Tertiary volcanic rocks.

Qfg **Alluvial fan deposits** Gray-brown to yellowish-brown, mod. well sorted to very poorly sorted granular coarse sand to sandy boulder gravel; predominantly arkosic. Forms broad, gently sloping, relatively undissected fan surfaces and steeper colluvial slopes with cambic soil development.

Qm **Alluvium of Military Road** Yellowish- to reddish-brown, poorly sorted granular sand to pebbly muddy sand derived from Qpf. Grades from pebbly deposits in southwest to sands at distal edge near Lemmon Valley playa.

Qfp **Axial-stream floodplain deposits** Brown to yellowish-brown, well-sorted slightly sandy mud to fine sand.

Qcd **Clay dunes** Brown to gray-brown, loose, mod. well sorted muddy fine sand and fine to med. sand-size aggregates of clay derived from playa and lake deposits. Stabilized and breached by recent stream channels.

Ql
Qfb
Qb **Deposits of late Pleistocene Lake Lemmon Ql: Lake deposits** Pale-yellow to gray, well-sorted slightly sandy silt to clay. Flat-lying; cut by recent stream channels. **Qfb: Forebeach deposits** Brown to yellowish-brown, poorly sorted, arkosic granular muddy sand to mod. well sorted very fine sand. **Qb: Beach bar deposits** Yellowish-tan to brown, mod. to poorly sorted granular sand to muddy sand; arkosic, generally unconsolidated. Mammoth bone dated (^{14}C) at 10,440 ± 490 yrs (TX-4960); camel bones also found.

Qfgo **Older alluvium, colluvium, and decomposed granite** Grayish-tan to reddish-brown, very poorly sorted muddy coarse sand and sandy pebble gravel to gravelly sand; arkosic, unconsolidated. Strongly argillic (B_2t) soil overlying weak duripan developed locally.

Qas **Alluvium of Stead Airport** Reddish-brown, very poorly sorted, arkosic pebbly muddy sand derived from Qpg and Qpf. Mod. developed argillic (B_2t) soil. Forms thin (≤ 2 m) veneer overlying Ts.

Qgs **Granitic alluvial fan deposits** Pinkish- to yellowish-brown, poorly to very poorly sorted granular sand. Well-developed argillic (B_2t) soil. Pebble and cobble ventifacts common at surface.

Qva **Volcanic alluvium** Brownish-red to dark-yellowish-brown, very poorly sorted pebbly muddy sand to muddy gravel and bouldery gravelly sand. Mod. dissected. Well-developed argillic (B_2t) soil. Forms thin (≤ 2 m) veneer overlying Ts..

Qpg **Pediment gravels** Tan to dark-reddish-brown, very poorly sorted cobbly sand to sandy gravel. Clasts predominantly granitic; some Tertiary volcanic and Mesozoic metavolcanic rock fragments. Strongly argillic (B_2t) soil with well-developed duripan (Cca).

Qpf **Alluvial fan deposits of Peavine Mountain** Reddish-brown to dark-yellowish-brown, poorly to very poorly sorted, poorly bedded muddy sandy pebble gravel. Commonly forms multicolored desert pavement composed primarily of altered andesite pebbles, arkosic sand, and lesser amounts of jasper, quartz, and metavolcanic clasts. Well-developed argillic (B_2t) soil. Forms thin (≤ 2 m) veneer overlying Ts.

Qgv **Old gravelly alluvium** Tan to reddish-brown, very poorly sorted cobbly muddy fine sand to gravelly sand. Predominantly arkosic with some rounded, carbonate-coated volcanic pebbles and cobbles (probably derived from Tg). Poorly indurated with strongly developed soil profile.

Qoa **Old alluvium** Tan to brown, very poorly sorted, mod. consolidated pebbly silt to unconsolidated gravelly sand and muddy sandy pebble gravel. Occurs as deeply dissected fan remnants. Strongly developed argillic (B_2t) soil with weak duripan (Cca).

Qag **Old alluvial gravels** Dark-reddish-gray, very poorly sorted sandy cobble to boulder gravel. Predominantly Tertiary volcanic clasts; minor granitic clasts. Strongly developed soil with duripan.

Qbv **Boulder alluvium** Tan to dark-gray, very poorly sorted sandy boulder gravel. Clasts predominantly granitic with lesser amounts of Tertiary tuffs, Kate Peak Formation, Peavine sequence, and Mesozoic basalt.

Qbg **Granitic boulder alluvium** Gray to brown, very poorly sorted sandy boulder gravel. Well-developed argillic (B_2t) soil.

Ts **Tertiary sediments** Cream to gray to pale-green, thick, interbedded alluvial and fluvio-lacustrine basin-fill sediments. Includes interbedded, unconsolidated to mod. well consolidated arkosic sandy gravel, gravelly sand, granular to very fine grained sand, tuffaceous sandstone, volcanic ostracod-bearing sandstone, slightly diatomaceous siltstone, and thin lenses of air-fall tuff. Commonly highly dissected and overlain by veneer of pebbly sand or lag gravel. Probably equivalent in age to sandstone of Hunter Creek (Bonham and Bingler, 1973).

Tg **Tertiary gravels** Gray to brown, very poorly sorted, mod. indurated, stratified bouldery cobble gravel to sandy gravel with thin, interbedded lenses of volcanic sandstone. 60% clasts of Tertiary volcanic rocks and basalt; 40% highly weathered to disintegrated granitic clasts. Well-developed duripan (Cca) > 3 m thick.

Tk **Kate Peak Formation** Gray to reddish-gray, porphyritic to glomeroporphyritic hornblende-biotite andesite flows. Vuggy, highly resistant to weathering. Forms rugged, bouldery outcrops.

Tp **Pyramid sequence** Dark-gray to reddish-purple, porphyritic basaltic andesite flows and agglomerate. Vesicular to scoriaceous near flow tops.

Ta **Alta Formation** Dark-gray to reddish-brown, thin, porphyritic pyroxene andesite flows. Distinctive platy fracture.

Note: In previous publications, the Tertiary tuffs described below were considered units of the Hartford Hill Rhyolite. However, this nomenclature has been abandoned (Bingler, 1978), and they are now distinct formations.

Tcs **Tuff of Chimney Springs** Orangish-yellow to yellowish-brown crystal tuff. 50-60% smoky quartz, sanidine, and minor biotite phenocrysts in a partially welded, devitrified, rhyolitic matrix.

Tnh **Nine Hill Tuff** Reddish-purple to pale-orangish-red, pumiceous, rhyolite vitric tuff. Densely welded, devitrified, with stretched and flattened pumice lapilli. Vugs with vapor-phase crystallization products common. Forms distinct ridges.

Tpt **Pumice tuff** Pale- to dark-gray, very pumiceous vitric-crystal tuff. Usually poorly welded, fine- to med.-grained, glassy, shard-rich ash with abundant pumice lapilli; phenocrysts of sanidine, quartz, few lithic fragments. Includes densely welded perlitic vitrophyre. Easily weathered, rarely crops out.

Tvt **Vitric tuff** Cream to yellowish-tan to pale-purple rhyolitic to rhyodacitic vitric to vitric-crystal tuff. Includes a variety of poorly to densely welded tuffs with sanidine, sanidine-smoky quartz, plagioclase-biotite, or biotite phenocrysts in a devitrified, locally pumiceous, fine-grained matrix. Forms resistant, knobby outcrops where densely welded.

Mzqm **Quartz monzonite** Pink to pale-gray, massive, med.- to coarse-grained, equigranular to porphyritic quartz monzonite to granite. Includes extensive aplite, graphic granite, quartz veins, and pegmatite dikes. Generally deeply weathered; forms low, rounded outcrops.

Mzgd **Granodiorite** Light- to dark-gray, fine- to coarse-grained, equigranular to porphyritic hornblende-biotite granodiorite. Mod. to highly fractured and faulted. Cut by basalt and aplite-pegmatite dikes and quartz and epidote veins. Highly resistant to weathering; forms blocky, jagged outcrops.

Mzfg **Foliated granitic rocks** Pinkish- to dark-gray, fine-to coarse-grained, equigranular, weakly foliated to gneissic diorite to granodiorite.

Mzv **Peavine sequence** White to dark-gray rhyolitic to andesitic metavolcanic rocks. Commonly porphyritic; copper mineralization locally. Forms resistant, knobby outcrops that are highly fractured to sheared in mineralized areas.

Contact Dashed where approximately located, dotted where concealed

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Lineaments

35 **Strike and dip of bedding**

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Outline of sand pit excavations

REFERENCES

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Mapping in part based on Soeller, S. A. (1978) Quaternary and environmental geology of Lemmon Valley, Nevada: unpublished M.S. thesis, University of Nevada-Reno.

Research for this map supported by U.S. Geological Survey Earthquake Hazards Reduction Grant No. 14-09-0001-20563

Scale 1:24,000

CONTOUR INTERVAL 20 FEET

DOTTED LINES ARE 10-FOOT CONTOURS

0 0.5 1 kilometer

0 0.5 1 mile

0 1000 2000 3000 4000 5000 feet

Base map: U.S. Geological Survey Reno NE 7½' quadrangle, 1967
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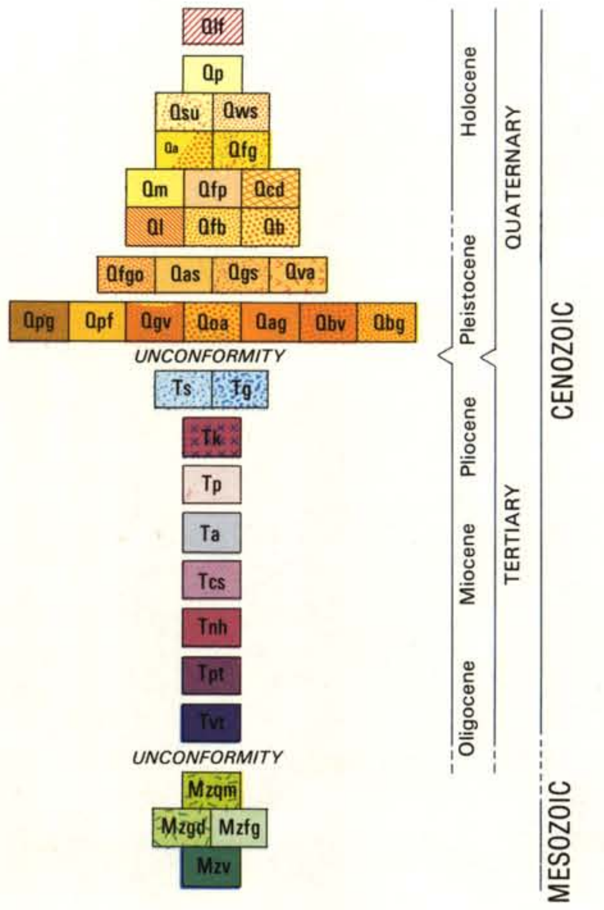
Compilation of Geologic Maps of the Reno NE Quadrangle (upper map and key) by Gail E. Cordy (1985) and the Reno Quadrangle (lower map and key) by H.F. Bonham Jr. and E.C. Bingler (1973)



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nbmg

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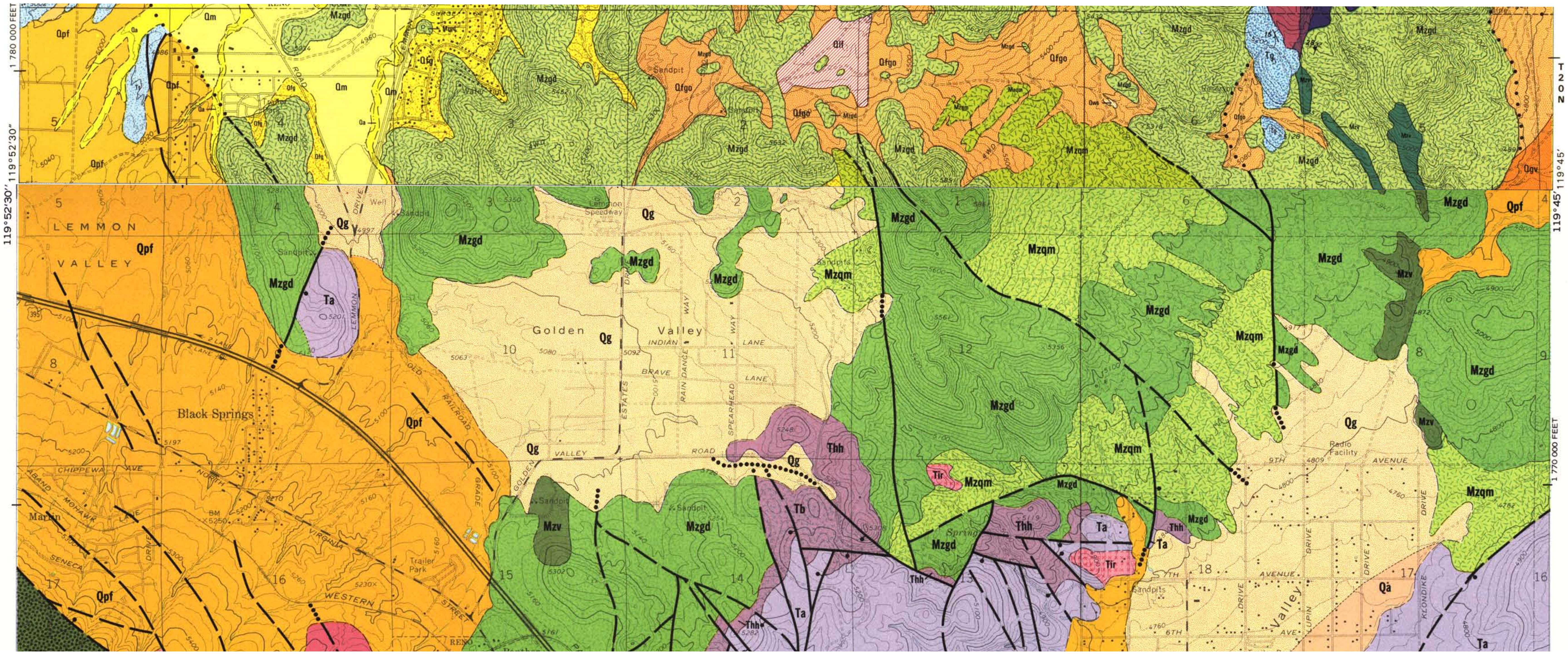
OLOGY



ENVIRONMENT

Qmg **Mainstream Gravel** Sandy cobble gravel confined to the present Truckee River floodplain.

Qfl **Floodplain and Lake Deposits** Thin sheet of medium- to thin-bedded clayey silt and sand. Contains discontinuous layers of silt and peat.

Qa **Alluvium** Poorly sorted clayey to silty gravelly sand, poorly bedded to unbedded.

Qg **Granitic Alluvium** Weathered granitic sand.

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Qdo **Donner Lake Outwash** Deposits similar to Tahoe outwash except weathered to depths of four feet or more.

Qps **Pediment and Stream Gravel** Thin deposits of sandy to clayey, cobble to small boulder gravel. Moderately to deeply weathered. Chalk Bluff area-contains numerous large, rounded to highly rounded cobbles and boulders of basalt and granitic rock. Peavine Creek area-contains many locally derived white to yellowish white, silicified andesite fragments.

Qgr / Qgrs **Gravel of Reno Qgr:** Moderately well-sorted sandy cobble gravel. Slightly cemented. **Qgrs:** Weakly-bedded deposits of coarse sand containing scattered small cobbles and thin cobble layers.

Qpf **Alluvial Fan Deposits of Peavine Mountain** Poorly sorted, pale yellowish to reddish brown, montmorillonitic, gravelly to sandy and clayey silt. White silicified andesite fragments common. Black Springs area—pale orange brown clayey and gravelly sand.

QUATERNARY

UNCONFORMITY

Th / Thd **Sandstone of Hunter Creek Th:** Pale brown to gray brown and greenish gray, prominently bedded, interlayered siltstone, silty sandstone, and sandy conglomerate. **Thd:** White to yellowish white diatomite and diatomaceous sandstone.

Tk / Tki **Kate Peak Formation Tk:** Gray, porphyritic, hornblende-biotite andesite flow containing phenocrysts of plagioclase, biotite, and hornblende. **Tki:** Intrusive rock lithologically similar to the flow.

Tir **Rhyolite Plugs** Flow-banded, light gray porphyritic rhyolite. Small quartz and feldspar phenocrysts in a fine-grained matrix.

Tsr **Silicified Rock** Silicified rock and breccia consisting almost entirely of fine-grained red-brown quartz, colored by iron-oxide. This unit is confined to areas of altered volcanic or granitic rocks.

Tg **Granitic Stock** Hypabyssal stock composed of several intrusive phases ranging in composition from pyroxene diorite through granodiorite porphyry to pyroxene syenite. Largely altered to cream-colored iron-stained rock made up of quartz, sericite, and clay. Locally contains chlorite, epidote and potassium feldspar. Pyrite is abundant in unweathered parts of the altered rock.

Ta **Alta Formation** Dark brown pyroxene andesite flows, flow breccia, and laharic breccia. Commonly altered to tan rock composed of quartz, sericite, and clay minerals or propylitized to gray green rock containing chlorite, calcite, albite, epidote, and clay minerals.

Tb **Epiclastic Volcanic Breccia** Greenish white volcanic breccia composed predominently of lithic fragments derived from the erosion of rhyolitic flows and ash-flow tuff. In many areas the fragments are altered to quartz, sericite, and clay minerals.

Thh **Hartford Hill Formation** Crystal-poor cream to buff rhyolitic ash-flow tuff with sparse crystals of quartz and feldspar in a moderately welded matrix of pumice and ash.

TERTIARY

UNCONFORMITY

Mzqm **Quartz Monzonite** Coarse-grained, light gray plutonic rock composed of microcline, quartz, plagioclase, and moderately abundant biotite. Deeply weathered and does not normally cropout.

Mzgd **Granodiorite** Gray hornblende-biotite granodiorite. Deuteric alteration has commonly formed actinolite and chlorite from hornblende and biotite; epidote, calcite, and sericite partially replace plagioclase. Not normally deeply weathered and usually forms numerous outcrops.

Mzv **Peavine Sequence** Gray to gray-green metavolcanic rocks with subordinate amounts of metamorphosed epiclastic volcanic sedimentary rocks. The metavolcanic rocks include rhyolite flows and pyroclastics and dacite to andesite flows and laharic breccias. Where fresh, highly resistant to erosion and tends to form bold outcrops.

MESOZOIC

Contact Long dashes where approximately located; short dashes where indefinite; dotted where buried.

Fault Dashed where approximately located; dotted where concealed. Ball on downthown side.

Alluvial Fan

Altered Rock

This map illustrates the distribution of bedrock and surficial deposits in the Reno Quadrangle. The geologic mapping was done as a reconnaissance, thus the user should regard this map as preliminary.

By H. F. Bonham Jr. and E. C. Bingler, 1973

Quaternary geology in part from Birkeland, P. W., Correlation of Quaternary Stratigraphy of the Sierra Nevada with that of the Lake Lahontan Area in *Means of Correlation of Quaternary Successions,* Univ. of Utah, 1968.

1 INCH EQUALS 2000 FEET

0 0.5 1 MILE

0 2000 4000 FEET

0 0.5 1 KILOMETER

0 1000 METERS

CONTOUR INTERVAL 20 FEET

DOTTED LINES ARE 10-FOOT CONTOURS

DATUM IS MEAN SEA LEVEL

Topographic base from U.S. Geological Survey Reno 7½′ quadrangle, 1967.

Cartography by Susan L. Nichols.

NEVADA BUREAU OF MINES AND GEOLOGY
UNIVERSITY OF NEVADA
RENO, NEVADA 89507

Appendix B

Well Log Tabulation

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
Adams-25534	9484	Spearhead Way	1984-7-11	Weathered green granite 24-94 Gray granite 94-188 with occasional fracture zones Hard gray granite 188-200	SWL 148	Screened 165-195
Aiken-36671	7650	Hillview Drive	1991-5-17	Green gray granite 169-338	SWL 150	Screened 298-338
Ariaz1-12815	7575	Tamra Drive	1972-12-25-	Occasionally fractured hard grey granite 65-200 ft	SWL 112	Screened 160-200
Ariaz2-37614 - **Deepened**	7575	Tamra Drive	1991-10-31	Hard gray granite 197-244 with occ fracture zones Hard black granite 244-265 with one fracture zone Gray granite 265-175	SWL 130	Screened 182-202 & 222-262
Bell-13738 **Duplicate of Conradt-13738**	3495	Deerfoot Lane	1973-12-17	Clay layers with small gravel 20-77 Med hard to hard volcanics 77-104 Med hard to hard fractured dark green granite 104-127 Dark green granite 127-145	SWL 70	Screened 124-164
Benedickt-24671	650	Colt Drive	1983-6-20	Brown clay to 13 ft Hard gray granite 13-87 Fractured granite 87-106 Gray granite 106-110	SWL 45	Screened 83-105
Biggie 11370	9075	Wigwam Way	1971-2-1	Soil/clay to 6 ft Decomposed granite 6-65 Red clay 65-73 Hard granite 73-82 Sand 82-84 Decomposed granite 84-90 Sand 90-93 Hard granite 93-100 Decomposed granite 100-135	SWL 58	Screened 56-96

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Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
Birdwell-18504	7215	Marlin Drive	1978-6-21	Brown clay layers to 115 ft Coarse sand 115-154	SWL 26	Screened 124-154
Buranzon-38352 - **Deepened**	7555	Vista View Drive	1992-7-27	Weathered granite with a few fracture zones & few hard granite layers 118-260	SWL 103	Screened 180-200 & 220-260
Chavez-18237	3410	Running Bear Lane	1978-5-29	Brown sand to 70 ft Brown decomposed granite 70-205 Brown yellow decomposed granite 205-235	SWL 135	Screened 215-230
Cobb-11467	7660	Hillview Drive	1971-3-21	Boulders & yellow clay to 52 ft Decomposed granite 52-90 Hard blue granite 90-124	SWL not listed on well log	Screened 84-104
Cohen-16627	7600	Hillview Drive	1977-6-25	Red clay & granitic sand to 12 ft Decomposed granitic sand 12-75 ft Hard granite 75-100 Tight granite with small fractures 100-169 Fractured 169-185 Green granite with small fractures 185-194 Fine to rocky comes out as coarse sand 194-211	SWL 107	Screened 163-207
Conradt-13738 = **Duplicate of Bell-13738**	3495	Deerfoot Lane	1973-12-17	Clay layers with small gravel 20-77 Med hard to hard volcanics 77-104 Med hard to hard fractured dark green granite 104-127 Dark green granite 127-145	SWL 70	Screened 124-164

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
Davis-18608	7320	Estates Road	1978-7-24	Sand to 3 ft Decomposed granite & clay 3-20 Clay 20-34 Decomposed granite – highly oxidized 34-82 Decomposed granite 82-156	SWL 44	Screened 95-156
Donshick-24981	9355	Wigwam Way	1983-10-6	Loose DG to 9 ft DG with brown clay 9-35 Weathered granite 35-145 Gray granite 145-183 Fractured granite 183-199 Gray granite 199-275 with fractured zones 116-228 & 255-258	SWL 115	Screened 209-228 & 248-268
Dresbach-49206-N - deepened	9255	Spearhead Way	1995-8-21	Gray granite 145-180 with fracture zone 167-172 Brown volcanic rock 180-192 over 1 ft white clay layer Gray granite 193-277 with fracture zone 209-211 & 261-272	SWL 112	Screened 177-197 & 217-237 & 257-277
Dunn-89325 - Deepened	680	Browning Drive	2003-4-25	Hard green granite 80-170 Yellow DG 170-200 Black basalt 200-230 Green granite black rock 230-240	SWL 26	Screened 180-200 & 200-220
Evans-46487-N - Deepened	7635	Hillview Drive	1994-8-15	Grante with some fractures 165-187 Hard granite fractured 187-300	SWL 146	Screened 160-300
Ewers-16759	2610	Margaret Drive	1977-8-15	Valley fill to 70 ft Granite solid 70-140 Fractured granite 140-185	SWL 85	Screened 140-180

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
Fenkell-47017 – Deepened	7565	Bluff View Way	1995-3-6	Gray granite 182-184 Weathered granite 184-203 Gray granite 203-270 with fracture zones 203-217 & 225-228 & 255-257	SWL 142	Screened 161-181 & 201-221 & 241-262
Folsom-85341	7665	Hillview Drive	1971-3-11	Soil & clay to 75 ft Decomposed granite 75-115 Boulders 115-120 Hard granite 120-125	SWL 75	Screened 85-125
Freeman-16384	9469	Wigwam Way	1977-4-22	Decomposed granite to 60 ft Gray granite 60-76 Decomposed granite with high quartz content 76-275	SWL 154	Screened 225-275
Gard-16763	2660	Margaret Drive	1977-7-13	DG & sand to 57 ft Sand & gravel 57 to 59 Diorite – broken 59-1985	SWL 56	Screened 140-180
Garner-18587	3495	Golden Valley Road	1978-7-20	Light brown clay to 80 ft Blue gray clay fractured 80-160 Purple clay 160-190 Blue gray clay 190-215 Purple rock fractured 215-260 Note: the “clay” below 160 ft is likely Hartford Hill volcanics	SWL 75	Screened 221-260
Gillaspy-17049 **pre-drilled**	9155	Wigwam Way	1977-10-6	Pre-drilled to 130 ft Decomposed granite - Brown & white 130-158 Gray granite med hard 158-200	SWL 105	Screened 91-200

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
Griffith-88360	9430	Arrowhead Way	2002-8-18	DG to 188 ft Fractured granite 186-223 Hard granite 223-248 with fracture zone 228-236	SWL 140	Screened 188-248
GV MW1				Silt & sand to 10 ft Quartz-rich granitic sand 10-136 Sandy clay 136-138 Cemented granitic sand 138-165 Bedrock 166-250		Screened 95-244
GV MW3				Sand, silt & clay to 10 ft Sand with clay lenses 10-20 Coarse granitic sand 20-60 Coarse granitic sand with tan clay stringers 60-70 Clean quartz sand 70-222 with tan clay 136-140 & 175-193 Bedrock 222-260		Screened 105-255
GV MW4				Sand, silt & clay to 10 ft Granitic sand with clay 10-50 Granitic sand with clay or small gavel in some intervals 50-190 Cemented sand 190-260		Screened 111-258

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
GV MW5				Silt & sand to 22 ft Sand with clay 22-52 Sand 52-60 Angular quartzite(?) fragments with sand & gravel 60-78 Sand 78-102 with small gravels below 98 Cemented sand 102-170 Quartz sand w/ brown silty clay 170-173 Cemented quartz sand 173-250		Screened 105-255
GV Park-21506		SE/4 NE/4 Sec 10 T20NR19#	1980-6-23	Overburden to 5 ft Decomposed granite soft 5-20 Fractured granite 20-120 Hard granite 120-140 Fractured granite 140-1880 Granite & sand 180-200 Hard granite 200-250 with fracture zone from 215-230	SWL 75	Screened 140-230
GV41-13061-N	3275	Warpaint Circle	1972-6-19	Brown to reddish brown sandy clay & silt layers to 49 ft Green to grey clay with some small gravel 49-90 Brown sandy clay 90-110 Weathered black or grey granite 110-140	SWL 62	Screened 100-140
GV42-30153-N - **Deepened**	3275	Warpaint Circle APN 83-176-03	1988-7-21	Weathered granite 143-155 with soft zone 145-147 Brown soft sandy clay 155-165 Weathered granite 165-200 with soft zone 174-179	SWL 102	Screened 140-160 & 180-200

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
Hedrick1-26315	7745	Tamra Drive	1984-10-22	Decomposed granite to 3 ft Soft weathered granite 3-15 Green med hard granite 15-96 Green granite 98-181 with soft zones 135-137 & 147-151 Gray granite 181-308 with soft zone 215-231 and fracture zones 284-285 & 298-299	SWL 235	Screened 272-308
Hedrick2-88386 - **Deepened**	7800	Tamra Drive	2002-10-22	Green granite 150-240	SWL 118	Screened 220-240
Hedrick3-116683 **Deepened**	7800	Tamra Drive	2013-5-24	Fractured gray granite 235-290 Multi-colored rock 290-340 Fractured black/white granite 340-360 Alternating zones of grey-white granite to tan granite 360-596 – decomposed granite & tan clay zones may represent fractures	SWL 210	Screened 516-596
Johnson-16668-M		Sun Cloud Circle – NE corner 4 Teepee Lane - SW/4 SE/4 Sec 11 T20NR19E	1977-7-15	Rhyolite 1-260 with Fractured Rhyolite 200-260	SWL 90	Screened 215-255
Jones-18503	7225	Marlin Drive	1978-6-30	Top soil & brown clay to 38 ft Brown DG with some clay 38-72 Decomposed granite brown & loose 72-120 Decomposed granite brown & coarse 120-145	SWL 40	Screened 125-145

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
Kjoge-17853	7185	Marlin Drive	1978-3-14	Brown clay to 101 Sand 101-105 Clay 105-115 Brown sand w/ some gravel 115-130 Brown clay 130-150	SWL 32	Screened 100-140
Knoles-24605	3505	War Paint Circle	1983-5-4	Brown clay with DG to 63 ft Brown clay 63-115 Yellow clay 115-172 White clay 172-270 Black rock 270-290 Weathered granite 290-370 with soft zones 316-318 & 335-338 & 359-370 Green granite 370-375	SWL 95	Screened 301-367
Larkin Baughman-39851	9421	Wigwam Way	1992-10-21	Brown clay w/ DG to 59 ft Weathered granite rusty colored 59-145 Harder granite weathered 145-375 with fracture zone 189-193 & soft zones 231-239 and 312-323 and 354-369	SWL 117	Screened 170-190 & 290-310 & 350-370
Lee-19327	3470	Brave Lane	1978-10-1	Decomposed granite 2-105 Boulder 105-107 Black rock 107-135 Clay 135-158 with some gravel 138-149 Cemented sand & gravel 158-220	SWL 158	Screened 105-115 & 135-155 & 185-205
Lewis-12555	7350	Estates Road	1972-8-17	Sandy clay & gravel to 70 ft Gravel 70-104 First water at 55 ft	SWL 40	Screened 80-100

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
Loader-18949	7220	Marlin Drive	1978-9-25	Brown sand & clay to 56 ft Decomposed granite brown & loose 56-122 Decomposed granite brown med hard 122-141 Coarse granite sand 141-175	SWL 30	Screened 131-175
Long-19190	2775	Cactus View Drive	1978-11-16	Decomposed granite to 20 ft Brown clay 20-45 Solid granite 45-85 Granite fractured 85-100	SWL 55	Screened 80-100
MacAlinden-13582	3425	Indian Lane	1973-10-3	DG with clay, hardpan, occasional clay lenses to 65 ft Weathered granite broken with some clay in fractures 65-70 DG brown 70-80 Weathered gray granite med hard 80-91 Weathered granite brown 91-98 Weathered gray granite med hard 98-141 very hard below 112	SWL 68	Screened 91-141
Marshley-12916-N	3445	Running Bear Lane	1973-1-25	Reddish clay w/ DG to 11 ft Decomposed granite with silt & some clay streaks 11-90 Silty sand w/ occ clay 90-131 Weathered gray granite 131-250 very soft but gradually becoming harder	SWL 96	Screened 166-205

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
Mayeroff-24574	775	Sherman Way	1983-4-20	Brown clay w/ some DG to 35 ft Decomposed granite 35-63 Green granite 65-116 weathered below 106 Green granite 116-166 with water-bearing fracture zones 116-120 & 165-166 Hard granite 166-175	SWL 50	Screened 122-144 & 164-175
Mayo1-11735	3460	Rolling Ridge Drive	1971-7-29	Hard & soft gray rock sometimes fractured 3-112 Red rhyolite fractures 112-150 Hard gray rock 150-155	SWL 64	No screened interval
Mayo2-39609-**Deepened**	3460	Rolling Ridge Drive	1992-9-16	Brown to red volcanic rock 106-150 Granite gray & hard 150-251 with fracture zones 165-166 & 186-187 & 205-207 & 235-235	SWL 115	Screened 186-246
McDonald-22808	7580	Hillview Drive	1981-5-11	DG with mix of clay to 40 ft Gray granite 40-185 Green granite 185-225 Broken gray granite fractures 225-250	SWL 105	Screened 230-250
McNinch-24836	9499	Wigwam Way	1983-2-26	Overburden to 4 ft DG 4-264 Hard fractured DG & quartz 284-343	SWL 200	Screened 324-343

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
Mentzer-24414	3565	Golden Valley Road	1983-2-17	Brown clay to 20 ft White med hard rock 20-65 Gray rock 65-140 Green & brown rock 140-210 Med hard rock 210-245 Fractured rock 245-270 with water 250-270 Green hard granite 270-275	SWL 110	Screened 249-269
Mosher-12737	7530	Rock Point Trail	1972-9-28	DG sand with some clay to 15 ft Reddish brown sandy clay 15-31 Weathered granite 31-90 Hard gray granite 90-200 with fracture zones 95-97 & 101-103 & 136-139 & 143-144; heavily fractured & water bearing 165-190	SWL 85	Screened 170-200
Nobach-44317-M	3550	Golden Valley Road	1992-7-6	Clay & sand clay to 15 ft Soft purple clay 15-22 Soft dark brown clay 22-29 Hard gray roc 29-35 Rock broken & fractured 35-51 Med hard tan rock 51-96 with soft zone 51-53 & 71-88 Med rock tan 88-96 Med rock gray 96-114 Med rock purple 114-116 Fractured gray rock 116-131	SWL 66.8	Screened 91-131

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
Peck-34775-N - **Deepened**	3200	Sun Cloud Circle	1990-10-15	Gray granite 79-115 with fracture zone 103-104 Gay granite 104-115 Weathered granite with clay streaks 115-127 Gray granite 127-152 with fracture zone 130-138	SWL 71	Screened 107-147
Pendill-23458	3485	Running Bear Lane	1981-10-23	Brown clay w/ DG to 78 ft Weathered granite with some clay 78-249 White granite with fractures 249-285 Gray granite 285-338 with fracture zones 305-307 & 330-335	SWL 160	Screened 225-175 & 285-305 & 318-338
Pilling-13513	9325	Wigwam Way	1973-4-18	Clay with gravel lenses to 66 ft Extra hard gray granite 66-193 with fracture zones 165-167 & 187-189	SWL 140	Open hole – no pump test
Powell (Kaspar)-19523	3430	War Paint Circle	1979-3-15	Sand to 30 ft Sandstone 30-170 Gravel 170-180 Granite 180-190	SWL 90	Screened 170-190
Priano (Harcinske)-11883-N	9350	Spearhead Drive	1971-8-25	DG to 65 ft Fractured granite 65-105 Med hard granite 105-135 Med hard & very hard granite 135-150 Very hard granite 150-187	SWL 80	Screened 137-187
Reimers-18889-N	7815	Tamra Drive	1978-8-21	Rock & dirt to 50 ft Rock 50-275 Sand & gravel 275-300 Rock 300-450	SWL 250	Screened 205-275 & 430-450

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
Rhodes-11726-N		NE/2 Sec 14 T20NR19E	1971-8-2	Broken brown rock to 15 ft Gray hard rock 15-95 Bown broken rock 95-105 Hard yellow rock 105-110 Red rhyolite very hard, broken & creviced 110-135	SWL 68	No screened interval
Robinson-32205	640	Browning Drive	1989-9-11	Brown clay w/ DG to 35 ft Green weathered granite 35-86 Green granite 86-131 with fracture zone 115-120 Gray granite 131-150 with fracture zones 136-138 & 145-147	SWL 40	Screened 100-140
Rodriguez-26313	7805	Tamra Drive	1985-6-24	DG to 6 ft Weathered green granite 6-35 Gray granite 35-101 Fracture zone 101-106 Weathered green granite 106-136 Gray granite 136-150 with fracture zone 143-144	SWL 89	Screened 111-150
Rumburg-69610	2625	Knob Hill Drive	1997-10-14	Clay with DG to 11 ft Weathered granite 11-27 Hard green granite 27-61 Weathered granite with clay streaks 61-95 Gray granite 95-160 with fracture zones 115-116 & 122-126 Weathered granite 160-192 with fracture zone 180-192 Gray hard granite 192-200	SWL 101	Screened 115-135 & 175-195

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
Schoensky (Schiwart)-104020-N	3275	Brave Lane	1974-5-20	DG with clay to 148 ft Decomposed granite 148-152 Granite 152-205	SWL not listed on well log	Screened 140-160
Steadman (Pratt)-82613-N	3435	Warpaint Circle	2001-1-22	DG to 130 ft White rock & quartz 130-173	SWL 70	Screened 163-173
Thomas - 20037	9441	Wigwam Way	1979-6-13	Top soil to 4 ft Brown med hard DG 4-48 Brown med loose DG 48-111 Brown DG hard 111-185 Light brown granite med hard 185-261 Light blue granite med hard & fractured 261-300	SWL 150	Screened 258-294
Walsh-41784-M - **Deepened**	9205	Spearhead Way	1993-5-3	Fine sand & small gravel 118-121 Hard broken gay rock 121-143 Broken fractured rock 143-146 Hard gray rock 146-155 Broken & fractured rock 155-165	SWL 142	Screened 121-161
Zebal-18607	945	Margaret Drive NE/4 SE/4 Sec 10 T20NR19E	1978-7-18	Overburden to 9 ft Sand 9-17 Sand & red clay 17-24 DG oxidized color 24-31 Red clay 31-47 DG with some clay layers 47-53 Fairy tight DG with some oxidation 53-78 Layers of tight & loose DG high oxidation 78-155	SWL not listed on well log	Screened 95-155
74367-GV13		NE/4 NE/4 Section 11 T20NR19E	1995-8-17	Granodiorite 250-450		Screened 240-450

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Well ID	**House #**	**Street**	**Year drilled**	**Well log**	**Static Water Level**	**Screened Interval(s)**
74367-GV14		NE/4 NE/4 Section 11 T20NR19E	1995-8-24	DG soft to 12 ft Firm DG 12-60 Mostly hard granodiorite with some softer zones – fractured & broken 60-450		Screened 200-240 & 140-450
GV15 **Recharge**		SW/4 SW/4 Sec 2 T10NR19E		Alluvium to 40 ft Granite no weathering 40-136 Fractured granite 136-143 Granite very hard 143-150 Weathered granite 150-155 Fractured granite 155-160 Granite major fracturing 160-180 Granite multiple fractures 180-320 Weathered granite 320-340 Consolidated fractured granite 340-350	SWL 70	Screened 160-400
74367-GV13		NE/4 NE/4 Section 11 T20NR19E	1995-8-17	Granodiorite 250-450		Screened 240-450
74367-GV14		NE/4 NE/4 Section 11 T20NR19E	1995-8-24	DG soft to 12 ft Firm DG 12-60 Mostly hard granodiorite with some softer zones – fractured & broken 60-450		Screened 200-240 & 140-450

