TODD GROUNDWATER

June 12, 2019

MEMORANDUM

To: Mr. Mark Chow, PE
County of San Mateo
555 County Center, 5th Floor
Redwood City, California 94063-1665

From: Daniel J. Craig. PG, CHG
Amber Ritchie, PG

Re: **Source Water Capacity Assessment**
CSA 11 Pescadero Water System
San Mateo County

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The County of San Mateo Department of Public Works (County) recently constructed a new supplemental groundwater production well (Well No. 3) near the town of Pescadero for the Pescadero Water System, County Service Area No. 11(CSA 11). The new well was constructed to augment or replace two nearby existing wells (Wells Nos. 1 and 2) operated by the County.

The need for a supplemental well was determined based on slowly but steadily-declining groundwater elevations in the existing CSA 11 wells over the past three decades. Between 1991 and 2002, levels in the existing wells declined at a rate of around one foot per year (ft/year - Todd Engineers, 2002), and levels continued to decline at a rate of around 0.5 ft/year between 2002 and 2018 (see below). The 2002 Todd Engineers report recommended that a deeper production well be installed to allow pumping from a greater saturated thickness of aquifer and provide extended lifespan capacity should water levels continue to decline in the future.

Todd Groundwater (Todd) performed an evaluation of the potential long-term yield of the new well, along with the existing wells. The yield estimates are based on information generated during drilling and testing of the new well, characteristics and operational performance of the existing wells, and other available hydrogeologic information. The long-term yield of the aquifer itself is dependent on numerous parameters including subsurface properties and on future precipitation and associated aquifer recharge, along with future pumping by other nearby groundwater users.

The hydrogeology of the study area (the area shown on **Figure 1**) was evaluated based on driller's logs for other nearby wells obtained from the California Department of Water Resources (DWR), well depths, reported capacities, and topographic and geologic maps. We evaluated available pumping capacity and historical water level trends for the existing County wells. Results of step-drawdown and constant-rate pumping tests of the new well also were analyzed.

The yields of the County wells (individually and collectively) are dependent on 1) the hydraulic characteristics of the aquifer (aquifer thickness, transmissivity, and storage properties), 2) the aquifer extent and boundary conditions, 3) amounts and distribution of natural recharge, and 4) the construction and hydraulic efficiencies of the well(s). Because the well efficiencies and aquifer hydraulic characteristics are essentially constant and given the ridgetop location and hydrogeologic regime of the bedrock aquifer, the future yields and longevity of the wells ultimately may be controlled by amounts of precipitation, aquifer recharge, and nearby pumping.

The following sections describe the hydrogeologic conditions of the study area, characteristics of other nearby wells, and characteristics and pumping performance of the new and existing wells. Conclusions are presented regarding the well system yield and capacity.

1. Study Area Hydrogeology and Local Well Characteristics

The hydrogeologic characteristics of the Pescadero area were evaluated based on published reports, maps, hydrologic data, driller's logs and completion reports for nearby wells, reported yields and capacities of nearby wells, and historical pumping and water level data for existing Wells Nos. 1 and 2.

A previous study of the Pescadero hydrogeology and County Wells Nos. 1 and 2 was conducted by Todd in 2002 (Todd Engineers, 2002). The Todd report summarized hydrogeologic conditions, aquifer characteristics, and historical groundwater level, groundwater quality, and well pumping data, and included a recommendation to install a third deeper well to pump from a thicker interval of the aquifer. A water supply alternatives evaluation was also prepared by Kennedy/Jenks consultants (K/J, 2003) that evaluated surface and groundwater supply sources and recommended installation of a third well. Two well installation and pump testing reports prepared by Geoconsultants, Inc. (1991, 1992) for the Bay City Flower 75-Acre Parcel just south of the CSA 11 wells were also reviewed.

Figure 1 shows the location of the study area and CSA 11 wells. The new and older CSA 11 wells are located along a north-south trending ridgeline, referred to as Butano Ridge. The topographic elevation contour lines on the figure show the geometry of the ridge. The ridge is bordered by Highway 1 and the Pacific Ocean on the west and Pescadero and Butano creeks on the north and east. A third creek, Arroyo de los Frijoles, is located south of the ridge and bisects the ridge. The County wells are located near the top of the ridge, at a land surface elevation of approximately 275 feet above mean sea level (ft amsl). Higher elevations occur along the ridge to the southeast of the County well locations.

Groundwater in the area occurs in two low- to moderately-yielding aquifers: 1) recent unconsolidated alluvium deposited adjacent to and within the valleys of Pescadero and Butano creeks, and 2) semi-consolidated to consolidated materials of the Cretaceous-aged Pigeon Point Formation, a fractured sandstone/siltstone. A third geologic formation, referred to as marine terrace deposits, exists as a thin veneer overlying the Pigeon Point Formation. The San Andreas fault system trends in a south/southeast to north/northwest direction through the area, just east of Butano Ridge (**Figure 1**).

The recent alluvium occurs in the creek valleys, and consists of interbedded gravel, sand, silt, and clay. The sand and gravel units are permeable but thin, reportedly limited to a thickness of around 50 feet.

The existing and new County wells are completed in the older Pigeon Point Formation. The Pigeon Point Formation is mainly composed of jointed or fractured sandstone (and occasional conglomerate) interbedded with siltstone and mudstone. Although the permeability of the Pigeon Point Formation is significantly lower than the recent alluvium, groundwater storage in the formation is greater. Based on drillers logs for deep wells drilled in the study area, the saturated thickness of the Pigeon Point Formation is several hundreds of feet thick.

Numerous domestic and irrigation wells have been installed in the study area. We obtained drillers logs of nearby wells from DWR and reviewed the hydrogeologic information and well characteristics documented in the logs. **Figure 2** shows the locations and depths of the wells completed in the Pigeon Point Formation and adjacent Butano Creek alluvium. The wells are installed to different depths, ranging from 12 to 780 feet below ground surface (ft bgs). Yields of nearby wells (as documented on the DWR Well Completion Reports) are relatively low. One measure of the well yields and hydraulic efficiency is well specific capacity, or the pumping rate of the well divided by the water level drawdown in the well. **Figure 3** shows the reported well specific capacities of nearby wells and CSA 11 Wells Nos. 1 and 2. Specific capacities of nearby wells range from less than 0.01 gallons per minute per foot of drawdown (gpm/ft) to 0.6-0.7 gpm/ft for a pair of wells near the coast. Specific capacities of the five wells at the nearby 75-acre site south of the CSA 11 wells range from 0.04 to 0.17 gpm/ft. The specific capacities of County Wells Nos. 1 and 2 at the times of their installations were 3.4 and 5.2 gpm/ft, or almost an order of magnitude higher than most other nearby wells. The pumping test conducted in August of 2018 showed new Well No. 3 to have a specific capacity of 4.44 gpm/ft (see **Section 4**), like the specific capacities of the two older CSA 11 wells.

Groundwater flow within the study area can be inferred from estimated groundwater elevations in existing wells. Although no recent regional groundwater monitoring of water level elevations has been conducted, depths to groundwater originally reported on some of the DWR well completion reports are available. **Figure 4** shows the reported depths to water at the times the wells were installed, spanning a range of dates. Depths to water ranged from generally less than 50 feet near the coastline and along Butano Creek, to over 100 feet in wells installed near the ridgetop, including the existing CSA 11 wells, which currently have depths to water of around 200 feet.

Figure 5 illustrates estimated groundwater elevations, based on the reported depths to water and estimated ground surface elevations. The estimated groundwater elevations shown are based on the depths to water reported on the well completion forms at the time each well was drilled, and therefore span a range of dates. Included on Figure 5 are inferred groundwater elevation contours, which indicate the directions of groundwater flow from higher to lower elevations. Note that the estimated groundwater elevations and inferred contours are considered approximate, due to uncertainties in well elevations and the large date range of the depth to water measurements. In general, the water table surface parallels the ground surface, with higher groundwater elevations near the top of the ridge, and lower elevations water levels along the bases of the ridge. This groundwater elevation pattern is referred to as a groundwater mound. Groundwater flows from higher to lower elevations from near the top of the ridge to lower elevations on either side. Groundwater inflow to the CSA 11 well area also occurs from higher water table elevations under Butano Ridge to the south and southeast of the CSA 11 wells. The potential cone of depression around the CSA 11 wells is illustrated with the 100-foot contour that indicates convergent inflow to the wells.

