Twenty-Second Annual Groundwater Monitoring Report (January 2019 - December 2019)

Prepared for

CADIZ

Cadiz Valley Agricultural Development

Prepared By:
GEOSCIENCE Support Services, Inc.

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CADIZ, INC.
TWENTY-SECOND ANNUAL GROUNDWATER MONITORING REPORT
(JANUARY 2019 – DECEMBER 2019)

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1.0 EXECUTIVE SUMMARY

This Twenty-Second Annual Report (Annual Report) summarizes data collected from January 2019 through December 2019. It was completed in accordance with recommendations presented in the County-approved 1993 Final Environmental Impact Report (FEIR) developed by URS Consultants, Inc. (URS) for the Cadiz Valley Agricultural Development, Cadiz, Inc. (Cadiz). In compliance with the FEIR, which requires monitoring of groundwater levels, electrical conductivity of groundwater, groundwater extraction, and changes in land surface elevation, a Groundwater Monitoring Plan (GWMP) was prepared and submitted to the County by GEOSCIENCE Support Services, Inc. (GEOSCIENCE) in 1997. The GWMP, which was approved by the County Planning Department, requires the submittal of reports summarizing monitoring data every five years. The first two Five-Year Summary Reports were submitted to San Bernardino County for the five years preceding 2003 and 2008. A comprehensive groundwater assessment was also completed by ESA as part of the Cadiz Valley Water, Conservation, Recovery and Storage Project (Water Project) Environmental Impact Report in 2012[1], which included required monitoring data from 2008 through 2012. This report was accepted as the Third Five-Year Report. The Fourth Five-Year Report (GEOSCIENCE, 2020) was recently submitted for the period from 2013 through 2018.

Cadiz owns approximately 34,000 acres in the Cadiz and Fenner Valleys located in eastern San Bernardino County, California, and actively farms approximately 700 acres of irrigated crops. Agricultural efforts are mainly citrus orchards with a few seasonal vegetables. Late in 2019, Cadiz partnered with Glass House Farms and began a trial program for hemp farming with continued development. Beginning in October of 2019, Cadiz began the construction of two replacement irrigation wells and one new well. The new wells will be included as part of future monitoring activities. Irrigation water for agricultural purposes is currently supplied by five production wells and will incorporate the three new irrigation wells in the future.

Key findings for this Annual Report covering the period from January 2019 through December 2019 are as follows:

[1] Complete 2012 Water Project FEIR available at: https://www.cadizwaterproject.com/public-environmental-review/

- Groundwater levels and trends over the year were generally stable and are within normal variations expected during pumping and recovery cycles.
- Groundwater quality (as measured by total dissolved solids [TDS] and electrical conductivity [EC]) continues to remain consistent with data from previous years.
- Total average groundwater production increased during the monitoring period from approximately 1,827 acre-ft/yr in 2018 to 2,498 acre-ft/yr for the period from January 2019 through December 2019.
- The most recent land surface elevation survey indicates that no ground subsidence has occurred over the reporting period.

2.0 INTRODUCTION

Cadiz, Inc. (Cadiz) is working with water agencies in Southern California to develop the Cadiz Valley Water, Conservation, Recovery and Storage Project (Water Project). The Water Project will provide an initial addition of 50,000 acre-feet per year (AFY) from a wellfield south-southwest of the Fenner Gap area (Figure 1) to the Metropolitan Water District of Southern California (MWD). As part of the Water Project development process, GEOSCIENCE Support Services, Inc. (GEOSCIENCE) presents the Twenty-Second Annual Monitoring Report (January 2019 – December 2019). This report has been prepared in compliance with the Groundwater Monitoring Plan (GWMP) submitted by Cadiz in 1997 and accepted by the San Bernardino County Planning Department. The GWMP addresses groundwater monitoring requirements specified in the FEIR, entitled "Findings, Facts in Support of Findings, and Statement of Overriding Considerations Regarding Final Environmental Impact Report (FEIR) for Cadiz Valley Agricultural Development, County of San Bernardino" (URS, 1993).

After County approval of the GWMP in 1997, and since 2009, Cadiz has been working with water agencies in Southern California to develop the Water Project. Santa Margarita Water District became the lead agency for California Environmental Quality Act (CEQA) compliance, and certified the Water Project FEIR (ESA 2012a) on July 31, 2012. San Bernardino County approved the FEIR and the Groundwater Management, Monitoring, and Mitigation Plan (GMMMP; ESA, 2012b)[2] on October 1, 2012. The GMMMP outlines specific management, monitoring, and mitigation guidelines for the Water Project, including pre-operational monitoring activities. The GMMMP also provides specific significance criteria for the Water Project, which will be applied to the Cadiz Valley Agricultural Development in a transition period from the GWMP to the GMMMP. The GMMMP is intended to replace the GWMP as Cadiz transitions the use of groundwater from irrigated agriculture to the Water Project. This Twenty-Second Annual Monitoring Report is being submitted in compliance with the GWMP; however, additional monitoring data are provided as a part of the transition toward the GMMMP. Figure 2 shows existing and planned monitoring components to be developed under the GMMMP.

After the Water Project passed the CEQA-required FEIR, continued geologic and hydrogeologic investigations in the Fenner Valley have been undertaken to support the FEIR conclusions. Dr. Miles Kenney (2011) presented findings regarding detailed geologic mapping of the Fenner Gap area. CH2M Hill (2010) presented an updated assessment of recharge to Fenner and Orange Blossom Wash Watershed areas, as well as an assessment of evaporative discharges from Bristol and Cadiz Dry Lakes. The CH2M Hill study included measurements of evaporation at the dry lakes taken by the Desert Research Institute (DRI). GEOSCIENCE (2011) conducted detailed groundwater flow and solute transport, and subsidence modeling. GEOSCIENCE (2011) model runs assess potential impacts to groundwater levels, groundwater

[2] Updated GMMMP is available at: http://www.cadizwaterproject.com/wp-content/uploads/2015/07/V7_Appx-B1-UPDATED-GMMMP.pdf

quality, and land subsidence caused by groundwater extraction and storage during the active phase of the Water Project. Dr. David Groeneveld (2012) completed two assessments – one of potential impacts to vegetation, and a second evaluating potential for dust generation due to lowered groundwater levels in the vicinity of the project. These assessments are included in the FEIR in Appendix E2: Fugitive Dust and Effects from Changing Water Table at Bristol and Cadiz Playas; Appendix F4: Vegetation, Groundwater Levels and Potential Impacts from Groundwater Pumping near Bristol and Cadiz Playas; and Appendix H: Hydrology Reports. These assessments represent the most up-to-date evaluation of groundwater conditions in the area. These additional assessments fulfill (and exceed) GWMP requirements. The County-approved GMMMP is also based on findings from these assessments.

As per County requirements and mitigation and monitoring suggestions outlined in the FEIR, this report summarizes annual changes in groundwater production, groundwater elevation, groundwater quality, groundwater storage and recharge, and land surface elevation.

2.1 Purpose and Scope

In accordance with the GWMP, the purpose and scope of this report is to summarize and compare monitoring data during the period from January 2019 through December 2019, including:

- Analysis of static groundwater level data over the report period and comparison to baseline[3] conditions;
- Analysis of groundwater quality data over the report period and comparison to baseline conditions;
- Compile and discuss groundwater extraction data for the report period;
- Discuss changes in land surface elevation for the report period; and
- Discuss potential impacts regarding water levels, water quality, and subsidence.

In preparation for the transition from GWMP to GMMMP reporting, this report includes groundwater level data from additional monitoring wells which will be used to establish additional baselines for the Water Project.

[3] Baseline conditions are primarily considered to be the average conditions of water level and quality from December 1995 through December 1996.

2.2 Location of Study Area

Cadiz Valley Agricultural Development (the study area) is in the Cadiz and Fenner Valleys, approximately 200 miles east of Los Angeles and 60 miles northeast of Twentynine Palms, within San Bernardino County, California (Figure 1). Cadiz owns approximately 34,000 acres of land located between the Marble and Ship Mountains and currently irrigates approximately 700 acres of farmland.

2.3 Groundwater Monitoring Well Network

In compliance with the GWMP, one monitoring well – Well 5/14-13[4] – has been designated in the Fenner Gap area to provide groundwater monitoring upgradient from Cadiz's seven-well agricultural wellfield. As part of the transition to the GMMMP, Well SCE-5 has been designated as an additional monitoring well. SCE-5 is in the Orange Blossom Wash, between the agricultural wellfield and Bristol Dry Lake, and will provide early indication of potential migration of groundwater with elevated levels of total dissolved solids (TDS) towards the agricultural wellfield.

"Group 1 Wells," shown on Figure 1, includes the seven irrigation and one monitoring well originally established as part of the GWMP monitoring network (GEOSCIENCE, 1997). The monitoring network was expanded in 2012 with the creation of the GMMMP (ESA, 2012b) to include a total of forty-seven (47) monitoring locations throughout the Cadiz and Fenner Valleys. These monitoring locations are shown on Figure 1 as Groups 2 through 6. Two of the original Group 1 irrigation wells – Cadiz Well No. 28 and Cadiz Well No. 27N – have been taken off-line and are now strictly used for monitoring purposes only (i.e., no groundwater extraction). In addition, three newly constructed irrigation wells (refer to Section 4.0) have been classified as Group 1 Wells. All monitoring network wells are identified in Table 1 and shown on Figures 1 and 2.

2.4 Land Subsidence Survey

Joseph E. Bonadiman & Associates, Inc. (JBA) performed a baseline survey of the Cadiz irrigation wells and the designated monitoring well 5/14-13 in December 1997. These baseline elevation data[5] are presented in previous Annual Reports (e.g., Foreman, 2016). JBA conducted subsequent surveys in 1999, 2000, 2001, 2002, 2007, 2010, 2013, 2014, and 2015 to continue to monitor the study area for land subsidence. As per the GMMMP, the land subsidence monitoring program will be expanded, including the establishment of a baseline condition as part of the pre-operational monitoring activities before groundwater pumping

[4] Some of the monitoring wells and all of the irrigation wells are in part, named from their corresponding township and range. See following link for more information on Township and Range survey system (e.g., 5/14-13 = Township 05N Range 14E Section 13 San Bernardino Baseline Meridian, or 21N = northern area of Section 21).

[5] Baseline elevation data were initially established at all irrigation wells and monitoring well 5/14-13 in December 1997. Five new points have been added since 2015 for additional control points.

begins for the Water Project. As a part of this transition, a new base reference station has been established in the Marble Mountains for use in future subsidence surveys, as described in the Seventeenth Annual Report (Foreman, 2015). In addition, Cadiz established five new land subsidence control points in 2015 as an ongoing transition from the GWMP to the GMMMP. Towill, Inc. (Towill) surveyed all original eight wells and the five new survey monuments in December 2016, 2017, and 2018. These data are presented and described in the Fourth Five-Year Summary Report (GEOSCIENCE, 2020), Appendix H of the FEIR (ESA, 2012a), and the Cadiz Valley Agricultural Development Annual Monitoring Reports.

2.5 Sources of Data

2019 production data, water quality data, and static groundwater elevation data from the irrigation and monitoring wells were used in preparation of this report. These data were collected by Cadiz and staff of GEOSCIENCE, which include State of California Professional Geologists, Certified Hydrogeologists, and Certified Engineering Geologists.

3.0 GEOLOGY AND HYDROGEOLOGY

A detailed description of the geology and hydrogeology of the Fenner, Orange Blossom Wash, Bristol, and Cadiz Watersheds are provided in Appendix H of the Water Project FEIR (ESA, 2012a). The following is a brief summary of the geology and hydrogeology of the area in the vicinity of the Cadiz Valley Agricultural Development.

3.1 Geologic Setting

The Cadiz Valley Agricultural Development is in part of the Basin and Range province of North America, in the eastern Mojave Desert of California, within portions of the Bristol, Cadiz, and Fenner Watersheds. Geologic formations in the area are composed of a variety of bedrock, alluvial, dune, and lacustrine deposits. Bedrock is composed of igneous, metamorphic, and consolidated sedimentary rocks which include carbonates, and generally form the perimeter of the main watersheds. However, large bedrock masses also occur within the watersheds, such as the Clipper Mountains.

The Bristol and Cadiz Watersheds form a broad depression that is referred to as the Bristol Trough (Thompson, 1929; Bassett et al., 1964; Jachens and Howard, 1992). This depression formed as a result of regional fault movement and is thought to be 6 to 10 million years old (Rosen, 1989). Unconsolidated alluvial, dune, stream, aeolian, and playa lake deposits fill the Bristol Trough.

3.1.1 Stratigraphy

The geology of the Bristol, Cadiz, and Fenner Watersheds is composed of three broad categories: crystalline bedrock exposed in the mountain ranges and hills, alluvial fan and valley fill sediments weathered from uplifted bedrock, and fine-grained (silt and clay) sediments and evaporite (sodium-chloride [NaCl], calcium-chloride [CaCl], and gypsum) deposits of the Bristol and Cadiz Dry Lakes. The crystalline basement rocks exposed in the mountain ranges of the study area consist primarily of Precambrian granitic and metamorphic rocks locally overlain by Paleozoic sedimentary rocks. Paleozoic rocks are sandstones, shales, slates, limestones, and dolomites. These sediments and the underlying basement rocks have been faulted and folded by periods of regional tectonism. The crystalline basement rocks are generally much less permeable than alluvial deposits – yielding limited quantities of groundwater (Freiwald, 1984). However, previously conducted field investigations of the Paleozoic limestone and dolomite sections that are fractured or contain solution cavities yield large quantities of groundwater (CH2M Hill, 2010). Outcrops of these carbonate units can be found on the eastern slope of the New York Mountains, in Lanfair Valley, north of the Clipper Mountains, in the Marble Mountains, in the Ship Mountains, in the southeast end of the Bristol Mountains, in the southern Kilbeck Hills, and in the eastern Old Woman Mountains (see Kenney, 2011, and Howard, 1992, for locations of these carbonate units). The carbonate units are significant aquifers where dissolution features are present in the subsurface, such as in the Fenner Gap area (CH2M Hill, 2010). Throughout the subject area, mostly fractured crystalline basement rocks form the boundaries of the groundwater aquifer system (CH2M Hill, 2010).

In the Fenner Valley, the Paleozoic section is unconformably overlain by clastic sediments and interbedded volcanic rocks of mid-to late-Tertiary age. The Tertiary volcanic rocks consist of lava flows of basaltic to andesitic composition, and pyroclastic tuffs of rhyolitic to dacitic composition. The United States Geological Survey (USGS) reports that a shallow trap-door caldera, roughly 10 kilometers in diameter, is centered in the eastern Woods Mountains (based on gravity and aeromagnetic anomalies). It was formed during a major eruption 15.8 million years ago, with resurgent eruptions filling the caldera with rhyolitic flows and tuffs. Dikes of similar composition are exposed in the Marble and Ship Mountains (CH2M Hill, 2010). The Tertiary sediments consist of conglomerate, fanglomerate, sandstone, siltstone, water-laid tuff, and lake sediments, which form a composite section more than 7,000 feet thick (Dibblee, 1980). The Tertiary sediments and interlayered volcanic rocks are gently dipping due to late-Tertiary extensional normal faulting.

The Quaternary and late-Tertiary alluvial fill in the Bristol Trough is largely derived from Precambrian basement rocks, Paleozoic sediments, and Tertiary volcanic rocks. USGS mapped alluvial deposits exceeding 300 meters in thickness in the northern Fenner Valley. Geophysical evidence indicates this alluvial fill locally exceeds 3,500 feet in thickness beneath a portion of the southern Fenner Valley (Maas, 1994) and even greater under Bristol Valley (CH2M Hill, 2010). These alluvial sediments form one of the principal aquifers in the subject area.

The playa sediments underlying the Bristol and Cadiz Dry Lakes consist of highly saline (brine-saturated) clay, silt, fine-grained sand, and evaporite deposits. The clastic sediments were deposited when stream flow and sheet flow from the surrounding alluvial fans spread onto the playas during major storm events (Gale, 1951). The evaporite deposits formed from evaporation of both surface water and groundwater that seeps into the playa sediments from the adjacent alluvial fans (Rosen, 1989).

Bristol and Cadiz Dry Lakes have static groundwater levels at or near the playa surfaces (Moyle, 1967; Rosen, 1989). Geophysical surveys of Bristol Dry Lake and Cadiz Dry Lake indicate sediments underlying the playas may extend to depths greater than 6,000 feet below ground surface (Simpson et al., 1984; Maas, 1994). These sediments have been penetrated by drill holes to depths of over 1,000 feet (Bassett et al., 1959; Rosen, 1989). Sodium chloride and/or calcium chloride are currently being recovered from trenches and brine wells on both playas. The principal recharge to the playas occurs as diffuse seepage of groundwater onto the playas from adjacent alluvial fans (Thompson, 1929; Gale, 1951; Bassett et al., 1959; Handford, 1982; Rosen, 1989).