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
GV15 **Recharge**		SW/4 SW/4 Sec 2 T10NR19E		Alluvium to 40 ft Granite no weathering 40-136 Fractured granite 136-143 Granite very hard 143-150 Weathered granite 150-155 Fractured granite 155-160 Granite major fracturing 160-180 Granite multiple fractures 180-320 Weathered granite 320-340 Consolidated fractured granite 340-350	SWL 70	Screened 160-400
Cross Section A						
11297	3275	Brave Lane	1970-11-15	Clay to 80 ft Decomposed granite 80-100	11297	3275
13061	3275	Warpaint Circle	1972-6-19	DG to 2 ft Clay, sandy clay layers to 20 ft Reddish sandy clay 20-49 Green-gray clay with some small gravel 49-90 Brown sandy clay 90-110 Weathered black or gray granite 110-140		

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Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
13562	7565	Estates Drive	1973-7-27	DG to 8 ft DG hardpan 8-12 Weathered gray granite with some clay 12-66 Soft broken granite 66-75 Med hard granite 75-106 with fracture zone 95-97 Very hard green granite 106-132 Med hard green granite 132-145 Very hard green granite 145-165		
16072	9070	Spearhead	1976-12-9	Brown clay to 18 ft Clay & DG sand mixed 18-85 Loose brown decomposed granite 85-128		
16627	7600	Hillview Drive	1977-6-25	Red clay & dg to 12 ft Decomposed granite 12-50 DG sand, clay some fractured areas 50-75 Hard granite 75-109 Granite tight with some small fractures 109-185 Green granite with fractures & some clay 185-194 Fine to rocky 194-207 Cemented sand & gravel 207-236		

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Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
16808	3430	Deerfoot Lane	1977-7-19	Brown to red clay to 42 ft Sticky clay – brown to white to brown 42-170 Gray soft rock 170-188 Brown decomposed soft rock 188-192 Hard broken brown rock 192-215		
18892	7625	Tamra Drive	1978-9-4	Dirt & rock to 25 ft Sand 25-100 Granite 100-300		
19921	3205	Indian Lane	1979-5-24	Sand with clay to 45 ft Sand, gravel w/ clay 45-86 Large gravel, sand & clay 86-105 Brown clay & sand 105-143 Course gravel & sand with clay 143-165		
22162	3575	Golden Valley Drive	1980-10-28	Clay & rock to 63 ft Hard DG 63-71 Gray clay & little DG 71-163 Fracture DG 163-200		
24414	3565	Golden Valley Road	1983-2-17	Brown clay to 20 ft White med hard rock 20-65 Gray rock 65-140 Green & brown rock 140-210 Med hard rock 210-245 Fractured rock 245-270 Green hard granite 270-275		

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Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
25560 - **Deepened**	3230	Indian Lane	1984-7-18	Weathered DG & quartz 155-172 Weathered qtz & granite 180-184 Med hard white granite 184-188 Qtz & granite coarse large grained 188-206 Soft quartz 206-212 White granite 212-216 Soft quartz weathered 216-222 Med hard white granite 222-225		
27752	7740	Tamra Drive	1986-9-8	Weathered granite to 27 ft Gray granite 27-300 with fractures 87-88 & 165-166 & 214-215 & 220-221 & 265-270 & 281-295		
30153 - **Deepened**	3275	Warpaint Circle	1988-7-21	Weathered granite 143-200 with soft zone 145-147 & 155-165 & 174-179		
30521	7670	Tamra Drive	1988-9-27	Decomposed granite to 44 ft Granite 44-53 Weathered granite 53-210 with alt softer layers Broken & fractured granite 210-280 with fractured zones 233-236 & 245-263 & 276-280		

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
42159	3605	Sun Cloud Circle	1993-6-30	Tan & brown "shail" to 89 ft Gray rock 89-130 softer 108-130 Dark brown rock 130-136 Very dark rusty brown rock 136-168 Hard rock 168-200 with fracture zones 170-173 & 181-182 & 196-200 with some water Light gray rock 200-225 with soft zone 200-204 Broken & fractured rock 225-240		
43768 – **Deepened**	3405	Deerfoot Lane	1993-10-11	Granite sands 127-130 Soft brown clay with granite sands 130-140 with soft zone 138-140 Weathered granite with clay streaks 140-227 with soft zones 163-165 & 210-212		
46290 – **Deepened**	7680	Jays Place	1994-9-19	Decomposed granite 252-256 Granite 256-301 with soft zones 283-290 & 296-301 Broken fractured granite 301-334 Granite with weathered streaks 334-360		
46487 – **Deepened**	7635	Hillview Drive	1994-8-15	Granite soft 165-187 Hard granite with fractures 187-300		

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
50044	3600	Sun Cloud Circle	1995-11-6	Yellow volcanic rock to 111 ft with rusty yellow color 49-64 Gray sandy clay 111-141 Brown to dark brown sandy clay 141-205 Gray clay 205-218 Brown sandy clay 218-242 Gray weathered granite 242-300 with fracture zones 255-261 & 287-291		
65314	3605	Golden Valley Road	1997 – 2-20	Red & brown dg to 8 ft Red & gray clay 8-15 Multi-colored volcanic rock med hard 15-110 Weathered granite with fractures 110-130 Green & gray clay stone 130-145 Multi-colored volcanic rock 145-155 Weathered granite 155-175 Multi-colored volcanic rock 175-210 Weathered granite hard 210-215 Green & black gravel 215-220		
97253 – **Deepened**	7575	Bluff View Way	2005-5-9	Gray granite 163-300 with soft zone 194-196 & 218-220 & 239-241 & 289-290		

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
98373	7765	Tamra Drive	2005-7-5	DG green clay to 10 ft Green granite 10-30 Blue/green/yellow granite 30-90 Red-brown clay blue-green granite 90-110 Fractured granite 110-195 Mostly black fractured granite 195-225 Blue-green granite with specs yellow clay 225-420		
Cross Section B						
11354 – **Deepened – prior well not constructed properly**	7571	Bluff View Way	2010-6-15	Gray hard granite 150-196 with fracture zone 186-188 Weathered granite 196-240 with fracture zones 205-206 & 230-231	SWL 130	11354 – **Deepened – prior well not constructed properly**
11439 – **Deepened**	7665	Hillview Drive	1971-9-5	Hard fractured gray granite 122-182 with some water & weathering 162-167	SWL 48	Screened interval not noted on log
12815	7575	Tamra Drive	1972-12-5	Alternating layers of sandy clay, silty sand & clay to 25 ft Dry yellow silt 25-30 Dry green-like silty 30-48 Yellow sandy clay 48-50 Green to brown silty sand 50-65 Hard grey granite occasionally fractured 65-200 with water bearing fractures 182-186 & 192-194	SWL 112	Screened 160-200

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
13597	630	Sherman Way	1973-4-30	Red clay with hard pan to 8 ft DG to 75 with alternating layers of some clay, some gravels Coarse sand 75-100	SWL 33	Screened 50-100
14699	6915	Pontiac Drive	1975-4-24	Hard brown to yellow clay with some sand to 55 ft Sandy brown clay with dg 55-65 Loose brown dg 65-75 Hard blue-green granite 75-84 Hard & soft sandy brown clay with dg 84-108 Hard to med hard gray-green granite 108-125	SWL 48	Screened 68-110
15283	6975	Pontiac Drive	1975-12-17	Dg sand with mix of brown clay to 76 ft Blue sand coarse with blue grey granite 76-100 Hard blue-grey granite with fractures & water bearing 100-111	SWL 35	Screened 93-111
15339	7570	Tamra Drive	1975-12-30	Overburden to 12 ft Blue rock w/ brown streaks 12-55 Brown clay & boulders 55-74 Gray granite 74-210 Broken gray granite 210-218 Granite 218-225	SWL 65	Screened 205-225
16688	700	Winchester Road	1977-7-13	Overburden to 6 ft Sandy clay with gravel 6-80 Brown sandstone 80-107 Fractured granite & volcanic rock 107-145	SWL 56	Screened 122-149

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
17319	2965	Valley View Drive	1977-10-19	Valley fill to 25 ft DG 25-80 Granite 80-190 with fractures 160-190 & some water at 80 ft	SWL 45	Screened 70-90 & 170-190
17970	345	Colt Drive	1978-4-11	Clay to 5 ft Fine sand 5-15 Soft dg 15-55 Granite hard 55-118 with fracture zones with some water 75-87 & 100-118	SWL not recorded on log	Screened 50-118
18949	7220	Marlin Drive	1978-9-25	Sandy clay to 56 ft Brown dg loose 56-122 Brown dg med hard 122-141 Course granite sand 141-175	SWL 30	Screened 131-175
19278	6855	Pontiac Drive	1979-1-4	Clay with dg to 105 Dg with large gravel 105-125 and water at 120	SWL 80	Screened 105-125
20875	7840	Tamra Drive	1980-3-17	Clay & rocks to 60 ft Granite 61-257 with fracture zone 235-240	SWL not recorded on log	Screened 237-257
GV Park-21506		SE/4 NE/4 Sec 10 T20NR19#	1980-6-23	Overburden to 5 ft Decomposed granite soft 5-20 Fractured granite 20-120 Hard granite 120-140 Fractured granite 140-1880 Granite & sand 180-200 Hard granite 200-250 with fracture zone from 215-230	SWL 75	Screened 140-230
24671	650	Colt Drive	1983-6-16	Brown clay to 13 ft Hard gray granite 13-110 with fracture zone 87-106	SWL 45	Screened 83-105

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
25771(1) 25771	735	Browning Drive	1984-10-3	Hard pan to 22 ft Dg 22-80 Hard granite with small amt of water 80-126 Clay 126-127	SWL 37	Screened 107-127
26165	665	Winchester Drive	1985-5-7	Brown clay w/ dg to 10 ft Weathered granite 10-17 Gray granite 17-155 with fractures zones 90-92 with water & 118-120 & 135-144	SWL 30	Screened 103-147
37614 – **Deepened**	7575	Tamra Drive	1991-10-28	Gray granite hard 197-244 Black granite hard 244-265 with fracture zone 248-253 Gray granite 265-275	SWL 130	Screened 182-202 & 222-262
38667 – **Deepened ?**	740	Browning Drive	1992-2-26	Hard green & black granite 118-170 Green & white granite with pyrite 170-180 Light green-dark green- white and reddish tan granite 180-239	SWL 36	Screened 209-229
82776	7200	N Virginia Street WEST OF US 395	2001-3-21	Clay & gravel to 72 ft Dg & boulders 72-135 Sand clay 135-167 Orange porphyry 167-214 White clay 214-218 Gray rock 218-277	SWL 111	Screened 217-277

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
85005	6980	N Virginia Street WEST OF US 395	1981-10-1	Red to brown clay 3-82 with hardpan 21-36 Gravel (water) 82-86 Red to brown clay with small rocks) 86-289 Gravel (water) 289-298 Brown clay with small rocks 198-304 Gravel (water) 304-318 Brown clay 318-321	SWL 82	Screened 297-321
94941	7860	Tamra Drive	2004-10-11	Dg with yellow clay to 15 ft Hard dark green granite 15-25 Dark blue green granite 25-248 Fractured granite 248-341	SWL 155	Screened 281-321
GV15 - 89899		Estates & Hillview SW/4 SW/4 Sec 2 T10NR19E	2003-2-19	Alluvium to 40 ft Granite no weathering 40-136 Fractured granite 136-143 Granite very hard 143-150 Weathered granite 150-155 Fractured granite 155-160 Granite major fracturing 160-180 Granite multiple fractures 180-320 Weathered granite 320-340 Consolidated fractured granite 340-350	Recharge Permit SWL 70	Screened 160-400
Cross Section C						
103807	9310	Bull Road SE/4 NE/4 Sec 11 T20NR19E	2006-10-12	Decomposed granite to 155 Fractured rock 155-200	SWL 73	Screened 160-200

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
11735	3460	Rolling Ridge Road	1971-7-29	Topsoil to 3 ft Hard & soft gray rock sometimes fractured 3-112 Red rhyolite – fractures & water bearing 112-150 Hard gray rock 150-155	SWL 64	Screen interval not recorded on log
12929	9255	Bull Road	1973-2-27	Soil to 2 ft Dry clay 2-17 Decomposed granite 17-235	SWL not recorded on log	Screened 146-211
Conradt-13738 = Duplicate of Bell-13738	3495	Deerfoot Lane	1973-12-17	Clay layers with small gravel 20-77 Med hard to hard volcanics 77-104 Med hard to hard fractured dark green granite 104-127 Dark green granite 127-145	SWL 70	Screened 124-164
14641	9110	Wigwam Way	1975-3-13	Decomposed granite sand topsoil to 3 ft Layers of brown to yellow to reddish brown clay with varying amounts of coarse sand or small gravel 3-127 Yellow sandy clays with coarse sand (water) 127-158 Hard gray granite 158-166 Hard to med hard brown rock (some water) 166-180 Hard black rock (water) 180-190	SWL 78	Screened 113-155
16384	9469	Wigwam Way	1977-3-22	Dg to 60 ft Grey granite 60-76 Decomposed gray granite high quartz content 76-275	SWL 154	Screened 225-275

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
Garner-18587	3495	Golden Valley Road	1978-7-20	Light brown clay to 80 ft Blue gray clay fractured 80-160 Purple clay 160-190 Blue gray clay 190-215 Purple rock fractured 215-260 Note: "clay" is likely Hartford Hill volcanics	SWL 75	Screened 221-260
Thomas - 20037	9441	Wigwam Way	1979-6-13	Top soil to 4 ft Brown med hard DG 4-48 Brown med loose DG 48-111 Brown DG hard 111-185 Light brown granite med hard 185-261 Light blue granite med hard & fractured 261-300	SWL 150	Screened 258-294
20250	3450	Rolling Ridge Road	1979-8-13	Rhyolite to 95 ft Volcanic & quartz 95-130	SWL 100	Screened 90-130
McNinch-24836	9499	Wigwam Way	1983-2-26	Overburden to 4 ft DG 4-264 Hard fractured DG & quartz 284-343	SWL 200	Screened 324-343
Donshick-24981	9355	Wigwam Way	1983-10-6	Loose DG to 9 ft DG with brown clay 9-35 Weathered granite 35-145 Gray granite 145-183 Fractured granite 183-199 Gray granite 199-275 with fractured zones 116-228 & 255-258	SWL 115	Screened 209-228 & 248-268

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
24998	3495	Golden Valley Road	1983-10-11	Light brown rock to 9 feet Red volcanic rock 9-20 Purple rock 20-90 Green granite 90-140 with fracture zone (water) 105-110 Gray granite 140-175 with fracture zones (water) 135-140 & 155-156 & 165-167	SWL 89	Screened 115-135 & 155-175
32062	4325	Indian Lane	1989-7-28	Brown lay with dg to 105 ft Weathered granite 105-145 White granite 145-188 with soft zone 165-166 & 180-188 Weathered granite 188-250 with soft zones 194-197 & 204-250	SWL 108	Screened 203-243
Mayo2-39609 - **Deepened**	3460	Rolling Ridge Drive	1992-9-16	Brown to red volcanic rock 106-150 Granite gray & hard 150-251 with fracture zones 165-166 & 186-187 & 205-207 & 235-235	SWL 115	Screened 186-246
39852 – **Deepened**	3450	Rolling Ridge Road	1992-10-13	Purple volcanic rock 130-165 Multi-colored rock 165-197	SWL 100	Screened 147-167
73431	8550	Spearhead Way	1998-9-1	Brown sandy clay to 34 ft Decomposed sands 34-38 Brown sandy clay 38-61 Gray clay 61-145 Purple clay 145-180 Weathered granite 180-185 Black fractured granite 185-219 Black hard granite 219-225	SWL 75	Screened 180-220

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
74367-GV14		NE/4 NE/4 Section 11 T20NR19E	1995-8-24	DG soft to 12 ft Firm DG 12-60 Mostly hard granodiorite with some softer zones – fractured & broken 60-450	SWL not recorded on well log	Screened 200-240 & 140-450
74373	3650	Sun Cloud Circle	1998-12-16	Brown to reddish brown volcanic rock to 91 ft Purple volcanic rock 91-146 Brown volcanic rock 146-172 Weathered granite 172-177 Gray granite 177-250 with fracture zones 177-179 & 205-235	SWL 50	Screened 204-244
96313	3750	Sun Cloud Circle	2005-5-5	Yellow clay with rock to 15 ft Gray, blue, yellow, red rock 15-120 Hard purple sticky clay 120-150 Dark green, blue volcanic rock 150-210 Blue green fractured rock 210-127	SWL 145	Screened 207-227
Cross Section D						
11758	7900	N Virginia – Skyline Mobile Home Park WEST OF US 395	1871-8-31	Dg to 30 ft Sandy gravel with clay 30-90 Boulders 90-93 Very hard rock 93-140 Sandy clays with hard & soft streaks 140-320 Hard white clay 230-248	SWL 63	Screened 60-227
Lewis-12555	7350	Estates Road	1972-8-17	Sandy clay & gravel to 70 ft Gravel 70-104	SWL 40	Screened 80-100
14548	3185	Indian Lane	1972-11-3	Dg with yellow clay to 74 ft Dg – brown sand 74-101	SWL 60	Screened 75-101

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
17852	7145	Marlin Drive	1978-3-13	Brown tight clay to 30 ft Brown clay with soft streaks 30-90 Sand 90-125 Sand with clay 125-145	SWL 32	Screened 110-135
17970	645	Colt Drive	1978-4-11	Clay to 5 ft Fine sand 5-15 Soft dg 15-55 Granite hard 55-118 with f 104-209racture zones with some water 75-87 & 100-118	SWL not recorded on log	Screened 50-118
Davis-18608	7320	Estates Road	1978-7-24	Sand to 3 ft Decomposed granite & clay 3-20 Clay 20-34 Decomposed granite – highly oxidized 34-82 Decomposed granite 82-156	SWL 44	Screened 95-156
18610	840	Browning Drive	1978-7-31	Clay & sand with some DG to 93 ft Blue clay 93-123 DG 123-150 Faults 150-165 Fairly hard rock 165-180 DG & granite 180-200 Fractured granite w/ water 200-204 Sand & gravel with some water 104-230	SWL 50	Screened 120-180 & 170-230
18702	9479	Wigwam Way	1978-6-30	DG to 280 ft Granite 281-340 DG 341-350	Dry Hole	

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
19921	3205	Indian Lane	1979-5-24	Sand with clay to 45 ft Sand, gravel w/ clay 45-86 Large gravel, sand & clay 86-105 Brown clay & sand 105-143 Course gravel & sand with clay 143-165	SWL 30	Screened 62-165
19949	550	Winchester Drive	1979-5-30	Brown clay med hard to 61 ft Brown clay with fine sand 61-86 ft Brown DG coarse 86-132 ft Brown clay 132-140 ft	SWL 35	Screened 88-130
20276	9440	Tomahawk Way	1979-8-14	DG – brown with clay streaks to 117 ft DG 117-133 Brown rock med hard 133-278 with soft streaks at 155-160, 177-179, 202-204, 245-250, and broken & fractured 225-230 Rock – med hard brown 278-300 Granite at 300	SWL 55	Screened 228-250 & 262-290
21356	9305	Spearhead Way	1980-7-11	DG to 42 ft Green gray granite 42-172 White granite 172-216 WB (?) 195-275 with fractures 216-275	SWL 102	Screened 186-275
24051	680	Golden Valley Road	1982-8-30	Brown clay with DG mixed to 39 ft Gray weathered granite 39-95 Yellow weathered rock 95-107 Gray weathered granite 107-149 – water bearing Fractured rock 149-165 Gray granite 165-190	SWL 55	Screened 160-190

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
24310		Skyline Mobile Home Park NW/4 Sec 15 T20N R19D	1982-12-12	Sand & gravel to 46 f Decayed gravel 46-138 Fractured volcanic rock 138-146 Volcanic rock – med hard 146-193 Granite hard gray 193-307 Fractured granite 307-348 Hard granite 348-351	SWL 215	Screened 307-351
25282	7410	Estates Road	1984-4-18	Brown sandy clay to 43 ft DG loose 43-63 Brown weathered granite 63-95 Fractured granite – water bearing 95-112 Med hard granite 112-125	SWL 45	Screened 91-118
34774	7360	Remington Road	1990-12-10-12	Brown clay with dg to 35 ft Weathered granite 35-61 Gray granite 61-135 with fractures 93-94 & 121-133	SWL 58	Screened 95-135
37616 - **Deepened**	3405	Running Bear Lane	1991-10-30	Green granit3 192-219 ft DG 219-307 Granite softer med hard 307-351 Hard fractured granite 351-392 Hard gray granite 392-414	SWL 120	Screened 374-394

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
45367	3185	Indian Lane	1994-8-17	Brown clay with DG to 8 ft Brown sandy clay & brown clay 8-39 Weathered granite 47-146 with soft fracture zones 95-97 (no water), 106-115 (water bearing), 138-146 Hard weathered granite 146-250 with fracture zones 195-197, 207-211, 2200-235	SWL 93	Screened 140-150, 190-200 & 220-240
73427	7900	N Virginia Street	1998-10-9	Sand & gravel to 10 ft Clay with minor sand 10-115 Consolidated sand 115-120 Andesite hard 120-130 Brown sand, rock 130-158 Andesite hard 158-305 Fractured andesite 305-338 Gray fractured volcanic 338-460 Hard gray volcanic 460-476 Gray fractured volcanic 476-601	SWL 320	Screened 320-600
7534	8600	N Virginia Street C&R Trailer Park	1963-8-20	Heavy clay & sand to 38 ft Clay, sand & broken rock 38-126 Clay, sand, gravel & broken rock with some water 126-158 Hard dry clay & shale 158-207 Clay, sand & broken rock 207-360 Water bearing 306-402 Hard rock 402-408	SWL 125	Screened 200-400

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
75530 - **Deepened**		NE/4 NE/4 Sec 11 T20N R19E Washoe County Utilities		250-540 Semi-solid granodiorite with softer areas of small land slide or slump	SWL not recorded on log	Screened 240-450
88390	9445	Tomahawk Way	2002-7-26	DG coarse to 25 ft Coarse sand & brown clay 25-65 Reddish-brown clay, hard granite 65-95 Bright green granite 95-160 Tan & white granite, rust-colored chips 160-200 Hard granite maroon & rust-colored 200-418	SWL 164	Screened 378-398
Cross Section E						
101415	6540	Meyers Avenue	2006-6-30	Clay with small gravel to 325 ft Blue "lime stone" 325-385	SWL 270	Screened 325-385
16249	7130	Estates Road	1977-1-12	Clay to sandy clay – brown to 51 ft Gray hard granite 51-55 Fractured blue-green granite 55-60 Hard blue-green granite 60-72 with fracture zone 65-71 Blue granite with brown decomposed granite sand lens 72-128	SWL 32	Screened 88-128

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
17293	3225	Sun Cloud Circle	1977-11-11	Overburden to 4 ft Granite 4-34 Decomposed granite 34-68 Gravel/sand cemented 68-96 with water-bearing fracture at 90 Granite with soft zones 96-200 – water bearing fractures at 125, 154 & 187	SWL 87	Screened 140-200
Long-19190	2775	Cactus View Drive	1978-11-16	Decomposed granite to 20 ft Brown clay 20-45 Solid granite 45-85 Granite fractured 85-100	SWL 55	Screened 80-100
19319 **See # 20989 & 28313**	2580	Knob Hill Drive	1979-1-26	Topsoil to 6 ft Firm decomposed granite 6-200 DG & granite 200-210	SWL 130	Screened 170-210
20293	2780	Cactus View Drive	1979-9-4	Topsoil to 3 ft Red clay & gravel 3-50 Conglomerated fractured rock 50-76	SWL 15	Screened 56-76
20989 **See # 19319 & #28313**	2580	Knob Hill Drive APN 88-040-36	1980-4-22	Top soil to 1.5 ft Brown clay 1.5-65 Green rock with brown clay layers 65-129 Gray granite with fractures 129-198	SWL 93	Screened 156-198
25545	2785	Cactus View Drive	1984-7-13	DG to 10 ft Green granite with some weathered 10-65 Gray granite 65-156 Fractured granite 156-178 Green granite 178-190	SWL 55	Screened 160-190

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
28313 – **Deepened** **See # 19319 & 20989**	2605	Knob Hill Drive	1986-11-18	Granite 210-240 with fractures 220-240	SWL 85	Extended well below casing 30 ft – hot water up heated on casing 60 ft good well. Backfilled with coarse rock in bottom of casing well will make 30 GPM.
29068	2760	Cactus View Drive	1987-9-3	DG to 4 ft Hard DG with boulders 4-38 Granite 38-61 Cemented gravel 61-89 Red clay 89-95 Fractured granite 95-138	SWL 55	Screened 100-138
30797	6510	Meyers Avenue	1988-12-21	Brown sandy clay with some gravel to 89 ft Soft zone – no water 89-93 Brown sandy clay with some gravels 93-149 Soft sandy clay 149-183 Brown sandy clay with gravels 183-245 Weathered green granite 245-295 Fractured granite 295-338 Green granite 338-350	SWL 255	Screened 279-339

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
33120	9215	N Virginia Street	1990-3-1	Multi-colored gravels with fine sand and clays to 76 ft Brown sticky clay 76-84 Multi-colored gravel with some brown clay 84-223 Blue-green rock with some fine sand 223-257 Brown sticky clay with gravels & sand 257-282 Green clay with some fine sand 282-362 Blue green white & red rock with some glue clay and fine sand 362-367 Blue clay 367-441 Blue black red & tan coarse gravels with some fine sand 441-477	SWL 320	Screened 337-357 & 457-477
36249	332	Lemmon Drive	1991-4-1	Clay & gravel to 28 ft Fractured granite 28-125	SWL 35	No screened interval noted on log

Appendix B: Well Log Tabulation

Well ID	House #	Street	Year drilled	Well log	Static Water Level	Screened Interval(s)
39853	9050	N Virginia Street	1992-10-24	Brown clay, cobbles, silt & broken rock to 42 ft Sands & gravel 42-64 Brown clay w/ broken rock 65-92 Sands & gravel 95-121 Brown clay sands with broken rock 121-200 Light blue clays sand w/ broken rock 200-239 Blue broken rock, brown clay, green clay layers 239-325 Blue clay, blue rock chips 325-630 Light blue rock, fractures w/brown silt clay 630-770	SWL 63	Screened 210-350 & 390-430 & 470-510 & 320-570 & 590-730 & 750-770

Notes:

70 well logs provided; however, **Conradt-13738** is a duplicate of **Bell-13738.**

Of the 69 remaining well logs provided, only 10 wells deepened - One well in each of the following years: 1988, 1990-1994, 2002 & 2003 with 2 wells deepened in 1995.

Appendix C

Calculation of Hydraulic Conductivity from Specific Capacity Data

Table C-1
Calculation of Hydraulic Conductivity from Specific Capacity
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

DRAFT

Well Log ID[1]	X	Y	Depth to Top of Perforation (ft)	Depth to Bottom of Perforation (ft)	Perforated Interval Length (ft)	Depth to Static Water Level (ft)	Yield (gpm)	Drawdown (ft)	Specific Capactiy[2] (gpm/ft)	Transmissivity[3] (gpd/ft)	Transmissivity (ft^2/d)	Hydraulic Conductivity[4] (ft/d)	Natural Log (Hydraulic Conductivity)
89049	2266945.0	14892771.6	180	824	644	272	10	820	0.01	24.4	3.3	0.01	-5.29
79973	2273365.4	14899993.3	140	340	200	56	12	340	0.04	70.6	9.4	0.05	-3.05
93735	2273537.9	14899590.7	259	420	161	191	10	300	0.03	66.7	8.9	0.06	-2.89
84479	2267744.8	14892740.6	265	365	100	201	8	360	0.02	44.4	5.9	0.06	-2.82
18889	2273211.0	14900588.1	205	450	245	250	6	100	0.06	120.0	16.0	0.07	-2.73
79975	2273241.3	14898625.9	160	300	140	96	15	300	0.05	100.0	13.4	0.10	-2.35
12916	2277693.2	14898203.9	165	250	85	96	10	240	0.04	83.3	11.1	0.13	-2.03
13872	2278499.3	14896686.4	265	345	80	150	10	240	0.04	83.3	11.1	0.14	-1.97
92277	2272571.3	14900678.0	177	477	300	300	10	60	0.17	333.3	44.6	0.15	-1.91
71686	2265640.0	14892831.1	334	396	62	170	13	357	0.04	72.8	9.7	0.16	-1.85
17049	2278313.3	14896484.1	91	200	109	105	15	200	0.08	150.0	20.1	0.18	-1.69
59478	2277698.6	14895590.2	235	320	85	120	15	250	0.06	120.0	16.0	0.19	-1.67
12736	2278029.6	14896208.9	140	257	117	78	12	129	0.09	186.0	24.9	0.21	-1.55
106605	2272079.2	14899971.5	366	467	101	329	15	138	0.11	217.4	29.1	0.29	-1.25
76971	2277075.6	14894570.4	204	297	93	125	30	280	0.11	214.3	28.6	0.31	-1.18
73430	2265918.4	14893265.9	320	420	100	170	35	300	0.12	233.3	31.2	0.31	-1.17
16072	2277146.5	14895829.6	88	128	40	75	8	125	0.06	128.0	17.1	0.43	-0.85
17048	2276482.9	14895083.3	176	200	24	115	8	200	0.04	80.0	10.7	0.45	-0.81
20523	2278018.4	14894526.7	145	185	40	120	12	175	0.07	137.1	18.3	0.46	-0.78
12462	2277961.0	14896233.3	140	185	45	70	8	100	0.08	160.0	21.4	0.48	-0.74
14723	2272996.9	14898057.3	140	200	60	100	15	140	0.11	214.3	28.6	0.48	-0.74
46487	2273747.5	14899290.3	160	300	140	146	20	79	0.25	506.3	67.7	0.48	-0.73
17879	2277593.8	14896056.0	118	158	40	100	11	150	0.07	146.7	19.6	0.49	-0.71
13786	2277153.7	14896480.9	140	170	30	100	10	165	0.06	121.2	16.2	0.54	-0.62
13591	2265550.5	14903108.2	60	100	40	39	5	58	0.09	172.4	23.0	0.58	-0.55
13583	2277868.2	14896429.3	173	228	55	90	16.11	135	0.12	238.7	31.9	0.58	-0.54
76583	2264820.9	14894293.2	300	340	40	142	30	340	0.09	176.5	23.6	0.59	-0.53
16255	2275421.4	14896733.1	95	135	40	65	9	100	0.09	180.0	24.1	0.60	-0.51
11304	2272488.4	14897430.2	40	146	106	36	10	40	0.25	500.0	66.8	0.63	-0.46
16855	2274900.6	14896961.1	154	178	24	70	8	140	0.06	114.3	15.3	0.64	-0.45
15586	2277639.9	14895377.3	106	146	40	65	12	125	0.10	192.0	25.7	0.64	-0.44
16015	2275738.7	14895587.4	90	130	40	55	12	125	0.10	192.0	25.7	0.64	-0.44
103807	2278896.7	14897363.9	160	200	40	73	8	80	0.10	200.0	26.7	0.67	-0.40

Table C-1
Calculation of Hydraulic Conductivity from Specific Capacity
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

Well Log ID[1]	X	Y	Depth to Top of Perforation (ft)	Depth to Bottom of Perforation (ft)	Perforated Interval Length (ft)	Depth to Static Water Level (ft)	Yield (gpm)	Drawdown (ft)	Specific Capactiy[2] (gpm/ft)	Transmissivity[3] (gpd/ft)	Transmissivity (ft^2/d)	Hydraulic Conductivity[4] (ft/d)	Natural Log (Hydraulic Conductivity)
13598	2277873.2	14897543.2	210	250	40	150	10	95	0.11	210.5	28.1	0.70	-0.35
16627	2273472.0	14898867.5	163	207	44	107	17.5	150	0.12	233.3	31.2	0.71	-0.34
17047	2274133.7	14897730.2	75	120	45	69	9	75	0.12	240.0	32.1	0.71	-0.34
11467	2274336.4	14899059.6	84	104	20	0	6	107	0.06	112.1	15.0	0.75	-0.29
96135	2275883.8	14896721.4	208	248	40	100	30	248	0.12	241.9	32.3	0.81	-0.21
13560	2275806.4	14899696.4	153	278	125	97	68	178	0.38	764.0	102.1	0.82	-0.20
13594	2268624.6	14897683.7	117	157	40	20	16.11	130	0.12	247.8	33.1	0.83	-0.19
15439	2278446.5	14896553.7	105	150	45	70	14	100	0.14	280.0	37.4	0.83	-0.18
16629	2277737.5	14898827.1	271	295	24	170	17	225	0.08	151.1	20.2	0.84	-0.17
13600	2277502.6	14897666.6	136	180	44	109	10	71	0.14	281.7	37.7	0.86	-0.16
18237	2277644.8	14898027.9	215	230	15	135	11	225	0.05	97.8	13.1	0.87	-0.14
11305	2272253.9	14897430.4	40	120	80	35	10	38	0.26	526.3	70.4	0.88	-0.13
13738	2278326.7	14895566.1	124	164	40	70	20	150	0.13	266.7	35.6	0.89	-0.12
17190	2276912.7	14896295.3	70	130	60	90	6	30	0.20	400.0	53.5	0.89	-0.12
17711	2272482.2	14897592.8	110	150	40	55	8	60	0.13	266.7	35.6	0.89	-0.12
82776	2271924.8	14888259.7	217	277	60	111	50	250	0.20	400.0	53.5	0.89	-0.12
16409	2277635.6	14894749.6	146	170	24	60	12	150	0.08	160.0	21.4	0.89	-0.12
12815	2273863.5	14899564.5	160	200	40	112	10	73	0.14	274.0	36.6	0.92	-0.09
13346	2277238.6	14894090.8	63	103	40	42	14	100	0.14	280.0	37.4	0.94	-0.07
15640	2276570.0	14898826.1	130	170	40	98	21	150	0.14	280.0	37.4	0.94	-0.07
14699	2273283.1	14893525.9	68	110	42	48	15	100	0.15	300.0	40.1	0.95	-0.05
13581	2276496.5	14898731.2	160	190	30	27	14	128	0.11	218.8	29.2	0.97	-0.03
94441	2273029.9	14900535.6	169	250	81	150	15	50	0.30	600.0	80.2	0.99	-0.01
13562	2274349.2	14898559.0	110	165	55	104	10	46	0.22	434.8	58.1	1.06	0.06
17563	2270021.0	14891864.3	116	275	159	97	72	114	0.63	1263.2	168.8	1.06	0.06
97170	2276281.9	14894879.5	150	250	100	75	30	75	0.40	800.0	106.9	1.07	0.07
11303	2272713.7	14897413.0	40	100	60	38	10	40	0.25	500.0	66.8	1.11	0.11
16614	2270390.4	14897083.8	97	120	23	30	10	100	0.10	200.0	26.7	1.16	0.15
101415	2266035.7	14892753.1	325	385	60	270	12	45	0.27	533.3	71.3	1.19	0.17
14138	2273566.3	14892972.3	101	151	50	64	23.08	100	0.23	461.6	61.7	1.23	0.21
12371	2277948.2	14896355.4	110	150	40	65	15	80	0.19	375.0	50.1	1.25	0.23
14549	2277823.9	14897550.2	112	182	70	90	10	30	0.33	666.7	89.1	1.27	0.24
15539	2273689.1	14894428.9	76	95	19	30	9	95	0.09	189.5	25.3	1.33	0.29
18486	2275744.8	14894898.2	90	150	60	45	15	50	0.30	600.0	80.2	1.34	0.29
88360	2278986.0	14897926.3	188	248	60	140	30	100	0.30	600.0	80.2	1.34	0.29

Table C-1
Calculation of Hydraulic Conductivity from Specific Capacity
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

DRAFT

Well Log ID[1]	X	Y	Depth to Top of Perforation (ft)	Depth to Bottom of Perforation (ft)	Perforated Interval Length (ft)	Depth to Static Water Level (ft)	Yield (gpm)	Drawdown (ft)	Specific Capactiy[2] (gpm/ft)	Transmissivity[3] (gpd/ft)	Transmissivity (ft^2/d)	Hydraulic Conductivity[4] (ft/d)	Natural Log (Hydraulic Conductivity)
14641	2278502.1	14896069.5	113	155	42	78	10	47	0.21	425.5	56.9	1.35	0.30
18931	2273293.7	14893757.8	124	146	22	55	14	125	0.11	224.0	29.9	1.36	0.31
13582	2278104.1	14896879.1	91	141	50	68	14.44	56	0.26	515.7	68.9	1.38	0.32
11909	2274200.3	14896968.6	60	182	122	0	10	15	0.67	1333.3	178.2	1.46	0.38
13514	2278331.5	14897532.8	160	205	45	160	10	40	0.25	500.0	66.8	1.49	0.40
23170	2265472.8	14894341.6	180	400	220	129	55	45	1.22	2444.4	326.8	1.49	0.40
88368	2273536.6	14893551.3	100	200	100	60	80	140	0.57	1142.9	152.8	1.53	0.42
12196	2273377.6	14899121.1	255	275	20	90	20	165	0.12	242.4	32.4	1.62	0.48
23580	2276672.3	14898769.5	242	282	40	120	30	120	0.25	500.0	66.8	1.67	0.51
11370	2278265.1	14895774.4	56	96	40	58	8	30	0.27	533.3	71.3	1.78	0.58
12918	2276271.8	14895445.7	108	138	30	44	21	105	0.20	400.0	53.5	1.78	0.58
13597	2273255.2	14896454.3	50	100	50	33	21.28	62	0.34	686.5	91.8	1.84	0.61
13561	2274081.2	14896994.7	97	130	33	49	17.64	76	0.23	464.2	62.1	1.88	0.63
73427	2269304.9	14892536.2	320	600	280	320	100	50	2.00	4000.0	534.7	1.91	0.65
20143	2276569.8	14895450.1	171	192	21	83	27	175	0.15	308.6	41.2	1.96	0.68
39309	2276920.8	14896254.8	120	320	200	310	15	10	1.50	3000.0	401.0	2.01	0.70
11908	2273215.9	14897599.1	76	96	20	0	6	40	0.15	300.0	40.1	2.01	0.70
12348	2275125.5	14896948.5	122	150	28	60	18	85	0.21	423.5	56.6	2.02	0.70
16249	2274181.8	14894881.6	88	128	40	32	24	77	0.31	623.4	83.3	2.08	0.73
12843	2273536.7	14894011.8	60	90	30	37	20	85	0.24	470.6	62.9	2.10	0.74
11386	2274346.9	14899253.9	100	120	20	0	5	30	0.17	333.3	44.6	2.23	0.80
15331	2277693.6	14893486.7	105	125	20	90	20	120	0.17	333.3	44.6	2.23	0.80
12737	2274283.3	14900389.2	170	200	30	85	25	100	0.25	500.0	66.8	2.23	0.80
15283	2273277.4	14893949.7	93	111	18	35	12	80	0.15	300.0	40.1	2.23	0.80
88946	2272790.9	14900419.5	165	225	60	100	20	40	0.50	1000.0	133.7	2.23	0.80
82613	2277561.3	14896446.1	153	173	20	70	30	173	0.17	346.8	46.4	2.32	0.84
15537	2278455.4	14896673.3	106	137	31	77	27	100	0.27	540.0	72.2	2.33	0.85
88390	2277703.0	14898538.4	378	398	20	164	23	132	0.17	348.5	46.6	2.33	0.85
13060	2274542.4	14896577.8	90	120	30	36	17	64	0.27	531.3	71.0	2.37	0.86
16626	2276351.3	14896903.9	145	171	26	90	30	125	0.24	480.0	64.2	2.47	0.90
13056	2272325.2	14898044.6	125	150	25	53	30	130	0.23	461.5	61.7	2.47	0.90
18238	2275883.1	14897755.6	140	200	60	75	73	125	0.58	1168.0	156.1	2.60	0.96
11813	2278357.2	14895914.2	92	133	41	85	10	25	0.40	800.0	106.9	2.61	0.96
16240	2269235.4	14891876.2	406	450	44	93	56	128	0.44	875.0	117.0	2.66	0.98
12243	2277114.0	14895267.8	77	97	20	60	12	60	0.20	400.0	53.5	2.67	0.98