Figure 6 is an east-to-west oriented cross-section view through Butano Ridge showing the CSA11 wells and nearby wells, along with 2002 and 2018 groundwater elevations in the CSA 11 wells and in groundwater elevations in nearby wells at the dates that they were installed. The larger depths to water in the CSA wells may indicate a pumping cone of depression around the CSA wells due to their continuous pumping operations, as illustrated by the inferred 2002 and 2018 water table lines. However, groundwater elevations in the CSA 11 wells remain well above sea level and are protected from seawater intrusion by the groundwater mound that causes outflow of groundwater beneath the Ridge to the ocean.

There is a finite amount of groundwater present in the mound beneath Butano Ridge that is available for production. The long-term sustainable production rate of the aquifer and CSA 11 well(s) is dependent on the amounts of recharge to the local mound, the amount of pumping by nearby wells, and other factors (see **Section 5**). Because of its isolated hilltop location, groundwater replenishment of the upper portions of the aquifer primarily occurs via infiltration of precipitation. Subsurface inflow to the lower portions of the aquifer (near or below sea level) also may occur from adjacent bedrock and alluvial aquifer areas. The annual amounts of recharge have not been estimated, but likely vary from year-to-year, depending on rainfall amounts. Development of accurate recharge estimates and sustainable yield of the aquifer would require significant new data collection and analysis, including determination of rainfall distributions, soil types and properties, topographic and slope analysis, the three-dimensional distribution of aquifer properties, groundwater levels across area, characterization of the amounts and distribution of other well pumping, and the analysis would require use of calibrated rainfall-runoff and numerical groundwater flow models.

2. Characteristics and Historical Operation of Existing Wells Nos. 1 and 2

Existing Wells Nos. 1 and 2, installed in 1992 and 1983, respectively, have supplied water to CSA 11 since the system was put in service. Well No. 1 has served as the primary well, with Well No. 2 serving as backup. Well No. 2 is permitted for use only during emergency situations. The wells are located on Butano Ridge, with Well No. 1 approximately 150 feet north of Well No. 2 (**Figure 7**).

Table 1 summarizes the characteristics and construction specifications of the existing wells. Both wells are constructed of PVC casing and screen, with 40-foot long screened intervals near the current water table elevation.

Table 1. Characteristics of CSA 11 Wells Nos. 1 and 2

CSA 11 Well Designation	Well No. 2	Well No. 1
Date Developed	Apr-83	Jan-92
Borehole Depth (feet bgs)	280	260
Final Well Depth (feet bgs)	247	260
Borehole Diameter (inches)	12	16
Casing Diameter (inches)	6	10
Casing and Screen Material	PVC	PVC SDR-21
Screened Interval (ft bgs)	207-247	210-250
Screen Size (inch)	0.040	0.040
Drilling Method	Mud Rotary	Mud Rotary
Drilling Company	Earthflow Drilling	Maggiora Brothers

The County routinely monitors total production, water levels under static and dynamic conditions, and groundwater quality, and has documented these parameters in monthly reports to the State Water Resources Control Board - Division of Drinking Water (DDW) for the Town of Pescadero Water System (Bracewell Engineering, monthly reports for County Service Area No. 11 No. W4100582 for January 2011 through July 2018). Groundwater production for Well No. 1 is tracked using a totalizing flow meter, which is inspected and recorded approximately twice a week. Water levels and water quality are monitored monthly as required by DDW.

Table 2 shows estimated annual water use for CSA 11 for the past five years, based on two sources: 1) meters at site address of CSA 11 customers; and 2) the well totalizer meter.

Table 2. CSA 11 Annual Groundwater Production		
Year	**Customer Water Meters (gpm)**	**Well Meter (gpm)**
2013	14.32	22.12
2014	13.27	19.86
2015	12.36	17.39
2016	12.16	17.65
2017	14.71	14.96

Total annual use over this period was relatively constant, ranging from 12.16 gallons per minute (gpm) during 2016 (or 19.6 acre-feet per year – AFY) to 14.71 gpm during 2017 (23.7 AFY). The peak water use between 2013 and 2017 occurred in August and September 2013, when an average of 19.4 gpm was used. The water use rates from customer meters are lower than pumping rates recorded by the CSA 11 well totalizing flow meter. The differences are attributed to non-metered water use for fire protection, pipeline flushing, water system pipeline losses/leaks, differences in reporting periods, and water meter inaccuracies. It was observed that the well meter was replaced in 2017, and the estimated 2017 use rates from customer meters and the well meter are more closely correlated than during previous years. Well No. 1 operates in on/off cycles, with produced water pumped directly to the existing 140,000-gallon storage tank (Tank No. 1) located approximately 800 feet north of the pumping wells (**Figure 7**). Well No. 2 is permitted for use only during emergency situations. Tank No. 1 has a diameter of 39 feet, with high- and low-level switches set at 15 and 13 feet, respectively. When Well No. 1 is operating, it typically pumps at rates of around 60 or 70 gpm for periods of approximately 4 hours, until the high-level in the storage tank is reached and the cycle fill volume of around 17,900 gallons is pumped. The well operating times are tracked and typically the wells are actively pumping about 25 % of the time. Note new Tank No. 2 has a diameter of 42 feet and associated larger storage capacity. Future operation of the well system and storage tanks is further discussed in Section 5.

The average water use between 2013 and 2017 is similar to the average historical use rate of 16 gpm between 1993 and 2001 (Todd, 2002), indicating current CSA 11 customer water demand is relatively constant or has declined slightly over time.

Figure 8 shows water level trends in the CSA 11 wells from 2002 to 2018. Groundwater elevations in Well No. 1 generally were measured monthly during this period whereas water levels in Well No. 2 have been measured only since 2014. Both static levels and levels during active pumping are measured. The hydrograph shows static water levels; pumping levels are typically 10-15 feet lower in each well when they are operating. The hydrograph shows that water levels in Well No. 1 declined approximately 8 feet over this 16-year period, at an average rate of approximately 0.5 foot per year (ft/yr). Except for seasonal fluctuations, water levels in Well No. 1 declined almost linearly between 2002 and 2014. Between January 2014 and June 2018, water levels in Well No. 1 stabilized slightly, while Well No. 2 showed water level declines of approximately one foot per year from January 2014 to January 2018. The stabilization of groundwater levels in Well 1 may be in response to lower annual water use during this period and above-average precipitation (and associated groundwater recharge) during Water Year 2016-17. Water levels in both wells have been relatively stable over the past 12 months.

Due to the declining water levels, the pump intake in Well No. 1 was lowered approximately 25 feet in 2011 to ensure groundwater could continue to be produced from the well. If levels continue to decline, eventually they will reach the current pump intake rendering it intermittently inoperable.

3. Well No. 3 Drilling and Construction

The new well (hereafter referred to as Well No. 3) was drilled and constructed during May through August 2018 by Maggiora Brothers Drilling, Inc. (Maggiora), under subcontract to Fort Bragg Electric, Inc. the prime contractor for the CSA 11 New Well and Storage Tank Project. New Well No. 3 is located 56 feet west-southwest of Well No. 1.

An initial attempt to construct a new well (referred to as Well No. 3-Original Site) was made during the summer of 2017. Well No. 3- Original Site is located approximately 1,000 feet north of the final Well No. 3 location, near the water storage tanks (**Figure 7**). The borehole for Well No. 3- Original Site was drilled to a depth of 300 feet bgs and the well was completed to a total depth of 260 feet bgs, with a screened interval of 110 to 250 feet bgs. However, during well development, the sustainable pumping rate was low (less than five gpm) and could not meet the target flow rate required for the new well. Accordingly, in 2018 Well No. 3 was re-drilled at the alternative site location in 2018.

Table 3 summarizes the characteristics of Well No. 3 in comparison with Wells Nos. 1 and 2. An 8 3/4-inch pilot borehole was drilled on May 23 and 24, 2018 to a depth of 370 ft bgs using an air-rotary drilling rig. After geophysical logging, the borehole was over-drilled to an 18-inch diameter using a mud-rotary system. A 10-inch diameter mild steel casing and stainless-steel wire-wrapped screen were installed with a screened interval of 250 to 350 feet bgs. A 10-foot tail-section of blank casing was installed beneath the screen bringing the total well depth to 360 ft bgs.