Cadiz and Bristol Dry Lakes are locally bordered by dune deposits of fine- to medium-grained windblown sand. These Holocene deposits overlie older playa deposits of differentiated Quaternary age (Moyle, 1967). Amboy Crater, located near the western margin of Bristol Dry Lake, is a basaltic cinder cone and lava field believed to be as young as 6,000 years (Hazlett, 1992).

3.1.2 Structure

The project area is located at the eastern margin of the Eastern California Shear Zone, a broad seismically active region dominated by northwest-trending, right-lateral strike-slip faulting (Dokka and Travis, 1990). Roughly a dozen fault zones showing evidence of Quaternary movement (during the last 1.6 million years) have been identified in and adjacent to Bristol, Cadiz, and Fenner Valleys (Howard and Miller, 1992).

Cadiz Valley is underlain by two inferred, major northwest-trending faults based on gravity and magnetic data (Simpson et al., 1984). These fault zones have strike lengths of at least 25 miles and may merge to the north and northwest with extensions of the Bristol-Granite Mountains and South Bristol Mountains fault zones (Howard and Miller, 1992; see MWD, 2001, for locations).

Right-lateral slip of as much as 16 miles along the Cadiz Valley fault zone has been postulated because of correlation of a distinctive Precambrian gneiss unit across the zone (Howard and Miller, 1992). Slickenside surfaces produced by fault movement and steeply dipping sediments recovered from cored drill holes beneath Cadiz Dry Lake suggest the fault zone displaces sediments of Pleistocene age (Bassett et al., 1959). Bristol Dry Lake is bordered by probable extensions of the Cadiz Valley and South Bristol Mountains fault zones to the east, and by probable extensions of the Broadwell Lake and Dry Lake fault zones to the west (Howard and Miller, 1992). Geophysical data indicate this structural depression may exceed 6,000 feet in depth (Simpson et al., 1984; Maas, 1994). Drill cores recovered from depths of more than 1,000 feet beneath Bristol Dry Lake indicate that subsidence of this basin began by Pliocene time and continues to the present (Rosen, 1989), suggesting that the area may be tectonically active.

3.2 Aquifer Systems

Based on available geologic, hydrologic, and geophysical data, the principal formations in the study area that can readily store and transmit groundwater (aquifers) are divided into three general units—an upper (younger) alluvial aquifer, a lower (older) alluvial aquifer, and a carbonate rock unit aquifer. However, the carbonate aquifers contain interbedded non-water bearing quartzite and shale (CH2M Hill, 2010; GEOSCIENCE, 2012).

The younger alluvial aquifer consists of Quaternary and late-Tertiary alluvial sediments, including stream-deposited sand and gravel with lesser amounts of silt (Moyle, 1967; GEOSCIENCE, 1999). The upper alluvial unit is as thick as approximately 1,000 feet in some locations (GEOSCIENCE, 1999 and 2012; CH2M Hill, 2010).

The lower alluvial aquifer consists of older sediments, including interbedded sand, gravel, silt, and clay of mid- to late-Tertiary age. Where these materials extend below the water table, they yield water freely to wells but generally may be less permeable than the upper aquifer sediments (Moyle, 1967; GEOSCIENCE, 1999; CH2M Hill, 2010). Production Well PW-1, located in Fenner Gap, draws water primarily from the upper and lower aquifers and yields 3,000 gallons per minute (gpm) with less than 20 feet of drawdown (GEOSCIENCE, 1999). The Cadiz agricultural wells draw water from the alluvial aquifers and typically yield 1,000 gpm to more than 2,000 gpm.

Based on findings from recent drilling in Fenner Gap, carbonate bedrock of Paleozoic age located beneath the alluvial aquifers contain groundwater and is considered a significant aquifer (GEOSCIENCE, 1999; CH2M Hill, 2010). Groundwater movement and storage in this carbonate bedrock aquifer primarily occurs in secondary porosity features (i.e., joints, faults, and dissolution cavities that have developed over time). Granite and metamorphic basement rock form the subsurface margins of the aquifer system. This basement rock is generally less permeable and typically yields smaller quantities of water to wells (Freiwald, 1984).

3.2.1 Groundwater Recharge and Flow Patterns

The primary sources of replenishment to the groundwater system in the project area include direct infiltration of precipitation (both rainfall and snowfall) in fractured bedrock exposed in mountainous terrain and infiltration of ephemeral streamflow in sand-bottomed washes – particularly in the higher elevations of the watershed. The source of much of the groundwater recharge within the regional watershed occurs at higher elevation (MWD, 2001; Davisson and Rose, 2000, USGS, 2014).

Precipitation infiltrates and moves downward to the water table. In some areas, the infiltrating water may be diverted to land surface or groundwater may intersect buried flow barriers (i.e., bedrock or faults) which can bring the groundwater to the surface, creating a spring. Otherwise, this infiltrating water moves vertically downward where it ultimately reaches the regional groundwater system and continues to flow downgradient through principal aquifer systems. (CH2M Hill, 2010).

Groundwater occurrence in fractured bedrock of the watershed perimeter's mountains has been known since before the turn of the twentieth century. The USGS documented the occurrence of wells and springs (referred to as "some desert watering places") throughout southeastern California and southwestern Nevada for the benefit of travelers and prospectors (Mendenhall, 1909). At least 10 wells and springs were documented in the mountains and hills around the Fenner Watershed and a number of wells were drilled into the alluvium by the Santa Fe Railroad. Another USGS study by Thompson (1929) provided additional information on more wells and springs in the study area to survey, mark, and provide protection of watering places. A more recent USGS survey of wells and springs in the area of study was conducted by Freiwald (1984). These studies provide evidence of the fractured nature of the surrounding bedrock and the continuous infiltration of precipitation and movement of water through these perimeter rocks. Although some groundwater is tapped by vegetation near the range fronts, the remainder moves slowly downgradient through Fenner Valley and Orange Blossom Wash into the Bristol and Cadiz depressions, where it eventually discharges to Bristol and Cadiz Dry Lakes. Evaporation of groundwater and surface water from the dry lakes over the past several million years has resulted in thick deposits of salt (primarily calcium chloride and sodium chloride) and brine-saturated sediments (Rosen, 1989). Thompson (1929), Gale (1951), Bassett et al. (1959), Handford (1982), and Rosen (1989) agree that the principal source of groundwater recharge to the playas occurs as diffuse seepage of groundwater into the playa sediments from the adjacent alluvial fans.

In general, groundwater within the watersheds flows downgradient in the same direction as the slope of the land surface. In Fenner Valley, groundwater generally flows southward and discharges through Fenner Gap toward Bristol and Cadiz Dry Lakes. In Orange Blossom Wash, located between the Marble and Bristol Mountains, groundwater generally flows southward from the Granite Mountains into Bristol Dry Lake. (GEOSCIENCE, 1999; CH2M Hill, 2010). CH2M Hill (2012) estimated the discharge to Cadiz area to be approximately 33,890 AFY, based on measurements made by DRI (2012), extrapolated over the surface areas of dry lakes for a full year. This evaporative discharge compares well with the estimated recharge rate of 32,000 AFY (GEOSCIENCE, 1995 and CH2M Hill, 2010).

4.0 GROUNDWATER EXTRACTION

Monthly groundwater extraction totals for each of the Cadiz irrigation wells are compiled in Appendix A. In 2019 the annual production from January through December 2019 was approximately 2,498 AFY. As described in the previous Monitoring Reports, average annual groundwater production for the Cadiz Valley Agricultural Development from 1993 through 2007 was approximately 5,500 AFY; and 2,100 AFY from 2008 through 2018. In 2018, the annual production from January through December 2018 was approximately 1,827 AFY. The general increase in total production is likely associated with the greater water demand for the growing number of mature citrus trees. Figure 3 shows annual (calendar year) groundwater production by Cadiz since 1986, which totals approximately 127,825 acre-feet (AF). This production does not include extractions at the office, trailer park, and labor camp wells, which are typically just an additional few acre-feet per year.

An additional production well (PW-1) was constructed in 1999 in the Fenner Gap as a test well for the proposed Cadiz Groundwater Storage and Dry-Year Supply Program, developed in partnership with MWD from 1997 through 2002. This well was used to supply water to two spreading basins during an 8-month investigation of the response of the aquifer system to artificial recharge. The total amount of groundwater pumped during this test (conducted between March and October 1999) was approximately 975 AF. Because water pumped from PW-1 was allowed to percolate back into the subsurface via the spreading basins, there was essentially no net withdrawal of groundwater from the aquifer system. The engine and pump assembly for PW-1 were removed in late 2002. A new engine and pump assembly were installed in 2008 to allow for further testing. A minor amount of groundwater (generally 10 AF or less) has been pumped annually since 2009 for the purpose of well maintenance and demonstrating the function of the spreading basins and the infiltration properties of the soils in the Project area.

Three additional test wells were constructed in 2009 and the beginning of 2010 in Fenner Gap as part of an updated hydrological and geological assessment of the groundwater resources in the Cadiz and Fenner Valleys conducted by CH2M Hill. The three test wells (TW-1, TW-2, and TW-3) were utilized to assess the hydrogeologic properties of the carbonate rock units and alluvium in Fenner Gap as part of feasibility studies for the Water Project. Since 2009, a minor amount of groundwater per year has been pumped from these wells for testing of water quality and aquifer capacity.

Three new irrigation wells (26, 34, and 35) were constructed in 2019 and the beginning of 2020 (two replacement wells and one new well) within the main agricultural development. Only one of the wells was finished in 2019 (Well 34). The other two irrigation wells (26, and 35) were constructed in early 2020 as replacement wells for 28 and 27N, which were permanently taken offline in 2009 and 2013, respectively and have been used as monitoring wells. None of these new wells are currently in operation. However, a total of approximately 20 AF was pumped from Well 34 during aquifer pumping tests. New Wells 26 and 35 were not tested in 2019 but similar amounts were pumped and will be described in the 2020 Annual Report.

Figure 3 shows total annual groundwater production for all wells, and Figures 4 through 10 show monthly pumping and groundwater elevation by well. Well 27N has not been utilized since June 2013 (permanently offline) and Wells 28 and 33 have been offline since 2009 (Well 28 is permanently offline). Well 33 is planned to be put back in service in 2020. Wells 22, and 33 were redeveloped and aquifer tests were conducted to assess improvement in specific capacity of each well. A total of 6.1, and 8.1 AF were pumped from these three wells, respectively, during the aquifer tests. Table 4-1 below summarizes annual groundwater production from each irrigation well from 1993 through 2019. While individual well data from 1986 through 1992 are not available, cumulative production for those years was approximately 28,130 AF.

Table 4-1. Annual Irrigation Well Groundwater Production

Year	Well 21S	Well 21N	Well 28*	Well 33 (Acre-Ft)	Well 27N*	Well 22	Well 27S	Total
1993	0	0	0	5	99	0	67	4,796
1994	836	0	554	1,125	1,021	63	1,136	4,736
1995	713	948	630	1,024	1,086	285	1,282	5,969
1996	834	520	702	1,156	1,045	343	1,120	5,720
1997	882	750	511	1,062	931	289	1,038	5,463
1998	699	1,033	507	1,047	493	583	725	5,087
1999	867	1,331	366	1,097	827	731	857	6,076
2000	783	1,263	512	1,145	738	893	759	6,092
2001	825	894	400	960	590	770	797	5,237
2002	881	1,008	495	1,012	759	799	540	5,495
2003	775	1,013	404	760	711	529	904	5,095
2004	712	524	376	686	819	543	569	4,229
2005	694	551	420	765	771	612	805	4,618
2006	806	731	166	840	840	861	193	4,438
2007	581	706	65	572	899	276	489	3,588
2008	329	463	2	6	435	0	735	1,970
2009	366	584	0	502	154	62	215	1,882
2010	356	590	0	0	0	62	858	1,867
2011	482	538	0	0	0	478	842	2,341
2012	511	559	0	0	536	7	751	2,364
2013	705	674	0	0	357	0	791	2,526
2014	421	405	0	0	0	0	498	1,324
2015	522	596	0	0	0	0	260	1,377
2016	884	613	0	0	0	0	361	1,858
2017	252	504	0	8	0	102	356	1,223
2018	458	666	0	0	0	163	540	1,827
2019	623	765	0	0	0	474	637	2,498

*Well Nos. 28 and 27N have been taken permanently offline since 2009 and 2013, respectively.

5.0 GROUNDWATER LEVEL CONDITIONS

5.1 Baseline Groundwater Elevations

In the First Annual Report (GEOSCIENCE, 1997a), groundwater elevations in feet above mean sea level (ft amsl) were calculated by subtracting the depth to groundwater from an estimated reference point elevation for each well. Approximate reference point elevations were determined by estimating the surface elevation of each well from the USGS 7.5-minute quadrangles (Cadiz Summit, Cadiz Lake NW, Calumet Mine, and Cadiz).

In December 1997, JBA (a California licensed land surveyor) performed a survey to establish the baseline elevation of the seven agricultural wells and monitoring well 5/14-13. JBA has since resurveyed all wells and surveyed newly installed monitoring wells through 2015, as described in the Eighteenth Annual Groundwater Monitoring Report (Foreman, 2016). Since 2015, five additional control points have been added and all thirteen points have been resurveyed by Towill since 2016. In addition, the resurvey includes conversion of the horizontal coordinates and vertical datum to the current NAD83 and NAVD88, respectively. Table 1 presents the location coordinates and vertical elevation with respect to these data.

In order to determine baseline groundwater level conditions for the Cadiz wellfield, historical groundwater level elevation data from November 1993 through December 1996 were evaluated. Baseline groundwater level conditions for the Cadiz wellfield have been based primarily on an average of December 1995 through December 1996 static groundwater levels. Table 2 presents a summary of these baseline groundwater levels, converted to the new datums.

Depth to static[6] groundwater in Group 1 wells is measured on a monthly basis by Cadiz and GEOSCIENCE staff. In 2018 and 2019, some of the wells in the monitoring network were equipped with transducers to measure water levels several times a day as part of the ongoing transition from the GWMP to the GMMMP. All other monitoring wells are measured by GEOSCIENCE staff on a quarterly basis using both electric water level sounders and transducers. The measured depths to groundwater are converted to groundwater elevations by subtracting the depth to groundwater from the surveyed reference point elevation for each well.

5.2 Groundwater Level Trends

Hydrographs for irrigation and monitoring wells have been prepared to illustrate trends in groundwater elevation measurements. These wells have been grouped for purposes of displaying these hydrographs over the large geographical area covered by the monitoring network. Generally, wells were grouped for

6 Static groundwater level readings are not always feasible due to the irrigation needs of the crops.

presentation purposes as opposed to any common features or characteristics; however, they are generally in the same geographic area. Figure 1 shows the well groups and Figures 11 through 16 present hydrographs for each well group. In general, groundwater levels in and near the Cadiz wellfield fluctuate in response to pumping and recovery cycles.

Groundwater levels near the wellfield declined consistently in response to Cadiz pumping, which reached maximum levels in the 1990s. Water levels then stabilized in the late 1990s and early 2000s, and have since recovered as extraction was reduced from the early 2000s through present. Table 2 provides a comparison of baseline groundwater levels with both 2018 and 2019 groundwater levels. In general, groundwater levels have recovered above baseline groundwater levels (the baseline was established during a period when Cadiz was actively farming a larger portion of their property, so groundwater levels were lower due to increased pumping). Monitoring well hydrographs outside the wellfield area, especially in and just north of the Fenner Gap area, suggest that groundwater levels have not fluctuated significantly over the long-term (see Figures 11 through 16).

6.0 GROUNDWATER QUALITY CONDITIONS

TDS concentrations in groundwater in the vicinity of the Cadiz Valley Agricultural Development irrigation wells are relatively low, with values generally around 300 milligrams per liter (mg/L). At Bristol and Cadiz Dry Lakes, evaporation of surface water and shallow groundwater concentrates dissolved salts, resulting in TDS concentrations as high as 298,000 mg/L (Shafer, 1964). In general, as groundwater moves toward the dry lakes from Fenner Gap and the surrounding mountains, it becomes more saline as "fresh" groundwater mixes with saline groundwater underlying the dry lakes. The fresh/saline groundwater interface, designated by a TDS concentration of 1,000 mg/L, is located near the margins of the two dry lakes (Figure 17). This interface is estimated using the TDS values of the wells in Group 6.

6.1 Baseline Groundwater Quality Conditions

Electrical conductivity (EC), which is directly proportional to TDS, is an additional measure of groundwater quality for the Water Project. Baseline EC measurements for Group 1 wells were collected starting in 1996 and were converted to TDS for comparison with 2018 and 2019 TDS values, as summarized in Table 6-1 below. Average baseline TDS levels for the Group 1 Wells range from 221 mg/L in Well 21S to 282 mg/L in Well 27N. Increases in TDS over time within the irrigation field are expected (see Section 6.2 for a detailed discussion).