Table C-1
Calculation of Hydraulic Conductivity from Specific Capacity
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

DRAFT

Well Log ID[1]	X	Y	Depth to Top of Perforation (ft)	Depth to Bottom of Perforation (ft)	Perforated Interval Length (ft)	Depth to Static Water Level (ft)	Yield (gpm)	Drawdown (ft)	Specific Capactiy[2] (gpm/ft)	Transmissivity[3] (gpd/ft)	Transmissivity (ft^2/d)	Hydraulic Conductivity[4] (ft/d)	Natural Log (Hydraulic Conductivity)
13516	2277984.5	14896903.0	100	140	40	97	10	25	0.40	800.0	106.9	2.67	0.98
94958	2277464.3	14899310.1	245	285	40	215	30	70	0.43	857.1	114.6	2.86	1.05
13249	2277434.5	14892929.5	82	122	40	86	54	122	0.44	885.2	118.3	2.96	1.08
11586	2277188.4	14896479.6	80	140	60	70	10	15	0.67	1333.3	178.2	2.97	1.09
13029	2270672.4	14896992.4	70	90	20	20	14	63	0.22	444.4	59.4	2.97	1.09
85341	2274302.7	14899269.3	85	125	40	75	10	22	0.45	909.1	121.5	3.04	1.11
12247	2275668.8	14896728.1	83	107	24	55	14	50	0.28	560.0	74.9	3.12	1.14
13559	2278389.8	14896777.4	100	140	40	72	25	53	0.47	943.4	126.1	3.15	1.15
11460	2277260.1	14893693.9	60	90	30	42	10	28	0.36	714.3	95.5	3.18	1.16
16248	2274196.7	14895046.1	83	103	20	35	24	100	0.24	480.0	64.2	3.21	1.17
13515	2277807.4	14896906.2	110	150	40	0	10	20	0.50	1000.0	133.7	3.34	1.21
13517	2277612.7	14897730.2	174	194	20	85	10	40	0.25	500.0	66.8	3.34	1.21
11297	2276618.9	14896153.5	80	100	20	60	8	30	0.27	533.3	71.3	3.56	1.27
12917	2277390.6	14894770.9	85	125	40	35	70	125	0.56	1120.0	149.7	3.74	1.32
111339	2271474.4	14897547.5	100	145	45	48	20	31	0.65	1290.3	172.5	3.83	1.34
23127	2272307.5	14897838.4	50	160	110	65	40	25	1.60	3200.0	427.8	3.89	1.36
19921	2275927.2	14896994.6	62	165	103	80	15	10	1.50	3000.0	401.0	3.89	1.36
89322	2277968.2	14899119.1	387	407	20	176	10	34	0.29	588.2	78.6	3.93	1.37
12361	2278000.2	14896236.1	94	120	26	70	12	30	0.40	800.0	106.9	4.11	1.41
14548	2275437.8	14896936.7	75	100	25	60	10	25	0.40	800.0	106.9	4.28	1.45
10942	2276384.1	14895458.7	96	116	20	51	10	30	0.33	666.7	89.1	4.46	1.49
23174	2272554.8	14897153.6	122	215	93	63	40	25	1.60	3200.0	427.8	4.60	1.53
12248	2275623.6	14895991.4	80	100	20	42	17	48	0.35	708.3	94.7	4.73	1.55
20250	2277821.4	14893099.3	90	130	40	100	15	20	0.75	1500.0	200.5	5.01	1.61
12267	2268823.0	14891817.2	173	215	42	153	17	21	0.81	1619.0	216.4	5.15	1.64
18236	2268829.4	14899864.4	156	196	40	150	20	25	0.80	1600.0	213.9	5.35	1.68
111354	2273822.4	14898570.2	200	240	40	130	14.2	15	0.95	1893.3	253.1	6.33	1.84
39310	2277183.3	14896438.4	280	340	60	330	15	10	1.50	3000.0	401.0	6.68	1.90
14482	2275633.8	14896951.0	74	94	20	53	15	30	0.50	1000.0	133.7	6.68	1.90
11383	2273570.4	14898935.7	102	120	18	72	10	18	0.56	1111.1	148.5	8.25	--
22162	2279340.7	14893388.1	170	200	30	122	22	18	1.22	2444.4	326.8	10.89	--
17966	2276918.7	14894743.6	152	172	20	35	14	15	0.93	1866.7	249.5	12.48	--
12555	2274487.4	14896095.8	80	100	20	40	40	42	0.95	1904.8	254.6	12.73	--
85005	2271830.5	14887524.8	297	321	24	82	25	20	1.25	2500.0	334.2	13.92	--
11376	2273655.1	14899106.3	60	80	20	51	20	18	1.11	2222.2	297.0	14.85	--

Table C-1
Calculation of Hydraulic Conductivity from Specific Capacity
Golden Valley Aquifer Recharge Assessment
Golden Valley Subbasin, Washoe County, Nevada

DRAFT

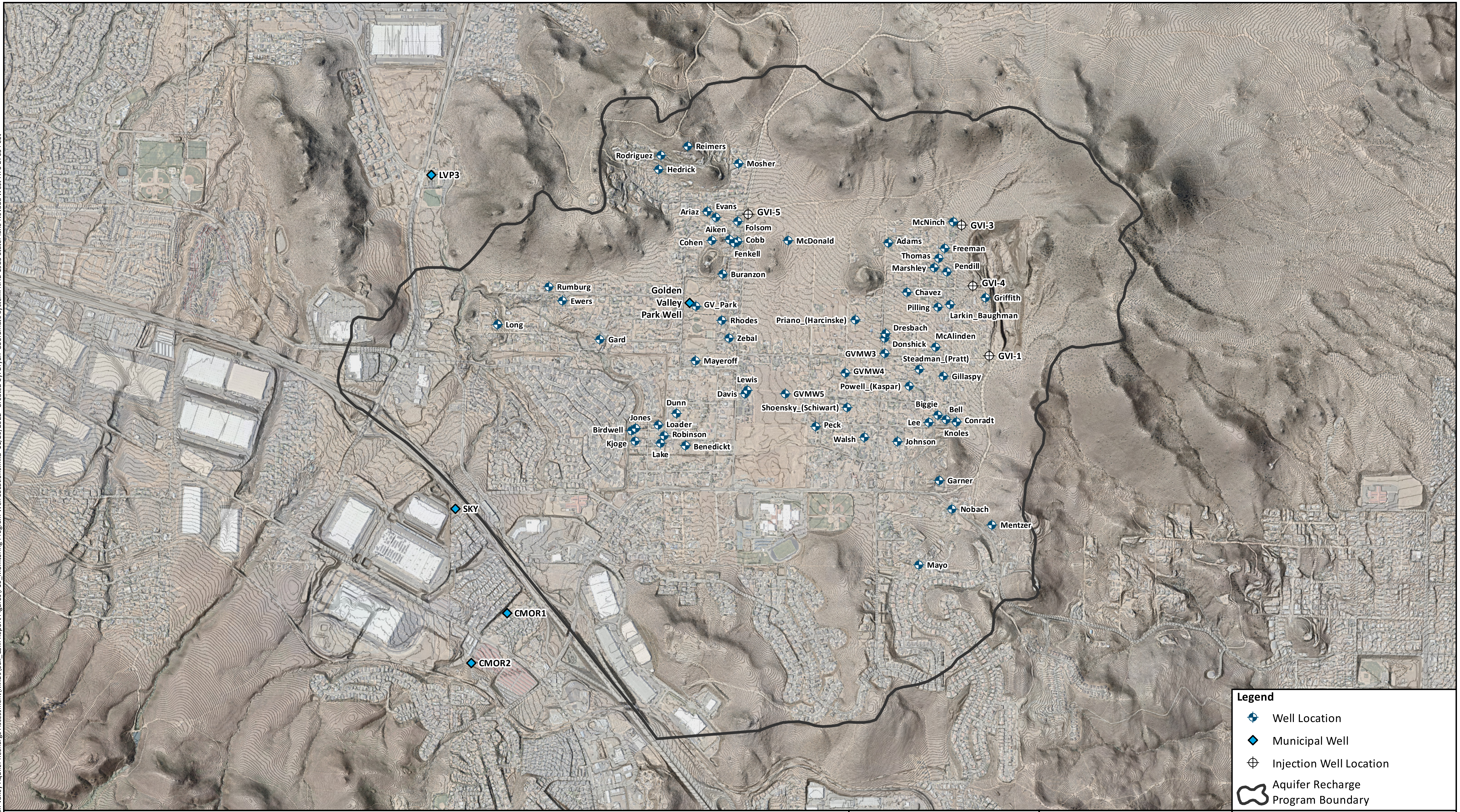
Well Log ID[1]	X	Y	Depth to Top of Perforation (ft)	Depth to Bottom of Perforation (ft)	Perforated Interval Length (ft)	Depth to Static Water Level (ft)	Yield (gpm)	Drawdown (ft)	Specific Capactiy[2] (gpm/ft)	Transmissivity[3] (gpd/ft)	Transmissivity (ft^2/d)	Hydraulic Conductivity[4] (ft/d)	Natural Log (Hydraulic Conductivity)
24310	2269493.3	14892696.7	307	351	44	215	320	125	2.56	5120.0	684.4	15.55	--
14547	2276344.2	14895634.1	90	130	40	47	20	8	2.50	5000.0	668.4	16.71	--
88386	2272911.3	14900268.0	220	240	20	118	15	12	1.25	2500.0	334.2	16.71	--
67627	2273278.4	14893840.9	175	195	20	42	20	15	1.33	2666.7	356.5	17.82	--
17840	2273502.3	14893561.3	80	100	20	60	28	20	1.40	2800.0	374.3	18.71	--
18835	2275792.1	14894473.4	58	78	20	50	17	8	2.13	4250.0	568.1	28.41	--
13567	2271521.6	14897555.1	110	130	20	87	31	13	2.38	4769.2	637.5	31.88	--
20293	2269302.7	14896946.2	56	76	20	15	50	20	2.50	5000.0	668.4	33.42	--
											Minimum:	**0.01**	
											Maximum:	**33**	

Statistics for values less than 8.25 ft/d:

Minimum:	**0.01**	
Maximum:	**6.68**	
Average:	**1.8**	0.12
Geomean:	**1.1**	--
Standard Deviation:	**1.5**	1.1
95% Confidence:		0.20
Add 95% Confidence to mean:		0.32
Subtract 95% Confidence from mean:		-0.07
Transform for 95% Upper Confidence Level:		**1.4**
Transform for 95% Lower Confidence Level:		**0.9**

Appendix D

Transient Simulation Hydrographs



File: N:\GIS\Prj\N022.001_Golden Valley Aquifer Recharge Assessment\MXDs\00x_CSM Report Figures\F10_Monitoring Program Well Locations.mxd 11/29/2022 Created by: Bryan Coordinate System: NAD 1983 StatePlane Nevada West FIPS 2703 Feet

Aerial Imagery Source: Nearmap, June 1st, 2022

0 850 1,700 3,400 Feet

1 inch = 1,700 feet

N

SAFETY FIRST

terraphase engineering

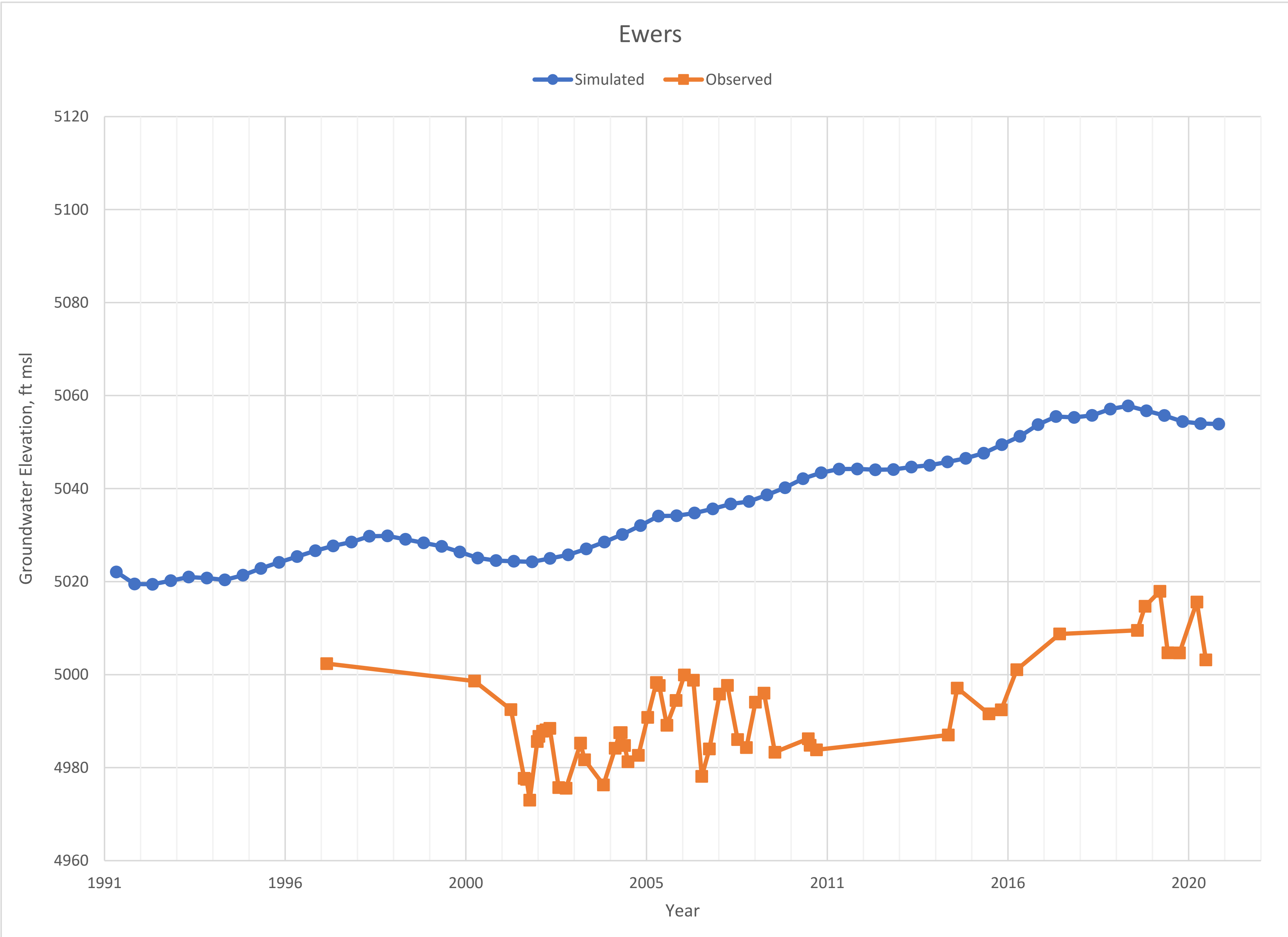
CLIENT: Washoe County Engineering and Capital Projects

PROJECT: Golden Valley Aquifer Recharge Assessment - Golden Valley, NV

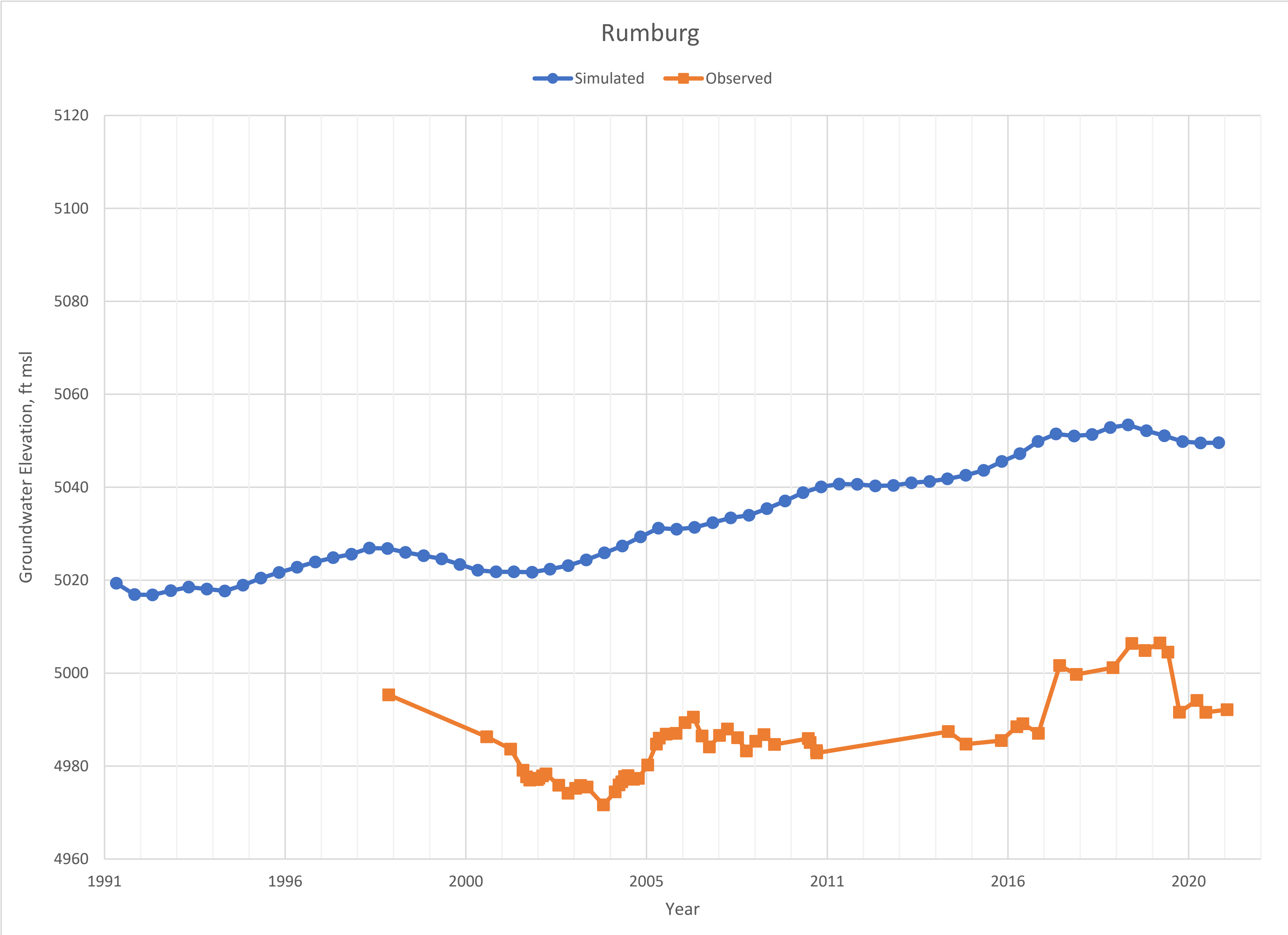
PROJECT NUMBER: N022.001.001

Monitoring Program Well Locations

FIGURE 11



Ewers
Simulated
Observed
Groundwater Elevation, ft msl
5120
5100
5080
5060
5040
5020
5000
4980
4960
1991
1996
2000
2005
2011
2016
2020
Year



Rumburg
Simulated
Observed
Groundwater Elevation, ft msl
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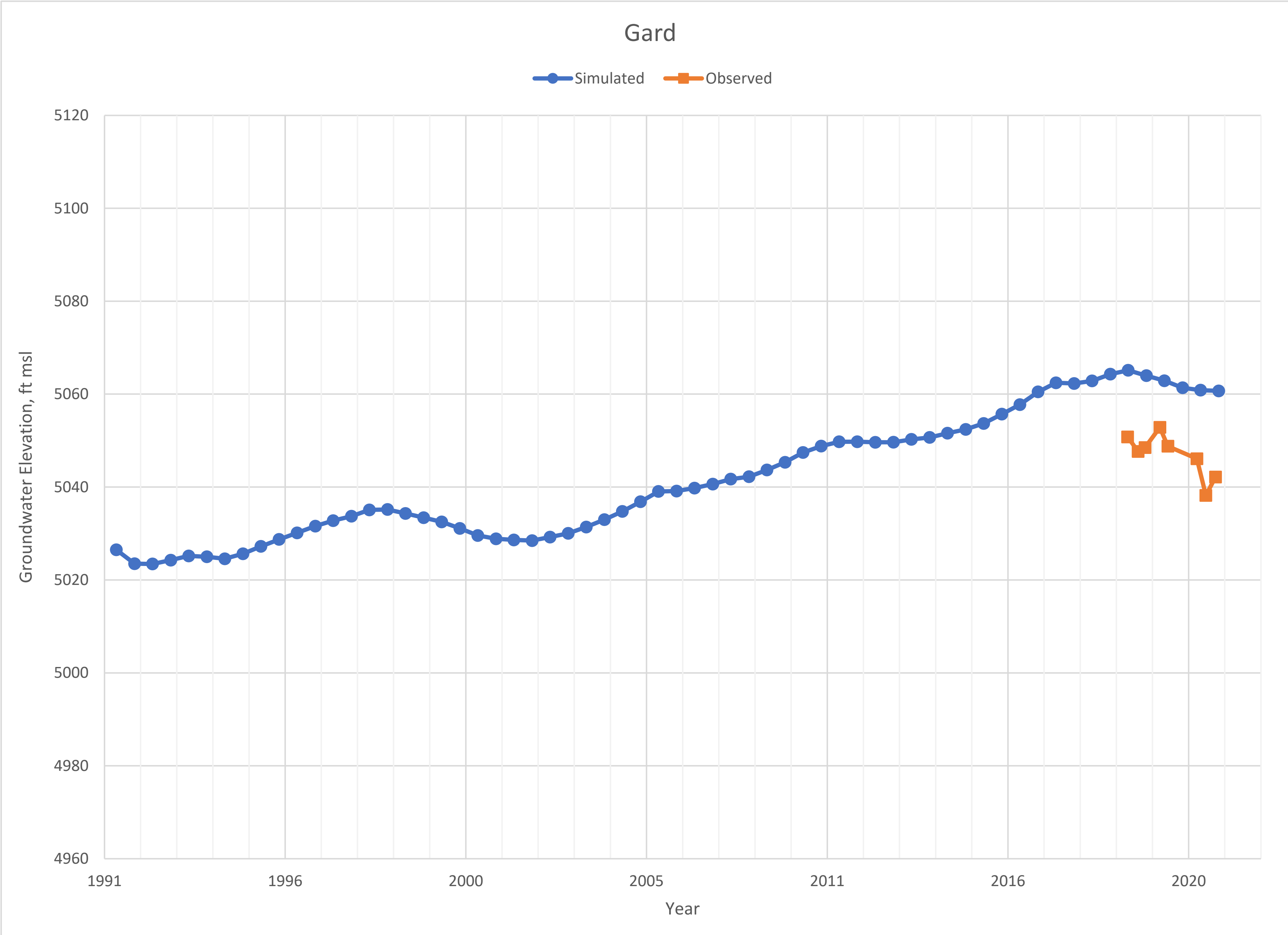
5100
5080
5060
5040
5020
5000
4980
4960
1991
1996
2000
2005
2011
2016
2020
Year


Gard
Simulated
Observed
5120
5100
5080
5060
5040
5020
5000
4980
4960
Groundwater Elevation, ft msl
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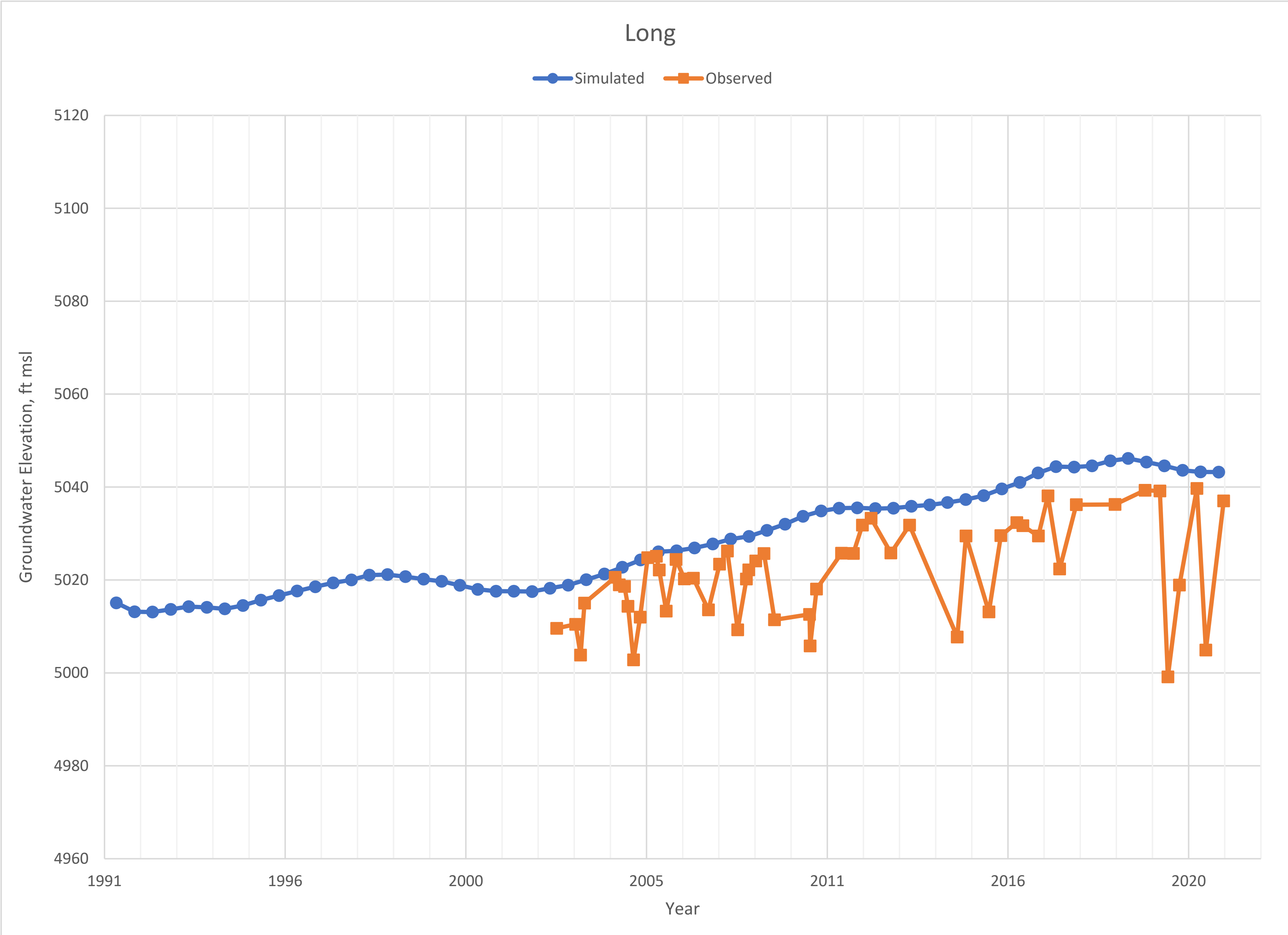
2000
2005
2011
2016
2020
Year



Long
Simulated
Observed
Groundwater Elevation, ft msl
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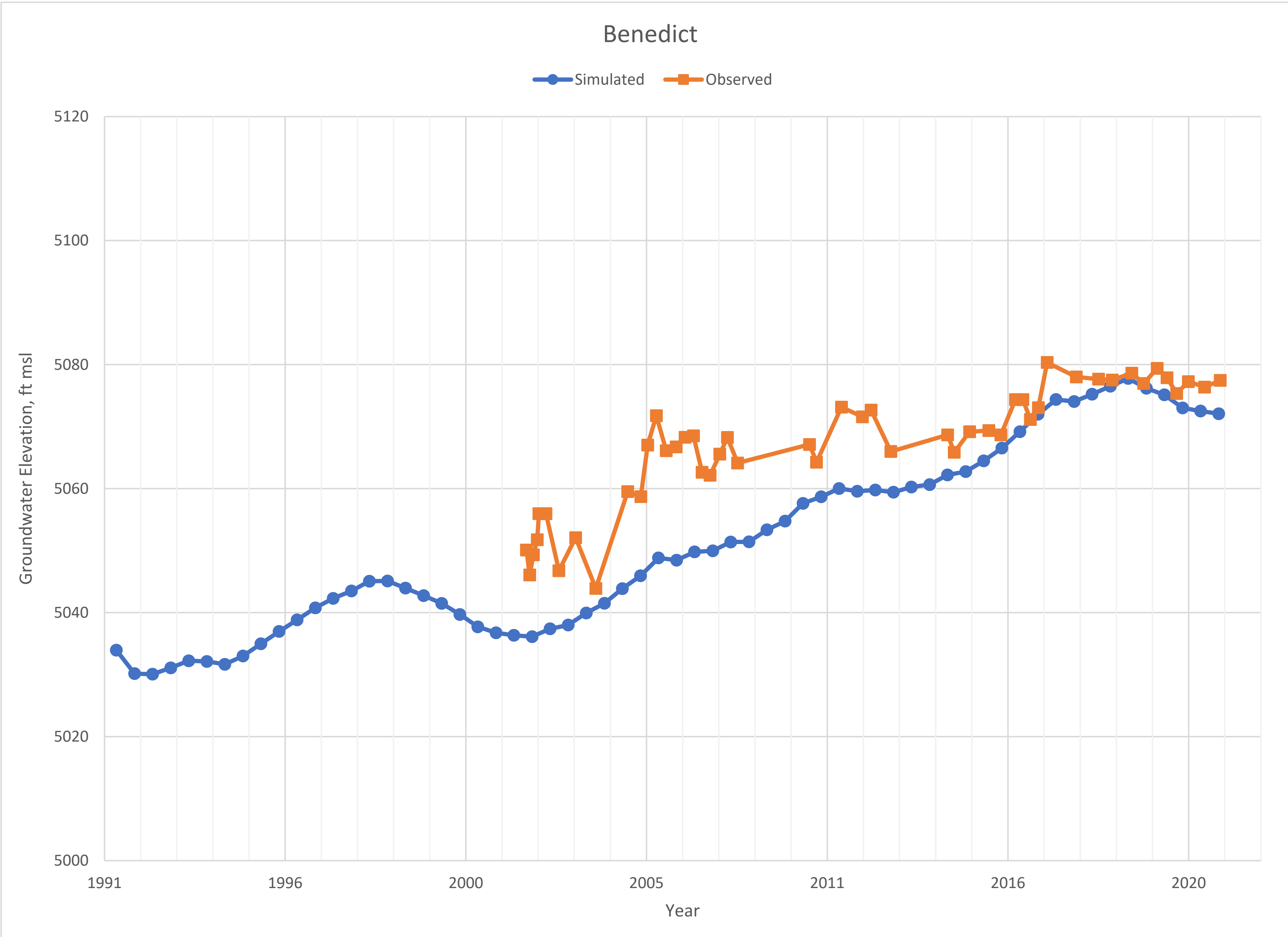
5100
5080
5060
5040
5020
5000
4980
4960
1991
1996
2000
2005
2011
2016
2020
Year


Benedict
Simulated
Observed
Groundwater Elevation, ft msl
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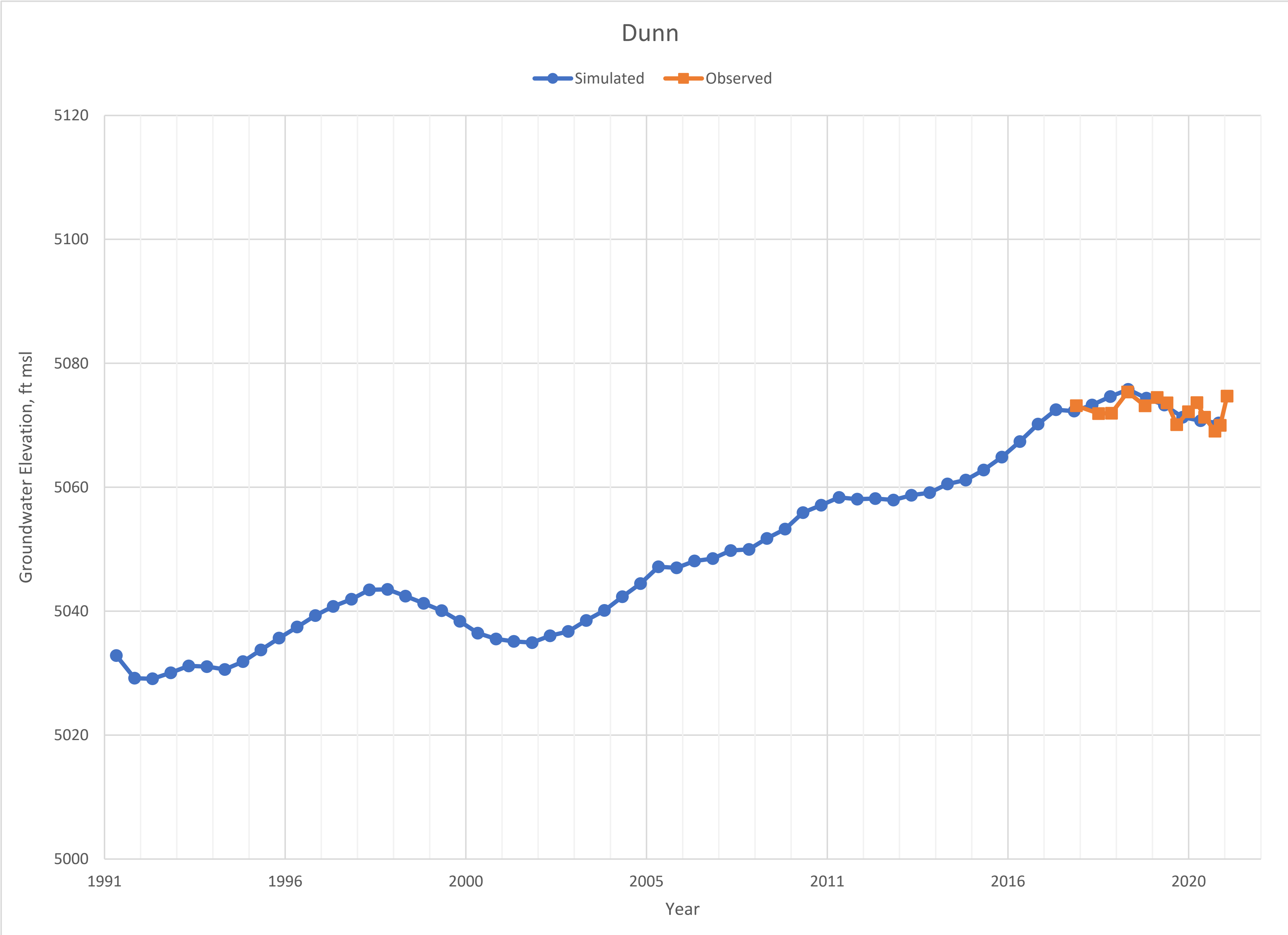
2011
2016
2020
Year