Table 3. Characteristics of CSA 11 Wells Nos. 1-3

	Well No. 2	Well No. 1	Well No. 3
Dates Drilled and Constructed	Apr-83	Jan-92	May-August 2018
Borehole Depth (feet bgs)	280	260	370
Final Well Depth (feet bgs)	247	260	360
Borehole Diameter (inches)	12	16	18
Casing Diameter (inches)	6	10	10

Table 3. Characteristics of CSA 11 Wells Nos. 1-3 (continued)			
Casing and Screen Material	PVC	PVC SDR-21	Mild Steel Casing/Stainless Steel Wire Wrap Screen
Screened Interval (ft bgs)	207-247	210-250	250-350
Screen Size (inch)	0.040	0.040	0.040
Drilling Method	Mud Rotary	Mud Rotary	Air and Mud Rotary
Drilling Company	Earthflow Drilling	Maggiora Brothers	Maggiora Brothers

A 2-inch steel sounding tube and 3-inch steel gravel fill pipe were constructed in the annular space, and Colorado Silica Sand (No 8/16) was used to gravel-pack the annulus between the casing/screen and boring wall. A bentonite plug seal was emplaced above the gravel pack, and a cement grout was used to seal the well. The well was developed by a combination of surging, swabbing, bailing, and pumping at rates of up to 120 gpm for a period of several days prior to initiation of step-drawdown and constant-rate pumping tests.

4. Well No. 3 Pumping Tests

Step-drawdown and constant-rate pumping tests of Well No. 3 were conducted between August 24 and 28, 2018. Maggiora installed a temporary electrical submersible pump in Well No. 3 and operated the pump during the tests. Temporary discharge piping was installed to direct water to an onsite discharge area. A butterfly valve and totalizing flowmeter were used to control and measure the discharge rate during the tests. Flow measurements and water levels in the pumping well were recorded by Maggiora, and Todd conducted water level monitoring of Well No. 1 during the constant-rate test.

The step-drawdown test was conducted on August 24, 2018. Well No. 3 was pumped at rates of approximately 60, 80, 100, and 120 gpm for durations of approximately one hour each. **Figure 9** shows the water level responses in Well No. 3 during step-drawdown test. The static water level at the beginning of the step test was 195.0 feet below the top of the well casing, and drawdowns at the end of each step were approximately 14, 18, 23 and 28 feet, respectively. The specific capacity (yield/drawdown) remained essentially constant at approximately 4.44 gallons per minute per foot of drawdown (gpm/ft) during each differential pumping period, indicating the new well is hydraulically efficient at these pumping rates with little or no frictional head loss at the higher rates.

The constant-rate test was conducted on August 27 and 28, 2018. During the test, Well No. 3 was pumped at an average rate of 103 gpm for approximately 21 hours. **Figures 10** and **11** shows the water level drawdown and recovery responses in Wells Nos. 3 and 1 respectively during the pumping and recovery periods. Total drawdown at the end of the pumping period was approximately 24.3 feet in the pumping well and 3.12 feet in Well No. 1. This corresponds to a specific capacity of 4.24 gpm/ft. After pumping was stopped, Well No. 3 quickly recovered to static, and Well No. 1 also showed a relatively rapid recovery response.

Figures 12 and **13** show semi-logarithmic plots of drawdown in Wells Nos. 3 and 1, respectively. In accordance with well hydraulics theory, water level drawdowns in both wells plot along a straight line (on a semi-logarithmic time scale). A decrease in the rate of drawdown was observed in Well No. 3 after approximately 300 minutes of pumping (5 hours), although water level measurements in the pumping well after this period may be inaccurate. Water level drawdown in Well No. 1 plots as a straight line after 10 minutes into the test. **Figure 14** shows a "residual drawdown" water level recovery curve for Well No. 1. Like the drawdown plots, later-time recovery data also plot along a straight line.

The water level drawdown data for Wells Nos. 3 and 1 and recovery data for Well No. 1 were evaluated using the Cooper-Jacob method (Driscoll, 1986) to estimate the aquifer transmissivity, hydraulic conductivity, and storativity. **Table 4** summarizes the estimated aquifer hydraulic properties for the pumping test. Based on the range of observed delta S values (0.34 to 0.81 feet per log cycle) from the drawdown and recovery curves, the estimated aquifer transmissivity ranges from 33,700 to 80,300 gallons per day per foot (gpd/ft) [or 4,500 to 10,700 feet^2/day]. Assuming an aquifer thickness of 100 feet (the screened interval length of Well No. 3), the hydraulic conductivity of the aquifer ranges from 45 to 107 feet/day. Note that the aquifer thickness contributing inflow to the well may be greater than 100 feet as groundwater in aquifer zones above and below the screen may flow vertically into the well. The estimated aquifer storativity is 1.1×10^{-5}, indicative of a fractured bedrock aquifer. The specific capacity of Well No. 3 is estimated to be 4.24 gpm/ft.

Table 4. Summary of Aquifer Hydraulic Characteristics

Well No.	Test Phase	ΔS	Transmissivity		Saturated Thickness	Hydraulic Conductivity		Storativity
		(feet)	(gpd/ft)	(ft^2/day)	(feet)	(gpd/ft^2)	(ft/day)	(-)
3	DD	0.81	33,700	4,500	100	337	45	-
1	DD	0.45	60,600	8,100	100	606	81	1.1×10^{-5}
1	Rec	0.34	80,300	10,700	100	802	107	-

Notes: Pumping rate was 103 gpm. **Δ**S - water level drawdown per log cycle. DD – drawdown. Rec – recovery. Storativity only calculated from drawdown in observation well.

These values are similar to the aquifer property estimates from a September 2001 pumping test of CSA Well No. 1, which indicated a transmissivity of 26,000 gpd/ft and storativity of 2.5×10^{-5} (Todd, 2002). The smaller transmissivity estimated for the 2001 Well No. 1 pumping test is in part due to the shallower well depth and smaller aquifer thickness for Well No. 1 as compared with Well No. 3. Transmissivities estimated for other nearby wells (including at the 75-acre parcel south of the CSA 11 wells) are lower, consistent with the reported lower specific capacities for nearby wells (**Figure 3**).

Based on the Well No. 3 pumping tests, the overall hydraulic efficiency and yield of the well are relatively high. The sustainable yield of the well appears to be greater than 100 gpm. Assuming the well pump intake is set at 240 ft bgs (or 10 feet above the top of the well screen) and the static water level is 195 ft bgs, the available drawdown in Well No. 3 is 45 feet. Given the well's specific capacity of 4.24 gpm/ft, the short-term yield of the well may be as high as 190 gpm, which greatly exceeds both average and peak daily demand.

5. Future Demand and Groundwater Supply

As described in Section 2, the total annual use over the past five years for CSA 11 was relatively constant, ranging from 12.16 to 14.71 gpm. Peak short-term use over this period was 19.4 gpm. Future water use is projected to remain relatively constant without any change to CSA 11 boundaries or significant change in property usage (County of San Mateo, 2013).

The short-term yield of new Well No. 3 is estimated to be as high as 190 gpm. Well Nos. 1 and 2 will remain serviceable, and an additional 60 to 70 gpm can be supplied by those wells, if permitted by DDW. Along with the storage provided by the CSA 11 water tanks the well and storage capacity greatly exceeds the average and peak short-term water use.

Table 5 lists the characteristics of storage Tanks Nos. 1 and 2, including high- and low-level switch set points and fill volume capacities between the points.

Table 5. Characteristics of CSA 11 Storage Tanks Nos. 1 and 2

	Set Points (feet)	Tank No. 1 Storage (gallons)	Tank No. 2 Storage (gallons)	Combined Storage (gallons)
Low Alarm	10.0	89,362	101,643	191,005
Start	13.0	116,170	132,136	248,306
Stop	15.0	134,042	152,465	286,507
High Alarm	15.6	139,404	158,563	297,967

Tanks Nos. 1 and 2 have a total combined capacity of almost 298,000 gallons. However, CSA 11 intends to maintain a storage volume of approximately 191,000 gallons in the tanks and operate the well(s) when the water levels in the tanks reach 13.0 feet.

Table 6 lists the times required to fill the tanks between the various tank levels with Well No. 3 operating at different pumping rates.