Table 6-1. Comparison of Baseline (1996) Calculated TDS with 2018 and 2019 TDS (mg/L)

Date	Well 21N	Well 21S	Well 22	Well 27N	Well 27S	Well 28	Well 33	Well 34[3]	Well 5/14-13	SCE-5
1996[1] Baseline TDS (Average)	238	221	258	282	257	240	223	-	261	-
2018 TDS[2]	270	330	290	570	290	210	440	-	312	305
2019 TDS[2]	280	260	280	630	290	210	330	250	260	310

Notes:
All 2018 and 2019 TDS values are laboratory reported, except for those mentioned below. Results from Wells 27N, 28, 33, SCE-5, and 5/14-13, used a bailer to sample; values may therefore be unusually high. Well 28: December 2017 TDS value was used to represent 2018, since the well was not accessible in 2018. Well 5/14-13: 2018 TDS value reported from dedicated transducer in well. Well 33: May 2017 TDS value was used to represent 2018, since the well was not accessible in 2018. Well SCE-5: 2018 TDS value reported from dedicated transducer in well.
[1]1st through 3rd Quarter 1996 laboratory EC values were converted to TDS and averaged for comparison.
[2]Values used for TDS comparison for 2018 and 2019 were sampled in November and December, respectively.
[3]Well 34 is a new well, which was sampled for the first time on December 19, 2019.

6.2 Groundwater Quality Trends

Field measurements of EC and TDS were made with a portable MyronL Ultrameter II hand meter that is calibrated to standard conductivity solutions. As EC is a relative indicator of TDS concentration, actual TDS measurements are reported along with EC data as an initial transition step toward the requirements of the approved GMMMP.

Group 1 wells were sampled for water quality (including TDS) during December 2017, and have been sampled quarterly from December 2018 through present. As an additional step towards GMMMP compliance, Cadiz is equipping some irrigation and monitoring wells with transducers that can continuously record EC, water level, and temperature data. It is expected that groundwater data collected since 2012 will be used to begin to define pre-operational groundwater quality conditions for the Water Project.

Table 3 shows recent average TDS values for the Group 1 wells. TDS has remained consistently below the 500 mg/L secondary Maximum Contaminant Level (MCL) for drinking water in all Group 1 wells except Well No. 27N, which is discussed below. Figure 18 shows Group 1 well chemograph plots of TDS from January 2013 through December 2019.

TDS in Group 1 wells appears relatively stable, with the exception of Wells 27N and 33. Groundwater samples collected from Well No. 33 in 2012 and 2014 were collected with a bailer, whereas in 2013 and 2017 a temporary pump was installed to purge the well before sample collection. These latter samples are likely a more representative sample of groundwater conditions at Well No. 33. Well 33 has recently been equipped with a pump and samples collected from Well 33 while pumping had a TDS value of 330 mg/L, which is consistent with historical pumping TDS values. Well 27N was taken permanently offline in 2013 and has since been only sampled with a bailer. Difference in sampling technique likely accounts for the some of the variation in TDS values. Increased irrigation, damage to the well during the last attempted rehabilitation, and leaks in the system may account for the rest (discussed below).

Well 27N was taken offline and redeveloped in 2011. Problems were encountered during the redevelopment process and the integrity of the well casing/screen was damaged, including loss of the bottom seal. A concrete plug was installed to reseal the bottom. However, it was apparent that the casing/screen required further repairs, as the well produced significant quantities of sand when in service. Well 27N was permanently taken offline in the middle of 2013. It is unclear if damage to the well casing/screen may have affected the distribution of flow of groundwater vertically along the casing, resulting in some changes in groundwater quality produced by the well. The groundwater samples collected in 2014 and 2015 at Well 27N showed a TDS value of 246 and 364 mg/L, respectively – consistent with historical levels. During 2019, Well 27N demonstrated a peak TDS value of 790 mg/L in June 2019, which has continued to gradually decrease to 630 mg/L in the September and December samples. This decrease in TDS may be due to residual or continued effects from concentrated increased irrigation (due to the increase of mature trees in the area), leaky irrigation pipes, earlier redevelopment efforts, and sampling techniques, as indicated by the fluctuations seen in Figure 18.

As described in the Sixteenth Annual Report (Foreman, 2014), the TDS spike observed in 2013 in 27N may have been caused by leaks in irrigation system distribution piping near Well 27N and the resultant flushing of salts from the thick vadose zone to underlying groundwater near these wells. Nearby irrigation wells (Wells 27S and 28) do not show increases in TDS concentrations (Figure 18), so it is probable that the TDS spikes in Well 27N are due to some localized condition instead of a long-term trend. Well 27N was equipped with a dedicated transducer with EC recording to help understand fluctuations in TDS. Since the observed TDS spike in mid-2019, concentrations have decreased from 790 to 630 mg/L in the most recent samples collected. Known irrigation leaks have since been addressed but irrigation in the area of 27N has increased due to water needs of mature trees. However, the cause of these spikes is anomalous and needs to be investigated further.

Well 33 was equipped with a pump and motor at the end of 2019 and was sampled in December of 2019 and March 2020 with TDS results of 330 mg/L for both events, which is consistent with historical levels.

Ongoing monitoring will be used to assess the origin of TDS spikes at any wells. Monitoring Well SCE-5 is one of several existing and new monitoring wells identified in the GMMMP for the Water Project to monitor the freshwater/saline groundwater interface between Bristol Dry Lake and the Cadiz wellfield (Figure 17). Well SCE-5 was sampled in 2012, 2013, and 2015 through 2019 to monitor potential encroachment of the freshwater/saline groundwater interface toward the agricultural wellfield. As shown in Figure 18 and Table 3, TDS of groundwater at Well SCE-5 has remained stable through time.

7.0 LAND SURFACE ELEVATION SURVEY

JBA conducted a Global Positioning System (GPS) survey in December 1997 to establish a baseline elevation for each of the seven irrigation wells and monitoring well 5/14-13 to facilitate detection of changes in land surface elevation over time. Subsequent surveys were conducted in 1999, 2000, 2002, 2007, 2010, 2013 to 2015, 2017, and 2018 to assess changes in land surface elevation at the benchmarks.

As described in the first Five-Year Summary Report (GEOSCIENCE, 2003), no apparent land subsidence was observed during the four surveys conducted between 1997 and 2002. Because both the area of irrigated land and the amount of groundwater extraction decreased from 2003 through 2007, annual land surface elevation surveys were not conducted for that period. JBA conducted a repeat survey of land surface elevation benchmarks in December 2007. The results of this survey document that all 2007 elevations are similar to those originally measured in 1997. Land surface elevation surveys were not conducted in 2008 and 2009 because there were no significant changes to acreage under cultivation or water use in those years. A land surface elevation survey was completed in 2010 as part of technical reporting for the Water Project, and another survey was completed in 2013. The results of these surveys are also similar to the 1997 baseline measurements. Any variations observed are considered to be within expected limitations of the approach. A survey was not conducted in 2019 because water levels have remained consistent, with no significant changes in acreage and only a slight increase in water use from the previous year.

The land subsidence monitoring program has been and will continue to be expanded as part of the GMMMP, including establishment of a baseline condition as part of the pre-operational monitoring activities before groundwater pumping is ramped up. As a first step in transitioning to the GMMMP, CH2M Hill (in coordination with JBA) established a new stable benchmark in the Marble Mountains and identified several existing stable benchmarks to serve as reference benchmarks for future subsidence surveys (Foreman, 2015). In addition, five new survey control points for subsidence monitoring were added in 2015. These monitoring points are shown in Figure 2.

New survey procedures were implemented in the December 2014 survey, as described in the Seventeenth Annual Report (Foreman, 2015). The new survey procedures establish benchmarks on Marble Mountain as reference points for the Cadiz subsidence surveys. The goal of the new procedures is to obtain a vertical accuracy of +/- 0.10 feet tolerance threshold. The 2018 survey (most recent) showed that all points are within or very near the +/- 0.10 feet limit of instrument accuracy. As groundwater elevations have not declined significantly, and have largely recovered over time, it is likely that differences in year-to-year values are within the vertical accuracy of the survey capability, which may be slightly larger than the goal of +/- 0.10 feet. Future surveys will determine if these variations are anomalies or a trend. The results of all GPS surveys of ground surface elevations suggest that no significant subsidence has occurred to date.

8.0 ANALYSIS OF POTENTIAL IMPACTS

Monitoring of groundwater levels and water quality is an important component of the Cadiz Valley Agricultural Development. During the past 19 years, monitoring of groundwater levels and EC and/or TDS provides for an assessment of groundwater conditions within the development area. No significant changes in groundwater levels or water quality trends have been observed during years of monitoring. The observed measurements of groundwater elevation and water quality indicate that water levels and water quality have remained relatively stable overall. There have been some minor fluctuations in water quality data collected at a few wells over the years of monitoring, but most, if not all, are anomalies that do not represent the general water quality of the area and more likely represent a localized issue with those wells, irrigation equipment, and/or sampling methods.

Land subsidence is a potential concern that can be triggered by groundwater pumping. Elevations measured by the GPS survey performed in 1997 established benchmarks from which changes in land surface elevation can be detected. Subsidence is most likely to occur in environments where groundwater withdrawals result in significant lowering of static groundwater levels within sediments dominated by silt and clay. Significant declines in static groundwater levels have not occurred in the area of the Cadiz agricultural wellfield. A survey was not conducted in 2019. However, the 2018 survey showed there is no long-term trend of land subsidence since 1997. The land subsidence monitoring program will continue to be expanded as part of the GMMMP, including establishment of a baseline condition as part of the pre-operational monitoring activities before groundwater pumping is ramped up. A 2020 survey is scheduled for the end of the year in response to a projected increased of irrigated acreage and increased use of water for maturing citrus trees.

9.0 SUMMARY AND CONCLUSIONS

The following summarizes groundwater conditions in the Cadiz Valley Agricultural Development project area over the period from January 2019 through December 2019:

- Variations in groundwater elevations measured in the irrigation wells are within normal ranges expected during seasonal pumping and recovery cycles. Generally, groundwater levels are above baseline levels in Cadiz irrigation wells as a result of pumping decreases and natural recharge in recent years.

- Groundwater levels in the monitoring wells in the vicinity of the irrigation wellfield are stable with slight increases in groundwater elevations. Groundwater levels in monitoring wells located as far as 12 miles upgradient from the wellfield and other pumping wells also show increasing groundwater elevation trends. Because these monitoring wells are located far beyond the area of influence of any pumping wells, these fluctuations in water levels likely reflect natural variations in recharge (i.e., wet and dry cycles). Groundwater levels measured in each well are shown in Figures 4 through 10; static (non-pumping), near-static (groundwater levels which may not have fully recovered from pumping conditions), and pumping groundwater levels are shown. Sharp drawdowns in groundwater elevation during pumping is expected and is not indicative of regional groundwater elevation trends. These figures show trends in groundwater levels within the wellfield area. In general, groundwater levels declined slightly in the wellfield area as pumping increased in the late 1990s, largely stabilized in the early 2000s as groundwater levels equilibrated to maximum pumping levels, and then rebounded in the late 2000s as groundwater pumping was reduced. For this report period (January 2019 through December 2019), and as early as 2005, groundwater elevations in most of the Group 1 wells show obvious recovery (see Figure 11). Based on the monitoring data, at the height of well extractions in 1999/2000, pumping did not generally affect groundwater levels beyond approximately one mile from the center of the wellfield.

- Irrigation wells and monitoring wells were sampled quarterly for water quality, including TDS, from January 2019 through December 2019. As stated in Section 1.0, supplemental information is provided here as an ongoing transition toward the requirements of the approved GMMMP. No significant changes in groundwater quality have been reported. Generally, groundwater quality appears to be stable. There are a few irrigation wells that have experienced increases in TDS and nitrate, which seem to be localized conditions (e.g., wells sitting idle or permanently offline, sampling methods used, redevelopment issues, and possibly increased irrigation and leaks from the irrigation system). Ongoing monitoring has indicated that TDS spikes at irrigation wells 21N and 33 were temporary and the TDS values have since dropped back down to normal levels immediately after the well had been turned back on (from 440 mg/L to 330 mg/L in Well 33).

Recent samples collected at Well 27N show a measured decrease of TDS of over 150 mg/L (from 790 mg/L to 630 mg/L).

- Average annual groundwater production for the Cadiz Valley Agricultural Development over the period from January 2019 through December 2019 increased slightly from 1,827 AFY in 2018 to 2,498 AFY. This increase can likely be contributed to the increased irrigation needed for more mature crops. Groundwater production by Cadiz since 1986 totals 127,825 AF.

- A survey of land surface elevation benchmarks was conducted in 2018. Results of this survey indicate that all NAVD88 elevations are similar to those measured in 2015 and there is no apparent evidence of subsidence since 1997 (baseline year for subsidence). Variations observed between surveys are considered to be within expected limitations of the approach. Since groundwater levels are essentially unchanged, no survey was conducted in 2019. However, due to projected increases in irrigated acreage and water use for more mature trees, a 2020 subsidence survey has been scheduled for late in the year.

- Based on the groundwater conditions observed during this monitoring period, irrigation pumping by the Cadiz Valley Agricultural Development has not resulted in any significant changes or adverse impacts to groundwater levels, groundwater quality, or land surface stability.

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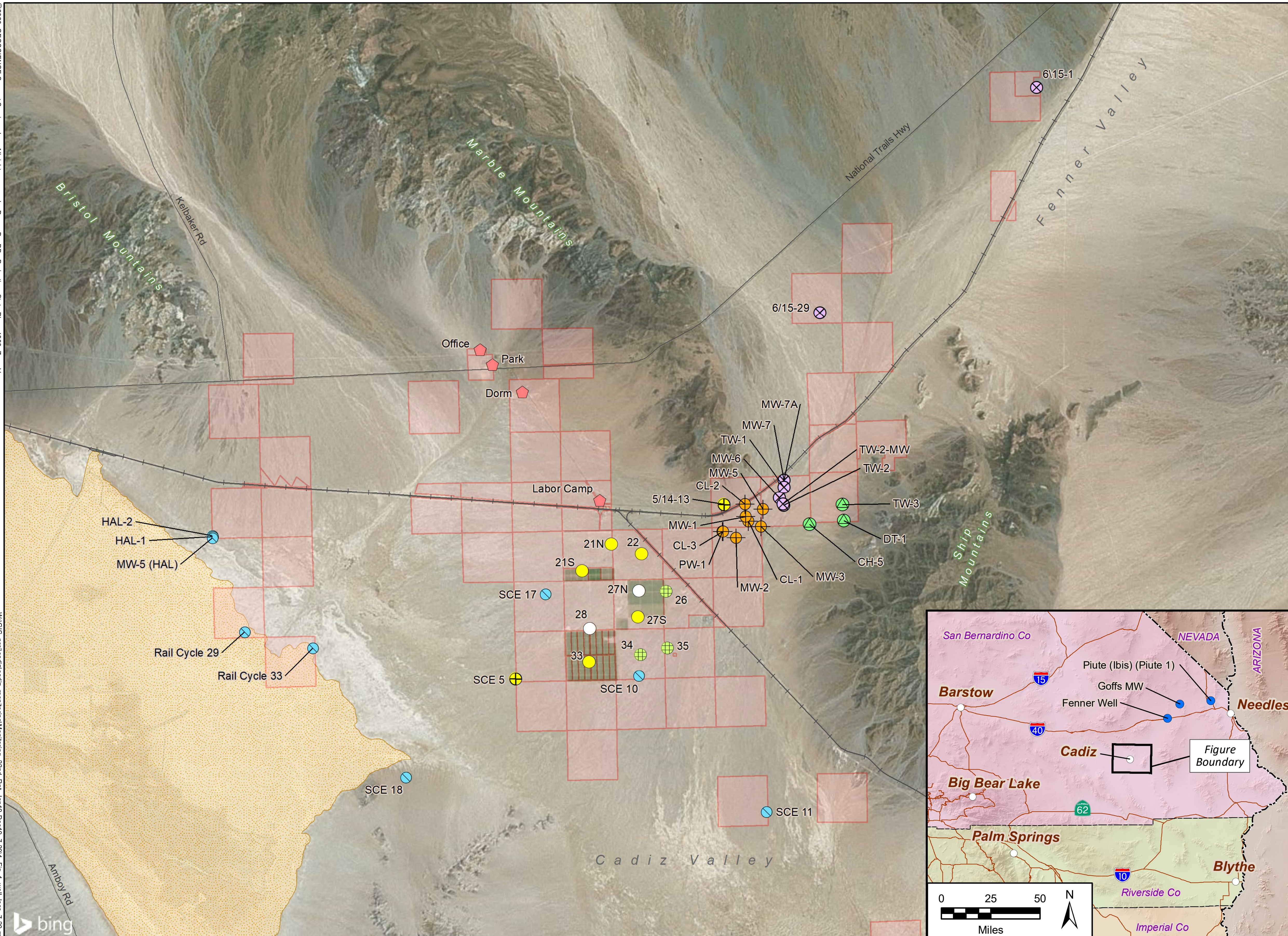
FIGURES