Dunn
Simulated
Observed
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Groundwater Elevation, ft msl
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2020
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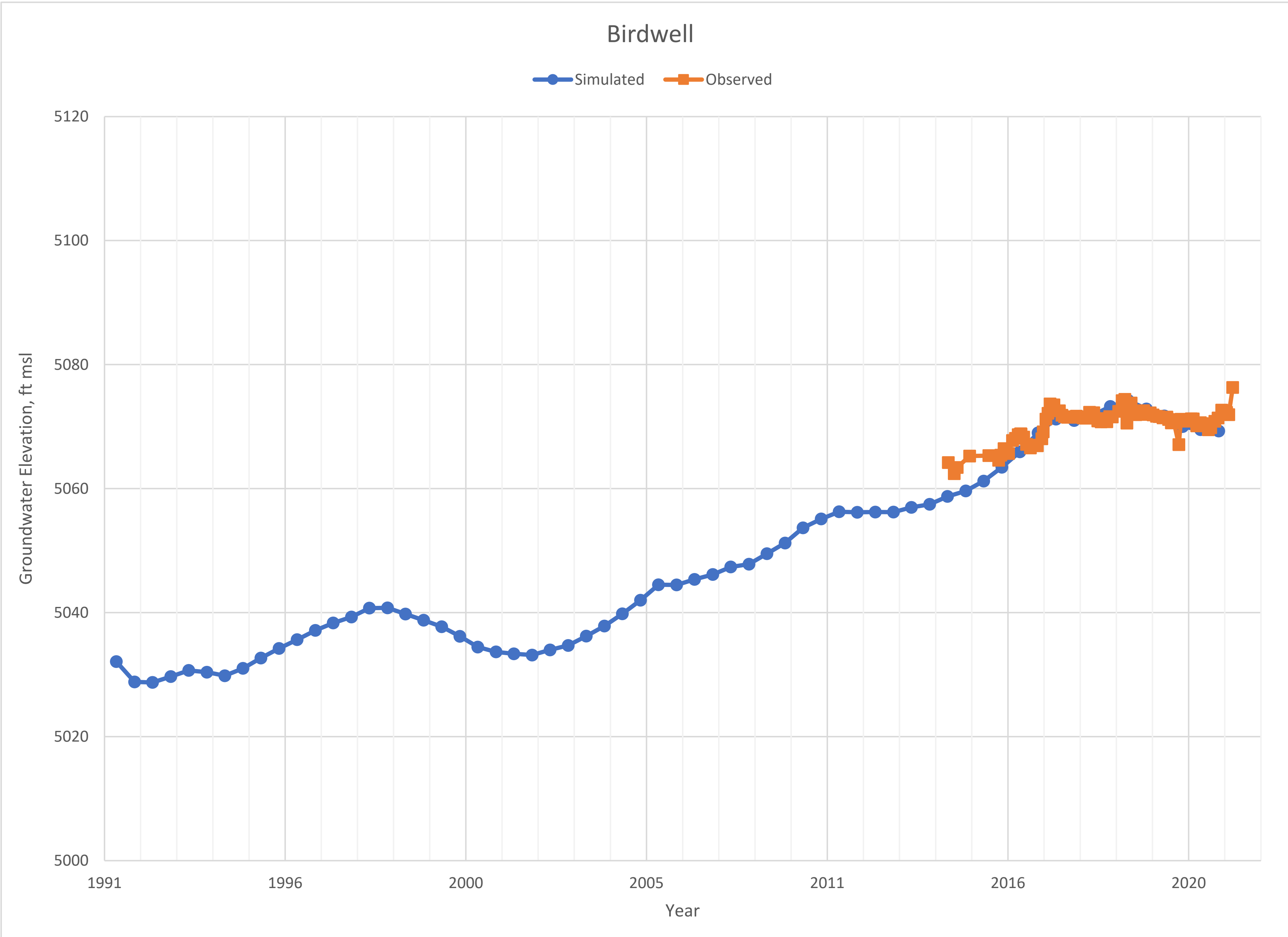
Birdwell
Simulated
Observed
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Groundwater Elevation, ft msl
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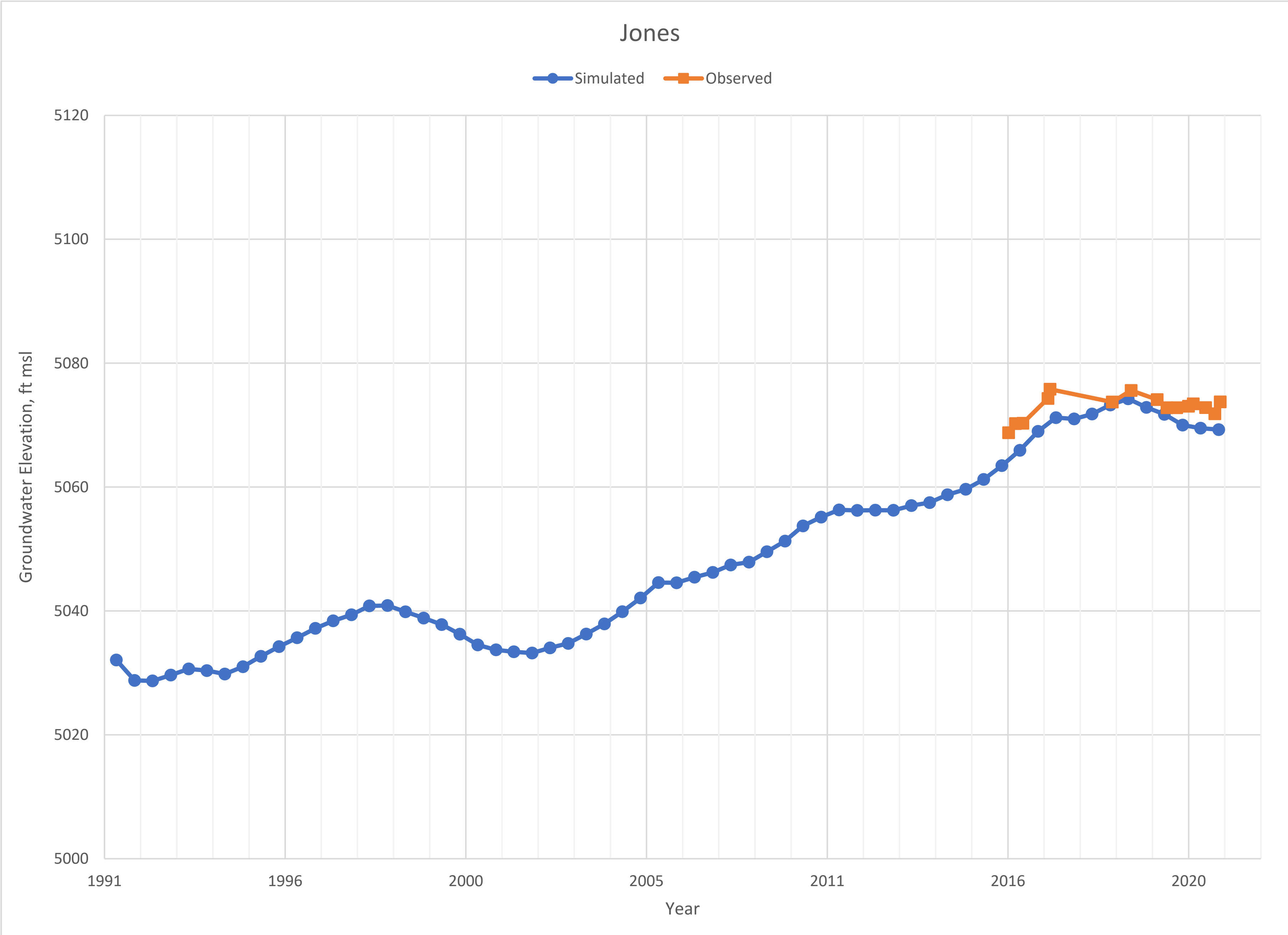
Year


Jones
Simulated
Observed
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Groundwater Elevation, ft msl
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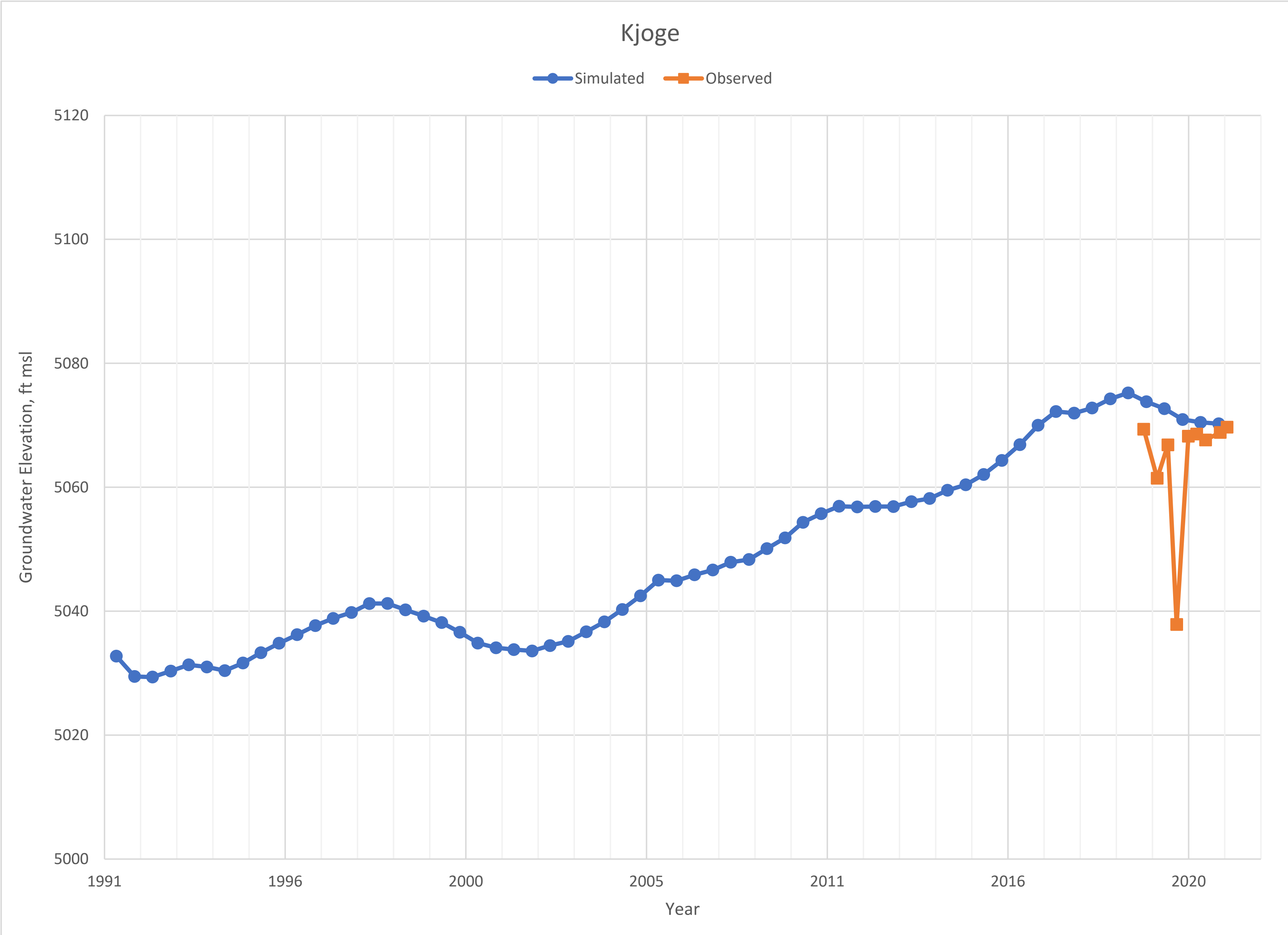
Year



Kjoge
Simulated
Observed
Groundwater Elevation, ft msl
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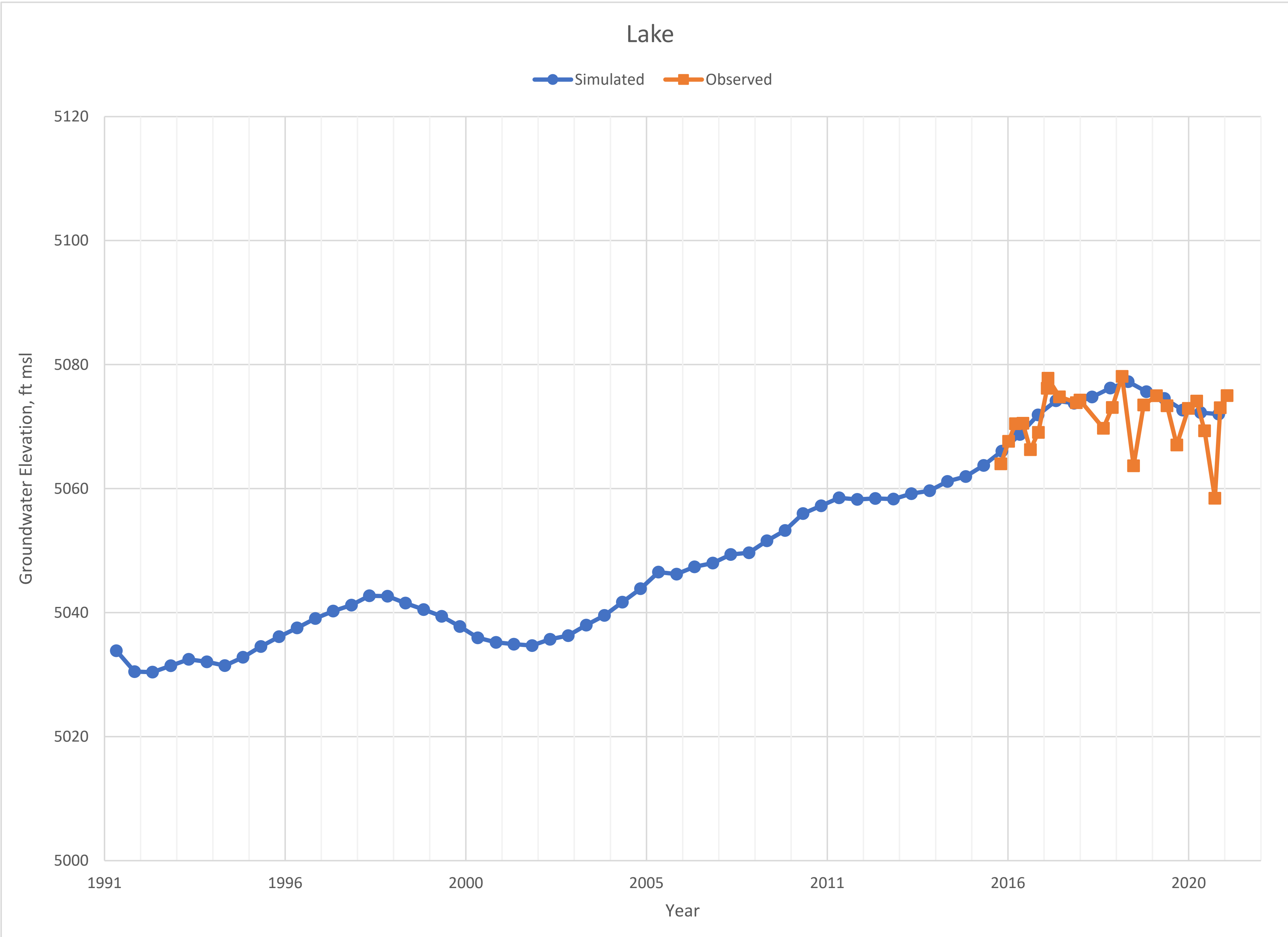
2016
2020
Year



Lake
Simulated
Observed
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Groundwater Elevation, ft msl
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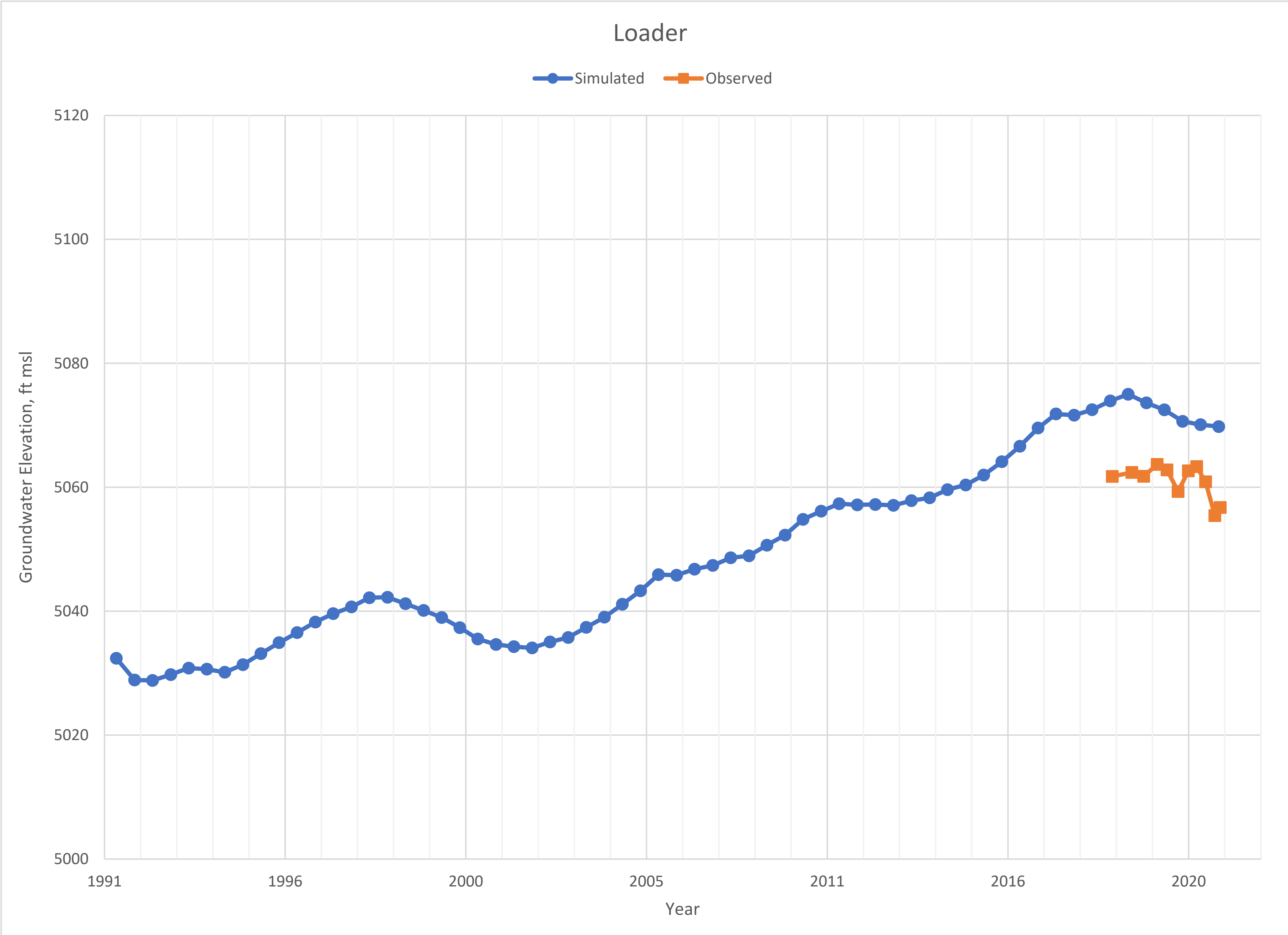
2020
Year



Loader
Simulated
Observed
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Groundwater Elevation, ft msl
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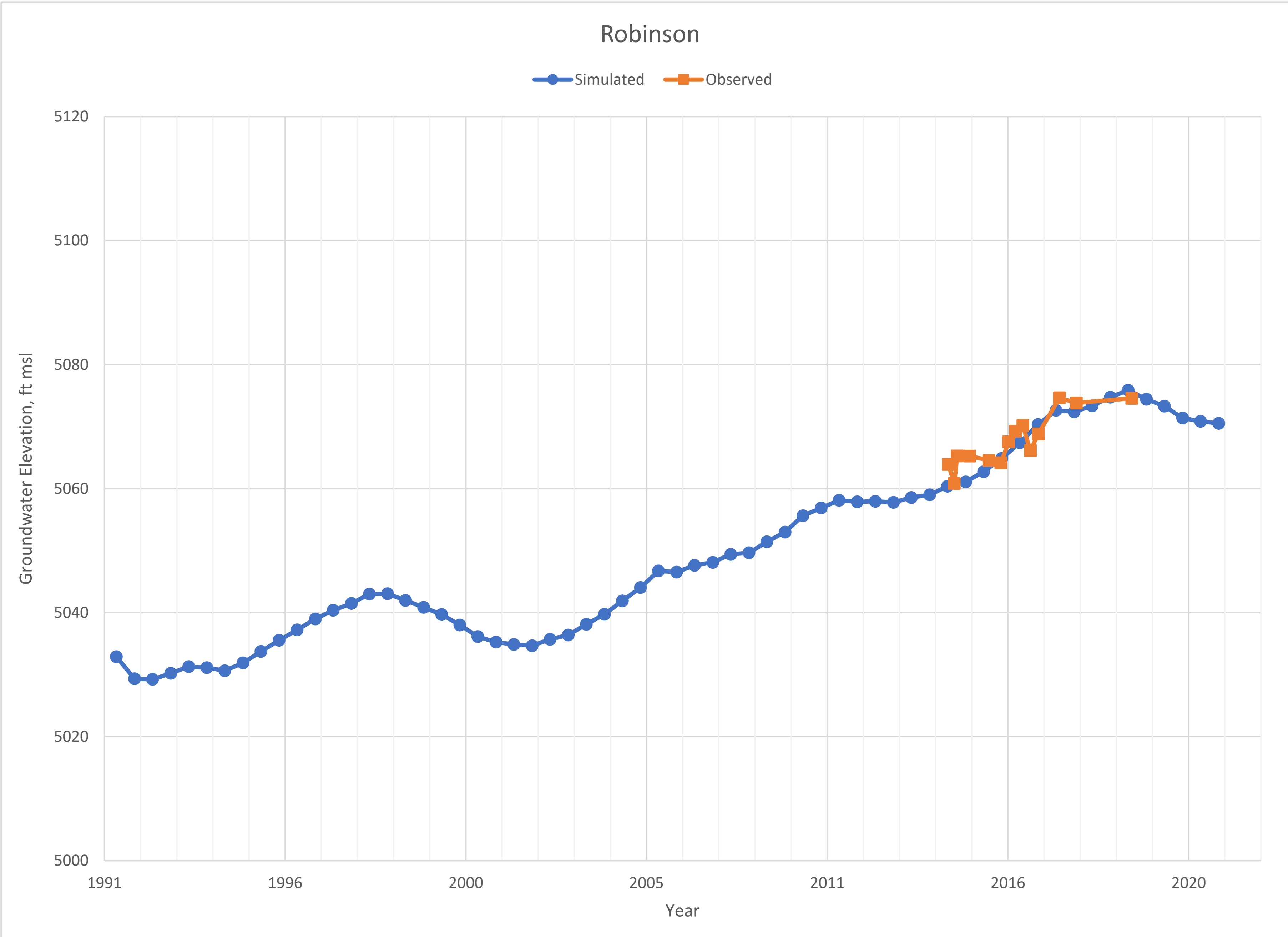
2020
Year



Robinson
Simulated
Observed
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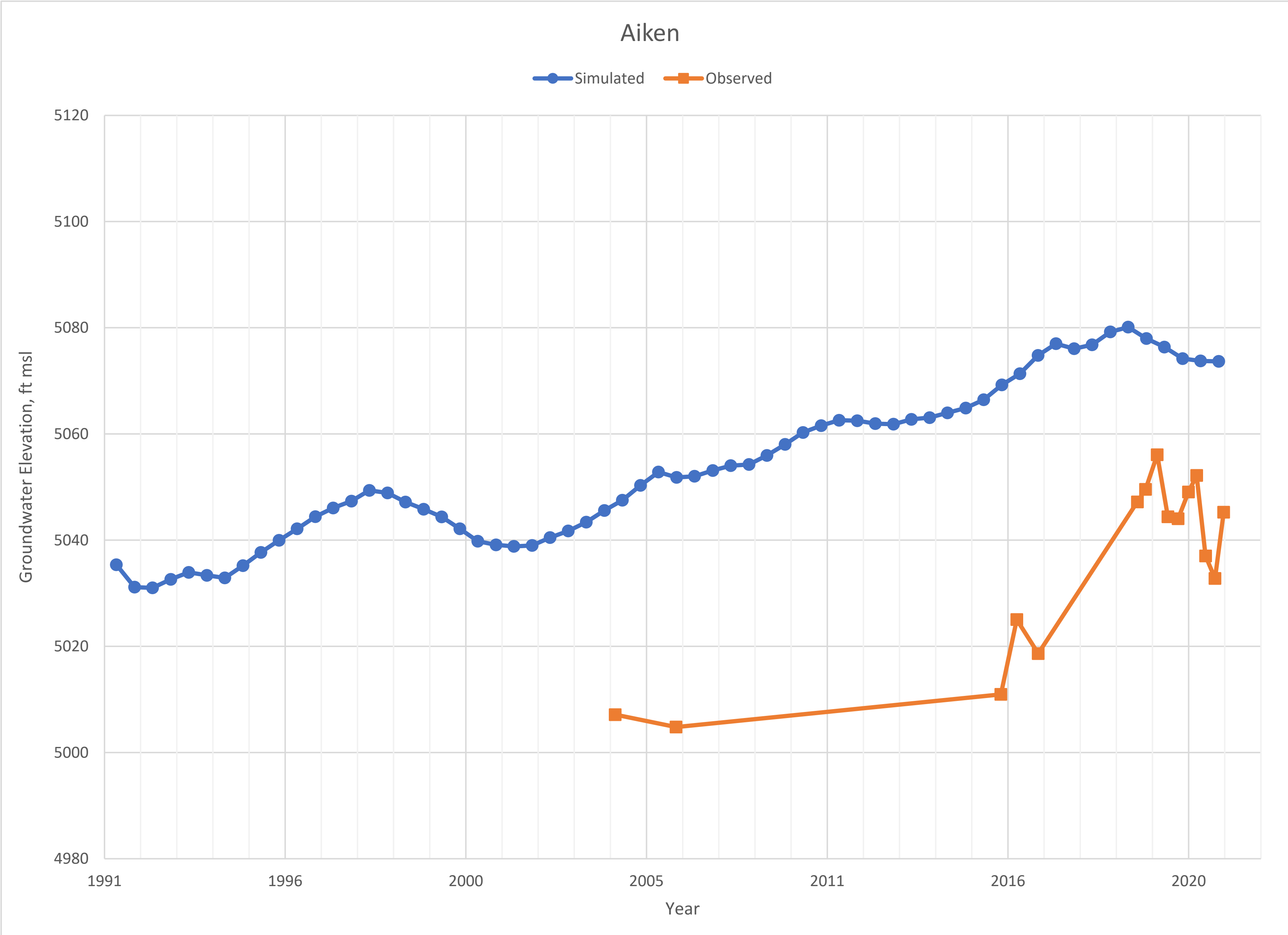
Year



Aiken
Simulated
Observed
5120
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4980
Groundwater Elevation, ft msl
1991
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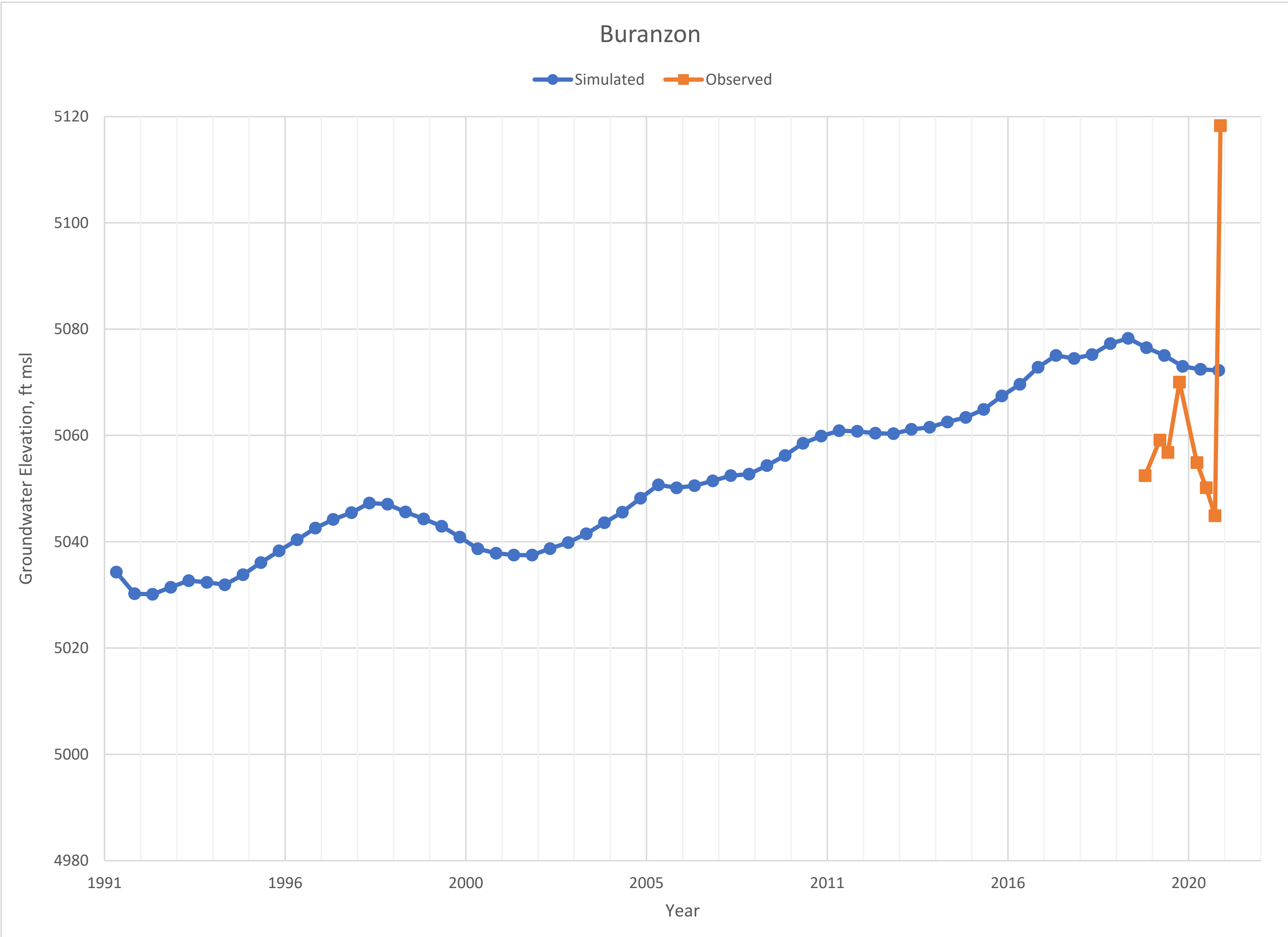
2020
Year


Buranzon
Simulated
Observed
Groundwater Elevation, ft msl
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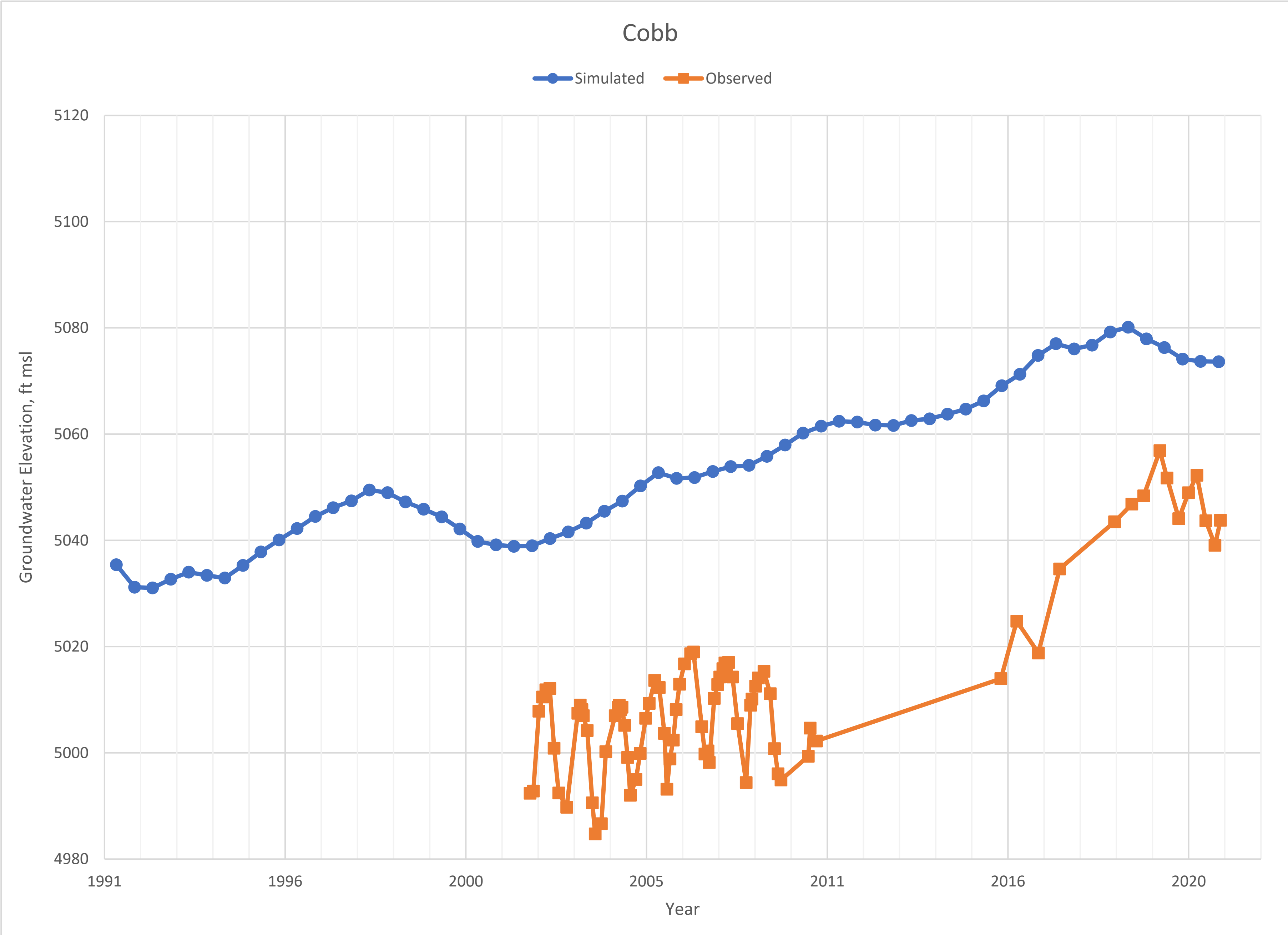
Year


Cobb
Simulated
Observed
Groundwater Elevation, ft msl
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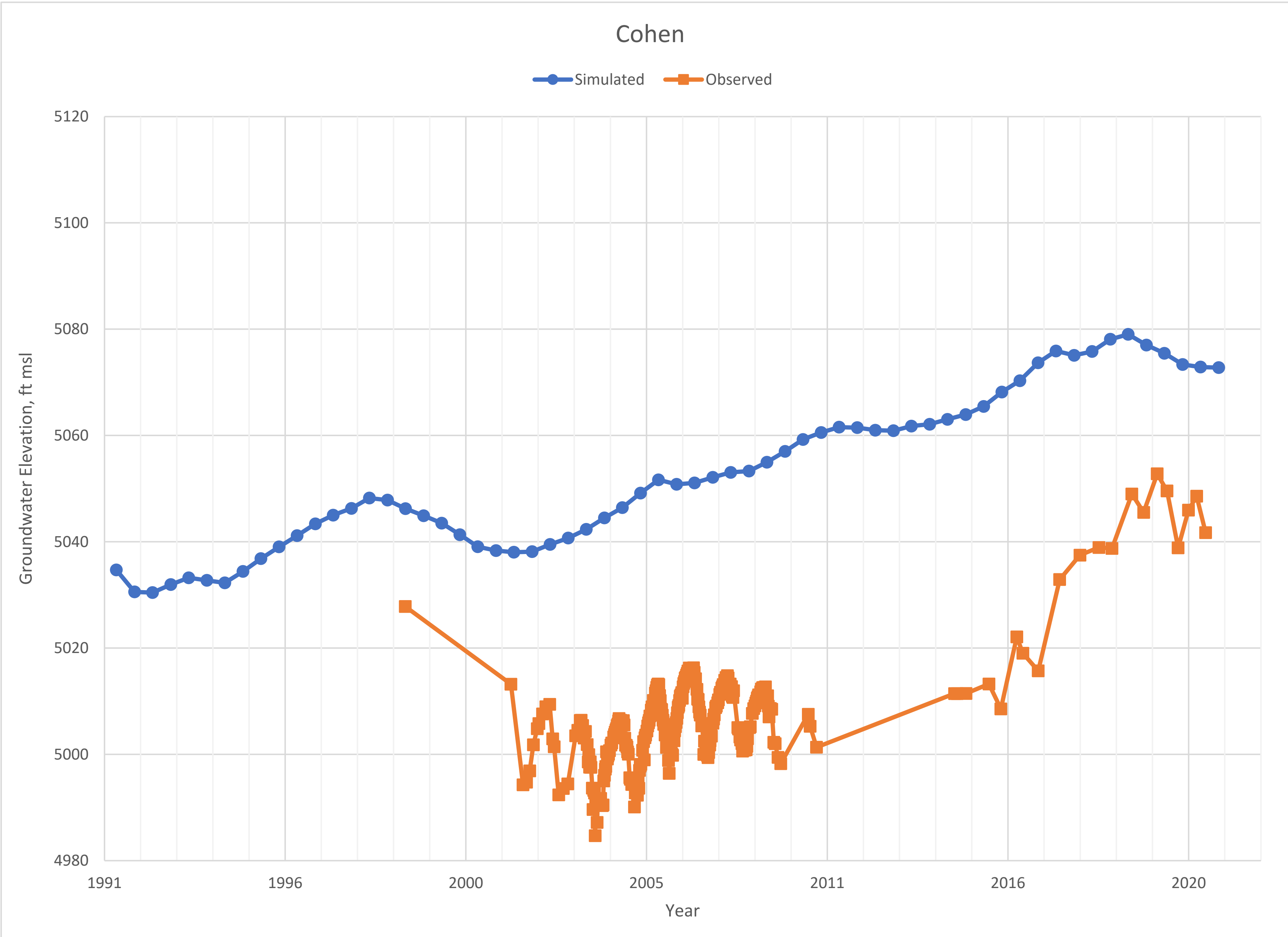
Year