Table 6. Combined Tanks Nos 1 and 2 Fill Times for Various Well Pumping Rates				
	Fill Time (minutes) Well at 140 gpm	**Fill Time (minutes) Well at 120 gpm**	**Fill Time (minutes) Well at 100 gpm**	**Fill Time (minutes) Well at 80 gpm**
Combined Tanks Nos. 1 and 2 Total Capacity	2,128	2,483	2,980	3,725
Combined Tanks Nos. 1 and 2 Low-High Levels	764	891	1,070	1,337
Combined Tanks Nos. 1 and 2 Start-Stop Levels	273	318	382	478

As listed in Table 6, the time required to completely fill both tanks when empty is 2,128 minutes (1.5 days) when Well No. 3 is operating at 140 gpm, and 3,725 minutes (2.6) days when the well is pumping at 80 gpm. However, assuming CSA 11 maintains a storage volume of approximately 191,000 gallons in the tanks, and only operate the well(s) between the start and stop levels of 13.0 and 15.0 feet (a total volume of 38,200 gallons), the times required to fill the tanks between these levels are 273 minutes (4.5 hours) for the well pumping at 140 gpm and 478 minutes (8 hours) when the well is pumping at 80 gpm. Thus, pumping can be performed during evening off-peak hours, when electrical power costs may be lower.

Long-term operation of the CSA 11 well system also depends on the sustainable yield of the aquifer and based on the historical water level trends in Wells Nos. 1 and 2, the aquifer sustainable yield may be lower than the short-term well capacities. The sustainable yield of the aquifer is dependent on not only the well capacities, but the amounts of recharge to and discharge from the aquifer system. The recharge and discharge amounts are often described in the form of a water balance, which provides an accounting of the inflows and outflows of an aquifer. Major inflows to the Butano Ridge aquifer and CSA 11 wells area include percolation of rainfall, irrigation return flows, subsurface inflow from higher elevations bordering the well area, and for the lower portions of the aquifer potentially infiltration from the nearby creeks. Major outflows include groundwater pumping by CSA 11 and other nearby groundwater users, groundwater outflow to the creeks, and subsurface outflow. Known groundwater pumping from Butano Ridge includes CSA 11, and groundwater likely is pumped by adjacent property owners for domestic and irrigation uses, but those amounts are unknown. Nonetheless, groundwater level data show a sustained decrease in groundwater storage that indicates a local imbalance of outflow over inflow.

Because development of a comprehensive water balance is beyond the scope of this study, the supply longevity was estimated by extrapolating the relatively uniform historical rate of water level decline into the future. Assuming the rates of CSA 11 pumping and of groundwater level decline remains constant at around 0.5 feet per year, the pump intake for new Well No. 3 is set at 240 ft bgs (or 10 feet above the top of the well screen) and available drawdown in Well No. 3 is 45 feet, then the longevity of the well is estimated to be 90 years. However, it is possible that the rate of groundwater level decline may increase in the future, if rates of recharge to the Butano Ridge aquifer decrease and/or nearby pumping by other groundwater users increases.

The future yield and longevity of the well system is in part dependent on local rates of recharge and discharge. Groundwater recharge has and will continue to be a function of the amounts and distribution of rainfall. Uncertainty in future climatic conditions (increased or decreased rainfall) due to climate change increases the unpredictability of further recharge rates and system longevity. The DWR, California Department of Public Health (CDPH), and other state and federal agencies are currently evaluating potential impacts of climate change on water resources of the state and San Mateo County (CDPH, 2017; DWR, 2018; DWR and US Environmental Protection Agency, 2011). Current (2017) CDPH climate models for the Bay Area Region predict that changes in rainfall patterns may occur, with a moderate decline in annual rainfall, 1 to 3 inches by 2050 and 4 to 5 inches by 2090, projected throughout the region (CCSM3 climate model, high carbon emissions scenario – CDPH, 2017). In addition, air temperatures are predicted to increase statewide, which will result in higher rates of water evaporation and potentially less infiltration and groundwater aquifer recharge. In the Bay Area Region, an increase in average temperature of 2°F and maximum increase of up to 5°F are predicted by 2050 for January periods. In July, an average increase in average temperature of 4°F is predicted by 2050 and up to more than 6°F is predicted by 2100 (CDPH, 2017). The combination of potential decreased rainfall (and associated decreased groundwater recharge) and increased air temperature (and associated increased evapotranspiration and possible increased outdoor water use) may result in less groundwater supply and greater demand.

CSA 11 water supply sustainability can be partially managed through operational actions, such as future lowering the pump in Well No. 3, or by developing additional local water supply sources (groundwater and/or surface water). It is also possible that the water table decline may stabilize or equilibrate, as a cone of depression may have developed or may continue to develop around the CSA 11 wells to the degree that causes increased local hydraulic gradients and associated increased groundwater inflow from adjacent areas of the aquifer.

It is recommended that the County continue to routinely monitor and evaluate discharge rates, water levels, and water quality in the CSA 11 wells, and plan for measures to ensure long-term supply sustainability. System monitoring and performance data should be routinely reviewed and evaluated by County staff or a contractor, to identify any undesirable trends as they occur and plan for mitigation measures. It is also recommended that CSA 11 limit future expansion of the service area boundary and associated increased water demand, at least until an alternative water source is identified and developed.

Attachments:

Figure 1 – Study Area Geology and Topography
Figure 2 - Nearby Well Depths
Figure 3 – Nearby Well Specific Capacities
Figure 4 – Depths to Water
Figure 5 – Groundwater Elevations
Figure 6 – Hydrogeologic Cross-Section
Figure 7 – Existing and New CSA 11 Wells and Tanks
Figure 8 – Long-Term Hydrograph of Wells Nos. 1 and 2
Figure 9 – Well No. 3 Step Test
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Figure 12 – Well No. 3 Drawdown - Constant-Rate Pumping Test
Figure 13 – Well No. 1 Drawdown - Constant-Rate Pumping Test
Figure 14 – Well No. 1 Residual Drawdown - Recovery Test

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Todd Engineers, 2002. Assessment of Source Water for the Pescadero Water System CSA 11. Prepared for San Mateo County Department of Public Works. March.