GEOSCIENCE



CADIZ AGRICULTURAL WELLFIELD AND MONITORING NETWORK

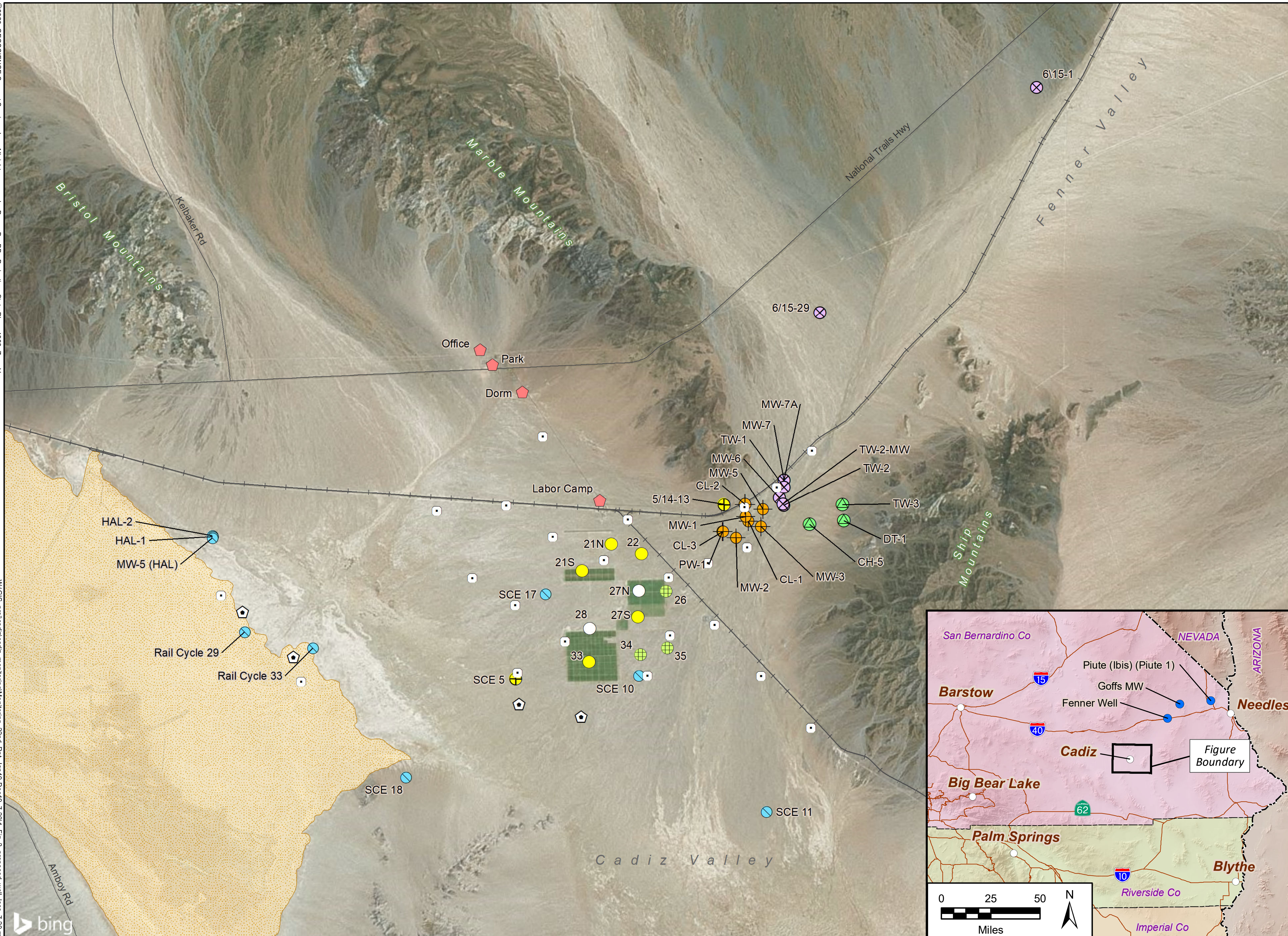
August-20

FIGURE 1

CADIZ, INC.

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-SECOND ANNUAL GROUNDWATER MONITORING REPORT (JANUARY 2019 - DECEMBER 2019)

GEOSCIENCE



EXPLANATION

Proposed Induced Flow and Brine Migration Cluster Well

Proposed Land Survey Benchmark

Well Location and Hydrograph Group

Group 1

- Agricultural Well } GWMP Monitoring Network (1997)
- Monitoring Well } GWMP Monitoring Network (1997)
- Agricultural Well Permanently Offline And Used As Well Field Monitoring Well Exclusively
- New Agricultural Well (2020)

- Group 2 } Extended Monitoring Network for GMMMP (2012)
- Group 3
- Group 4
- Group 5
- Group 6

Note: Wells are grouped by GWMP and geographic location

Groundwater Elevation Measuring Point

Cadiz-Owned Land

Bristol Dry Lake

N

0 2 4

Miles

PROPOSED MONITORING POINTS (SUBSIDENCE AND WELLS)

W:\GIS_proj\cadiz\cadiz_monitoring\Monitoring_22nd_Rpt_Jan19-Dec19_7-2011_Fg_2_proposed_well_locs_7-20.mxd

August-20

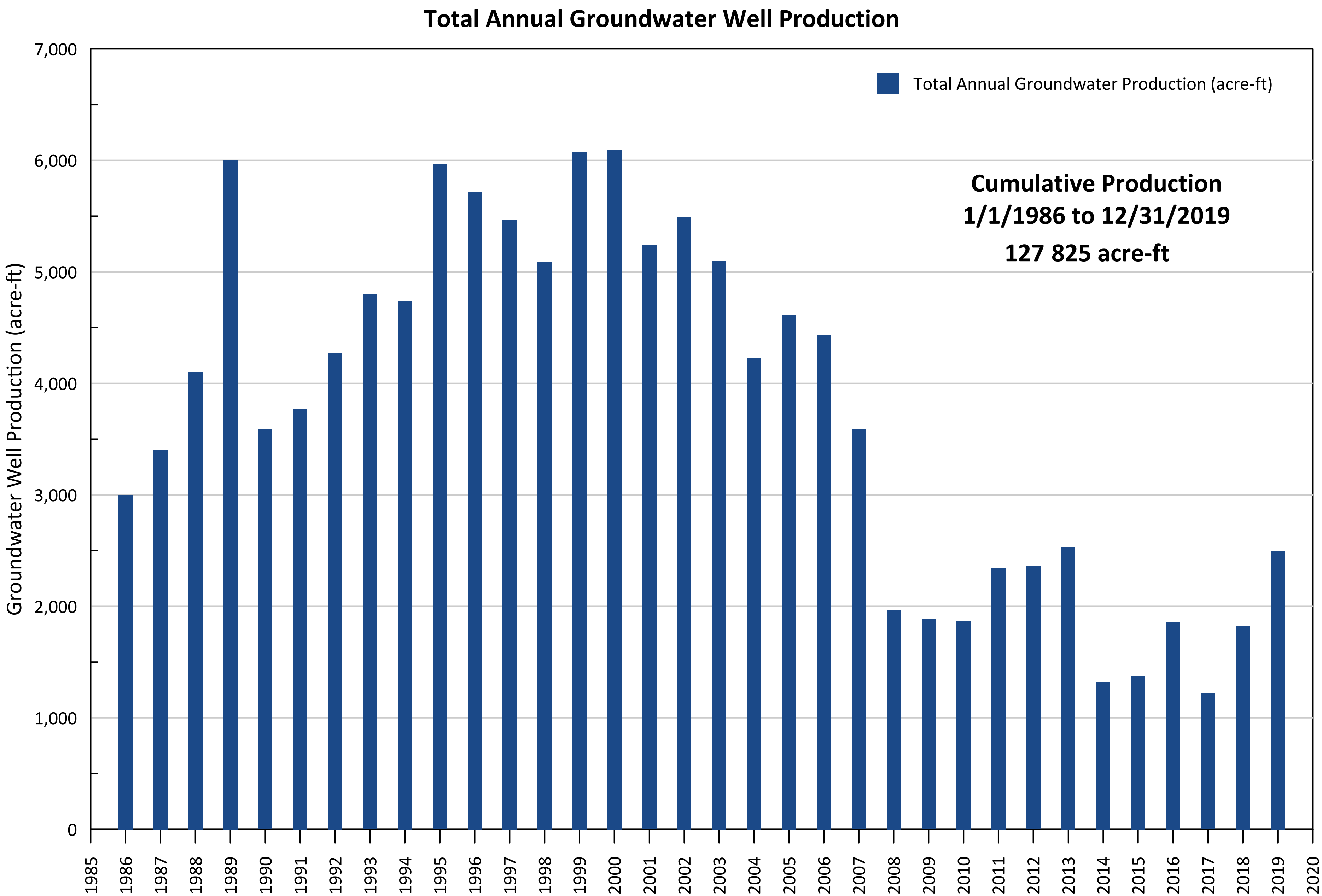

Total Annual Groundwater Well Production
Total Annual Groundwater Production (acre-ft)
Cumulative Production
1/1/1986 to 12/31/2019
127 825 acre-ft
Groundwater Well Production (acre-ft)
0
1,000
2,000
3,000
4,000
5,000
6,000
7,000
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
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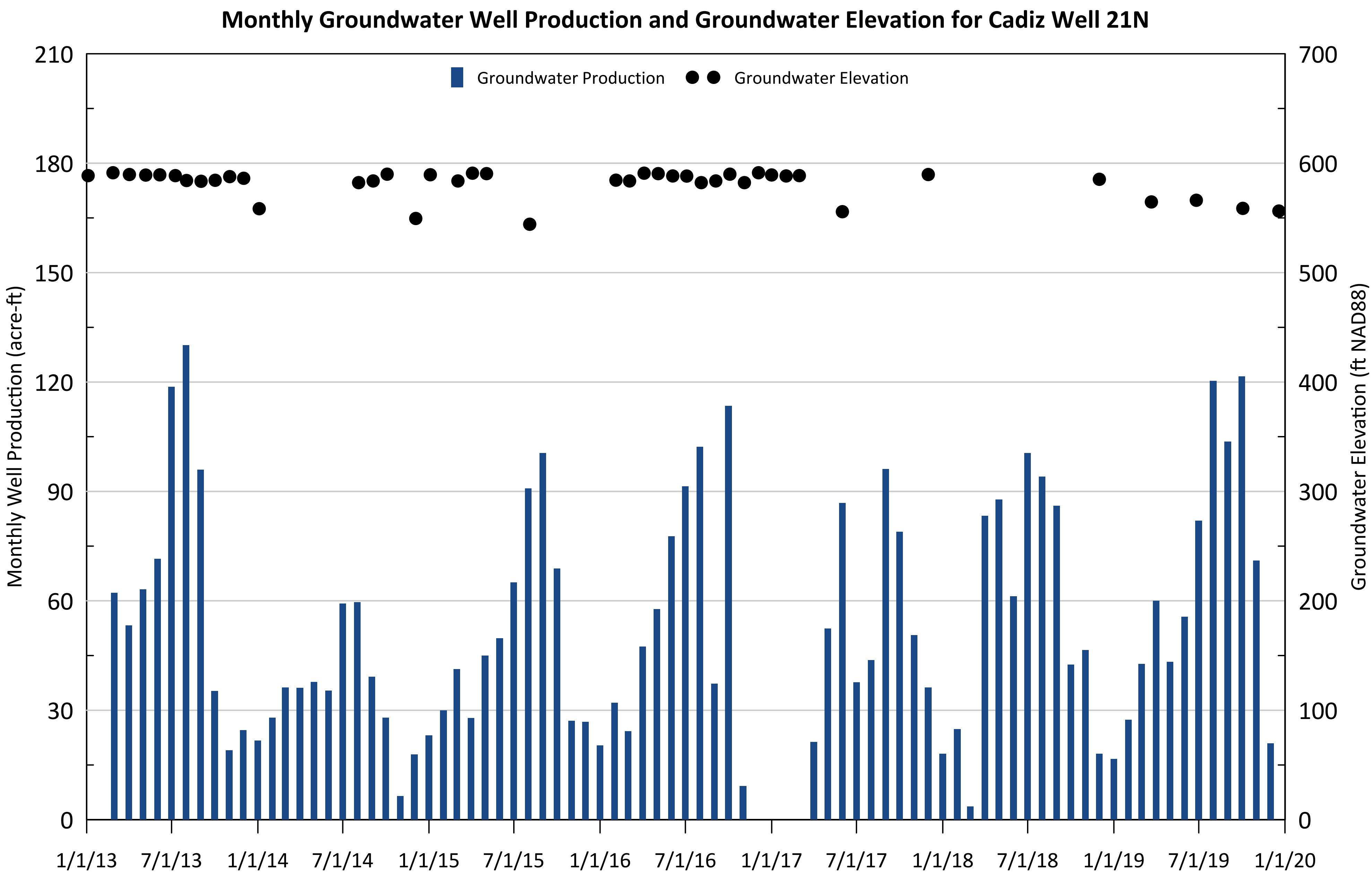
Figure 4