Cohen
Simulated
Observed
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Groundwater Elevation, ft msl
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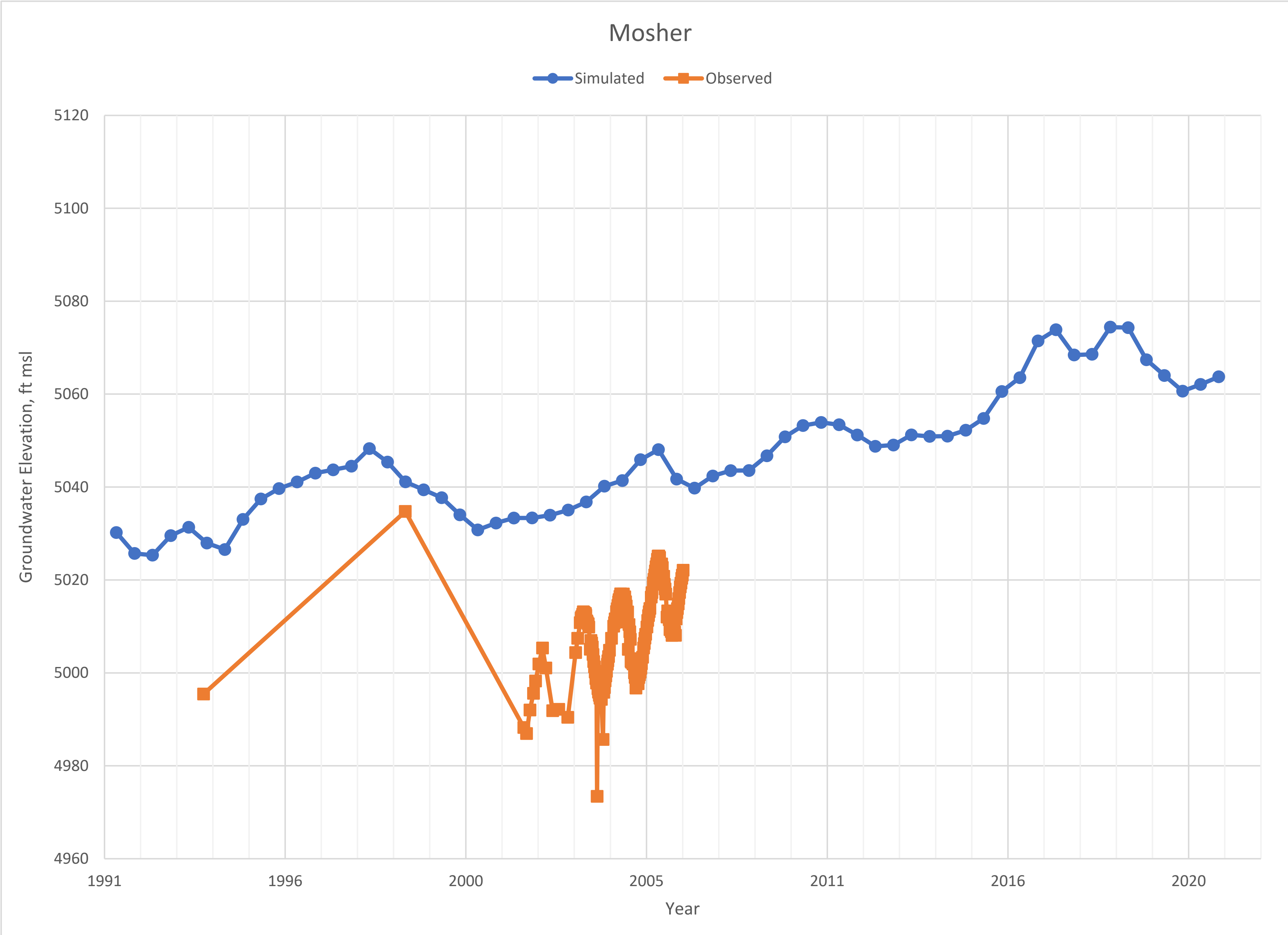
Year



Mosher
Simulated
Observed
Groundwater Elevation, ft msl
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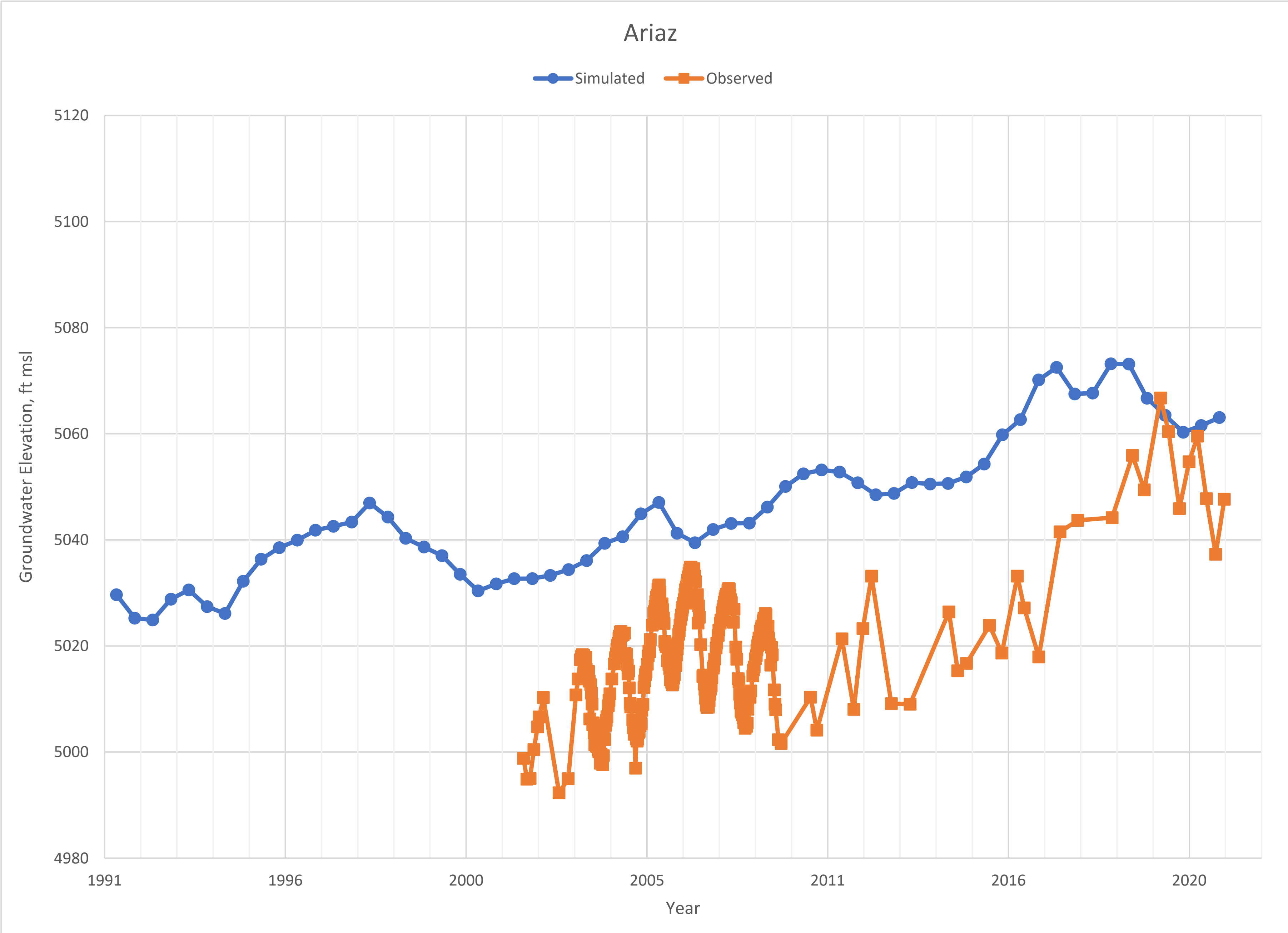
2011
2016
2020
Year



Ariaz
Simulated
Observed
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4980
Groundwater Elevation, ft msl
1991
1996
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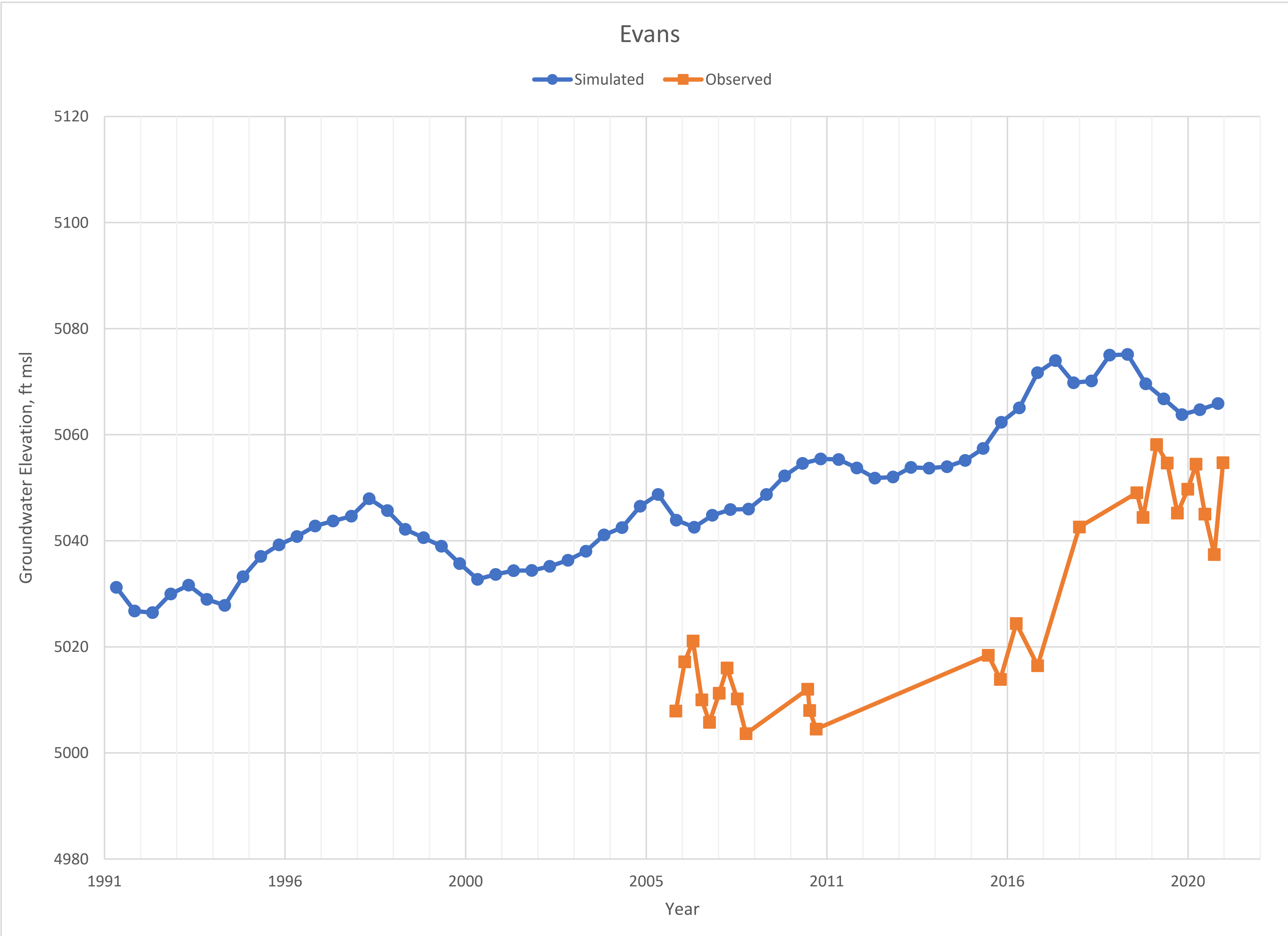
2020
Year



Evans
Simulated
Observed
Groundwater Elevation, ft msl
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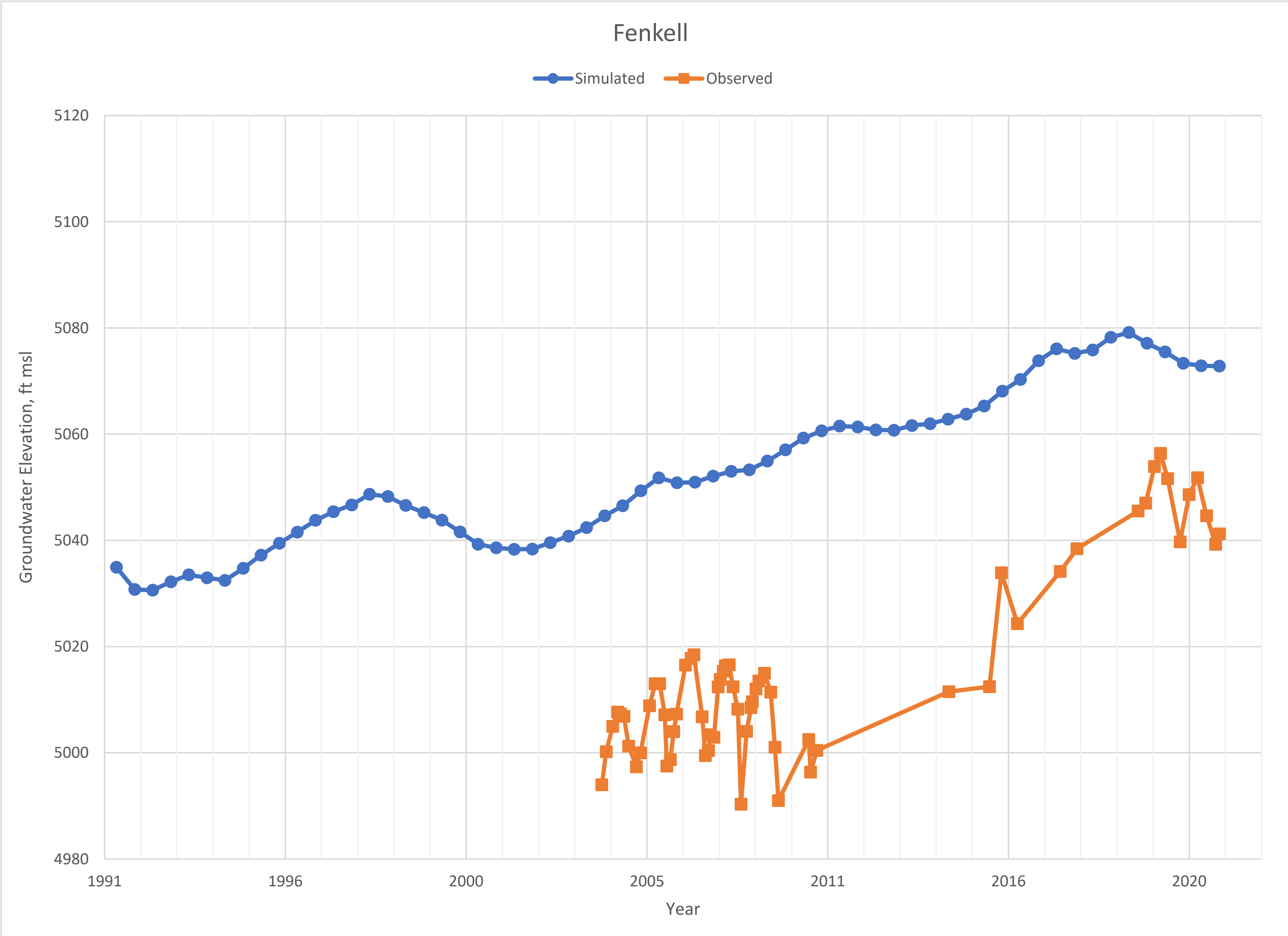
2016
2020
Year


Fenkell
Simulated
Observed
Groundwater Elevation, ft msl
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1991
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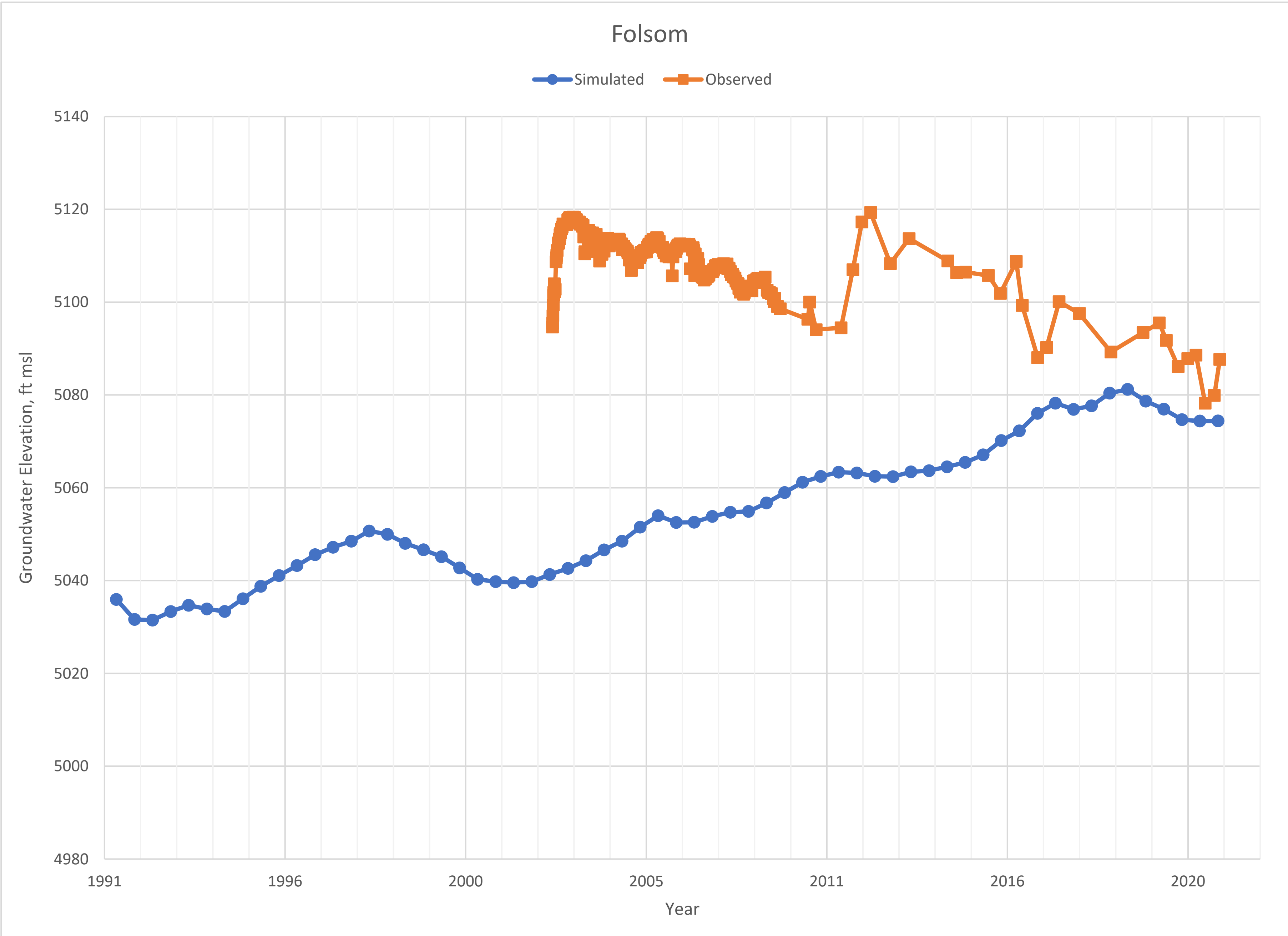
2020
Year



Folsom
Simulated
Observed
5140
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5020
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4980
Groundwater Elevation, ft msl
1991
1996
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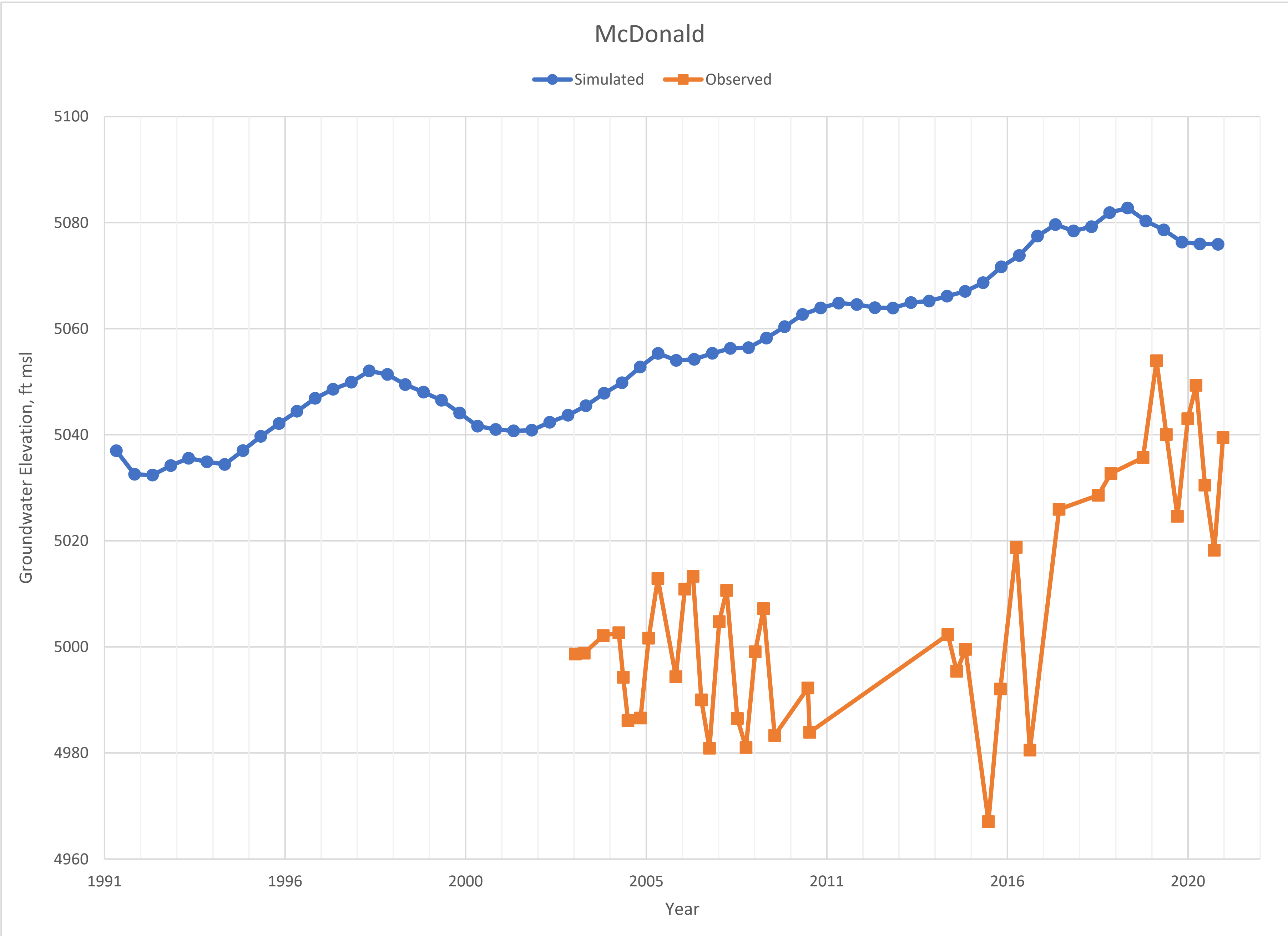
2011
2016
2020
Year


McDonald
Simulated
Observed
5100
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5060
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5000
4980
4960
Groundwater Elevation, ft msl
1991
1996
2000
2005
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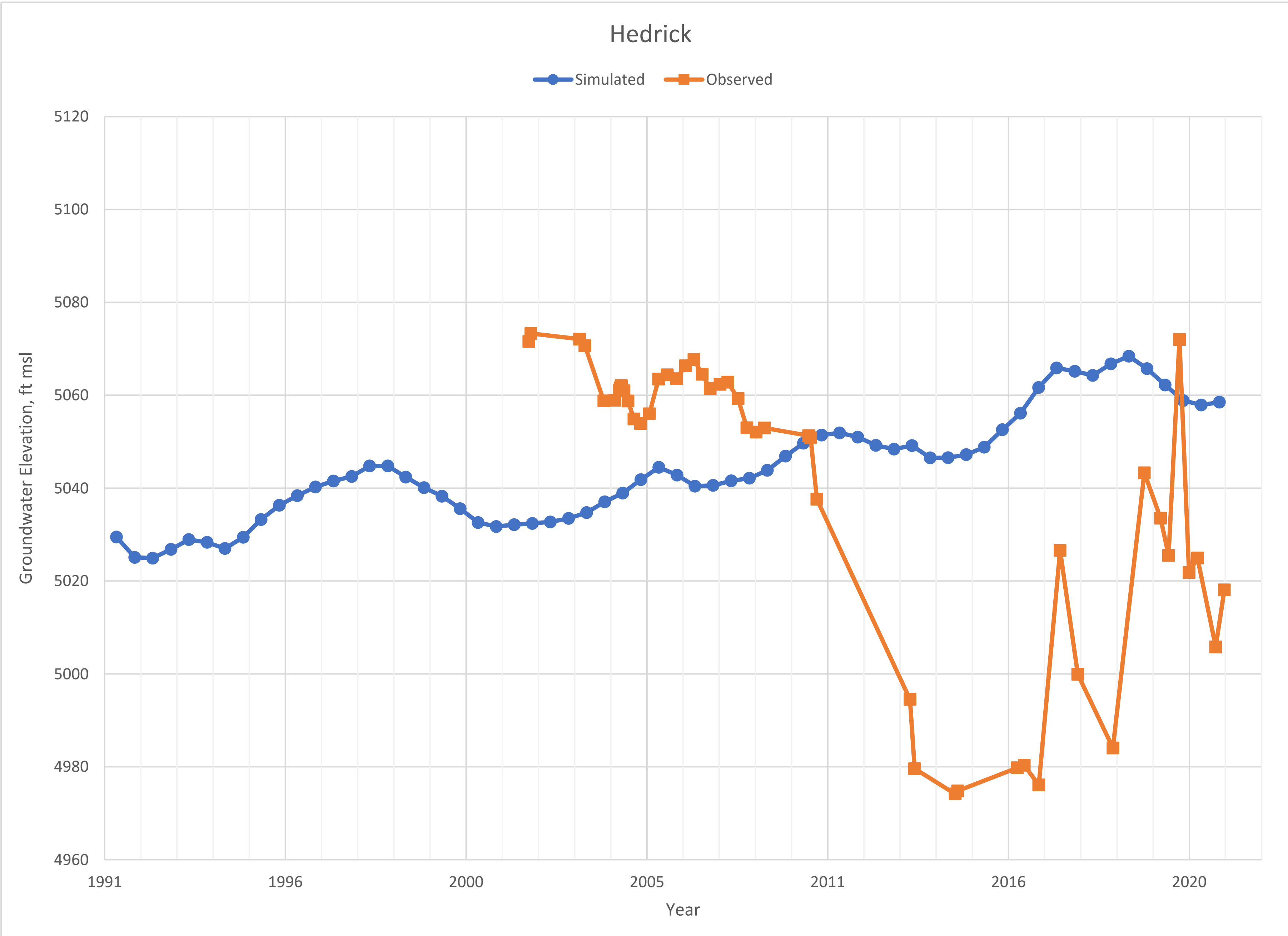
2016
2020
Year



Hedrick
Simulated
Observed
Groundwater Elevation, ft msl
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1991
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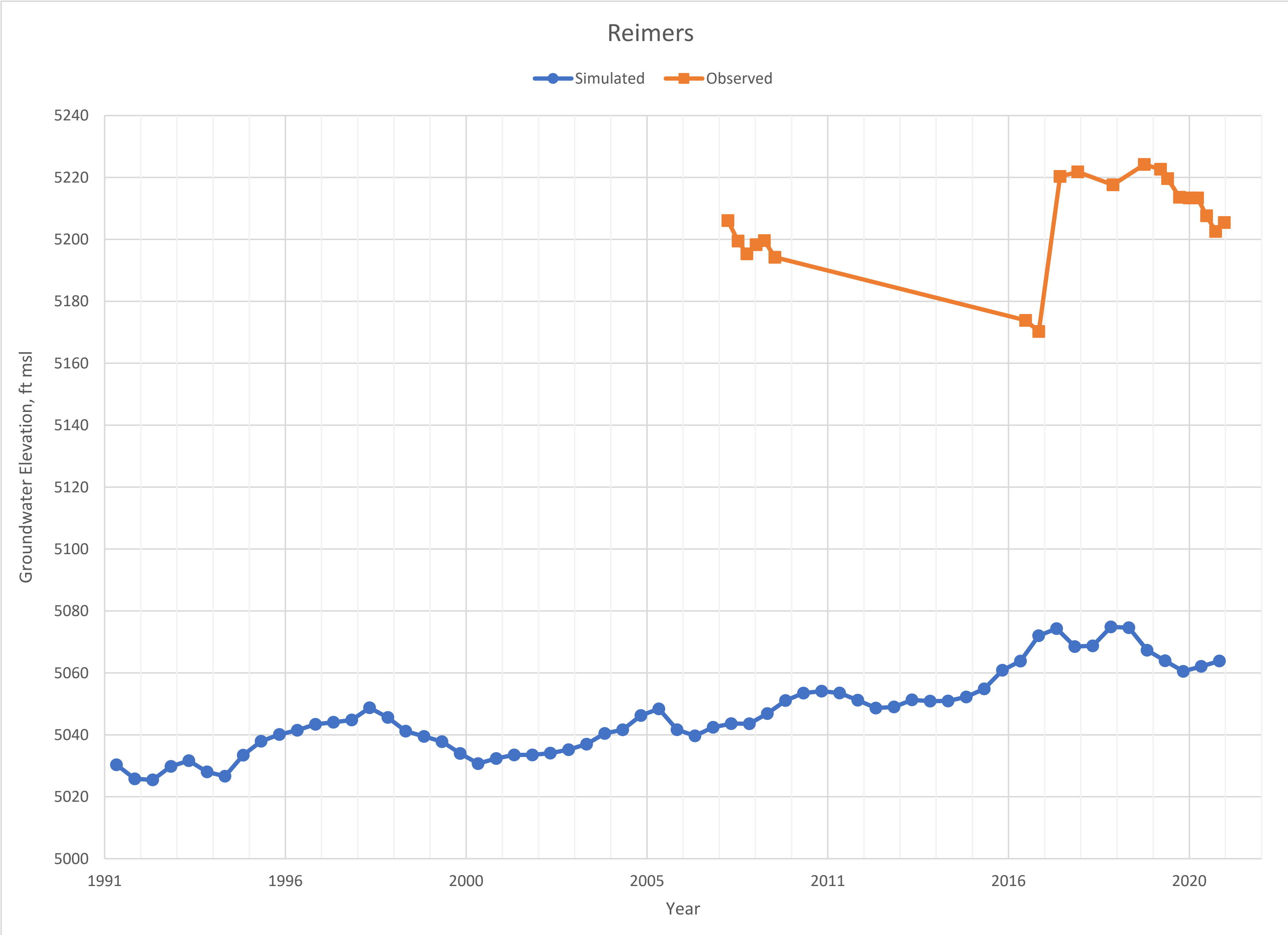
2016
2020
Year



Reimers
Simulated
Observed
5240
5220
5200
5180
5160
5140
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Groundwater Elevation, ft msl
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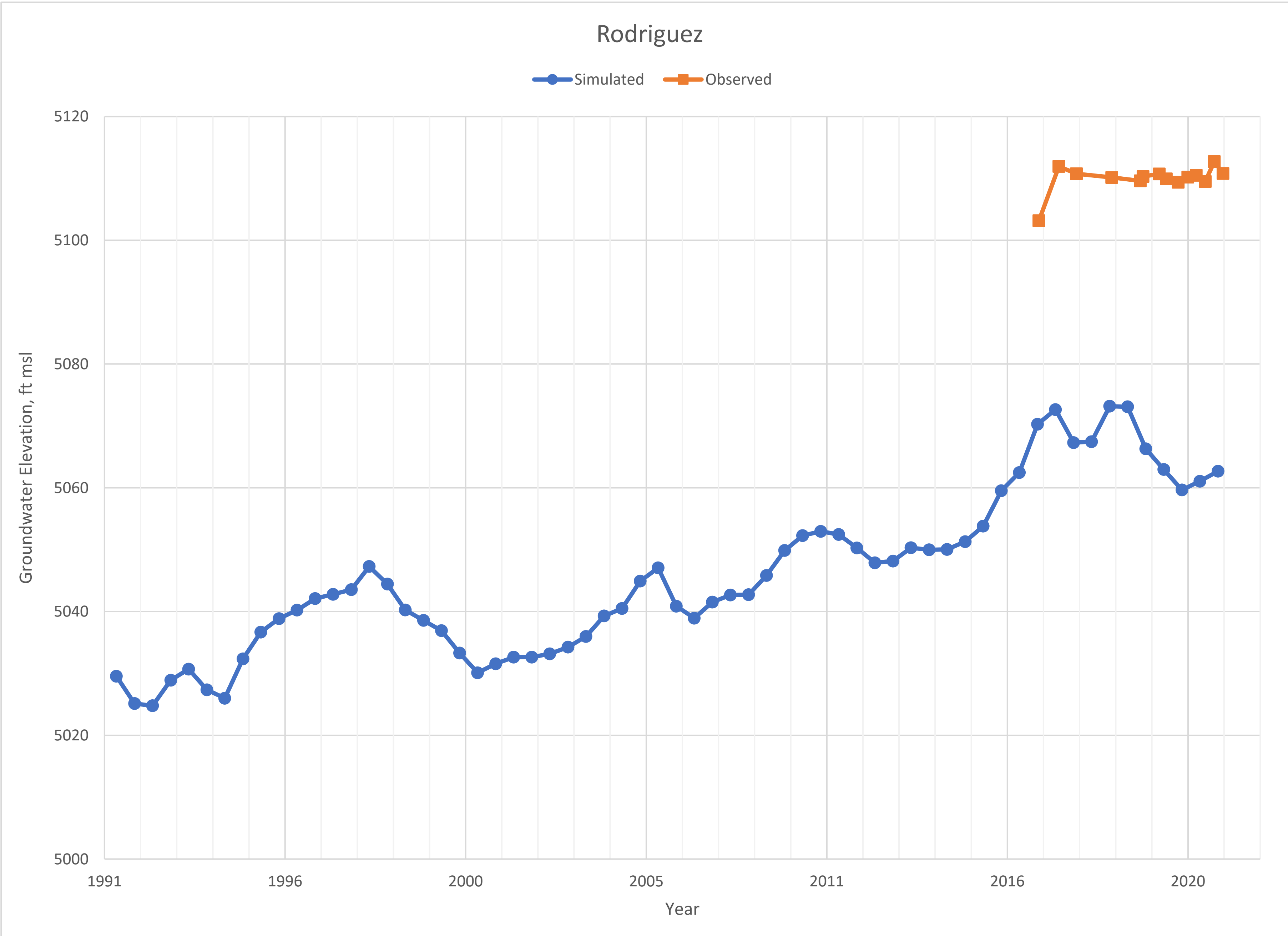
2020
Year


Rodriguez
Simulated
Observed
Groundwater Elevation, ft msl
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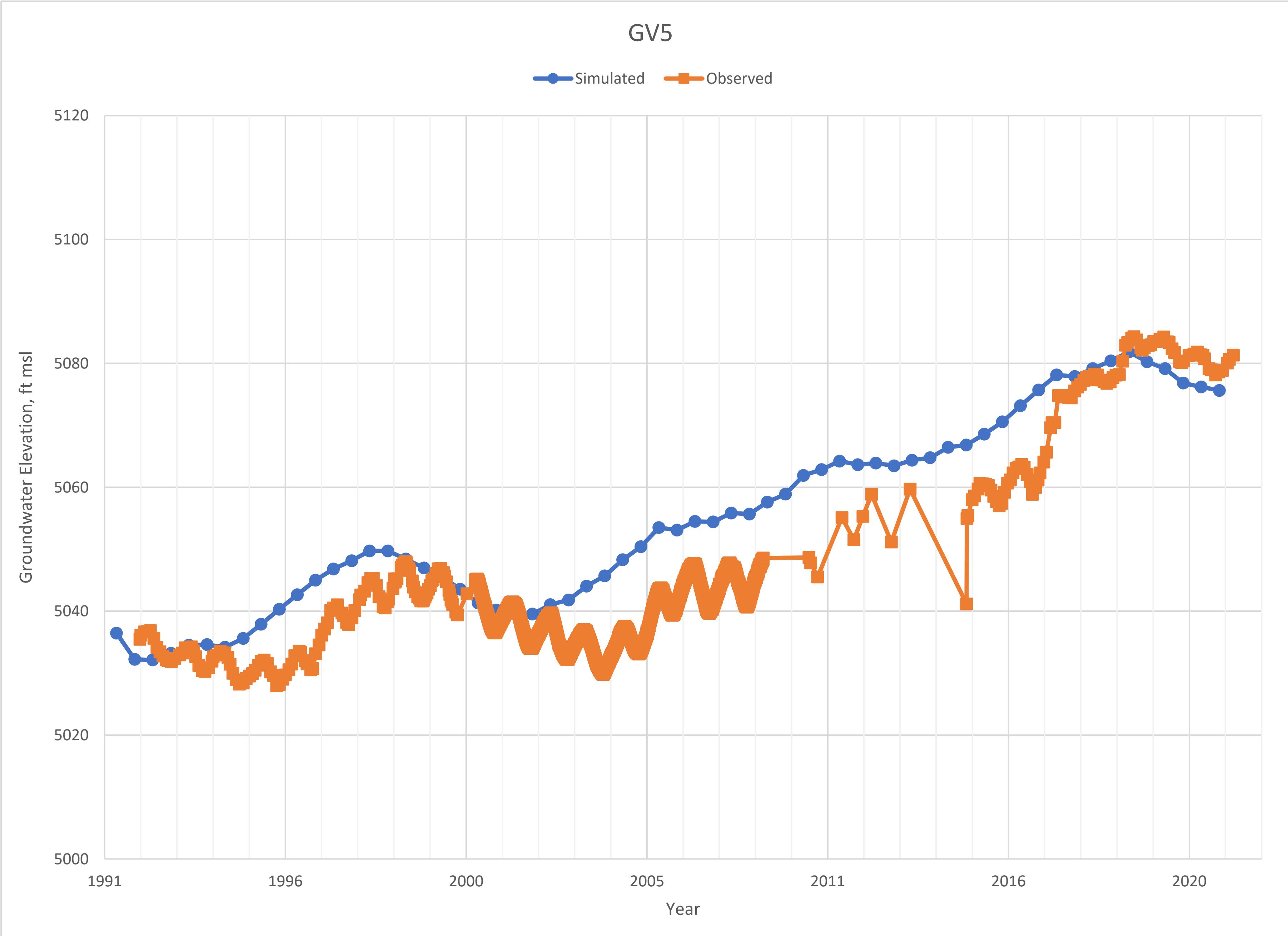
2020
Year