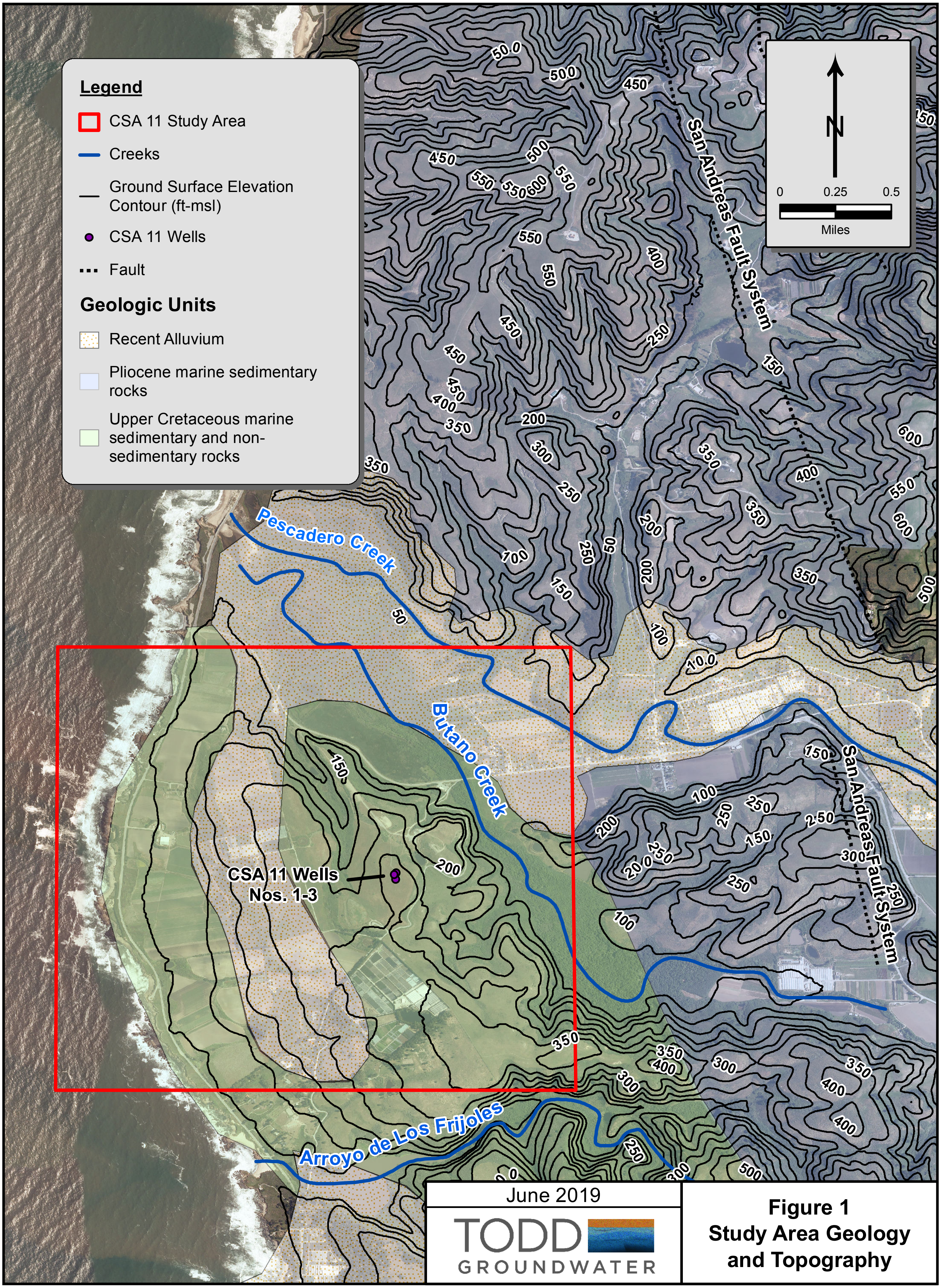

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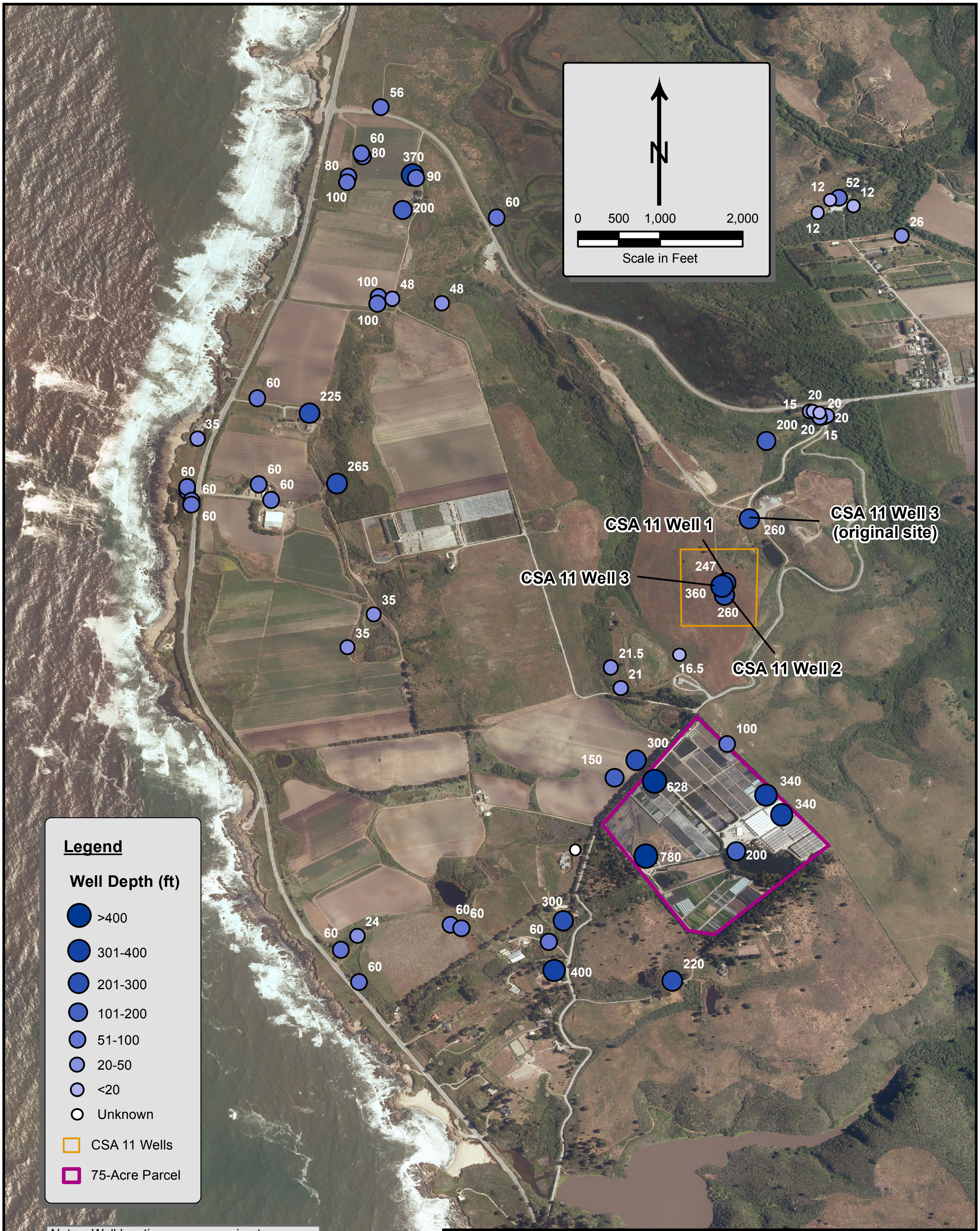
Figure 1
Study Area Geology and Topography



Notes: Well locations are approximate and based on Township Section listed on DWR well log, except for CSA 11 wells and wells at 75-acre parcel sited from well completion report map (Geoconsultants, 1992)