GEOSCIENCE

Figure 5

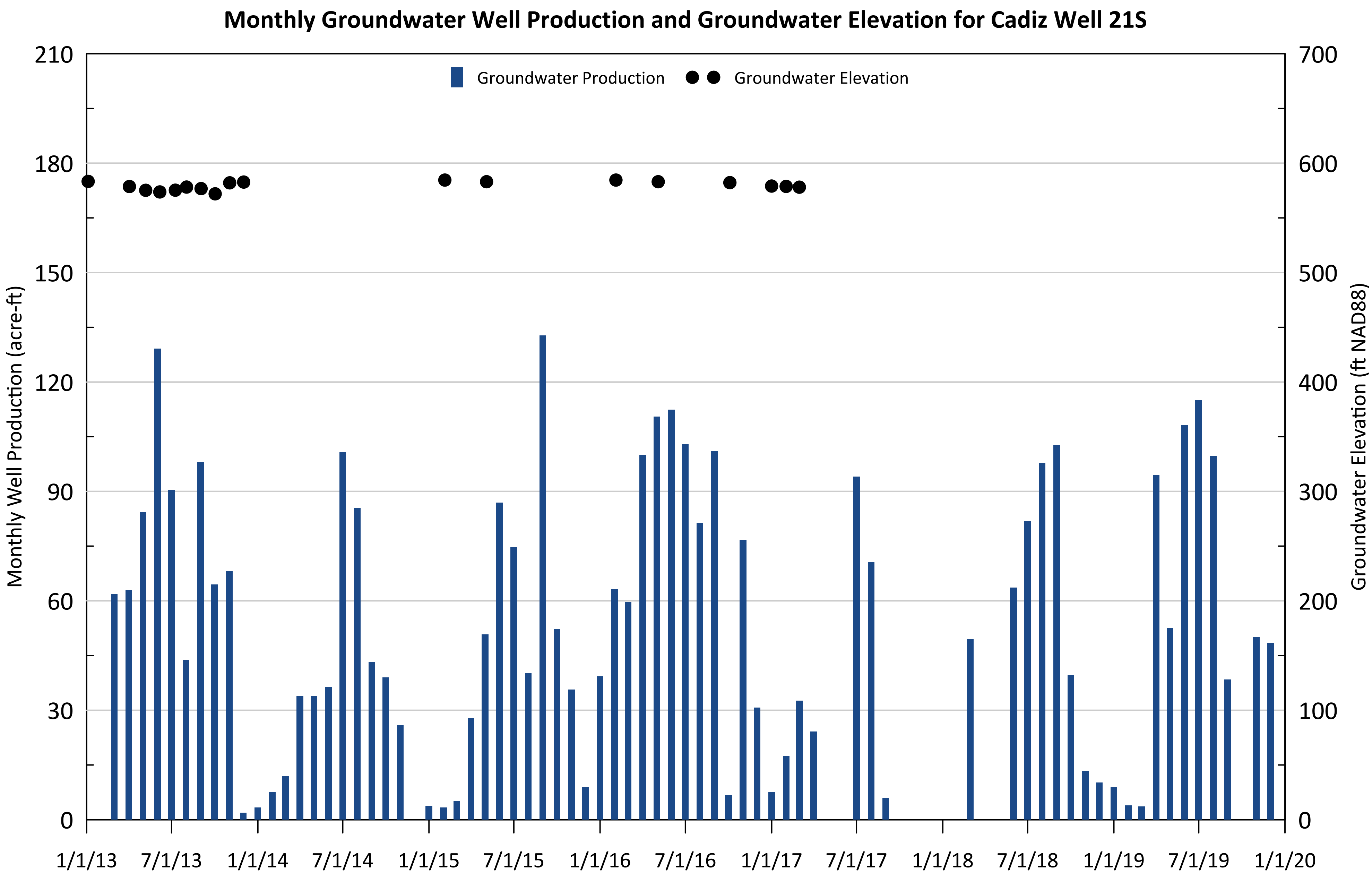

Monthly Groundwater Well Production and Groundwater Elevation for Cadiz Well 21S
Groundwater Production
Groundwater Elevation
Monthly Well Production (acre-ft)
Groundwater Elevation (ft NAD88)
210
180
150
120
90
60
30
0
700
600
500
400
300
200
100
0
1/1/13
7/1/13
1/1/14
7/1/14
1/1/15
7/1/15
1/1/16
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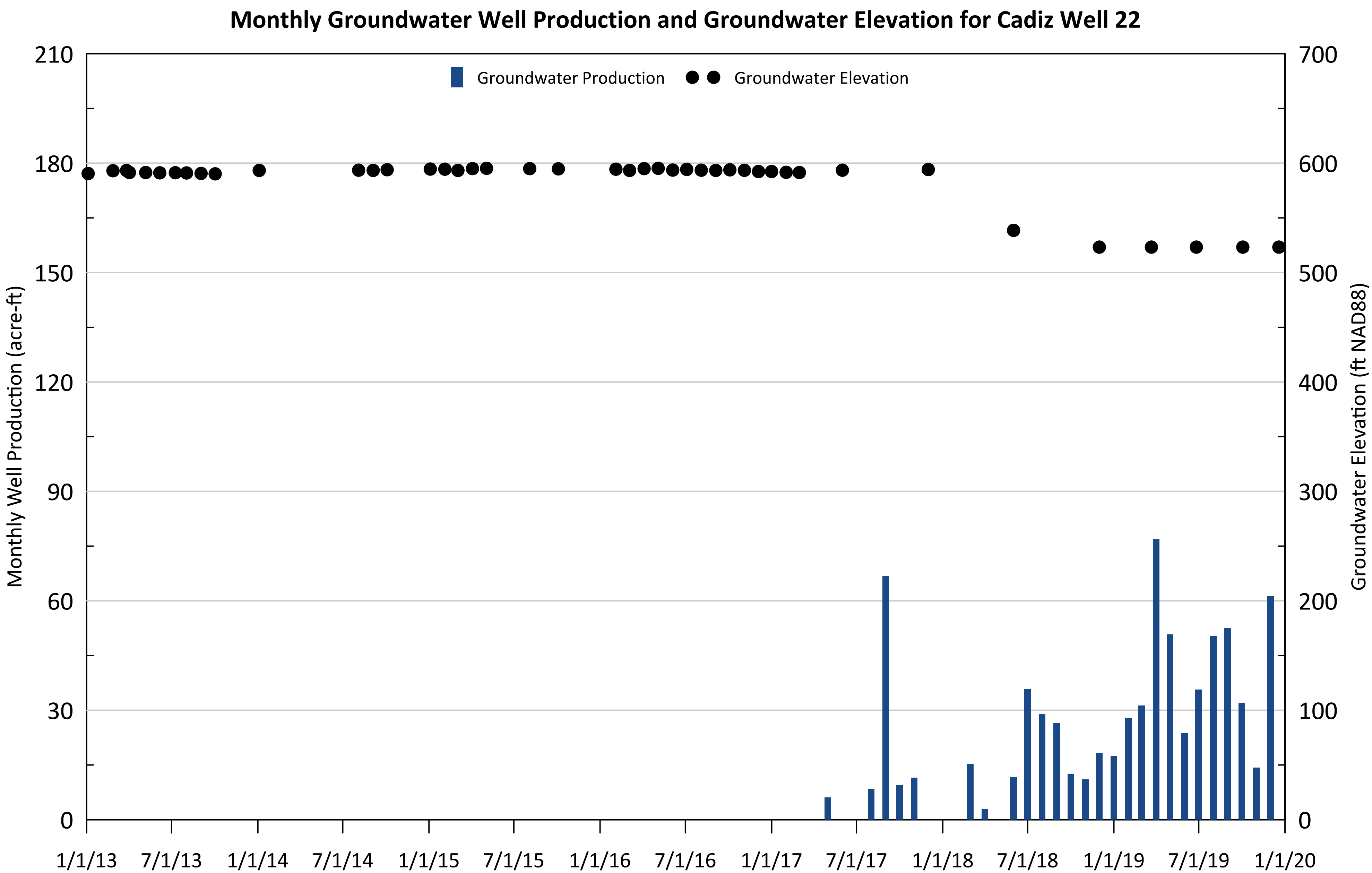
Figure 6


Monthly Groundwater Well Production and Groundwater Elevation for Cadiz Well 22
Groundwater Production
Groundwater Elevation
Monthly Well Production (acre-ft)
Groundwater Elevation (ft NAD88)
210
180
150
120
90
60
30
0
700
600
500
400
300
200
100
0
1/1/13
7/1/13
1/1/14
7/1/14
1/1/15
7/1/15
1/1/16
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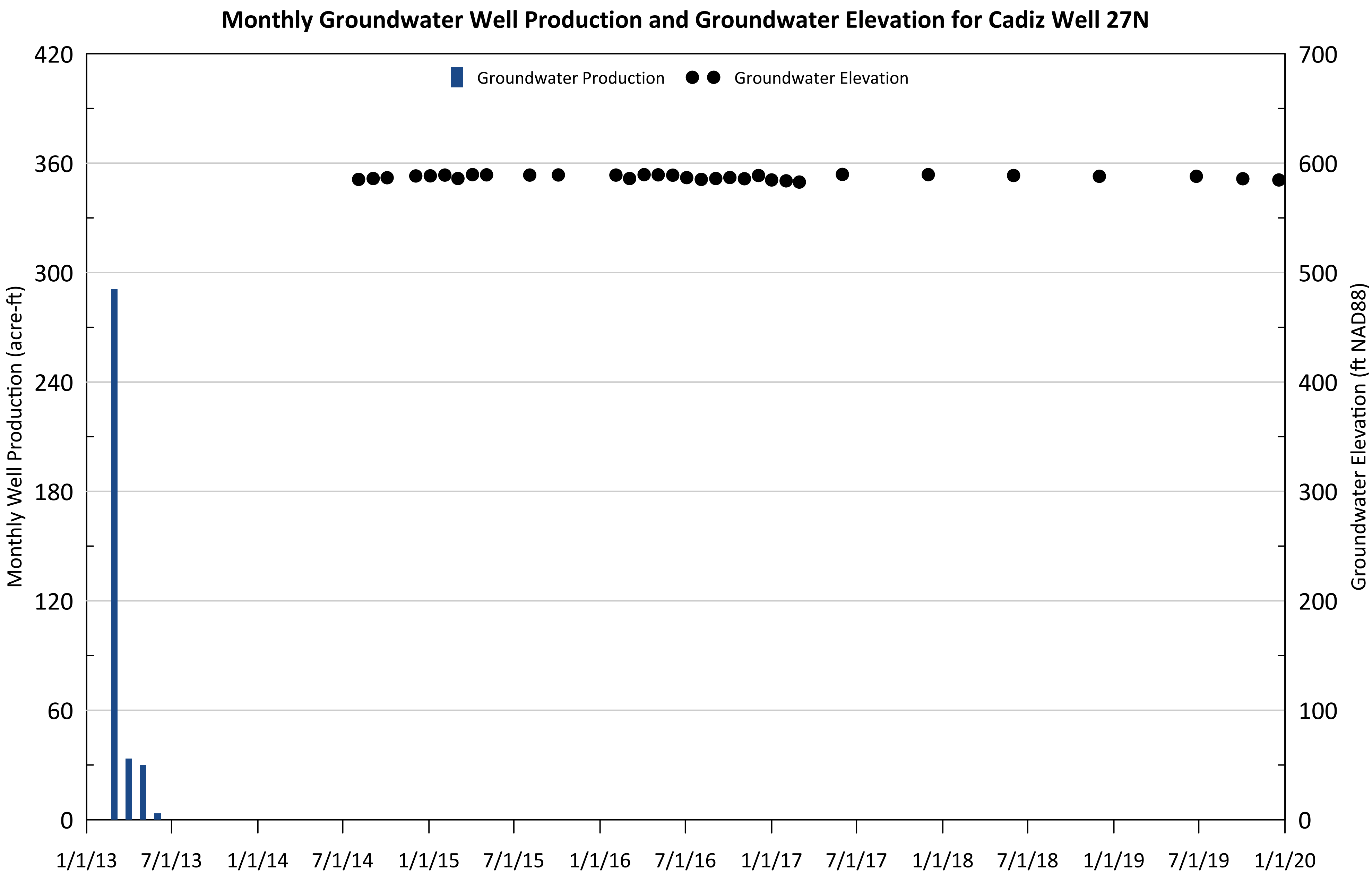
1/1/20

Figure 7


Monthly Groundwater Well Production and Groundwater Elevation for Cadiz Well 27N
Groundwater Production
Groundwater Elevation
Monthly Well Production (acre-ft)
Groundwater Elevation (ft NAD88)
420
360
300
240
180
120
60
0
700
600
500
400
300
200
100
0
1/1/13
7/1/13
1/1/14
7/1/14
1/1/15
7/1/15
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1/1/20

Figure 8

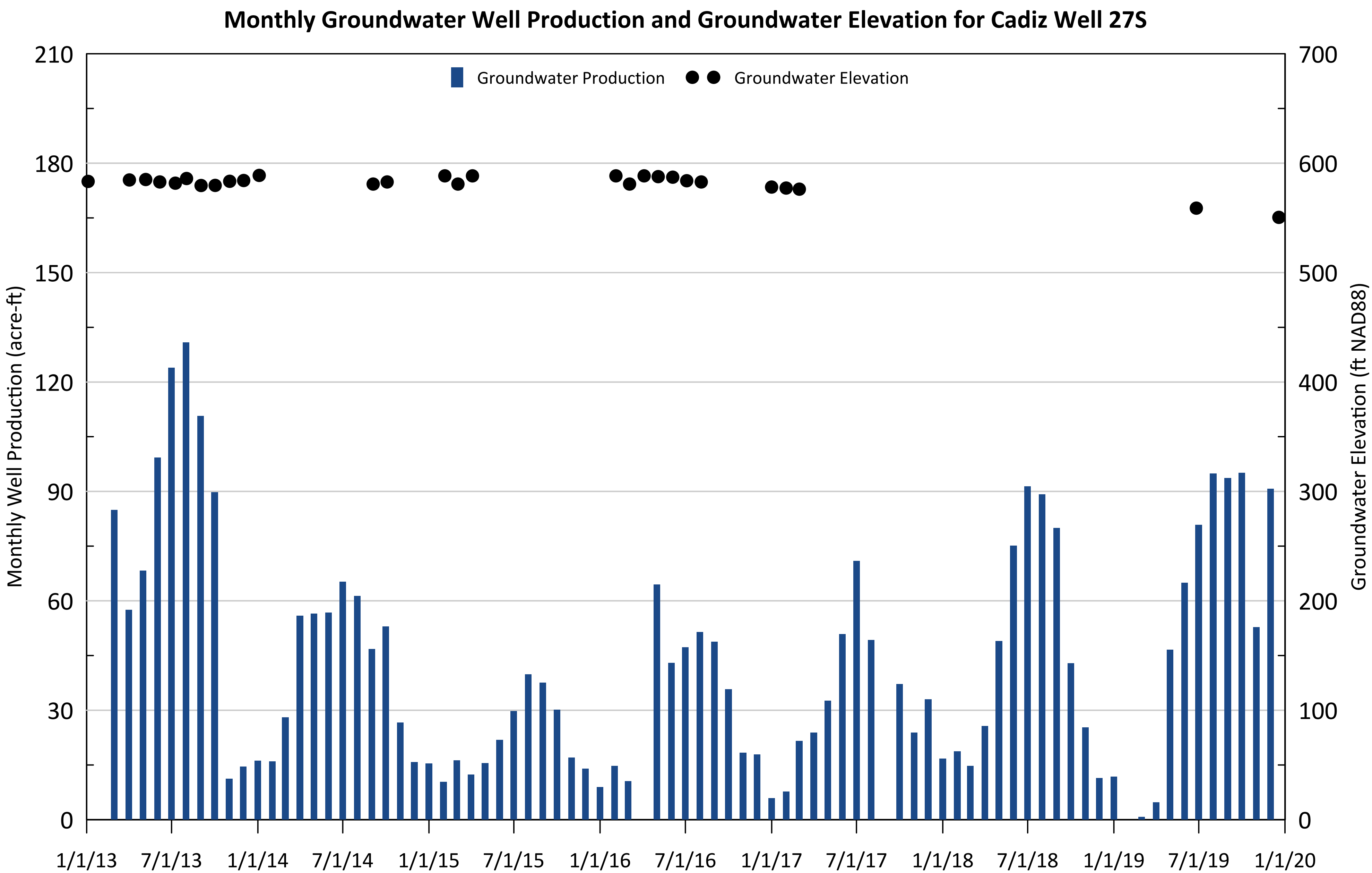

Monthly Groundwater Well Production and Groundwater Elevation for Cadiz Well 27S
Groundwater Production
Groundwater Elevation
Monthly Well Production (acre-ft)
Groundwater Elevation (ft NAD88)
210
180
150
120
90
60
30
0
700
600
500
400
300
200
100
0
1/1/13
7/1/13
1/1/14
7/1/14
1/1/15
7/1/15
1/1/16
7/1/16
1/1/17
7/1/17
1/1/18
7/1/18
1/1/19
7/1/19
1/1/20

Figure 9

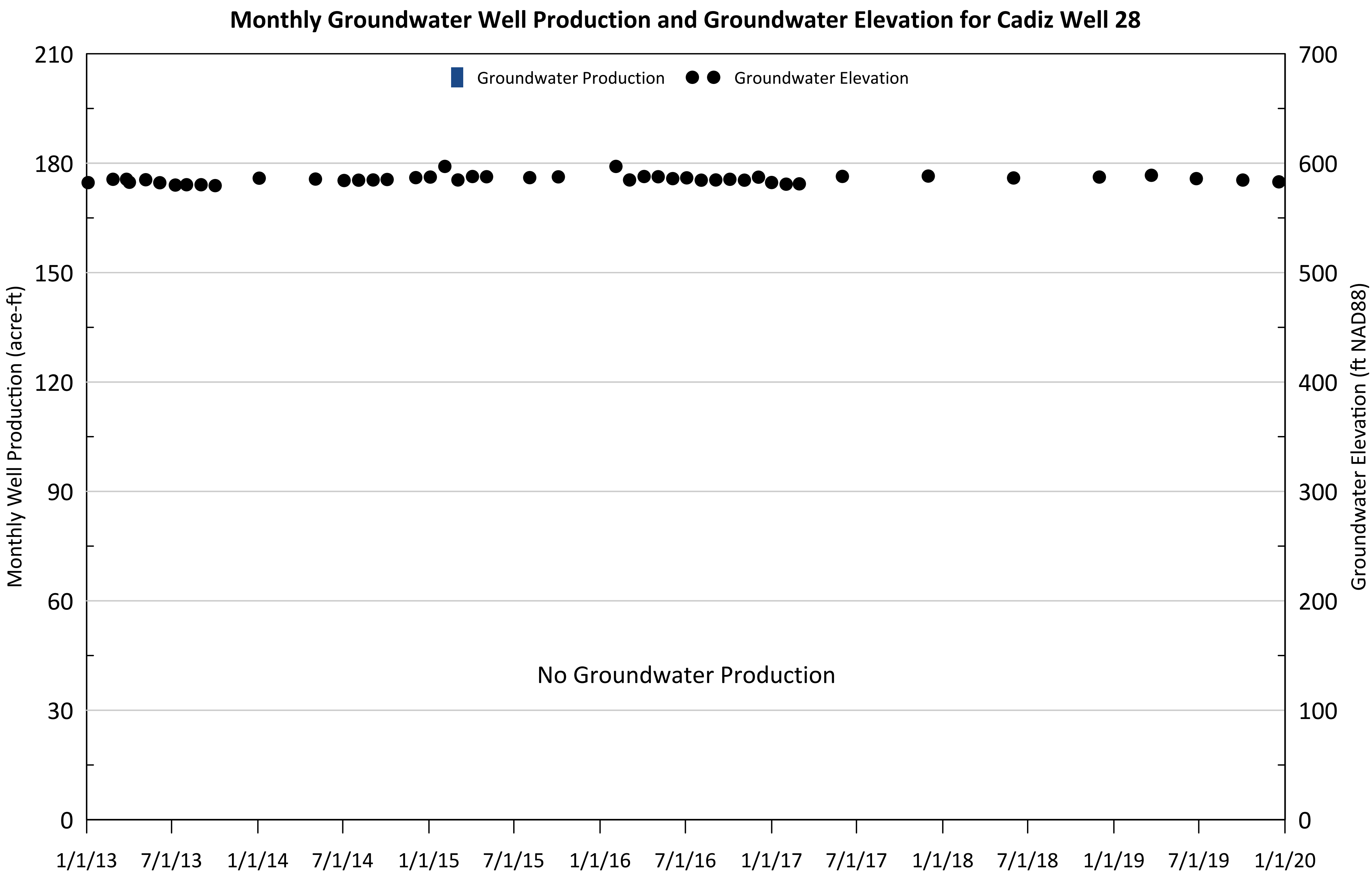
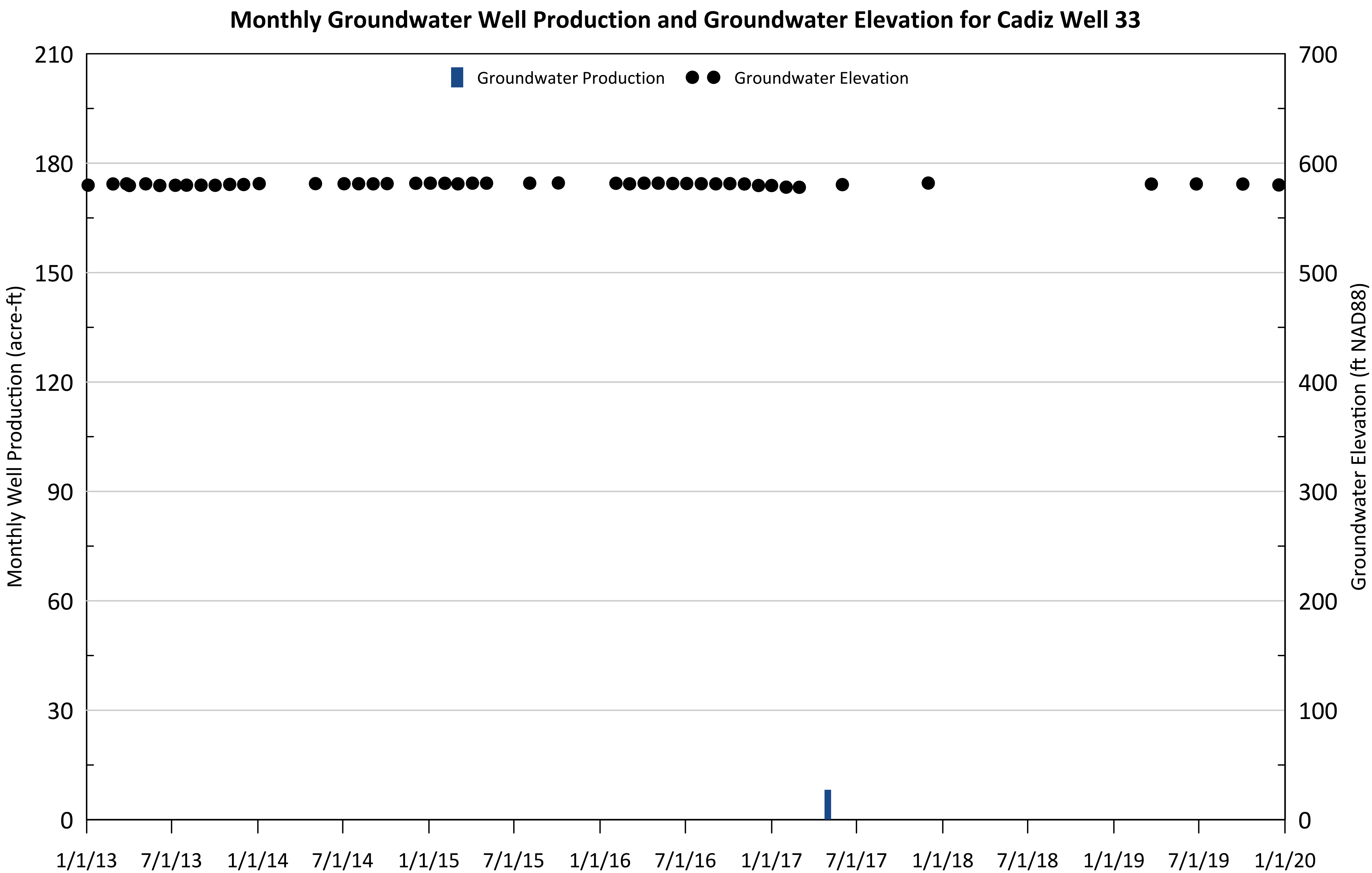