GV5
Simulated
Observed
Groundwater Elevation, ft msl
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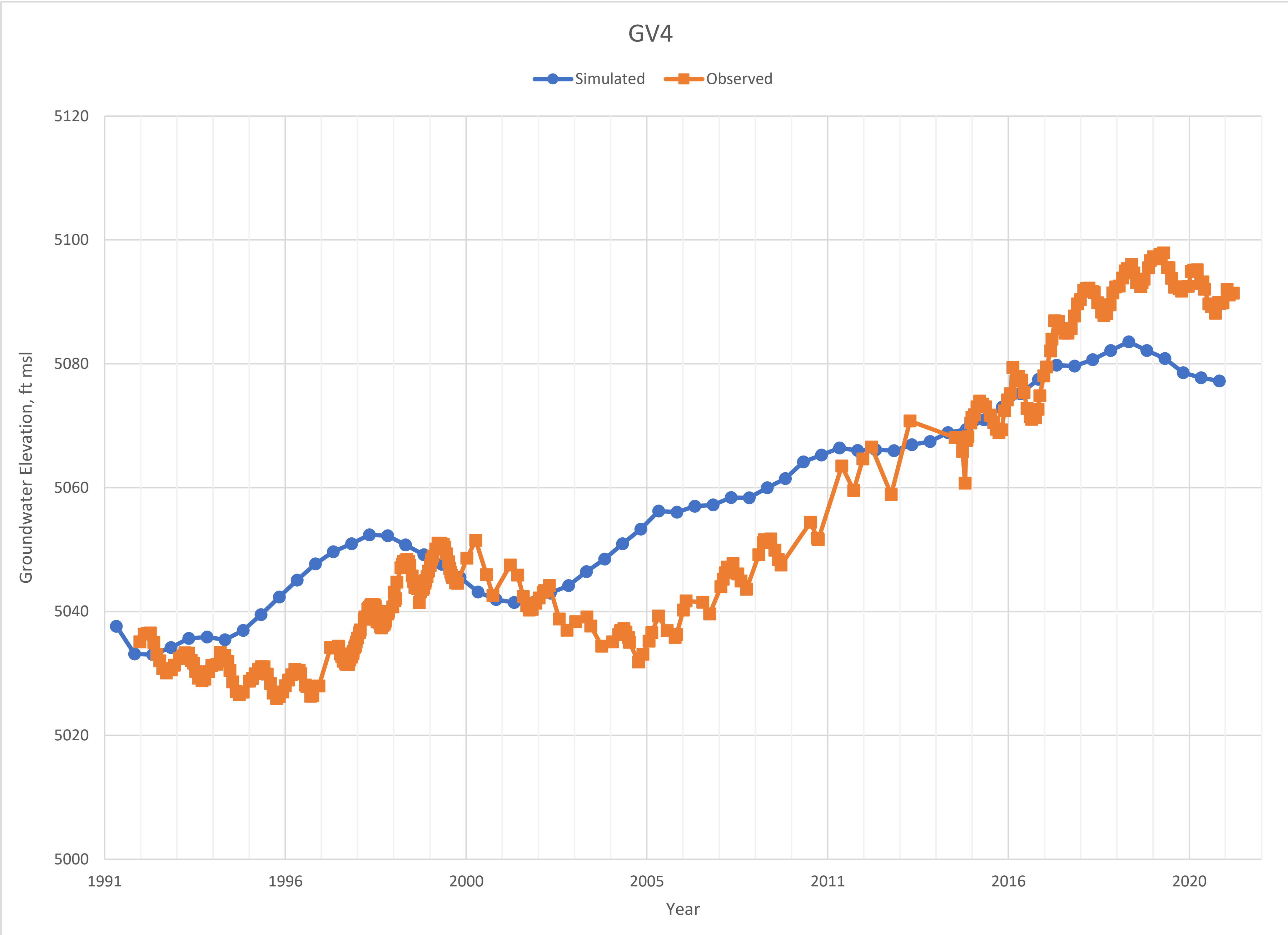
Year


GV4
Simulated
Observed
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Groundwater Elevation, ft msl
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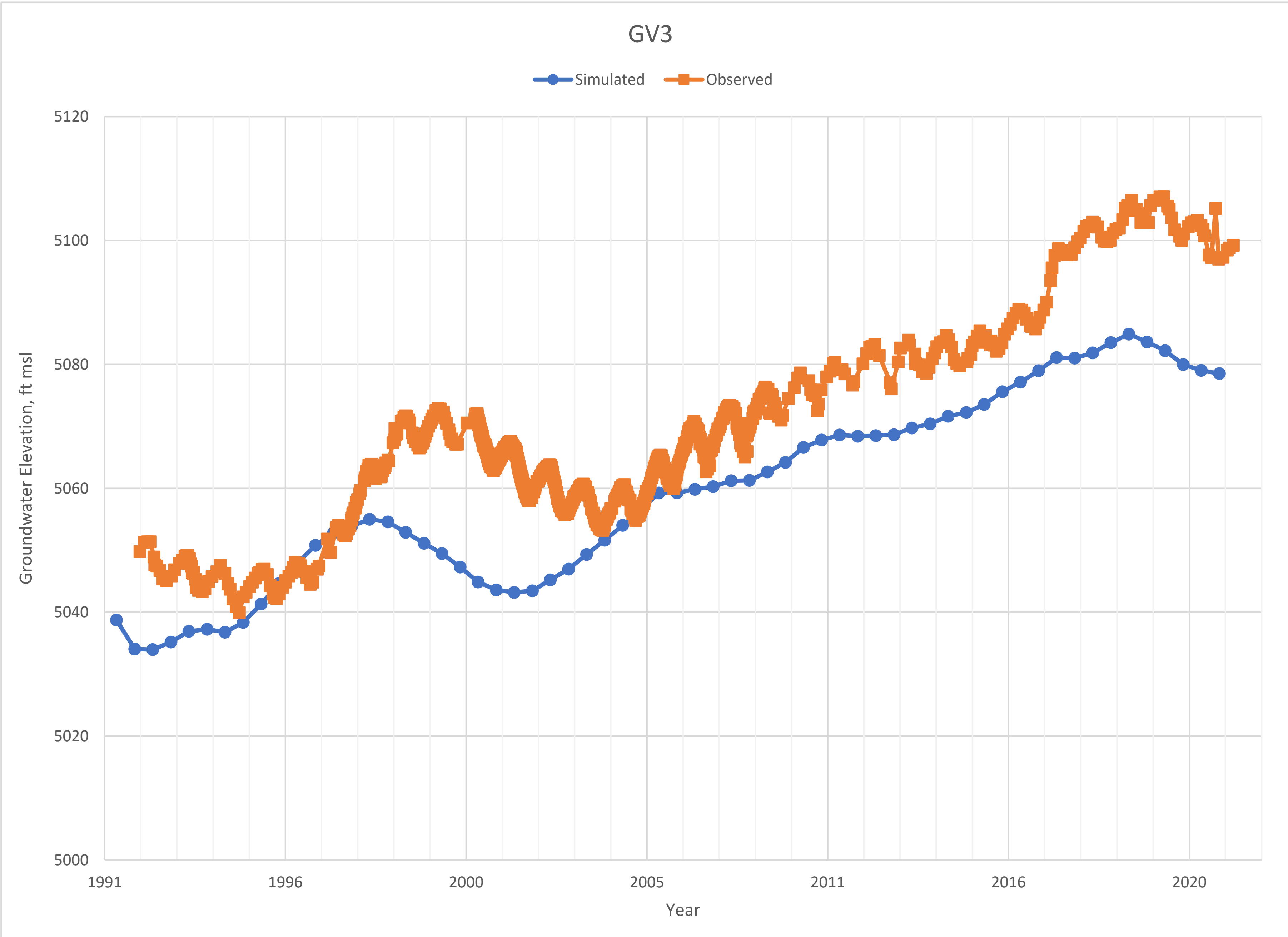
2020
Year


GV3
Simulated
Observed
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Groundwater Elevation, ft msl
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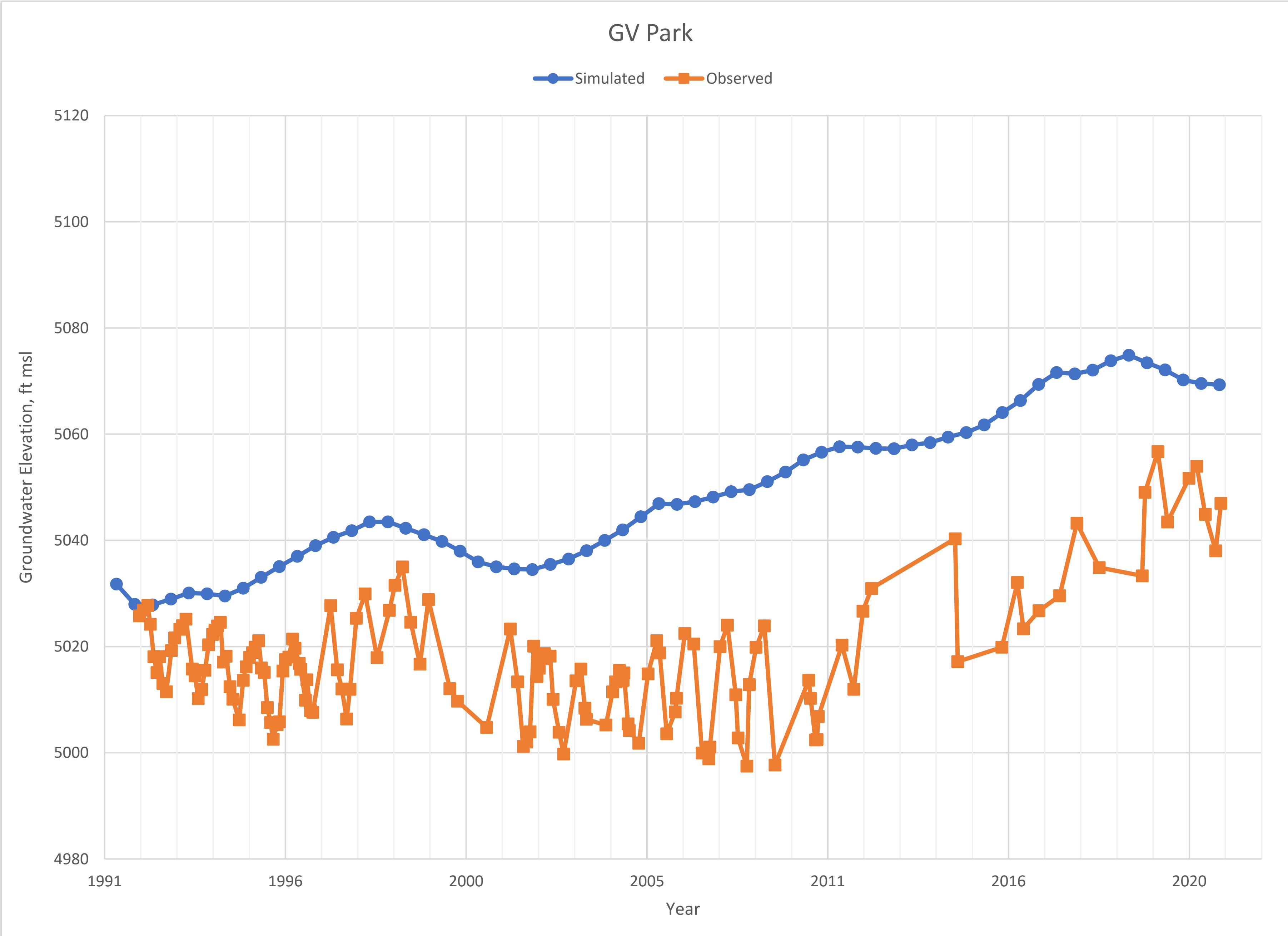
Year


GV Park
Simulated
Observed
Groundwater Elevation, ft msl
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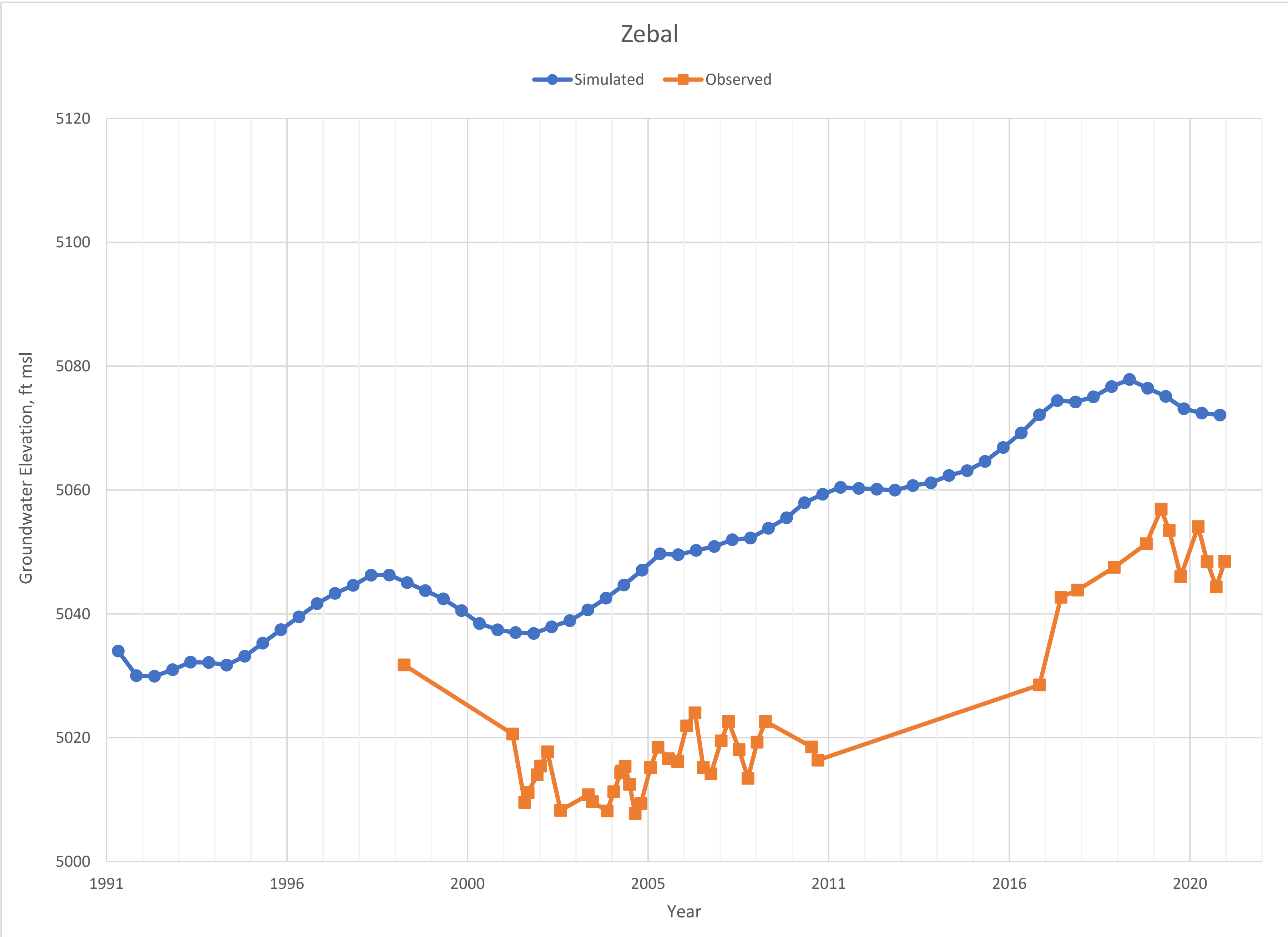
Year


Zebal
Simulated
Observed
Groundwater Elevation, ft msl
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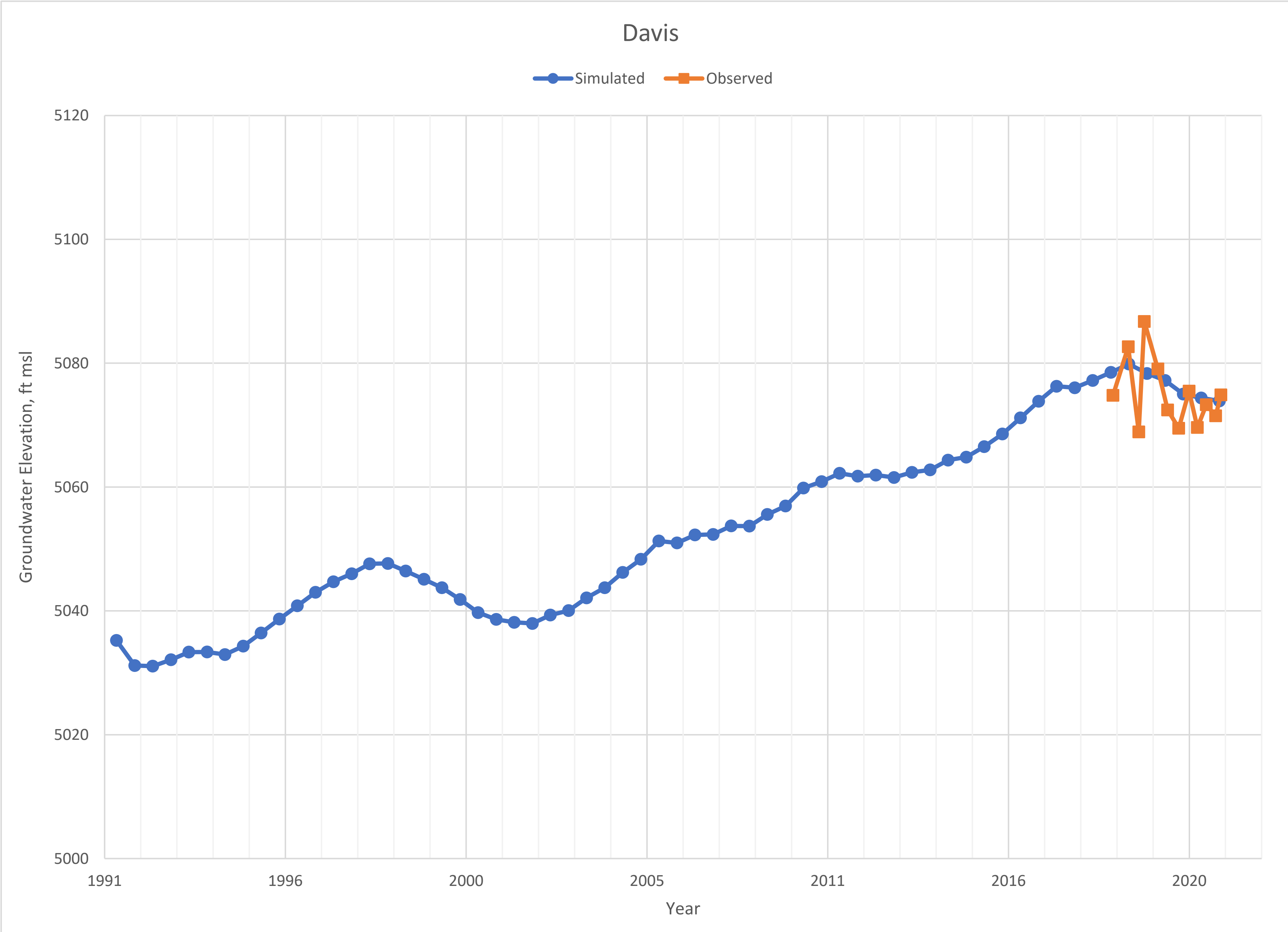

Davis
Simulated
Observed
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Groundwater Elevation, ft msl
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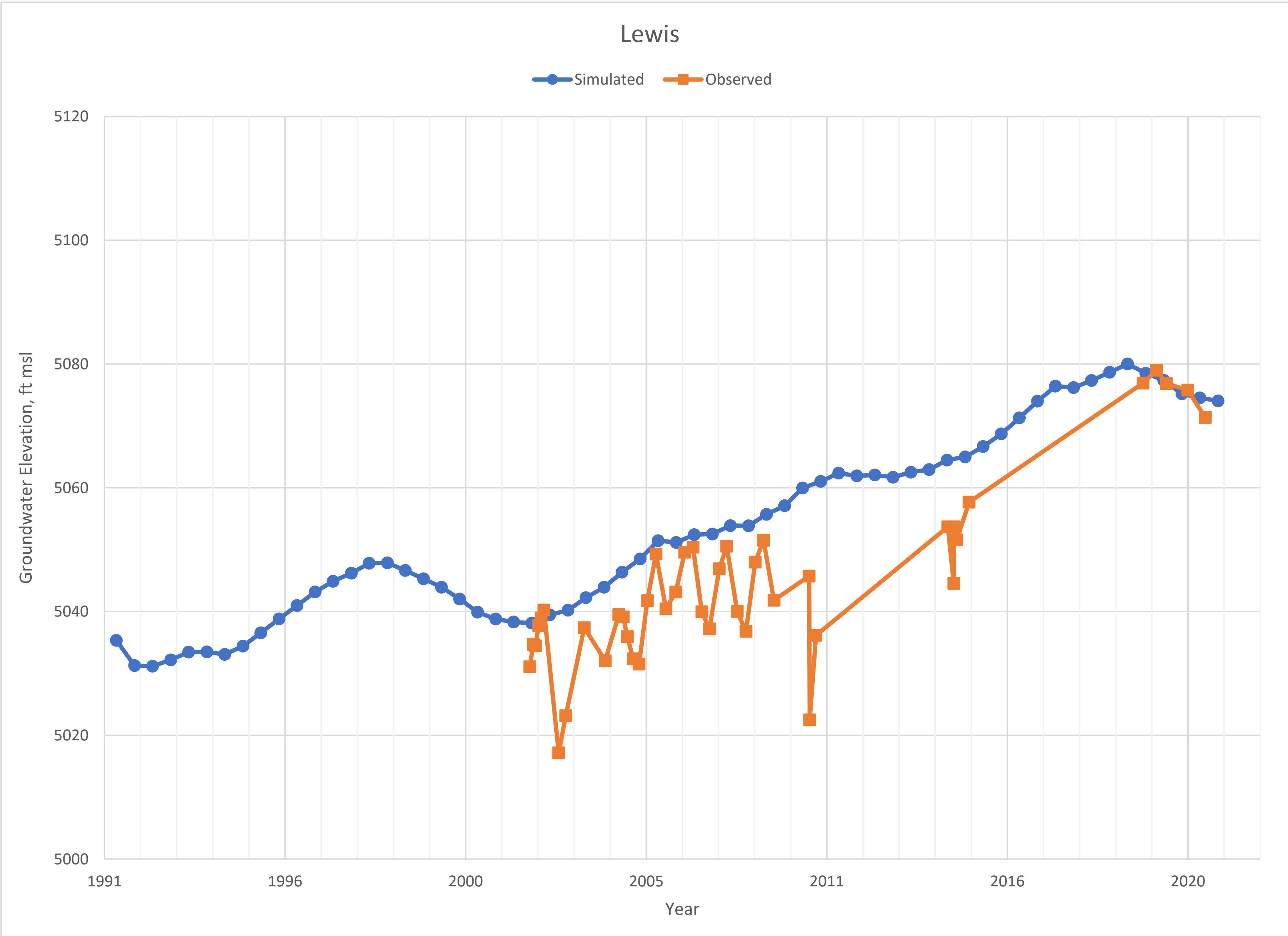

Lewis
Simulated
Observed
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Groundwater Elevation, ft msl
1991
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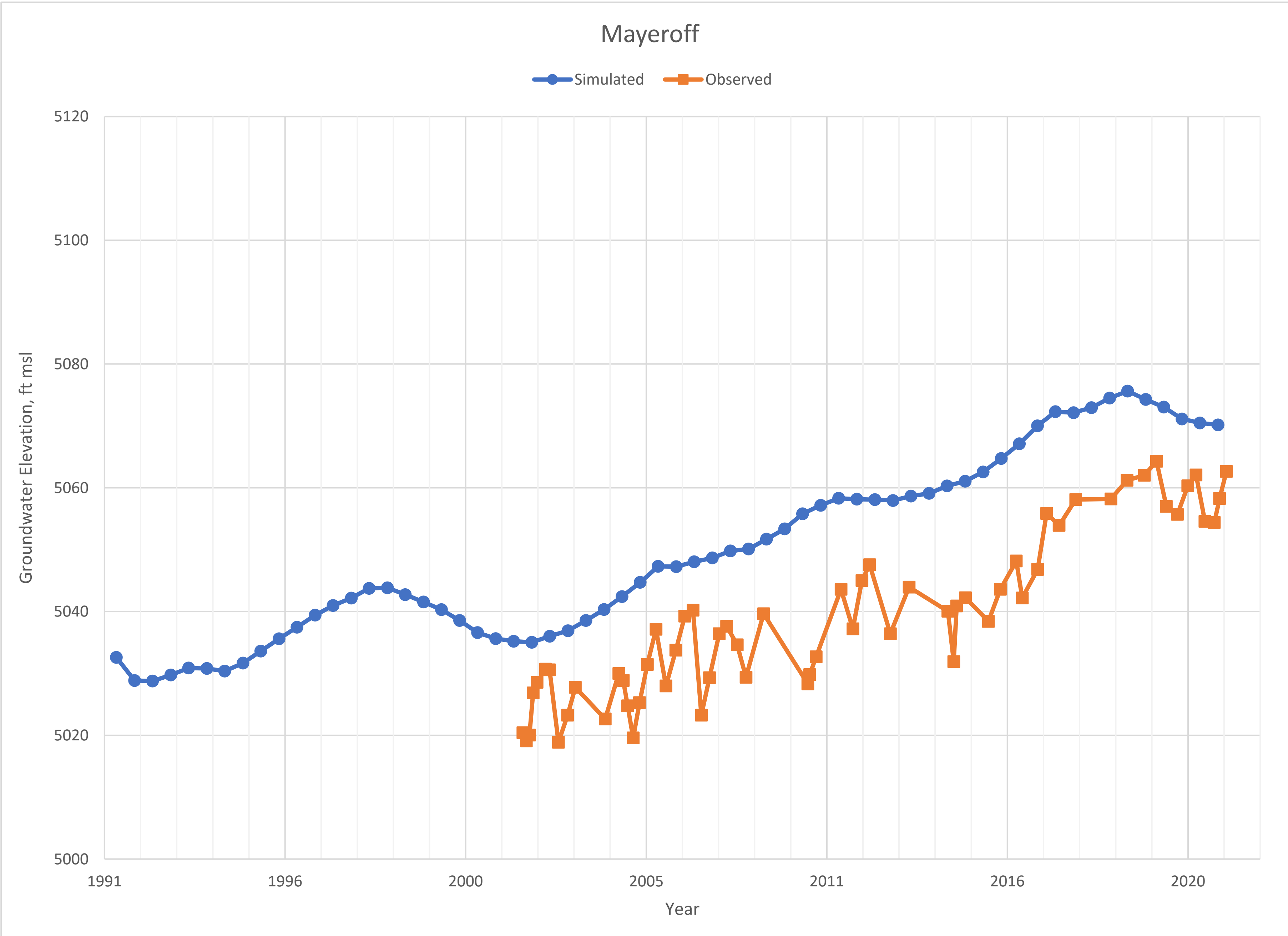
Year


Mayeroff
Simulated
Observed
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Groundwater Elevation, ft msl
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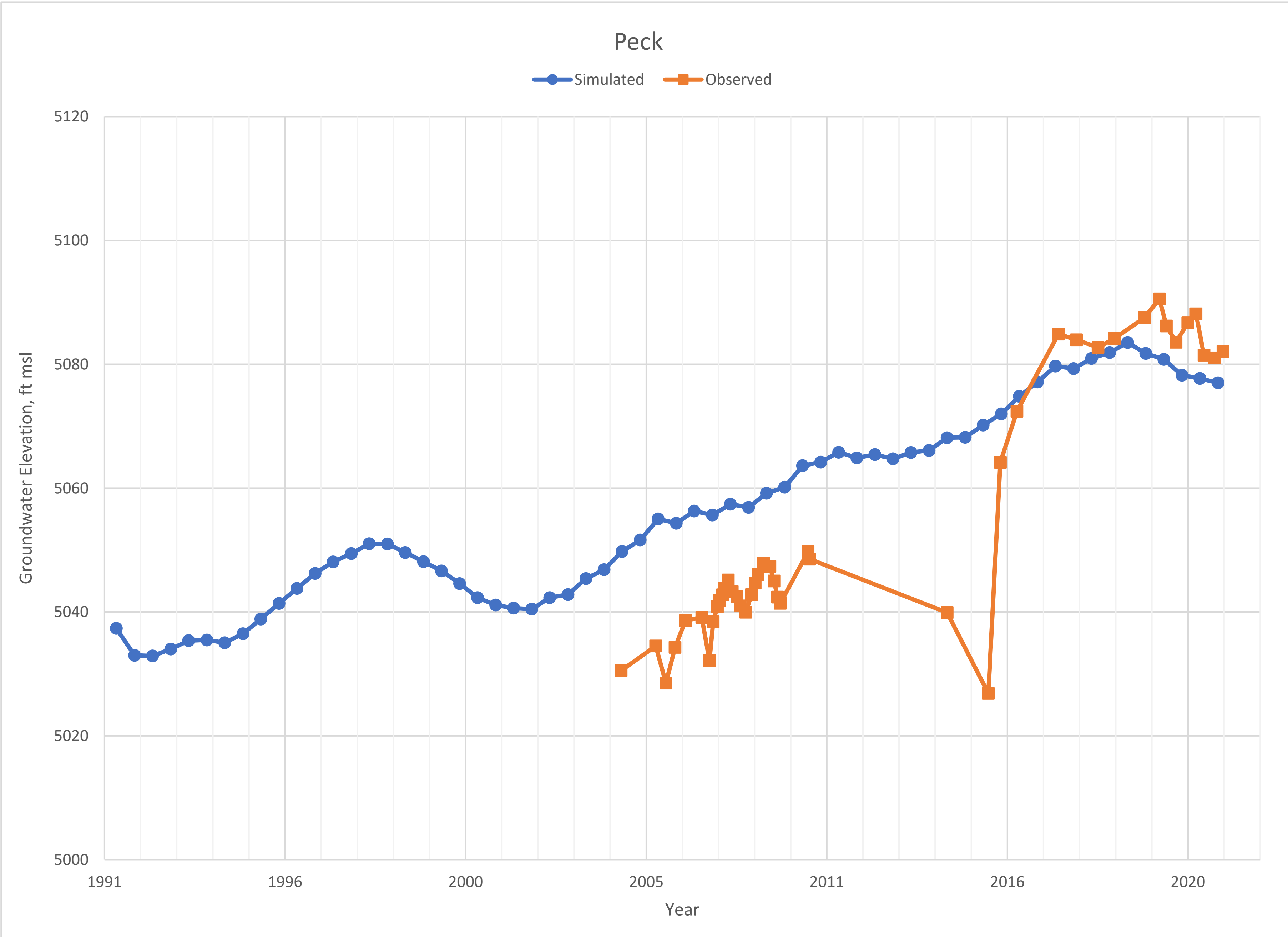
Year



Peck
Simulated
Observed
Groundwater Elevation, ft msl
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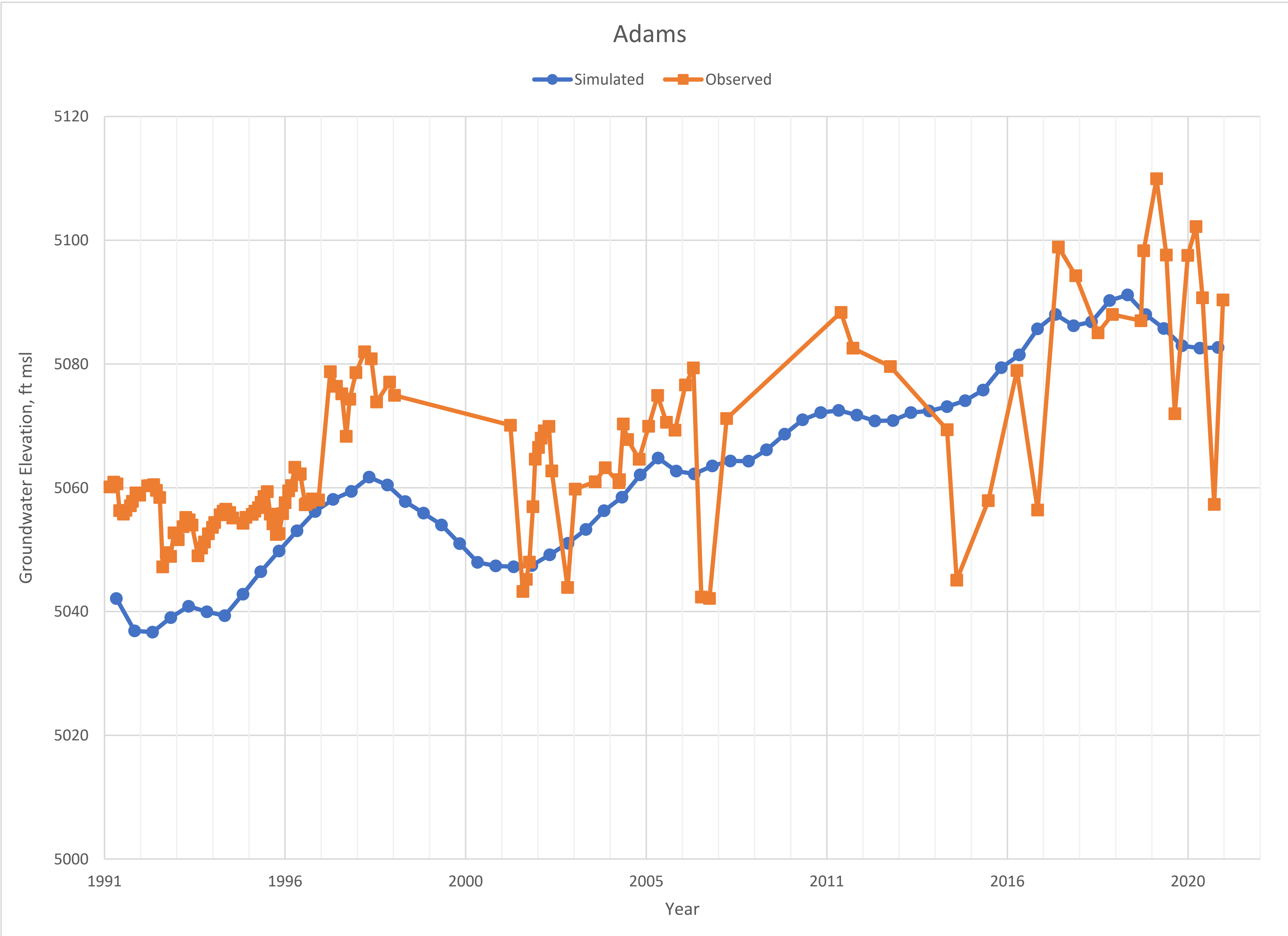
Adams
Simulated
Observed
Groundwater Elevation, ft msl
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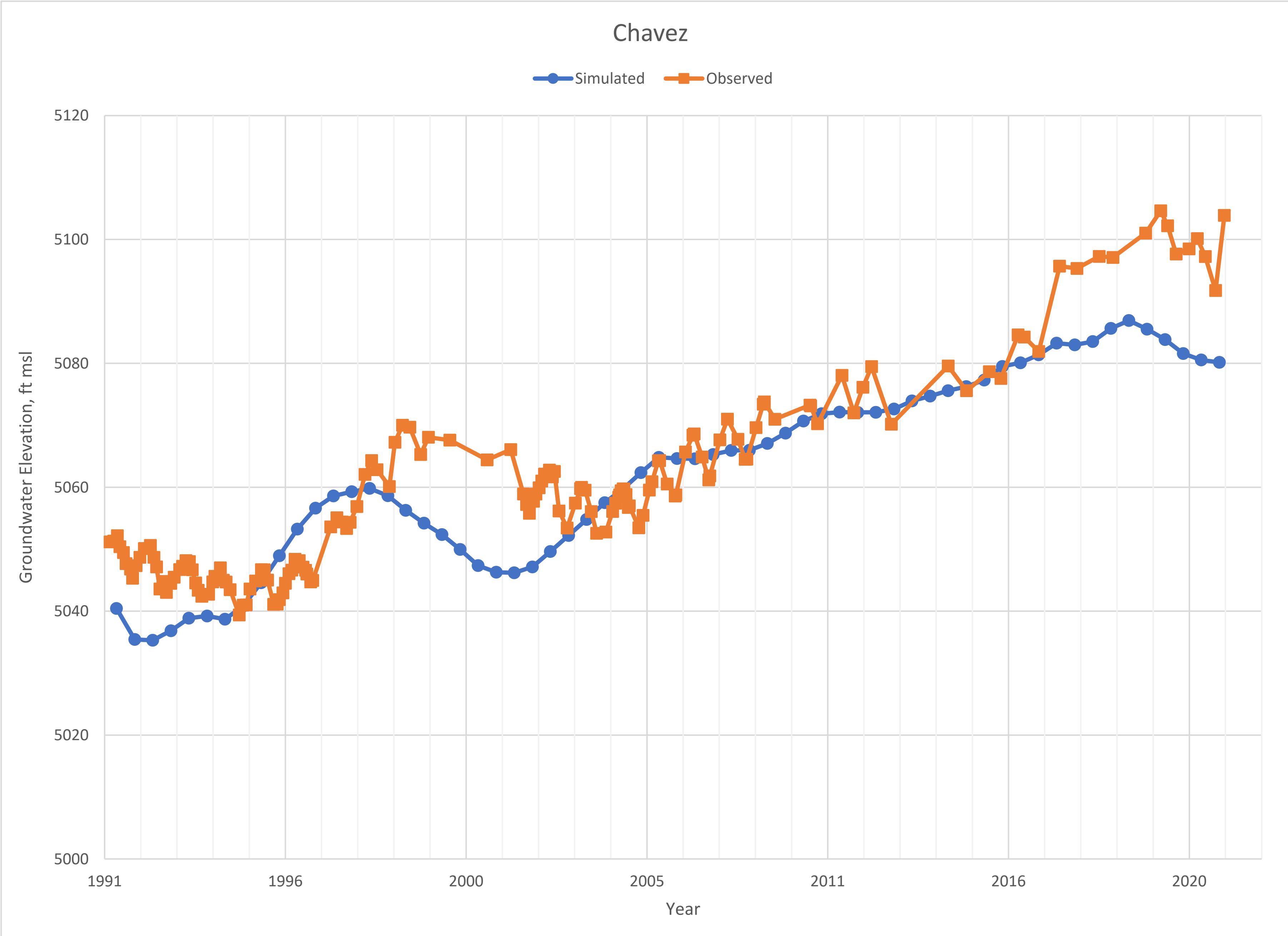
Year