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Figure 2
Nearby Well Depths

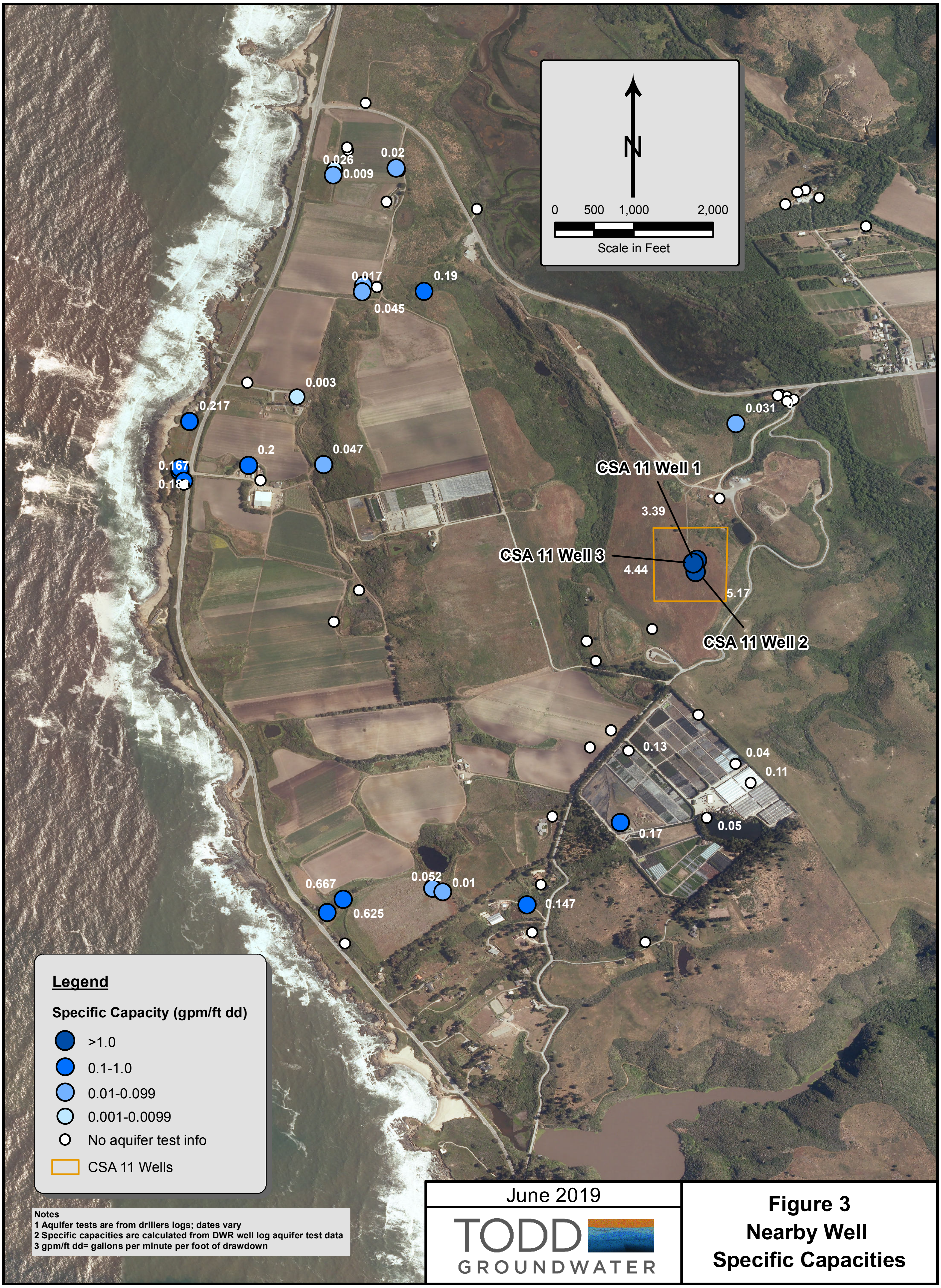

Figure 3
Nearby Well Specific Capacities

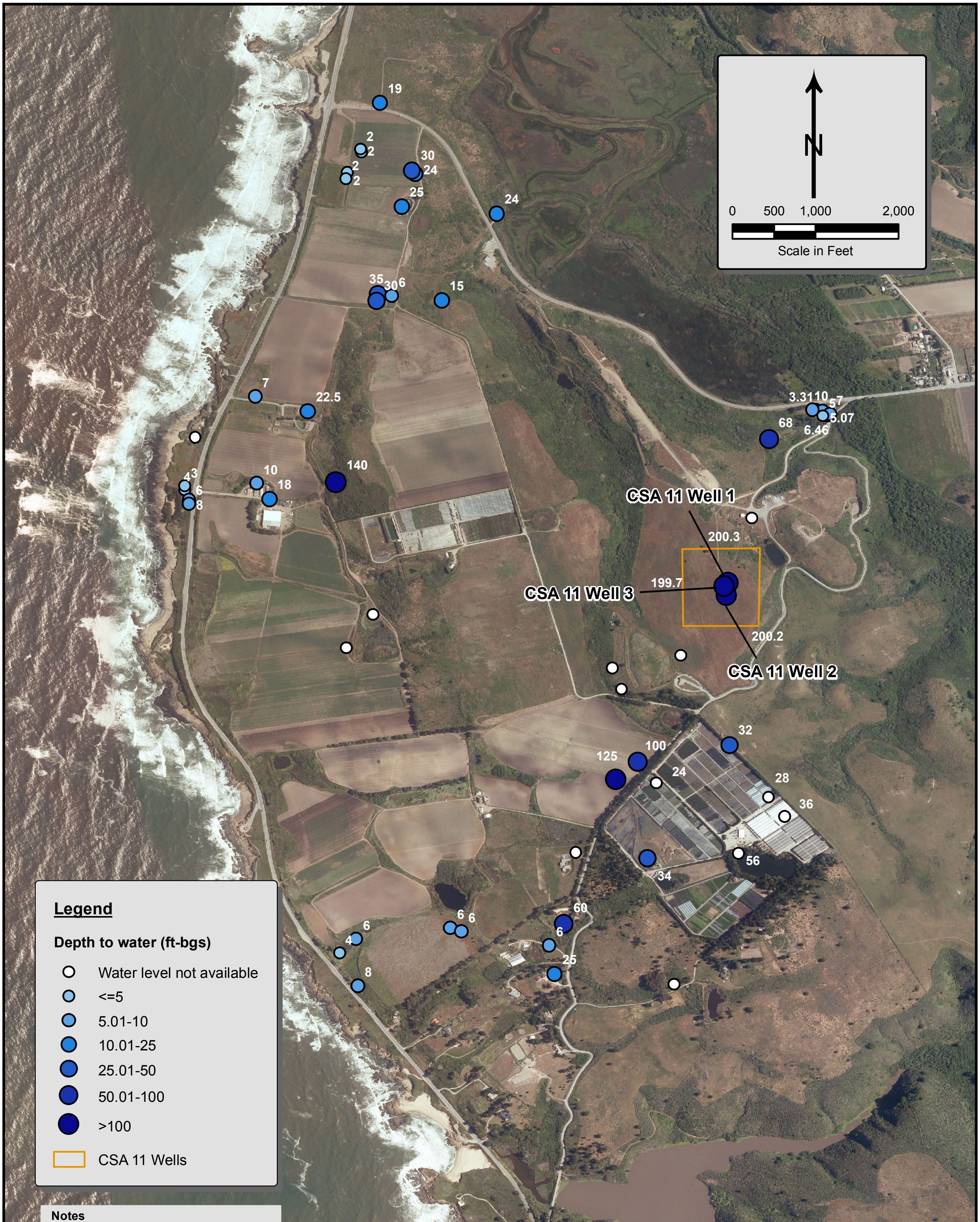

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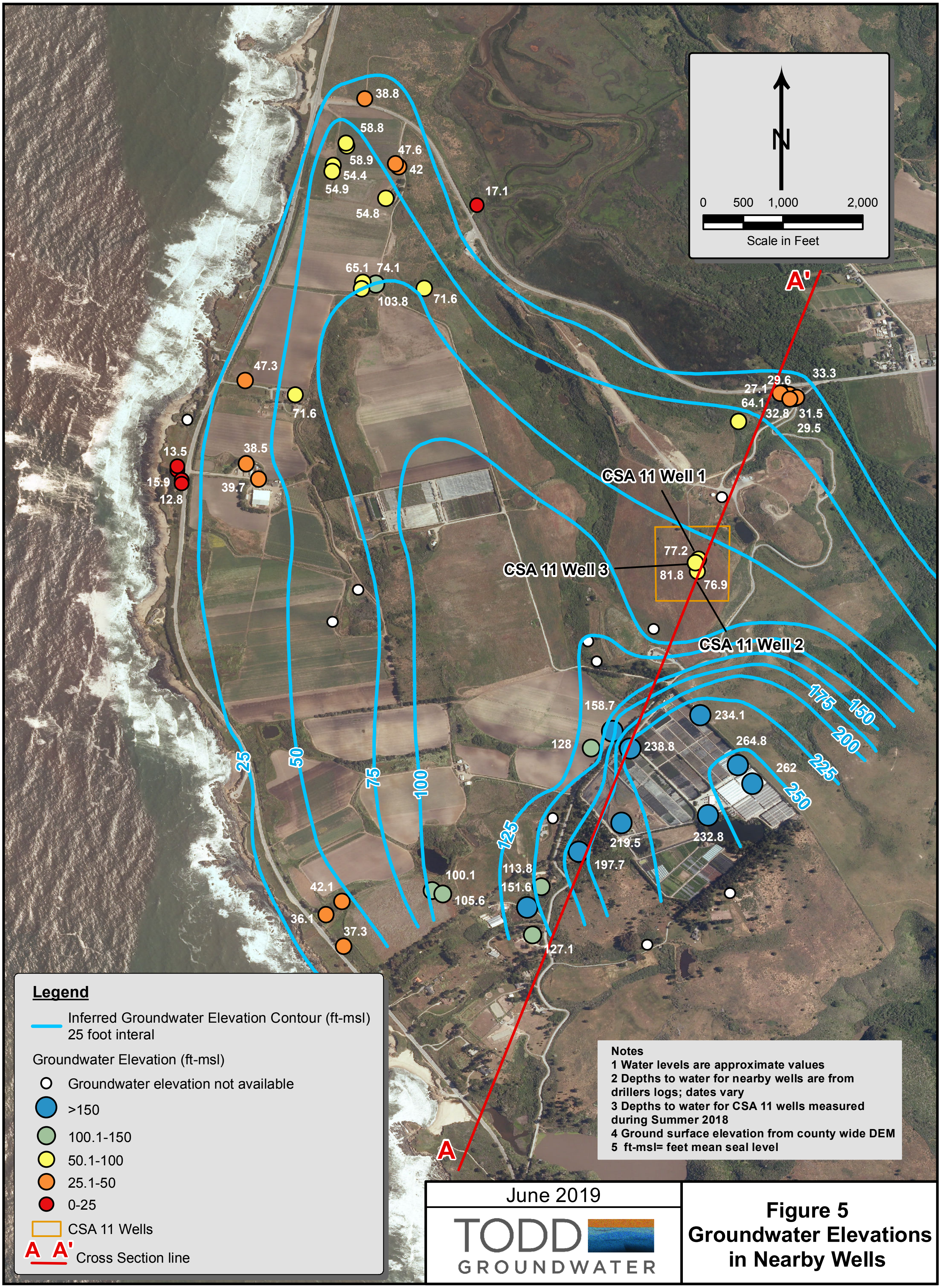
Figure 4
Depths to Water in Nearby Wells