Monthly Groundwater Well Production and Groundwater Elevation for Cadiz Well 28
Groundwater Production
Groundwater Elevation
Monthly Well Production (acre-ft)
Groundwater Elevation (ft NAD88)
210
180
150
120
90
60
30
0
700
600
500
400
300
200
100
0
No Groundwater Production
1/1/13
7/1/13
1/1/14
7/1/14
1/1/15
7/1/15
1/1/16
7/1/16
1/1/17
7/1/17
1/1/18
7/1/18
1/1/19
7/1/19
1/1/20

Figure 100



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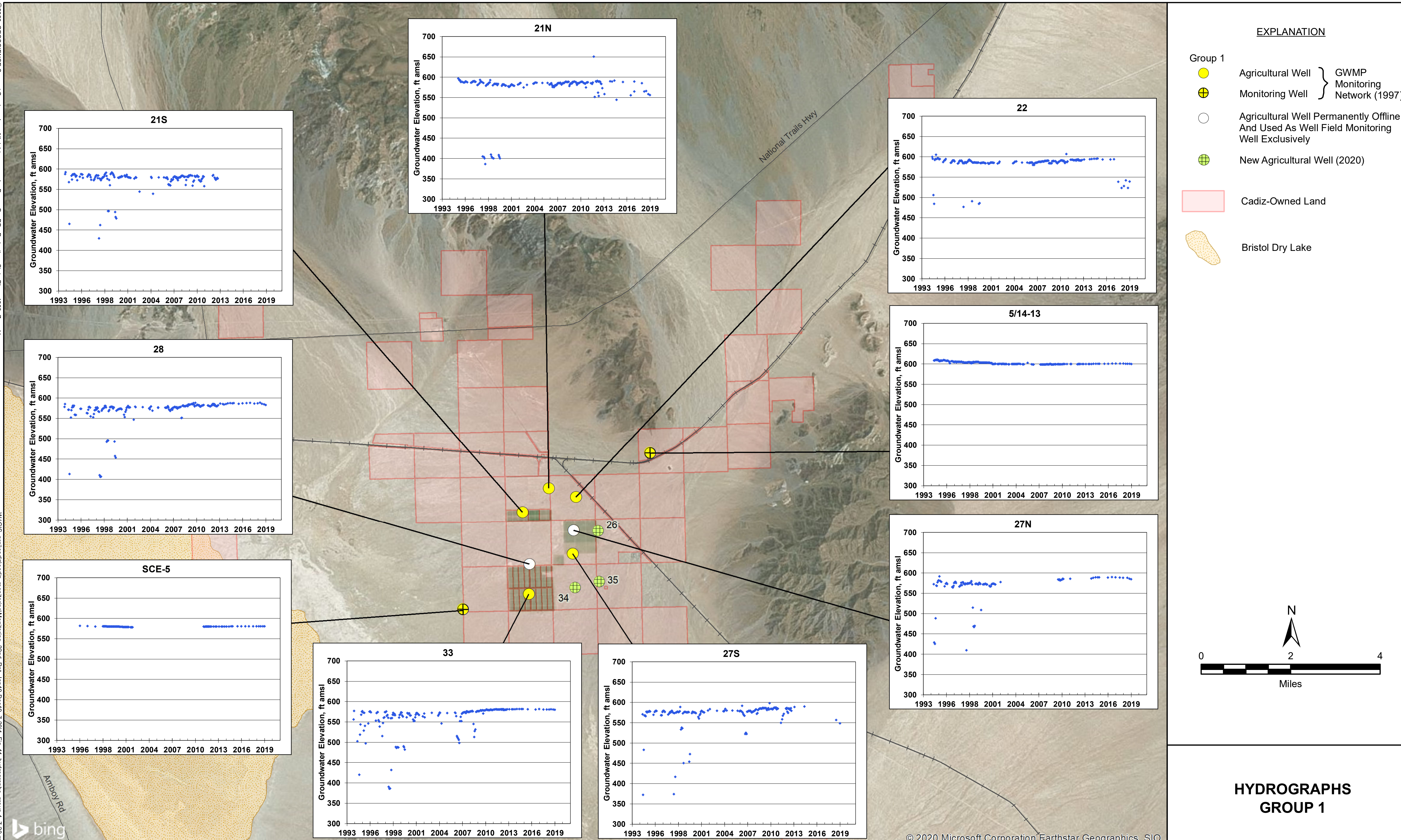


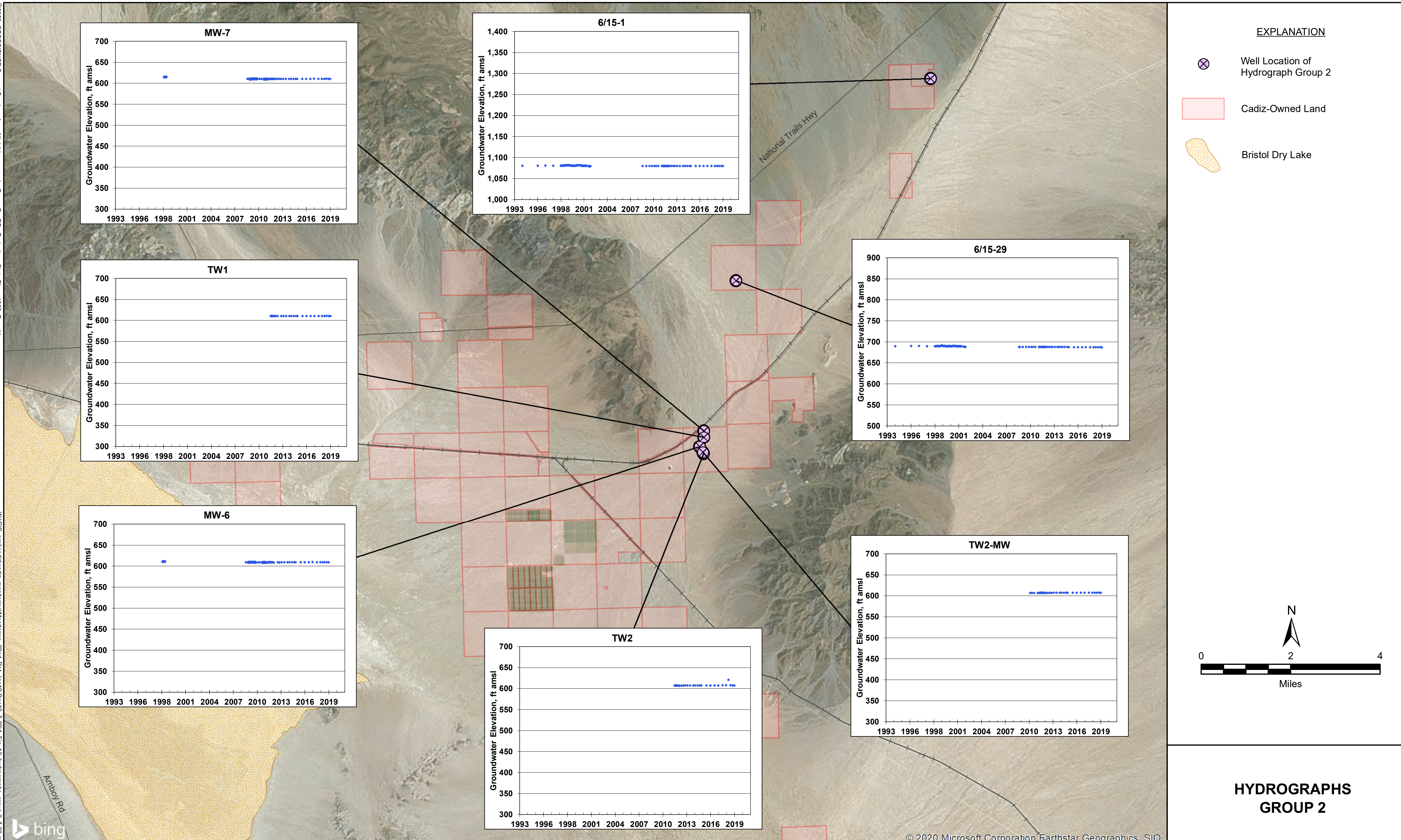
August-20

CADIZ, INC.

FIGURE 11

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-SECOND ANNUAL GROUNDWATER MONITORING REPORT (JANUARY 2019 - DECEMBER 2019)

GEOSCIENCE



HYDROGRAPHS GROUP 2

W:\GIS_proj\cadiz\cadiz_monitoring\Monitoring_22nd_Rpt_Jan19-Dec19_7-2011_Fig_12_hydrographs_group-2_7-20.mxd

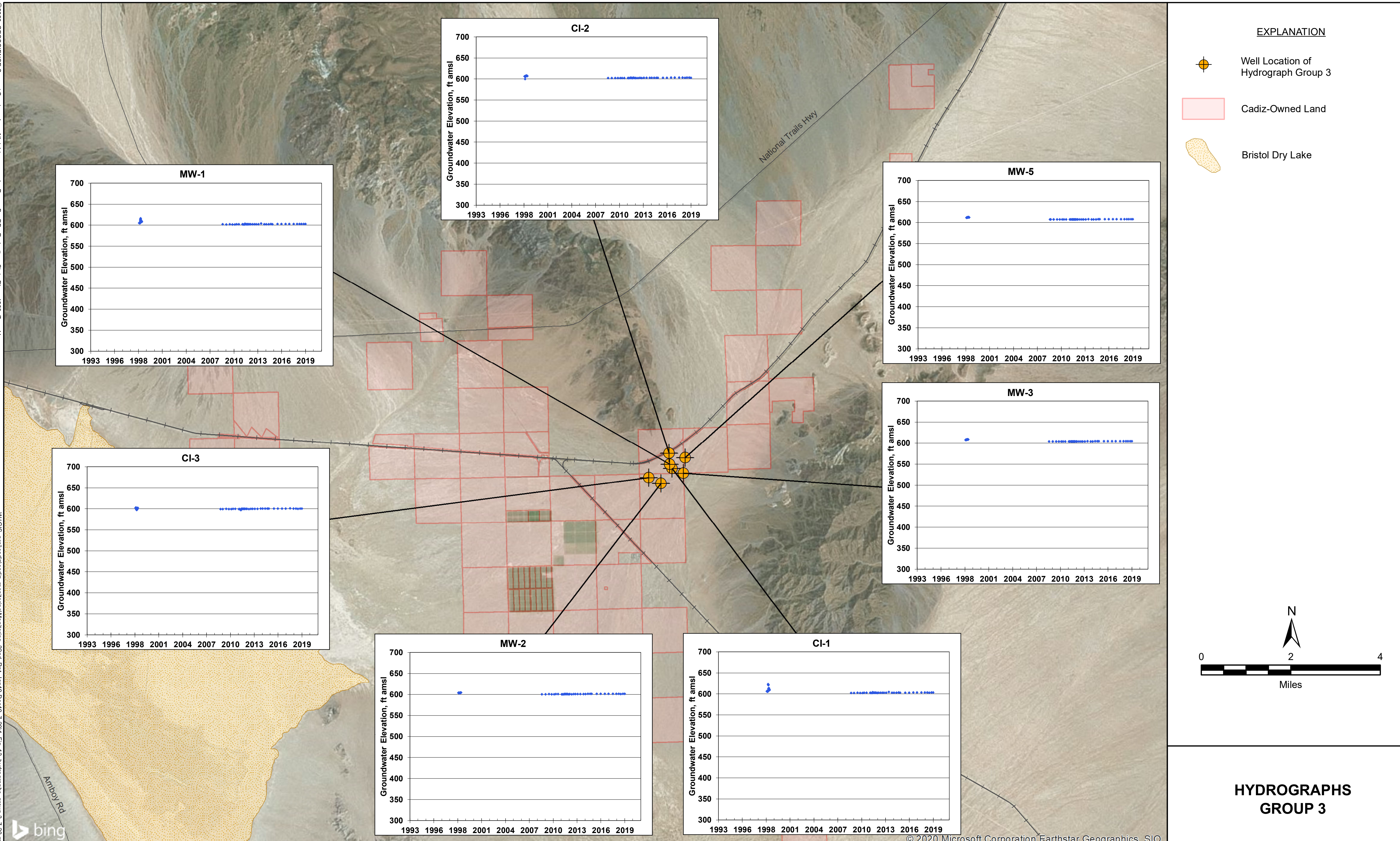
August-20

CADIZ, INC.