Chavez
Simulated
Observed
Groundwater Elevation, ft msl
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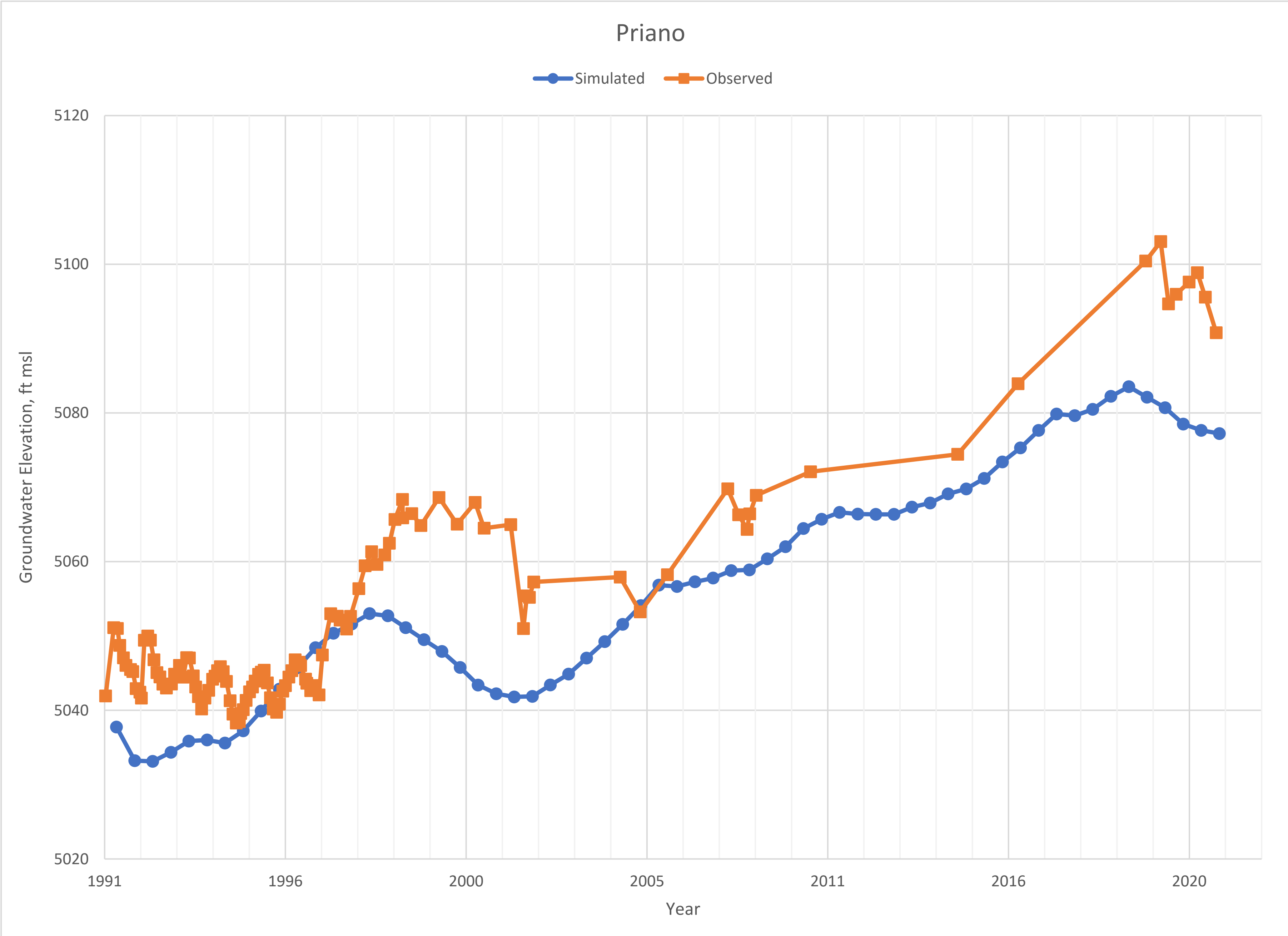
Year


Priano
Simulated
Observed
Groundwater Elevation, ft msl
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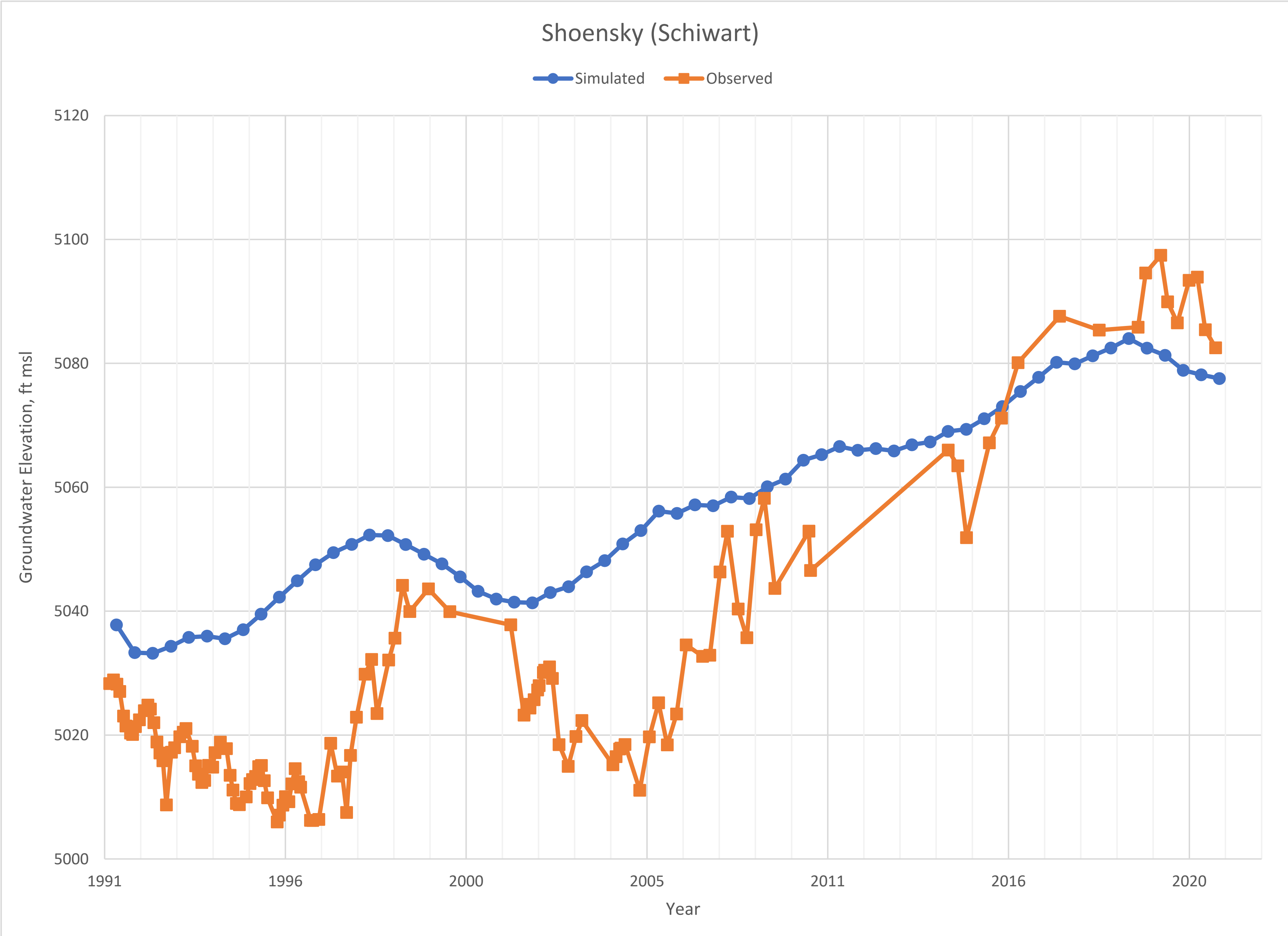
Year



Shoensky (Schiwart)
Simulated
Observed
Groundwater Elevation, ft msl
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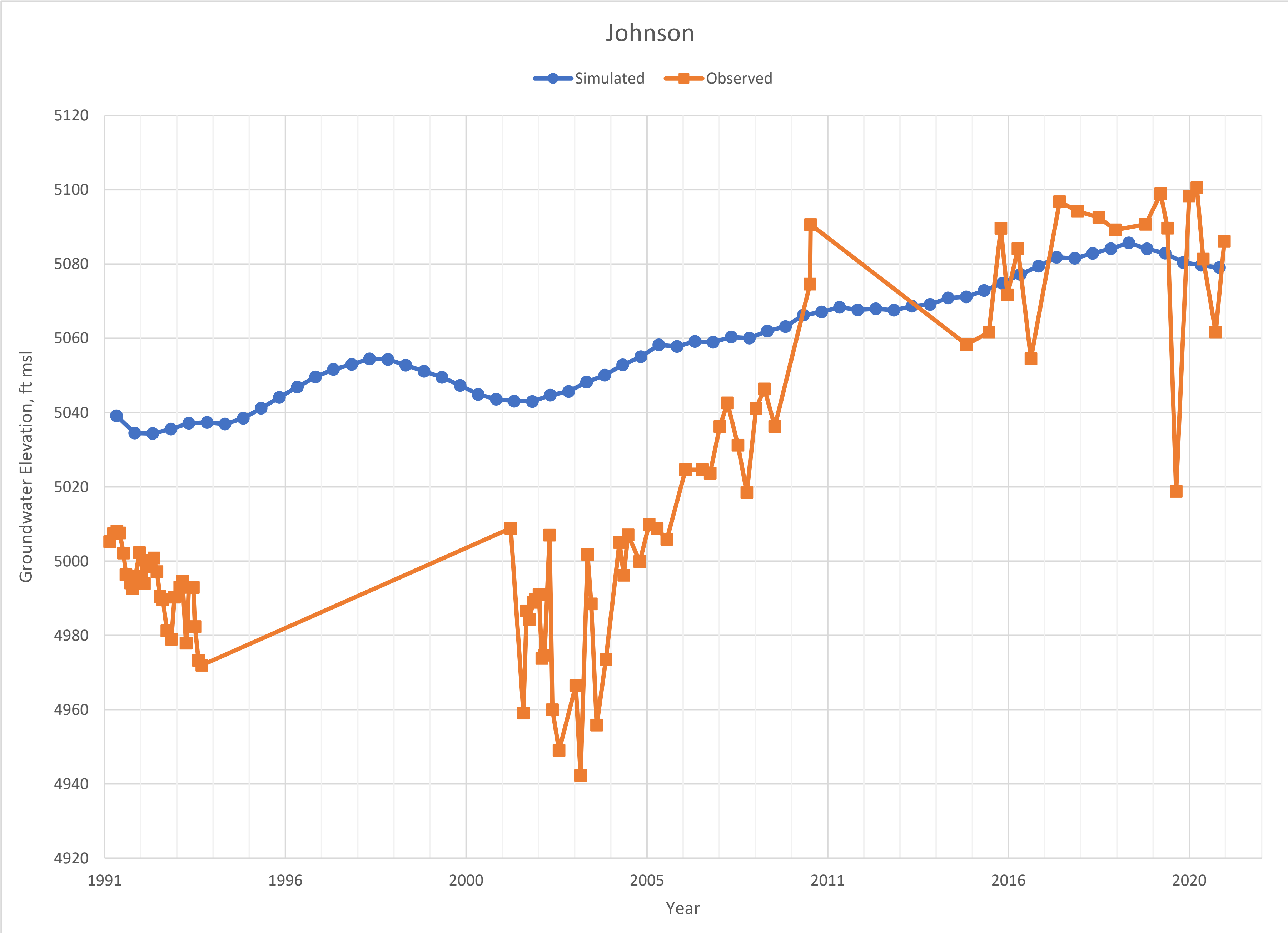
Year



Johnson
Simulated
Observed
Groundwater Elevation, ft msl
5120
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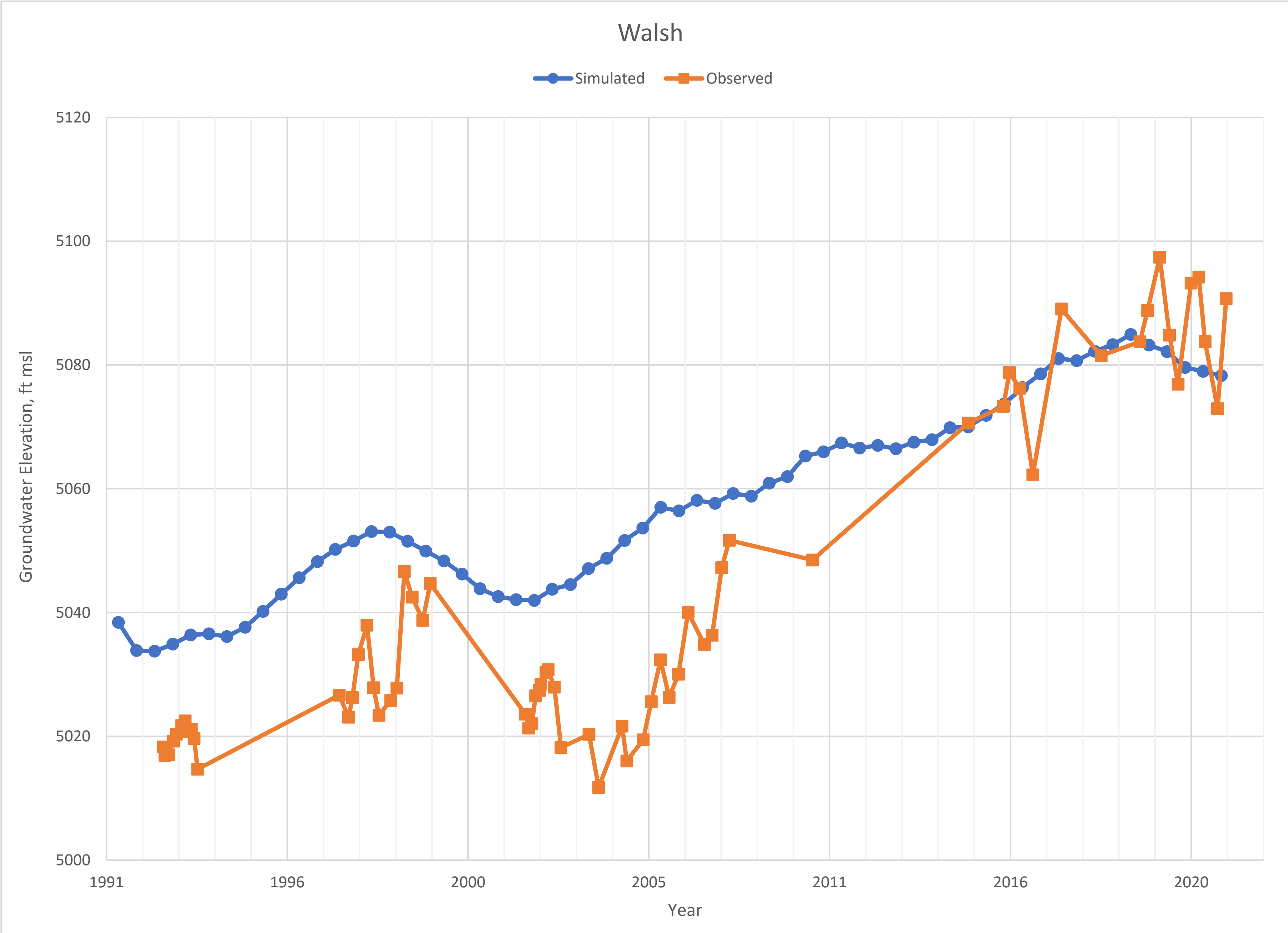
2016
2020
Year



Walsh
Simulated
Observed
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5000
Groundwater Elevation, ft msl
1991
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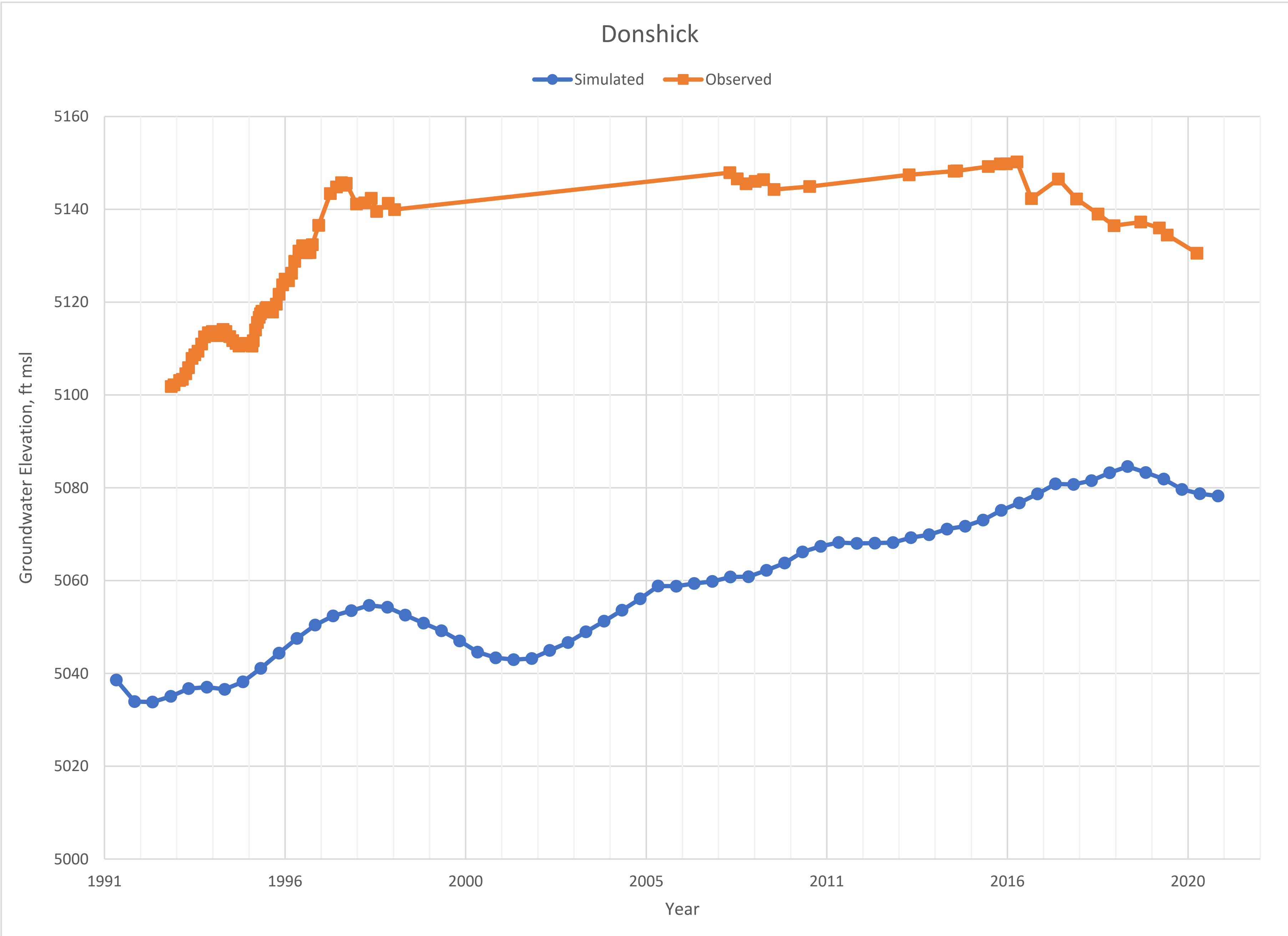
2016
2020
Year



Donshick
Simulated
Observed
Groundwater Elevation, ft msl
5160
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5100
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1991
1996
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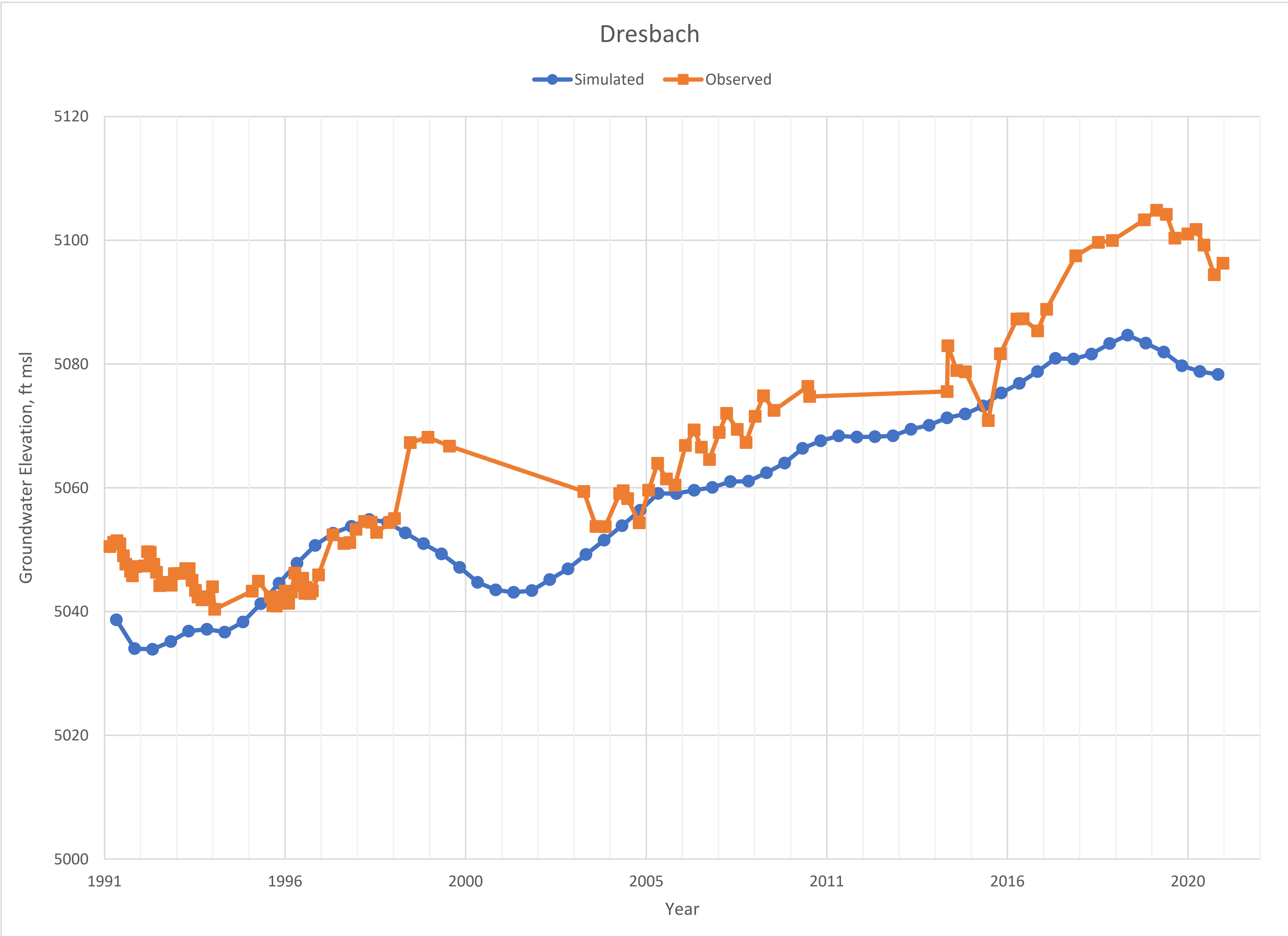
2005
2011
2016
2020
Year


Dresbach
Simulated
Observed
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5000
Groundwater Elevation, ft msl
1991
1996
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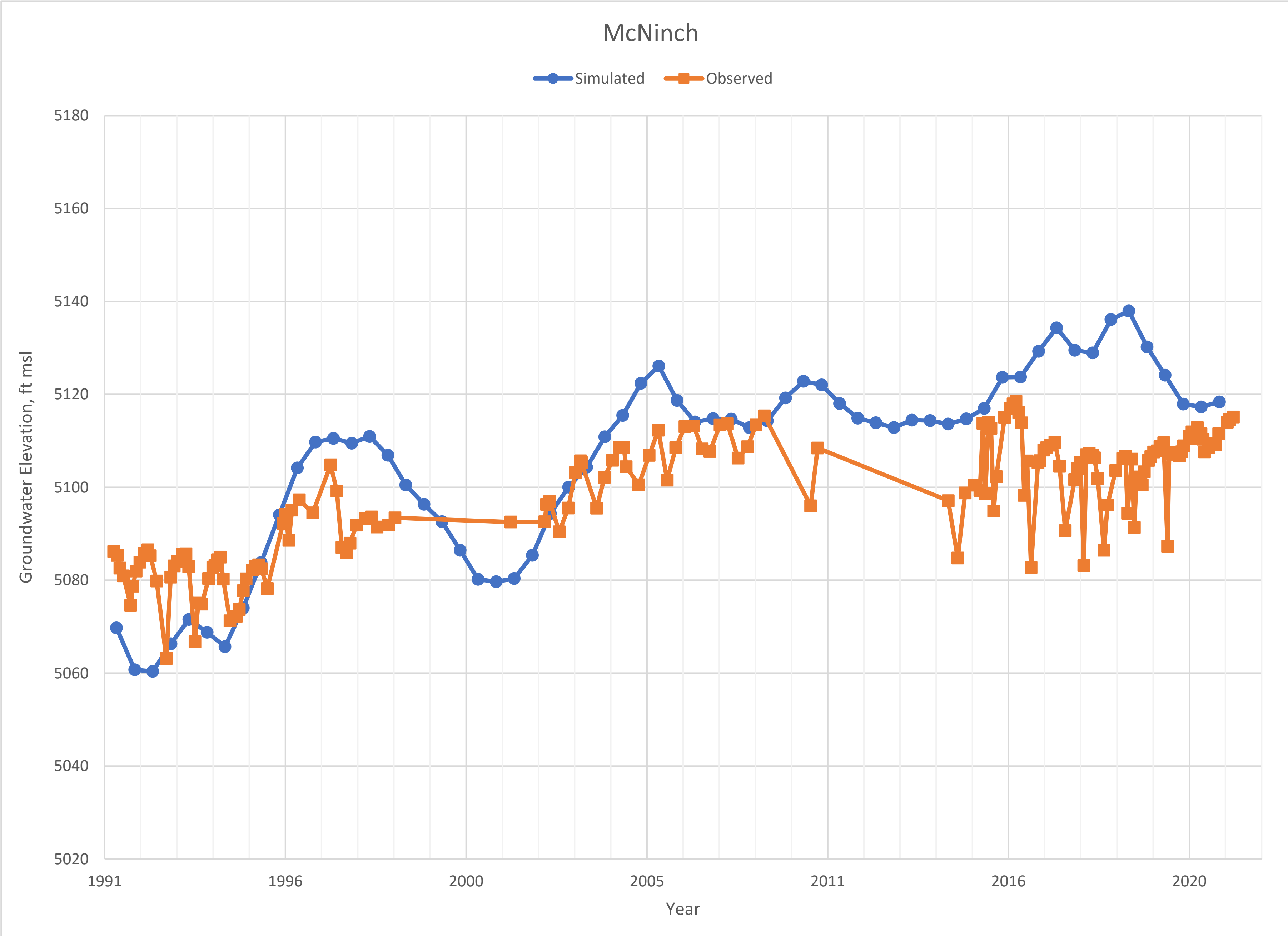
2020
Year


McNinch
Simulated
Observed
5180
5160
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Groundwater Elevation, ft msl
1991
1996
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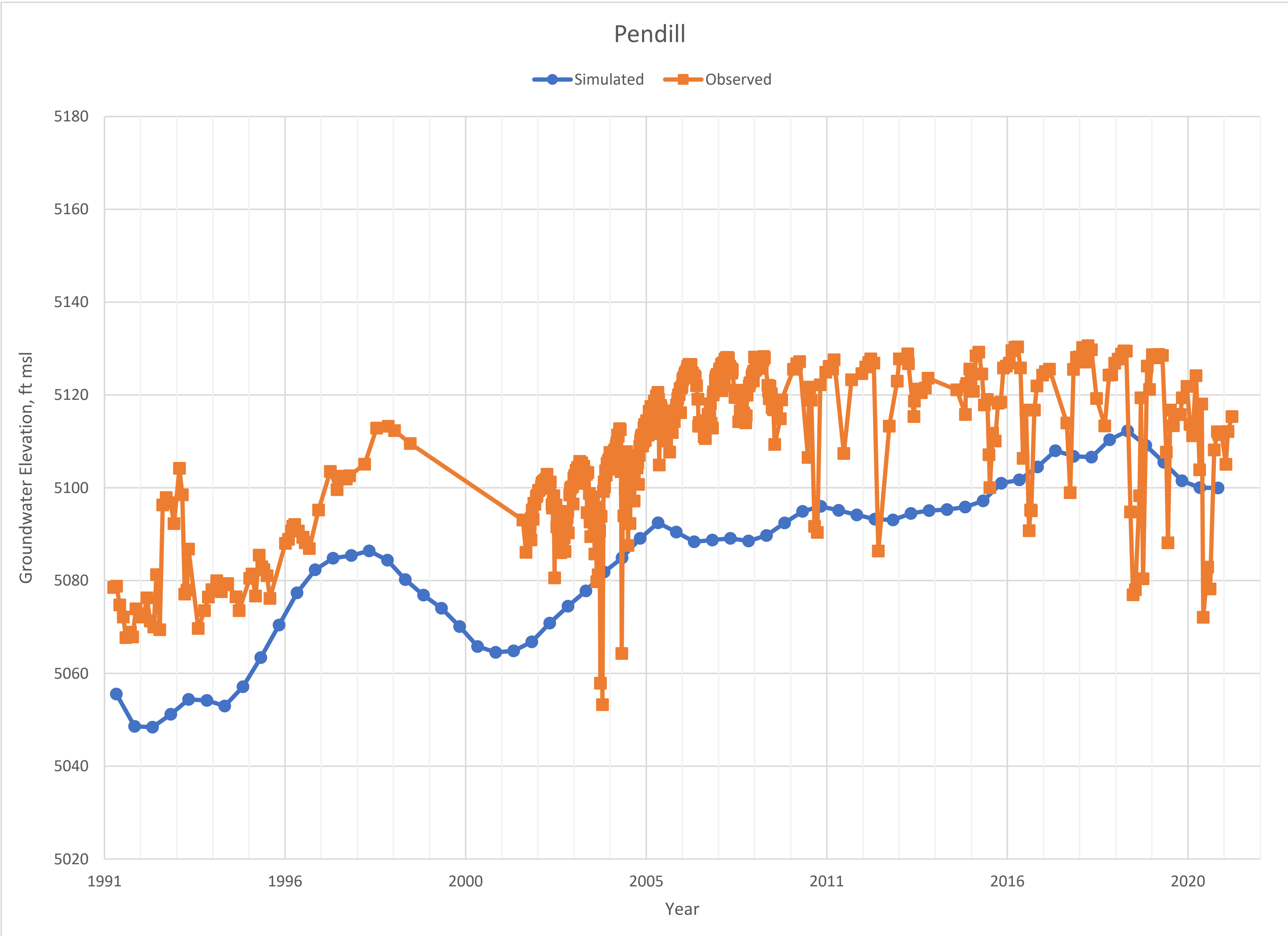
2016
2020
Year



Pendill
Simulated
Observed
5180
5160
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Groundwater Elevation, ft msl
1991
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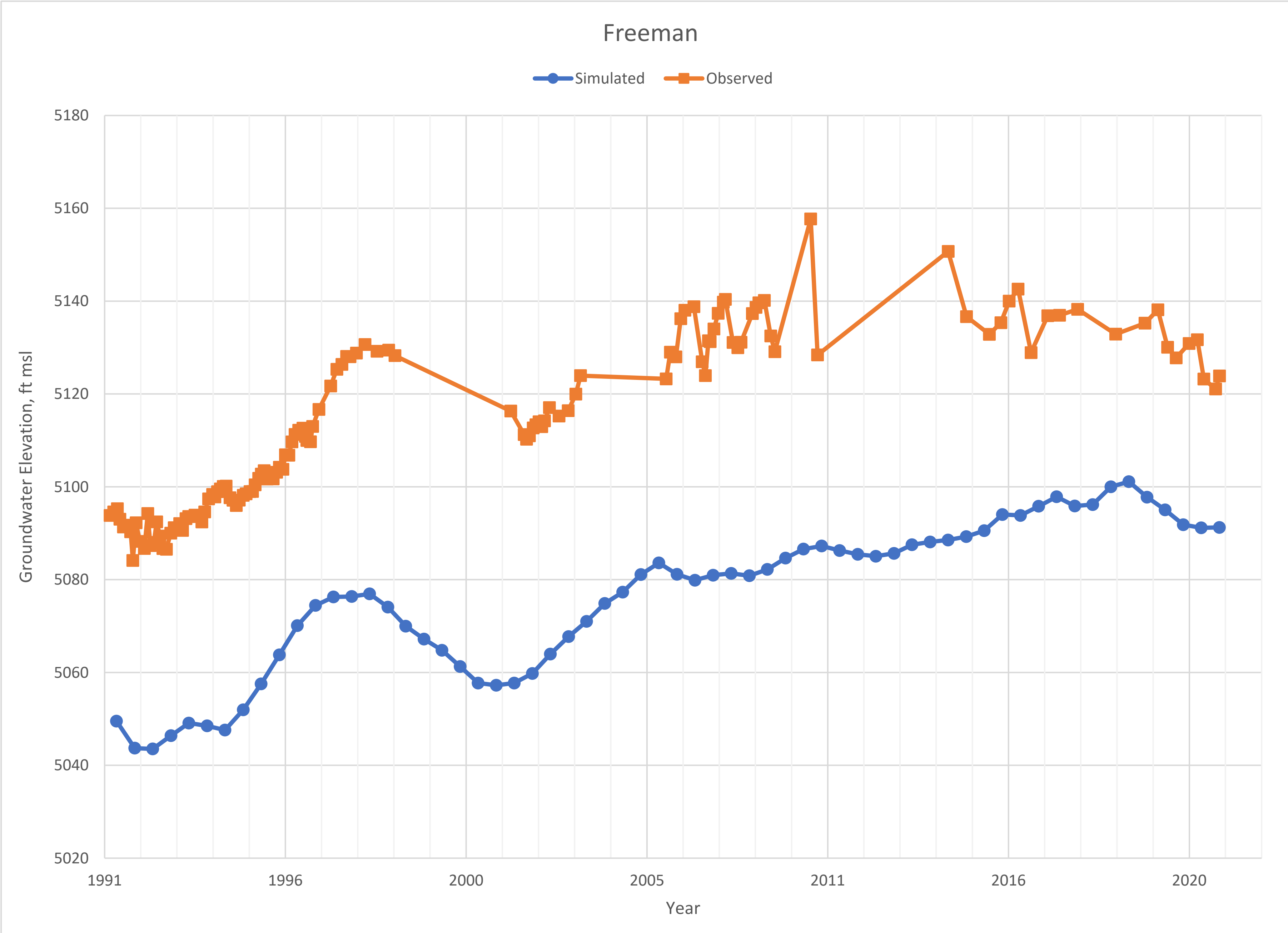
2020
Year



Freeman
Simulated
Observed
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Groundwater Elevation, ft msl
1991
1996
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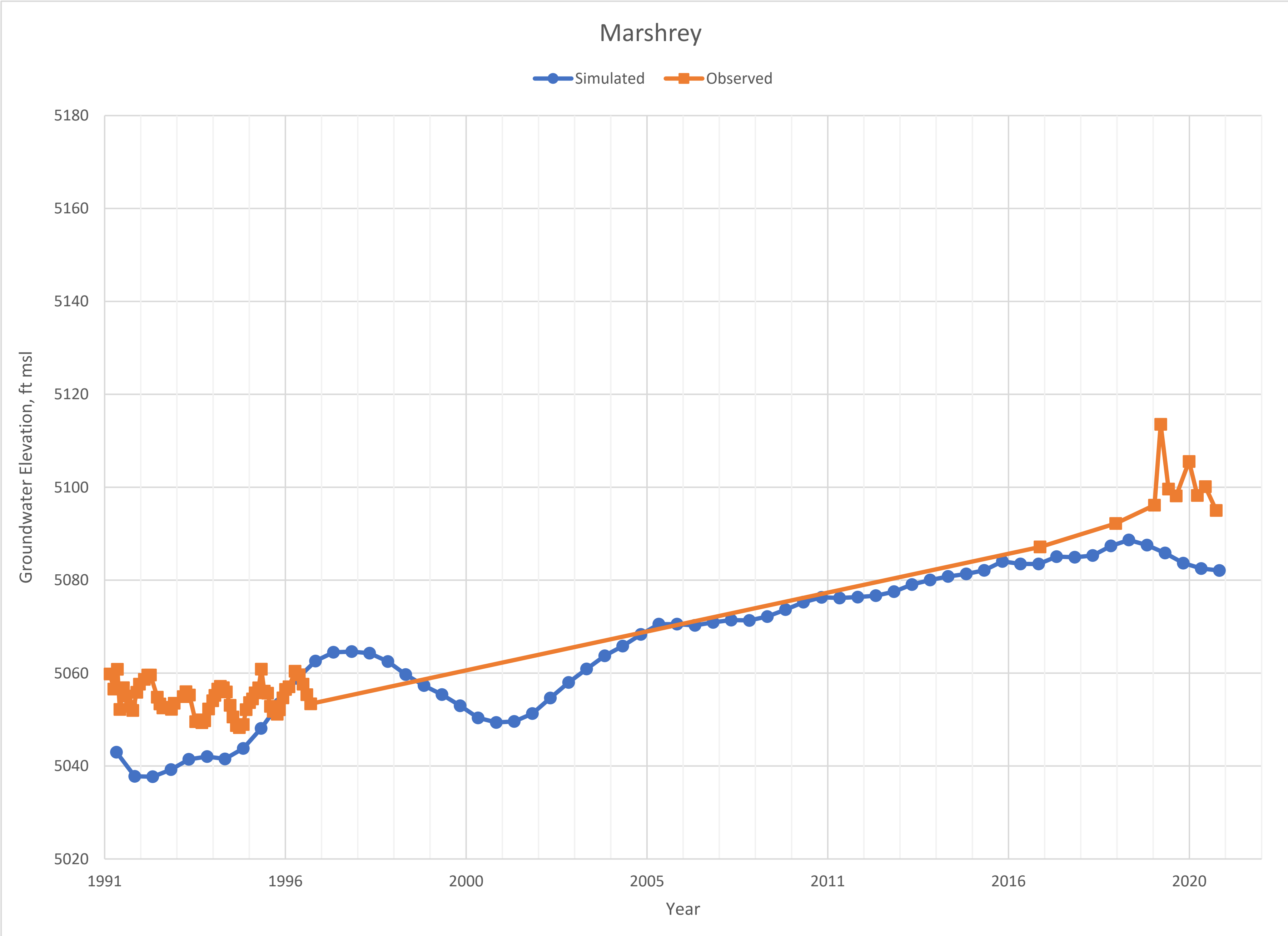
2016
2020
Year