Notes
1 Water levels are approximate values
2 Depths to water for nearby wells are from drillers logs; dates vary
3 Depths to water for CSA 11 wells measured during Summer 2018
4 Ground surface elevation from county wide DEM
5 ft-msl= feet mean seal level

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Figure 5
Groundwater Elevations in Nearby Wells

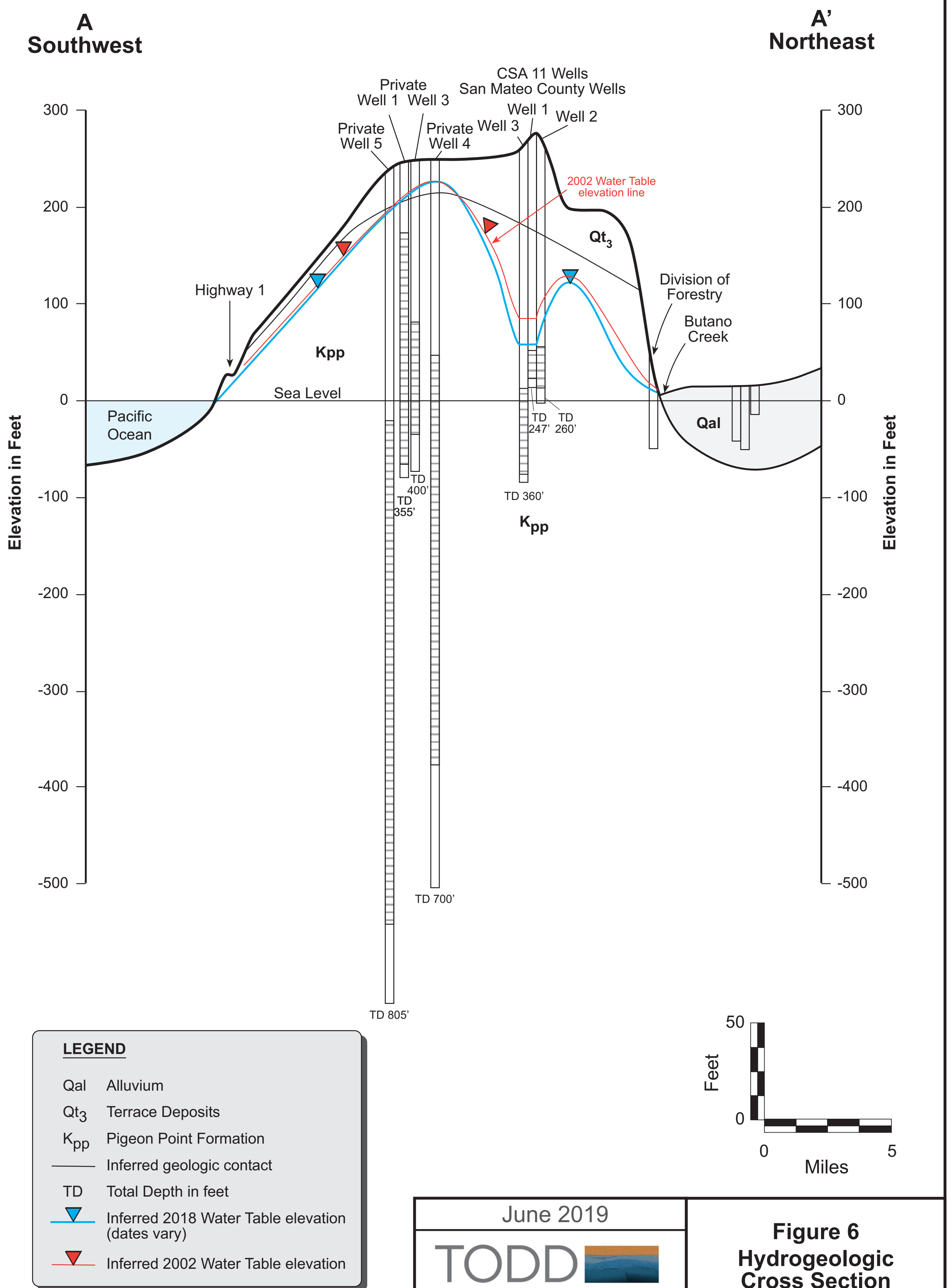

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Figure 6
Hydrogeologic Cross Section

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Figure 7
Existing and New CSA 11 Wells and Tanks