FIGURE 12

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-SECOND ANNUAL GROUNDWATER MONITORING REPORT (JANUARY 2019 - DECEMBER 2019)

GEOSCIENCE



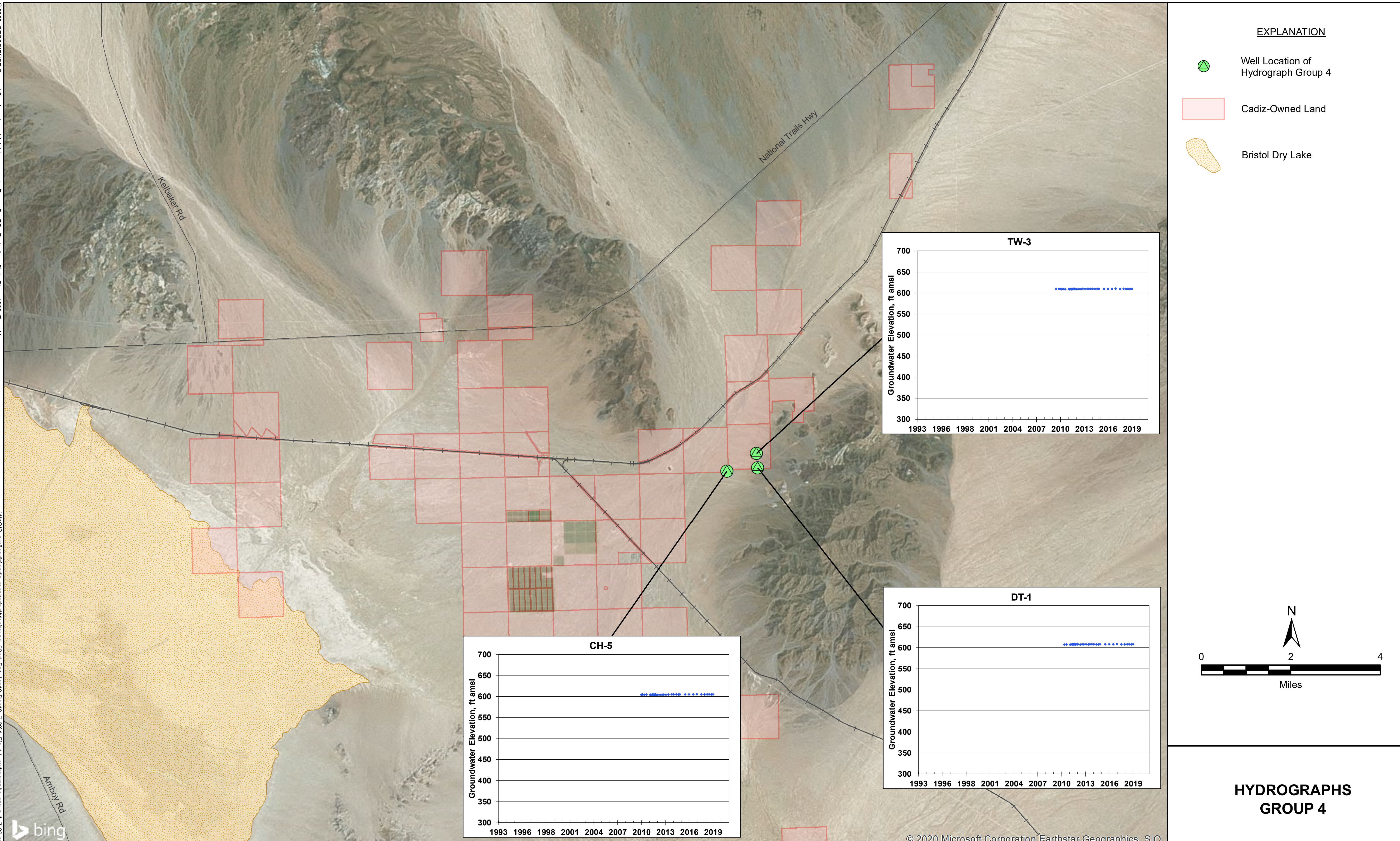
August-20

CADIZ, INC.

FIGURE 13

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-SECOND ANNUAL GROUNDWATER MONITORING REPORT (JANUARY 2019 - DECEMBER 2019)

GEOSCIENCE



HYDROGRAPHS GROUP 4

W:\GIS_proj\cadiz\cadiz_monitoring\Monitoring_22nd_Rpt_Jan19-Dec19_7-2011_Fig_14_hydrographs_group-4_7-20.mxd

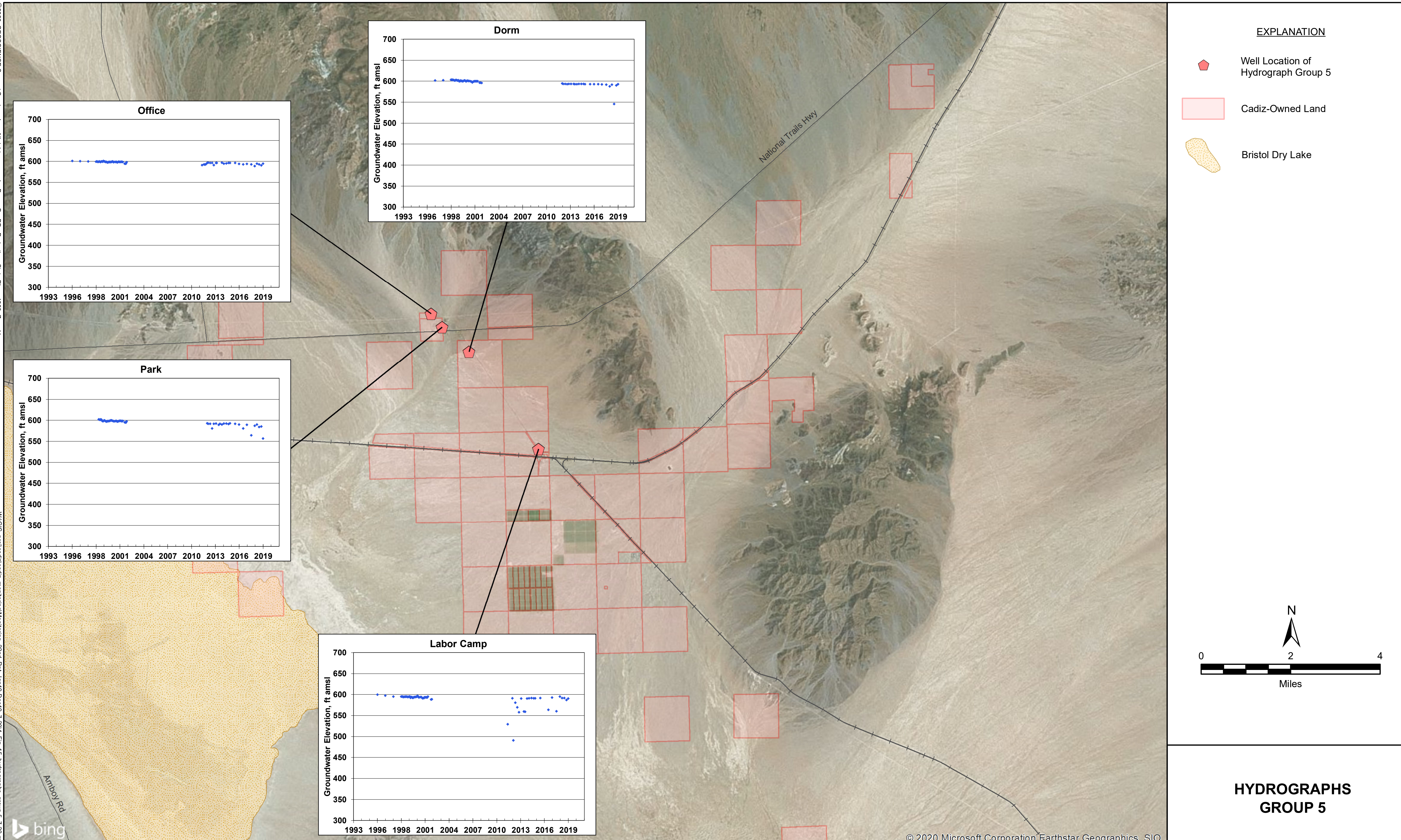
August-20

CADIZ, INC.

FIGURE 14

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-SECOND ANNUAL GROUNDWATER MONITORING REPORT (JANUARY 2019 - DECEMBER 2019)

GEOSCIENCE



W:\GIS_proj\cadiz\cadiz_monitoring\Monitoring_22nd_Rpt_Jan19-Dec19_7-2011_Fig_15_hydrographs_group-5_7-20.mxd

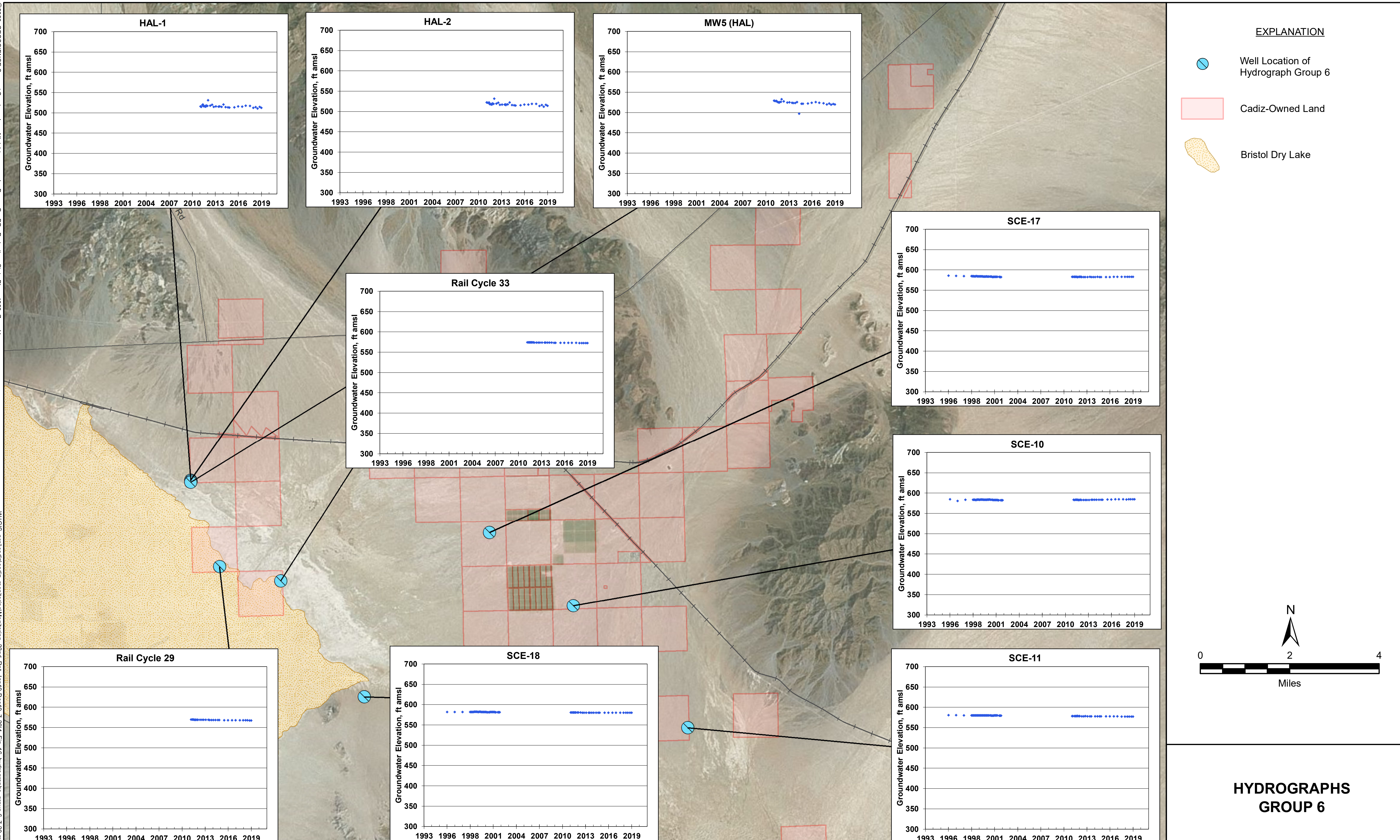
August-20

CADIZ, INC.

FIGURE 15

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-SECOND ANNUAL GROUNDWATER MONITORING REPORT (JANUARY 2019 - DECEMBER 2019)

GEOSCIENCE



W:\GIS_proj\cadiz\cadiz_monitoring\Monitoring_22nd_Rpt_Jan19-Dec19_7-20\Fig_16_hydrographs_group-6_7-20.mxd

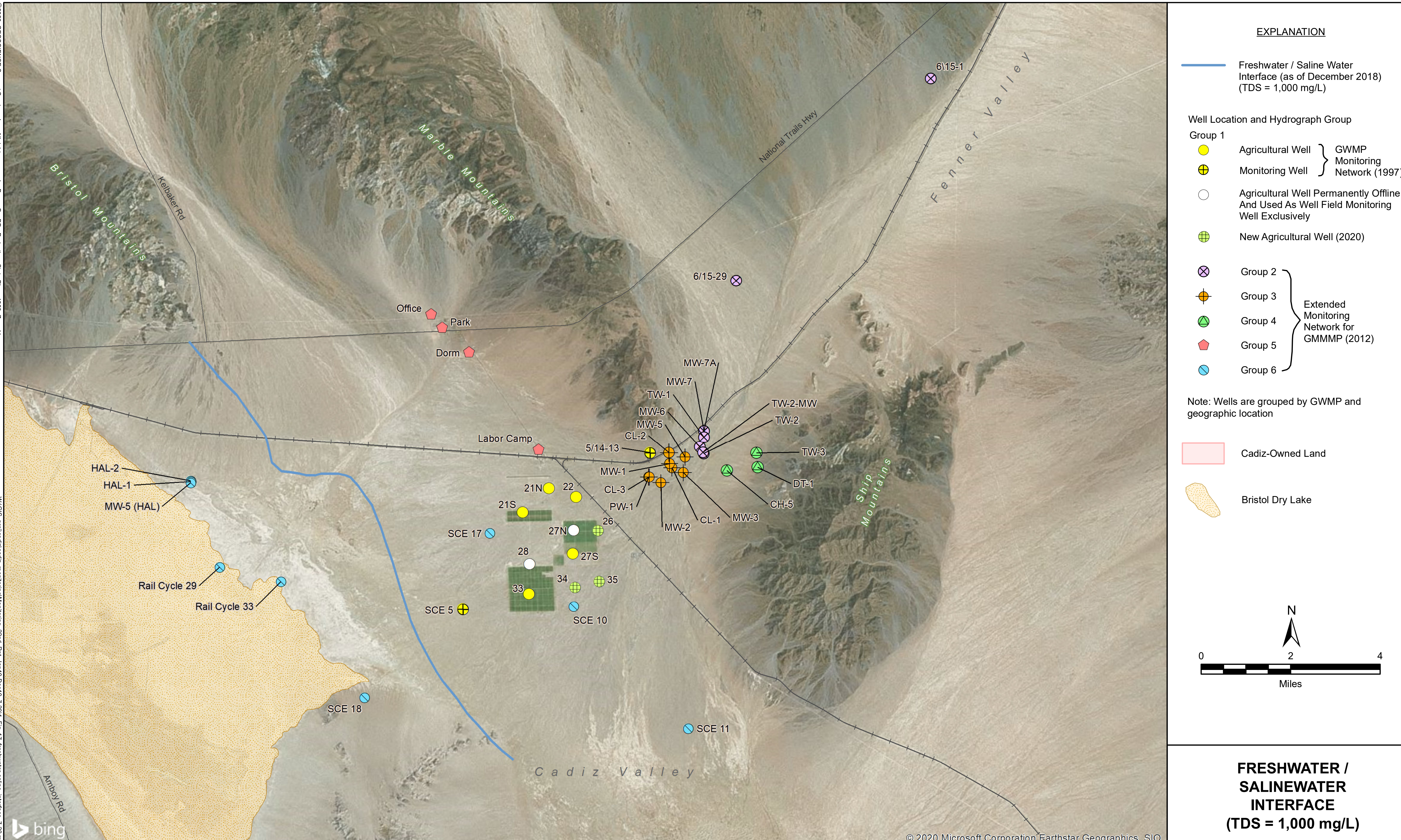
August-20

CADIZ, INC.