Marshrey
Simulated
Observed
5180
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Groundwater Elevation, ft msl
1991
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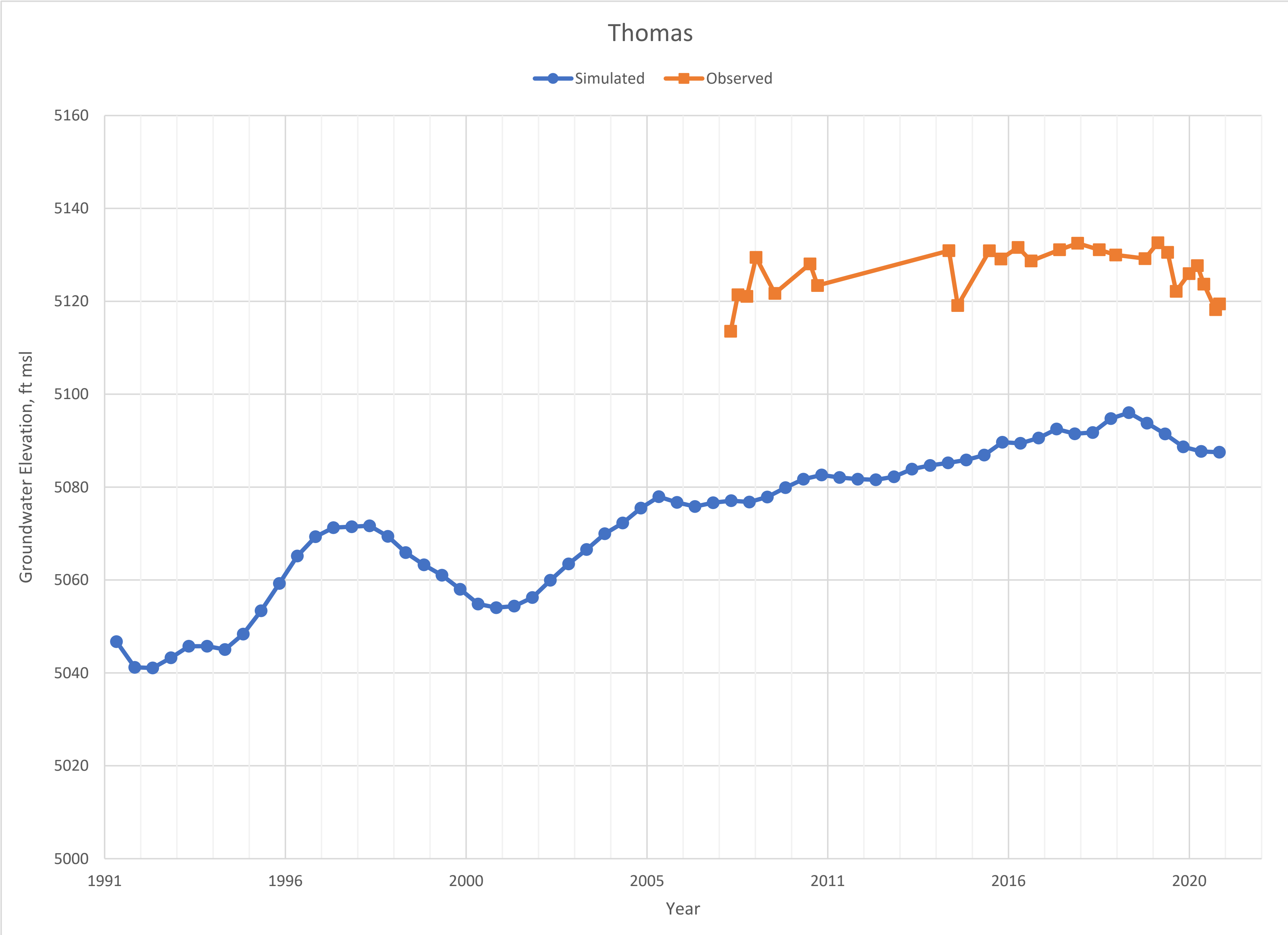
Year


Thomas
Simulated
Observed
Groundwater Elevation, ft msl
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1991
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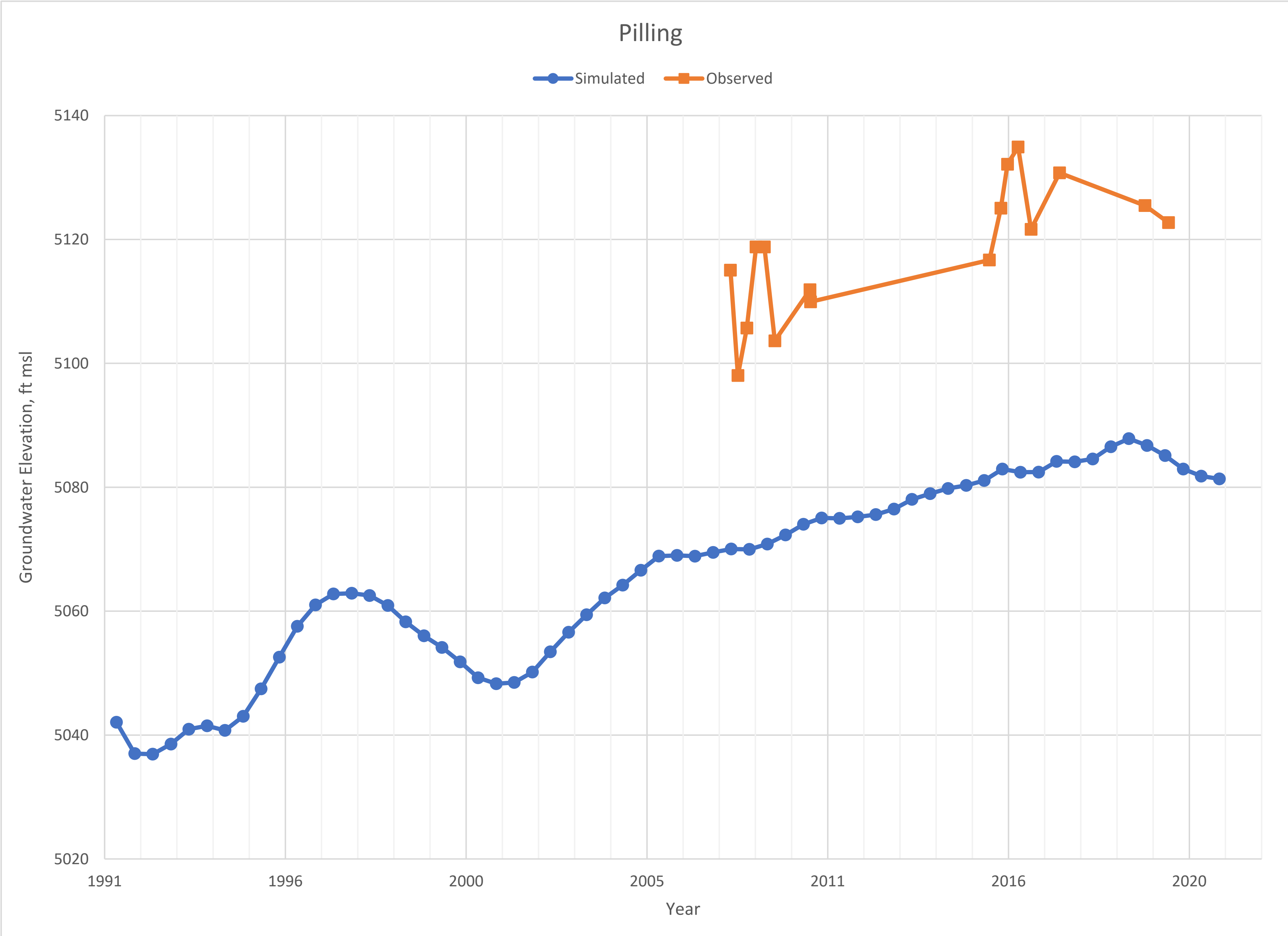
2016
2020
Year


Pilling
Simulated
Observed
Groundwater Elevation, ft msl
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1991
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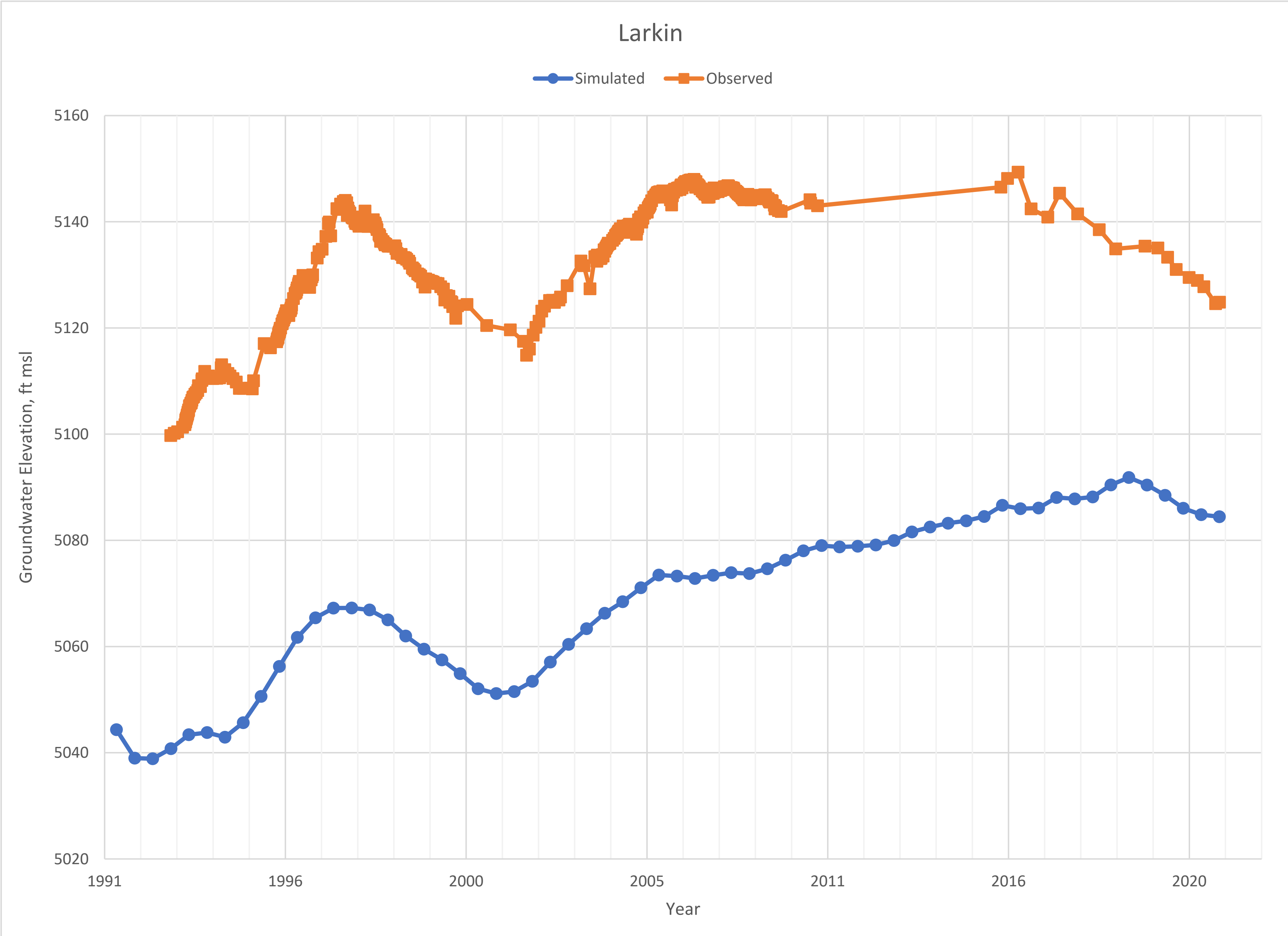
2016
2020
Year


Larkin
Simulated
Observed
Groundwater Elevation, ft msl
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1991
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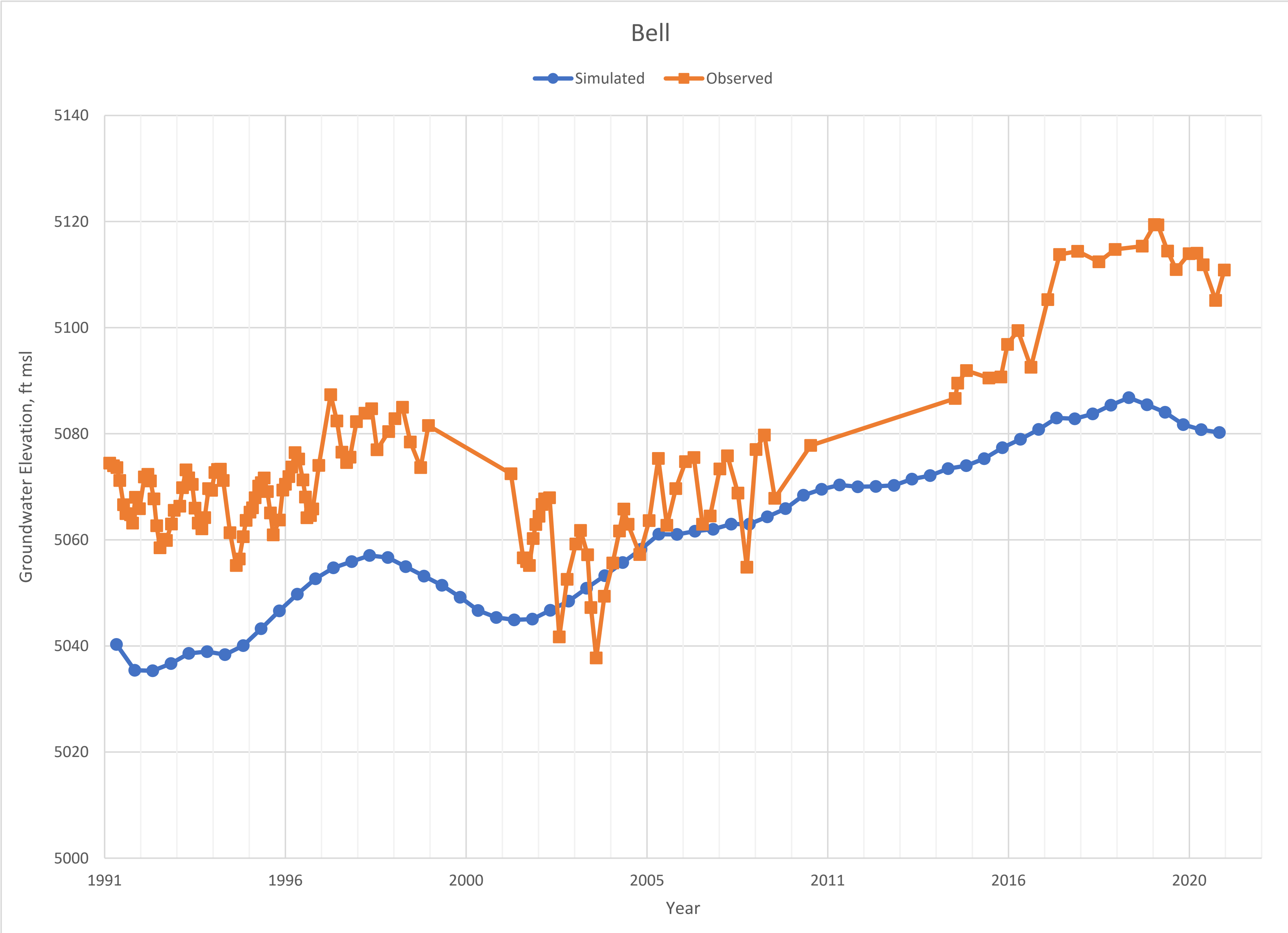
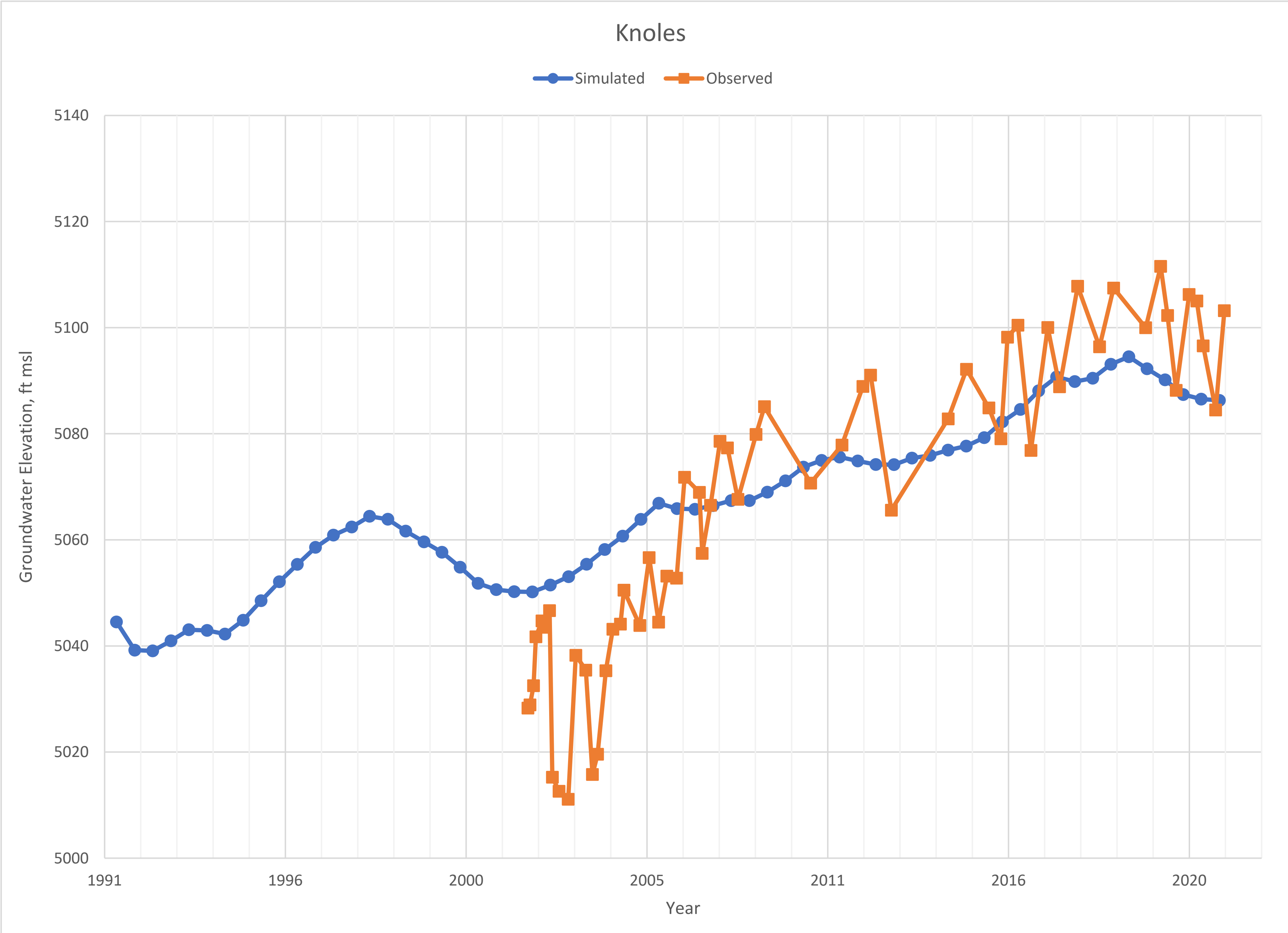
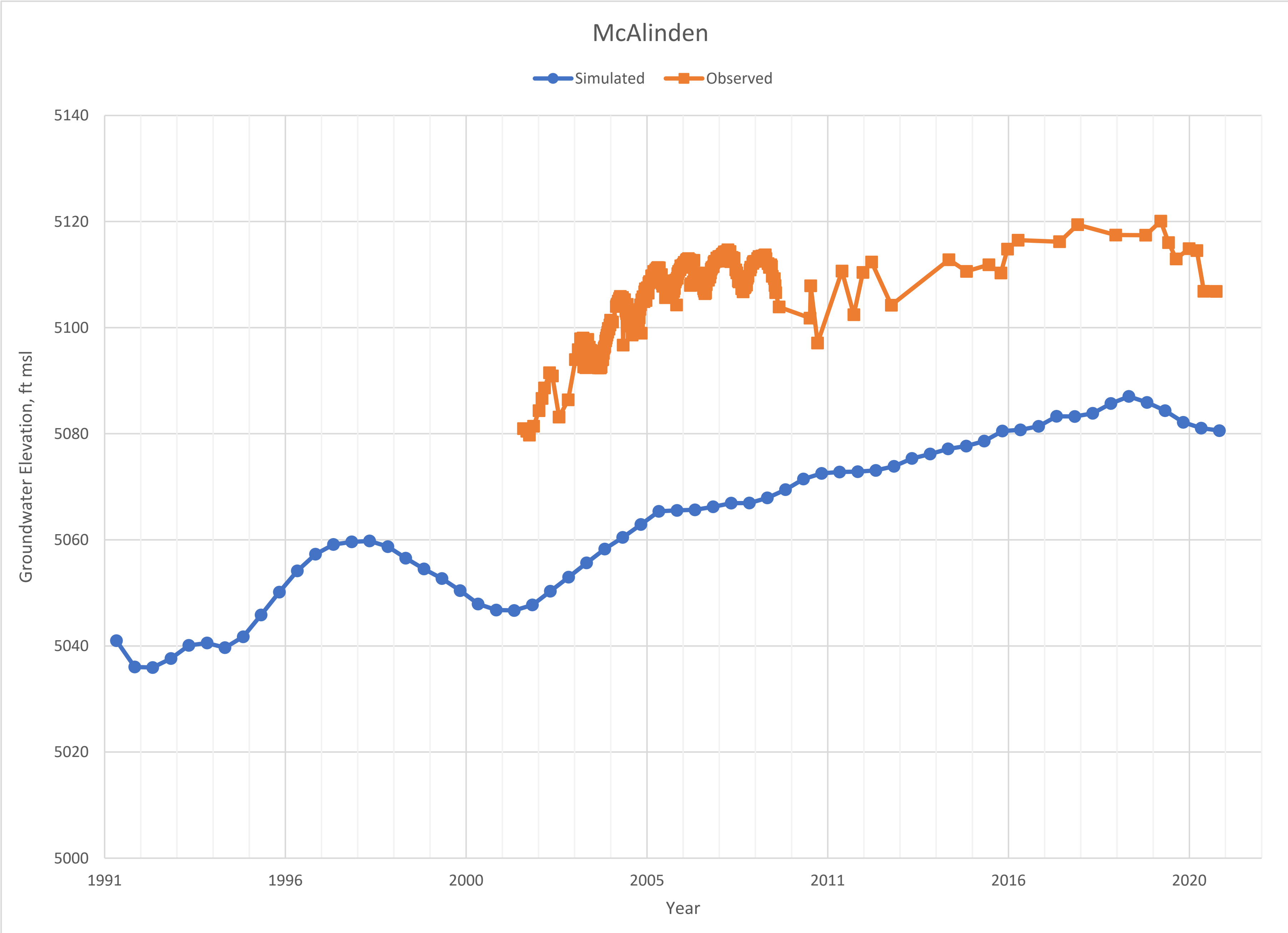
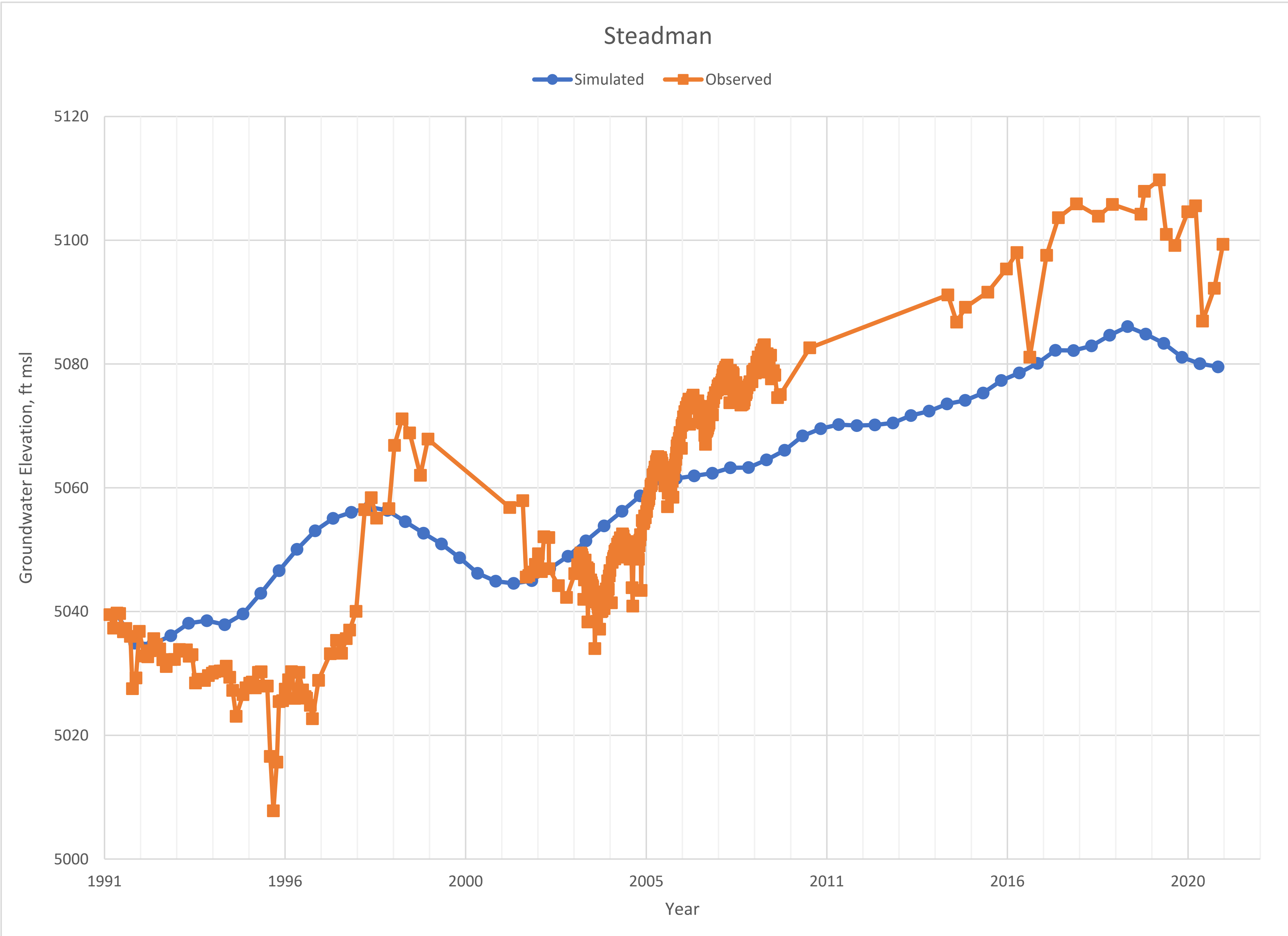
2020
Year

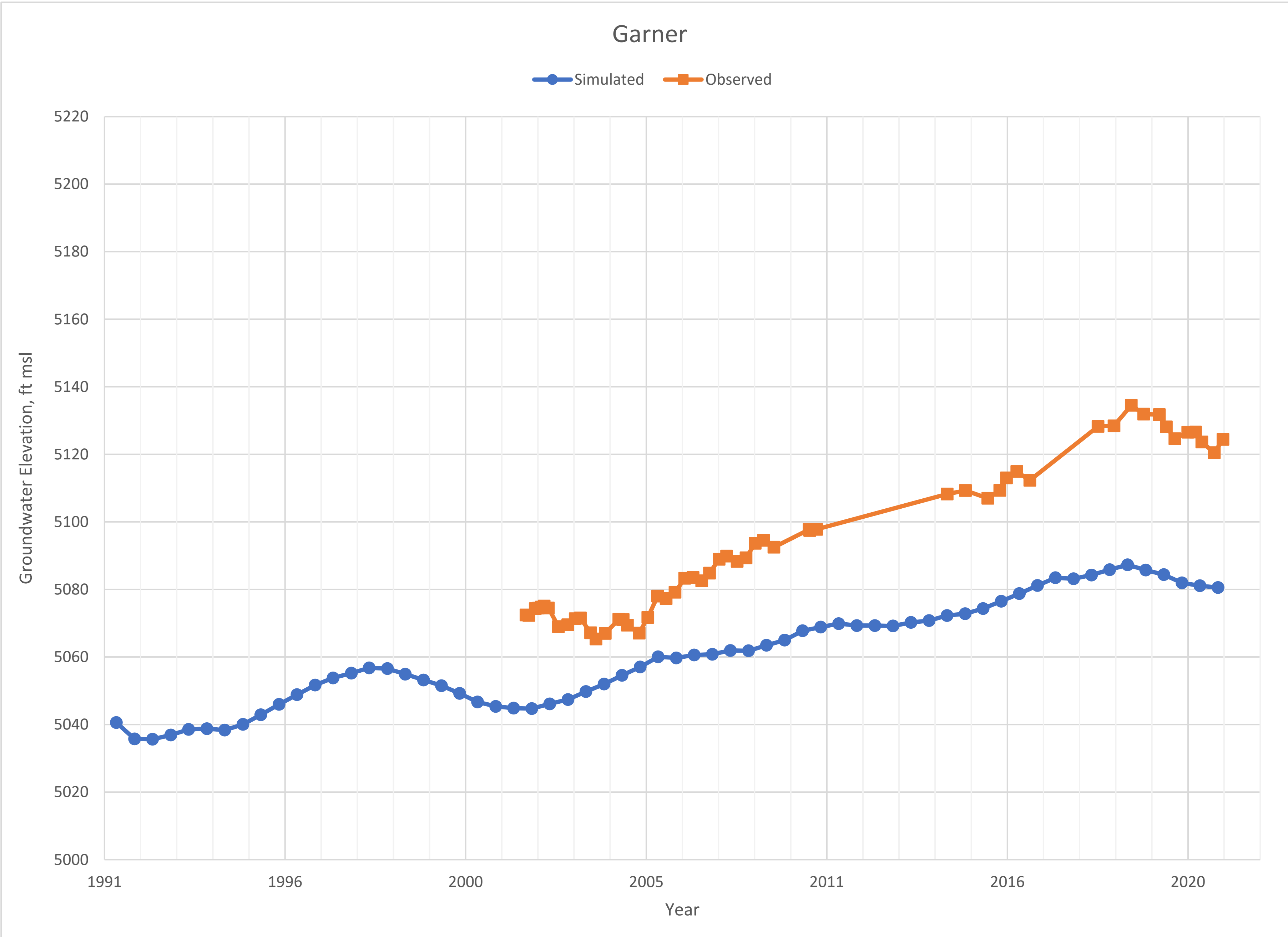

Bell
Simulated
Observed
Groundwater Elevation, ft msl
5140
5120
5100
5080
5060
5040
5020
5000
1991
1996
2000
2005
2011
2016
2020
Year


Knoles
Simulated
Observed
5140
5120
5100
5080
5060
5040
5020
5000
1991
1996
2000
2005
2011
2016
2020
Groundwater Elevation, ft msl
Year

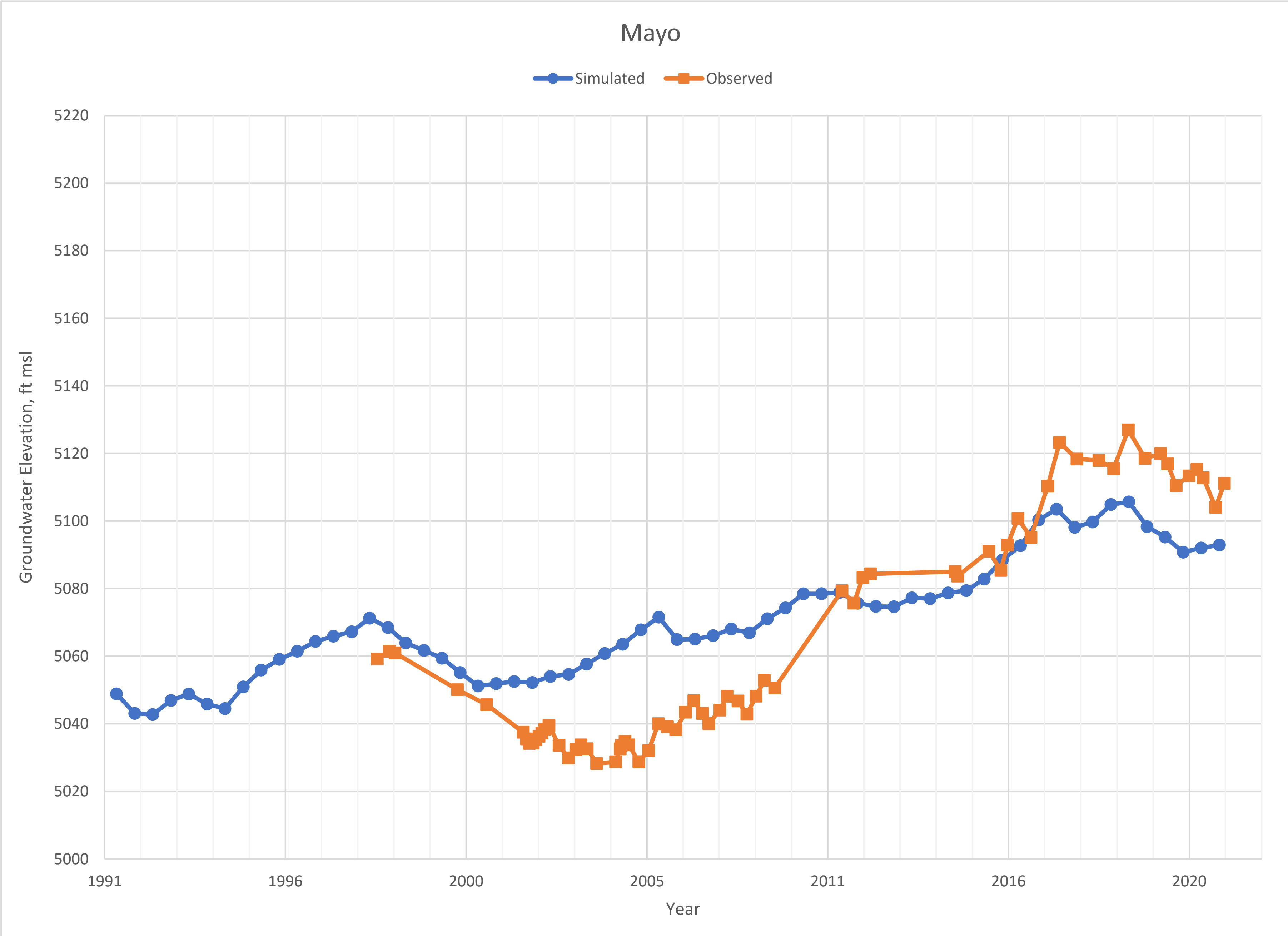


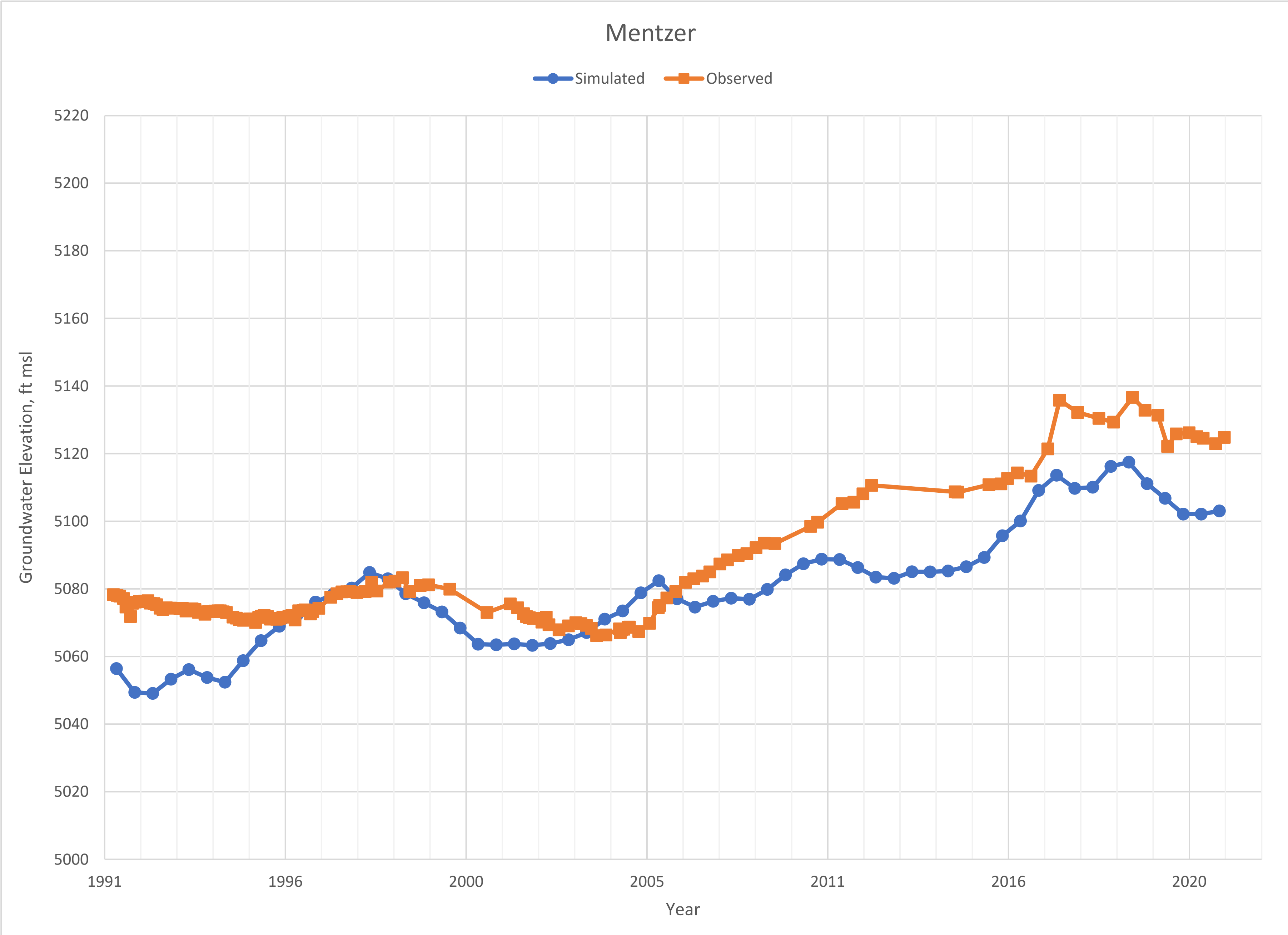
McAlinden
Simulated
Observed
5140
5120
5100
5080
5060
5040
5020
5000
Groundwater Elevation, ft msl
1991
1996
2000
2005
2011
2016
2020
Year


Steadman
Simulated
Observed
Groundwater Elevation, ft msl
5120
5100
5080
5060
5040
5020
5000
1991
1996
2000
2005
2011
2016
2020
Year



Garner
Simulated
Observed
5220
5200
5180
5160
5140
5120
5100
5080
5060
5040
5020
5000
Groundwater Elevation, ft msl
1991
1996
2000
2005
2011
2016
2020
Year


Mayo
Simulated
Observed
Groundwater Elevation, ft msl
5220
5200
5180
5160
5140
5120
5100
5080
5060
5040
5020
5000
1991
1996
2000
2005
2011
2016
2020
Year



Mentzer
Simulated
Observed
5220
5200
5180
5160
5140
5120
5100
5080
5060
5040
5020
5000
Groundwater Elevation, ft msl
1991
1996
2000
2005
2011
2016
2020
Year