FIGURE 16

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-SECOND ANNUAL GROUNDWATER MONITORING REPORT (JANUARY 2019 - DECEMBER 2019)

GEOSCIENCE



W:GIS_proj\cadiz\cadiz_monitoring\Monitoring_22nd_Rpt_Jan19-Dec19_7-2011_Fig_17_freshwater-saline_interface_7-20.mxd

FRESHWATER / SALINEWATER INTERFACE (TDS = 1,000 mg/L)

August-20

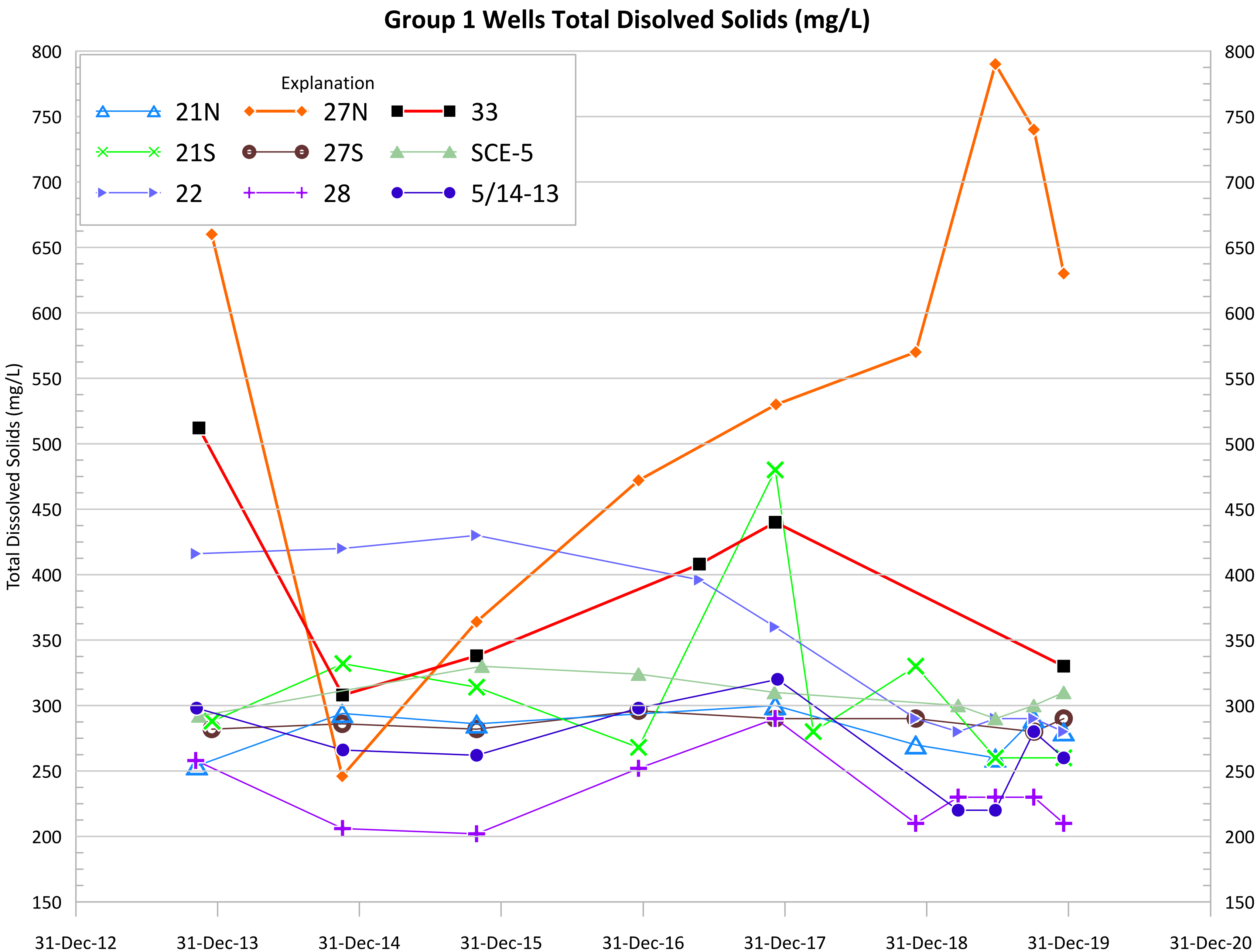
CADIZ, INC.

FIGURE 17

CADIZ VALLEY AGRICULTURAL DEVELOPMENT - TWENTY-SECOND ANNUAL GROUNDWATER MONITORING REPORT (JANUARY 2019 - DECEMBER 2019)

GEOSCIENCE

Figure 18


Group 1 Wells Total Disolved Solids (mg/L)
Explanation
21N
27N
33
21S
27S
SCE-5
22
28
5/14-13
Total Dissolved Solids (mg/L)
800
750
700
650
600
550
500
450
400
350
300
250
200
150
31-Dec-12
31-Dec-13
31-Dec-14
31-Dec-15
31-Dec-16
31-Dec-17
31-Dec-18
31-Dec-19
31-Dec-20

TABLES

Table 1: Production and Monitoring Well Construction Details

Well Designation	Date Completed	Coordinates (NAD83)		Elevation (ft msl)	Drilling Method	Borehole Diameter (inches)	Conductor Depth (ft bgs) (Diameter)	Total Borehole Depth (ft bgs)	Cased Depth (ft bgs) (Diameter)	Screened Interval (ft bgs)	Filter Pack Interval (ft bgs)	Seal Interval (ft bgs)
		Latitude	Longitude									
TW-1 (Alluvium Section)	10/28/2009	34° 31' 38"	115° 26' 55"	940.04	Mud Rotary (to 455 ft) Dual Tube (to 1,002 ft)	24 (to 50 ft) 17.5 (to 461 ft) 9.5 (to 1,022 ft)	50' (18-inch)	1,022	455 (10")	355 - 440	335 - 445	0 - 335
TW-1 (Carbonate Section Open Borehole)	"	"	"	"	"	"	"	"	"	455 - 1,002	"	"
TW-2	12/8/2009	34° 31' 12"	115° 26' 56"	921.29	Flooded Reverse (to 798 ft) Dual Tube (to 1,380 ft)	42 (to 35 ft) 32 (to 340 ft) 17.5 (to 798 ft) 9.5 (to 1,160 ft) 5.25 (to 1,380 ft)	35' (32-inch) 340' (24-inch)	1,380	799 (10")	340 - 779	0 - 785 [1]	0 - 340
TW-2 (post May 2011)	5/14/2011	"	"	"	Dual Rotary (redrilled 870 - 1160 ft)	"	"	1,160	10" to 799 8" to 1,004	340 - 779 869 - 992	"	"
TW2-MW	10/21/2010	34° 31' 13"	115° 26' 56"	921.87	Dual Tube (to 740 ft)	5.25 (to 740 ft)	-	740	720	600 - 700	575 - 740	0 - 575
TW-3	2/22/2010	34° 31' 11"	115° 25' 41"	1,055.73	Dual Tube (to 960 ft) Rock Core (to 1,942 ft)	6 (to 85 ft) 5.25 (to 960 ft) 3.5 (to 1,230 ft) 2.75 (to 1,942 ft)	-	1,942	522	502 - 522	472 - 1,774	0 - 472
CH-5	11/5/2010	34° 30' 51"	115° 26' 23"	975.34	Dual Tube (to 349 ft) Rock Core (to 1,191 ft)	6 (to 55 ft) 5.25 (to 349 ft) 3.5 (to 1,191 ft)	-	1,191	438 (1.5")	338 - 438	55 - 1,191	0-55
DT-1	2/28/2011	34° 30' 54"	115° 25' 40"	1079.74'	Dual Tube (to 1,500 ft)	30 (to 42 ft) 20 (to 935 ft) 12 (to 1,285 ft) 6.5 (to 1,500 ft)	38' (24-inch) 935' (12-inch)	1,500	980	935 - 975	895 - 900	0-895
PW-1	8/20/2009	34° 30' 46"	115° 28' 13"	875.72	Mud Rotary	36 (to 30 ft) 26 (to 830)	30' (30-inch)	830	820	300 - 800	50 - 830	0-50
5\14-13[1]	6/16/1905	34° 31' 14"	115° 28' 11"	894.86	Unknown	Unknown	Unknown	592	590 (5-inch)	280 - 590	Unknown	Unknown
6\15-1[1]	1/1/1994	34° 38' 23"	115° 21' 22"	1,374.68	Unknown	Unknown	Unknown	799	500 (5-inch)	300 - 793	Unknown	Unknown
6\15-29[1]	1/1/1994	34° 34' 33"	115° 26' 04"	1,136.99	Unknown	Unknown	Unknown	809	809 (5-inch)	305 - 809	Unknown	Unknown
CI-1	1/1/1999	34° 30' 56"	115° 27' 41"	896.96	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 320 ft)	Unknown	320	310 (2")	250 - 310	200 - 320	0 - 20
CI-2	12/1/1998	34° 31' 14"	115° 27' 44"	904.77	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 690 ft)	Unknown	690	420 (2")	300 - 420	250 - 420	0 - 20
CI-3	12/1/1998	34° 30' 46"	115° 28' 14"	876.43	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 800)	Unknown	800	500 (2")	300 - 500	250 - 500	0 - 20
MW-1	1/1/1999	34° 31' 01"	115° 27' 44"	897.02	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 500)	Unknown	500	400 (2")	300 - 400	250 - 400	0 - 20
MW-2	1/1/1999	34° 30' 39"	115° 27' 57"	877.30	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 400)	Unknown	400	400 (2")	300 - 400	250 - 400	0 - 20
MW-3	1/1/1999	34° 30' 50"	115° 27' 25"	897.57	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 550)	Unknown	550	400 (2")	300 - 400	250 - 400	0 - 20
MW-5	1/1/1999	34° 31' 08"	115° 27' 22"	913.30	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 400)	Unknown	400	400 (2")	300 - 400	250 - 400	0 - 20
MW-6	1/1/1999	34° 31' 20"	115° 27' 01"	928.77	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 800)	Unknown	400	400 (2")	300 - 400	250 - 400	0 - 20
MW-7	1/1/1999	34° 31' 38"	115° 26' 54"	940.57	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 600)	Unknown	600	600 (2")	500 - 600	265 - 600	0 - 30
MW-7a	1/1/1999	"	"	"	Track mounted rotary drilling rig	12.25 (to 20 ft) 6.5 (to 600)	Unknown	600	400 (1")	300 - 400	265 - 600	0 - 30
SCE 5[2]	Unknown	34° 28' 18"	115° 32' 37"	686.84'	Unknown	Unknown	Unknown	Unknown	137 (1.5-inch)	49 - 135	Unknown	Unknown
SCE 10[2]	Unknown	34° 28' 22"	115° 29' 59"	748.84'	Unknown	Unknown	Unknown	Unknown	178 (1.5-inch)	47 - 176	Unknown	Unknown
SCE 11[2]	Unknown	34° 25' 51"	115° 27' 25"	672.40'	Unknown	Unknown	Unknown	Unknown	120 (1.5-inch)	84 - 117	Unknown	Unknown
SCE 17[2]	Unknown	34° 29' 55"	115° 31' 58"	731.99'	Unknown	Unknown	Unknown	Unknown	158 (1.5-inch)	148 - 156	Unknown	Unknown
SCE 18[2]	Unknown	34° 26' 37"	115° 34' 59"	631.13	Unknown	Unknown	Unknown	Unknown	79 (1.5-inch)	69 - 79	Unknown	Unknown
21N[1]	1995	34° 30' 36"	115° 30' 35"	793.47	Unknown	42 (to 50 ft) 26 (to 928 ft)	50' (30-inch)	920	920 (16-inch)	250 - 490 570 - 900	250 - 900	0 - 50

Table 1: Production and Monitoring Well Construction Details

Well Designation	Date Completed	Coordinates (NAD83) Latitude	Coordinates (NAD83) Longitude	Elevation (ft msl)	Drilling Method	Borehole Diameter (inches)	Conductor Depth (ft bgs) (Diameter)	Total Borehole Depth (ft bgs)	Cased Depth (ft bgs) (Diameter)	Screened Interval (ft bgs)	Filter Pack Interval (ft bgs)	Seal Interval (ft bgs)
21S[1]	1984	34° 30' 09"	115° 31' 13"	763.03	Unknown	28	40' (30-inch)	790	790 (16-inch)	348 - 778	Unknown	Unknown
22[1]	1994	34° 30' 25"	115° 29' 57"	813.18	Unknown	26	60'	894	890 (16-inch)	320 - 400 580 - 630 670 - 710 740 - 880	Unknown	Unknown
26[1,3]	2020	34°29' 82"	115°29' 43"	813.00	Mud Rotary	34 (50-270ft) 28 (270-1,000ft)	50 (36-inch)	1000	980 (18-inch)	390 - 430 480 - 565 640 - 690 725 - 960	250 - 1,000	0 - 250
27N[1]	1989	34° 29' 46"	115° 30' 02"	790.94	Unknown	28	40' (30-inch)	800	800 (16-inch)	360 - 760	Unknown	Unknown
27S[1]	1989	34° 29' 19"	115° 30' 04"	778.40	Unknown	28	40' (30-inch)	990	990 16-inch)	400 - 900	Unknown	Unknown
28[1]	1987	34° 29' 07"	115° 31' 06"	741.21	Unknown	28	40' (30-inch)	800	800 (16-inch)	400 - 800	Unknown	Unknown
33[1]	1984	34° 28' 32"	115° 31' 09"	729.13	Unknown	28	40' (30-inch)	790	790 (16-inch)	355 - 776	Unknown	Unknown
34[1,3]	2019	34°28' 27"	115°30' 94"	752.00	Mud Rotary	28	50 (36-inch)	1140	1,120 (18-inch)	400 - 470 500 - 1,100	196 - 1,140	0 - 196
35[1,3]	2020	34°28' 54"	115°29' 00"	787.00	Mud Rotary	28	50 (36-inch)	850	830 (18-inch)	420 - 560 580 - 810	200 - 850	0 - 250
Labor Camp	Unknown	34° 31' 24"	115° 30' 50"	785.74	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Office	Unknown	34° 34' 03"	115° 33' 15"	736.64	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Dorm	Unknown	34° 33' 18"	115° 32' 23"	711.49	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Park	Unknown	34° 33' 47"	115° 33' 00"	721.09	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Piute (Ibis)	Unknown	34° 56' 31"	114° 47' 33"	1,457.89	Unknown	26	50	924	860	290 - 840	0 - 860	0 - 50

Notes:
(1) Township/ Range and Section used for well names (ex., 5/14-13 = Township 05N Range 14E Section 13 San Bernardino Baseline Meridian, or 21N = northern area of Section 21) Latitude/Longitude UnkownD83; elevation data UnkownVD88.
(2) Screened Interval Determined from Video Log of Wells - May 2013 ft = foot/feet
(3) Well has not been surveyed yet, elevation was approximated using Google Earth.
ft bgs = feet below ground surface
ft msl = feet (relative to) mean sea level

Table 2: Recent Groundwater Elevations Compared to Baseline

Well	Date for computing adjustment from NAVD27 to NAVD88	Value	Correction (NAVD27 to NAVD88)	Baseline Value NAVD27	Adjusted Baseline Value NAVD88	Maximum Non-pumping GW Level for 2018	Difference (2018 Max Level from Baseline)	Maximum Non-pumping GW Level for 2019	Difference (2019 Max Level from Baseline)	Difference (Between 2018 and 2019)
21N[1,4]	Dec-95	583.15	3.72	584.32	588.04	589.59	1.55	563.02	-25.02	-26.57
21S[2]	Dec-95	583.45	4.09	580.38	584.47	576.73	-7.74	576.73	-7.74	0.00
22[1,4]	Dec-95	587.99	3.01	586.62	589.63	594.64	5.01	594.64	5.01	0.00
27N	Dec-95	571.38	2.45	567.56	570.01	587.96	17.95	588.03	18.02	0.07
27S[3,4]	Dec-95	573.73	2.66	572.57	575.23	585.47	10.24	585.47	10.24	0.00
28	Dec-95	570.39	3.10	565.61	568.71	586.5	17.79	588.94	20.23	2.44
33	Dec-95	572.62	2.79	571.33	574.12	580.33	6.21	581.03	6.91	0.70
5/14-13	Dec-95	603.99	3.46	602.85	606.31	601.19	-5.12	600.62	-5.69	-0.57

Note: Negative values indicate groundwater level rise relative to Baseline levels

[1] Denotes static water levels taken during December 2017 for 2018 and 2019 value as measurments not available in 2018 and 2019.

[2] Denotes January and September 2013 values for Max Non-Pumping Levels for 2018 and 2019 respectively as measurements not available in 2018 or 2019.

[3] Denotes static water levels taken during December 2018 and 2019 values.

[4] Denotes pumping water levels taken during December 2019.

Table 3: 2019 TDS Values for Group 1 Wells

	21N	21S	22	27N[1]	27S	28[1,2]	33[1,2]	34[3]	SCE-5[2]	5/14-13[2]
Date Sampled	TDS (mg/L)									
3/22/2019	-	-	280	-	-	230	-	-	300	220
6/26/2019	260	260	290	790	-	230	-	-	290	220
10/3/2019	290	-	290	740	280	230	-	-	300	280
12/19/2019	280	260	280	630	290	210	330	250	310	260
Average TDS Value in 2019	277	260	285	720	285	225	330	250	300	245

Note: All TDS values are derived from laboratory analysis

(1) Sampled with bailer after 2012

(2) Sampling port became lodged or could not collect sample after 2017

(3) Well 34 was sampled at the end of the constant rate aquifer pumping test on 12/19/19 shortly after being constructed.

APPENDIX A

MONTHLY GROUNDWATER EXTRACTION TOTALS

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Monthly Irrigation Well Groundwater Production								
Year	Month	Well 21N	Well 21S	Well 22	Well 27N*	Well 27S	Well 28	Well 33
2019	January	16.60	8.83	17.37	0.00	11.75	0.00	0.00
2019	February	27.41	3.90	27.83	0.00	0.00	0.00	0.00
2019	March	42.69	3.54	31.28	0.00	0.77	0.00	0.00
2019	April	60.00	94.55	76.78	0.00	4.73	0.00	0.00
2019	May	43.21	52.52	50.72	0.00	46.59	0.00	0.00
2019	June	55.61	108.23	23.73	0.00	64.91	0.00	0.00
2019	July	81.98	115.05	35.66	0.00	80.80	0.00	0.00
2019	August	120.25	99.61	50.33	0.00	94.92	0.00	0.00
2019	September	103.67	38.43	52.56	0.00	93.66	0.00	0.00
2019	October	121.53	0.00	32.03	0.00	95.04	0.00	0.00
2019	November	70.98	50.11	14.22	0.00	52.75	0.00	0.00
2019	December	20.93	48.38	61.19	0.00	90.75	0.00	0.00

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