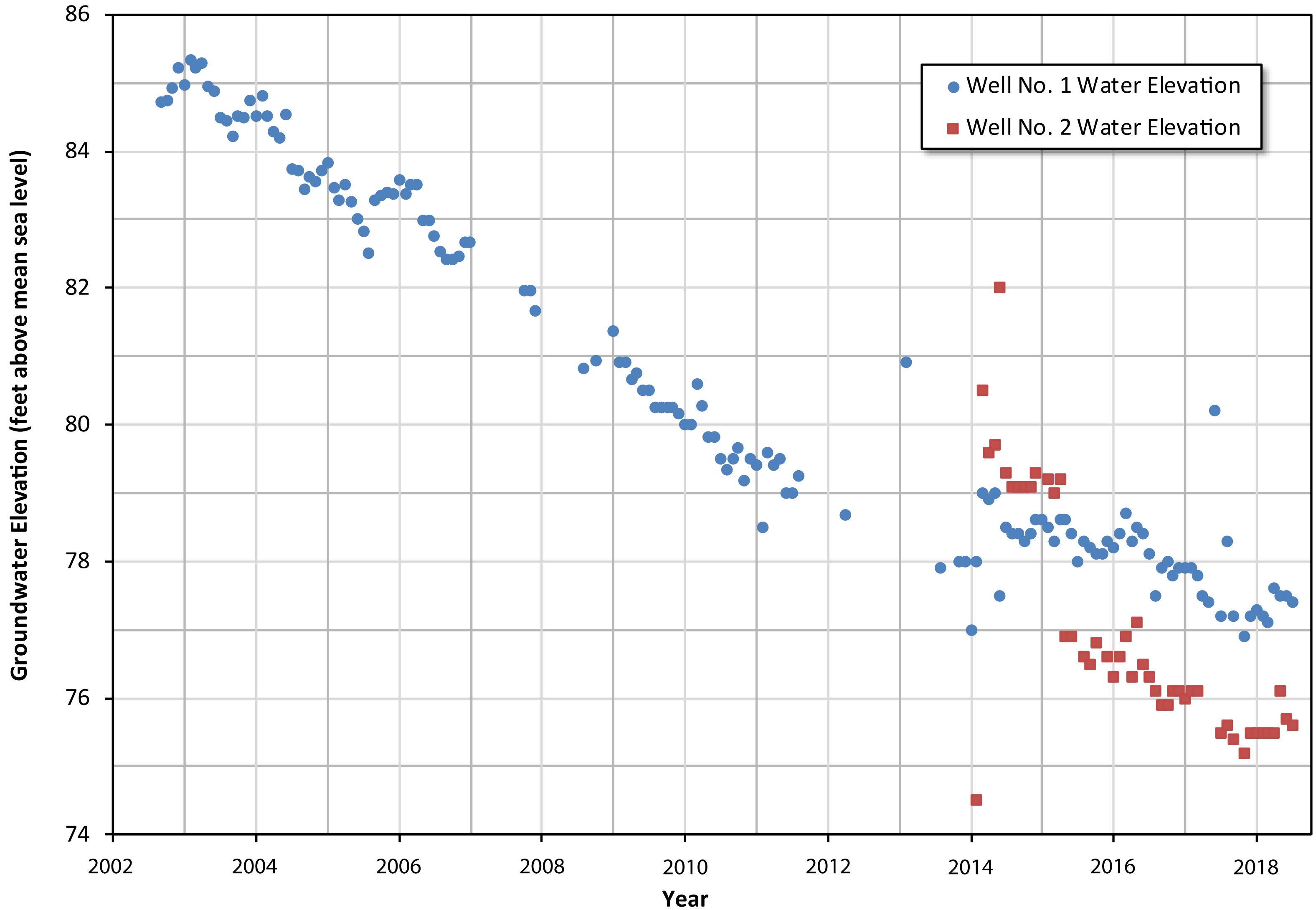

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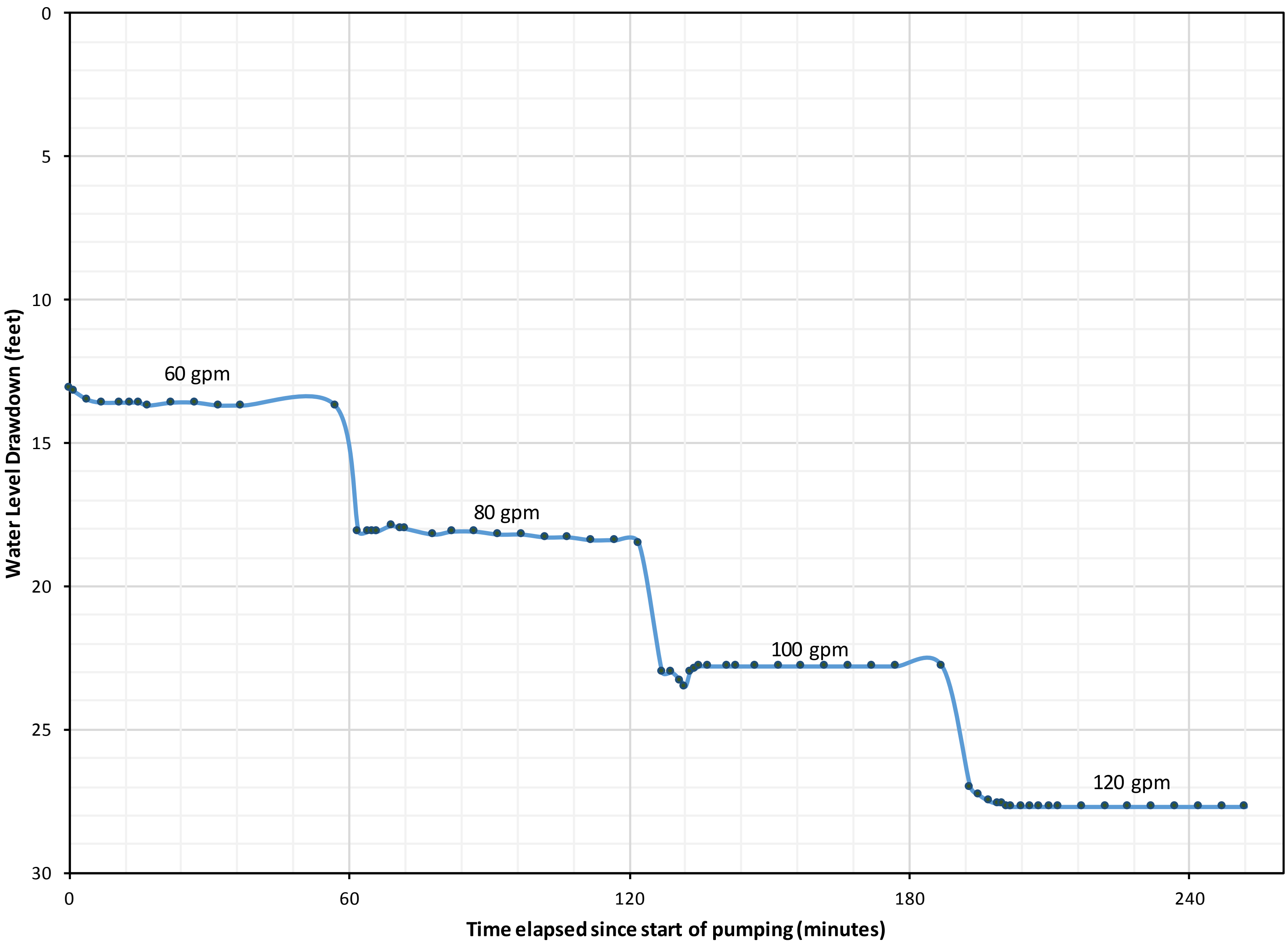
Figure 8
Long-Term Hydrograph of Wells Nos. 1 and 2



Step-drawdown test performed on August 24, 2018

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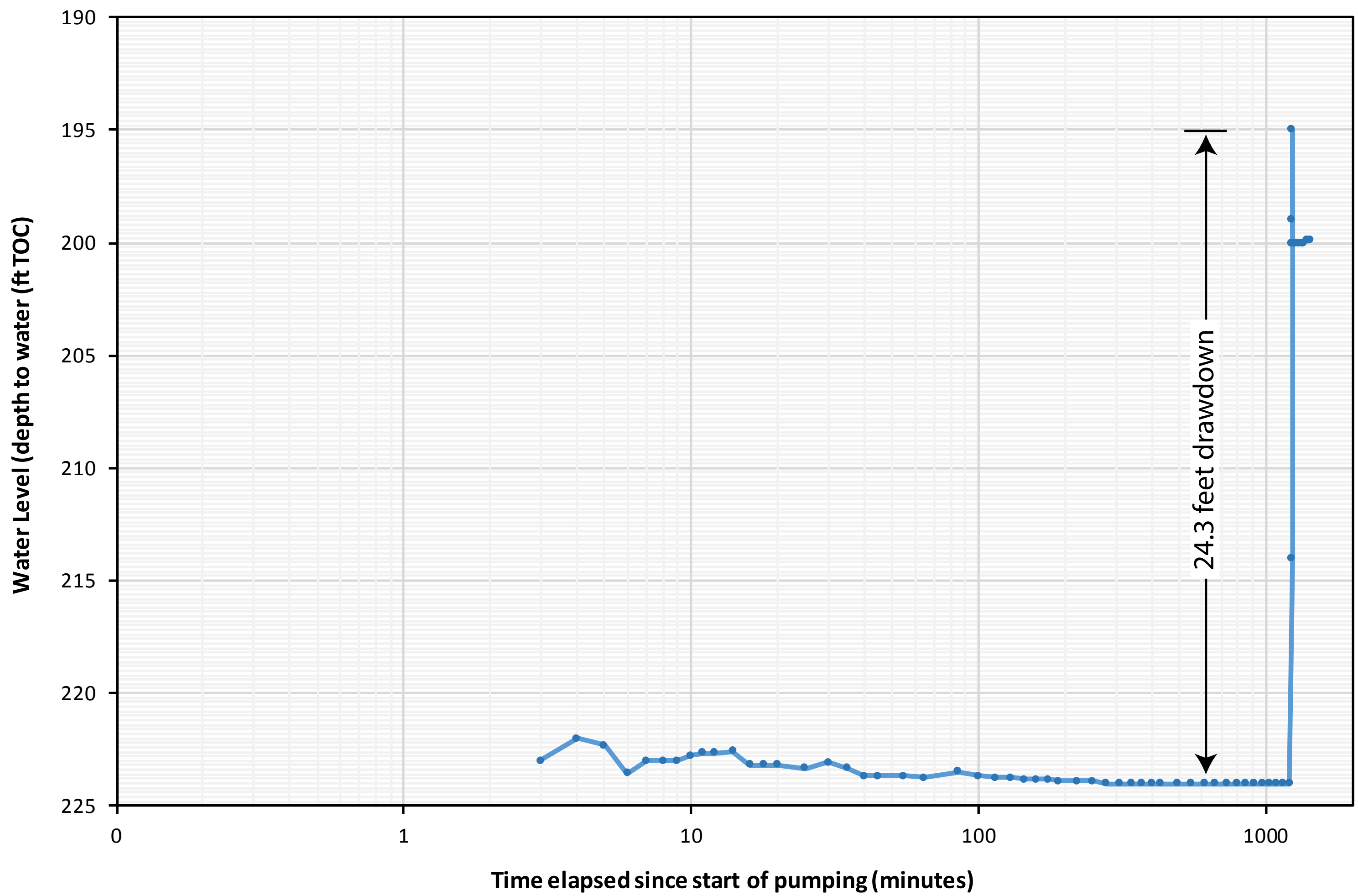
Figure 9
Well 3
Step Test



Pumping test performed on August 27-28, 2018
ft TOC - feet below top of well casing

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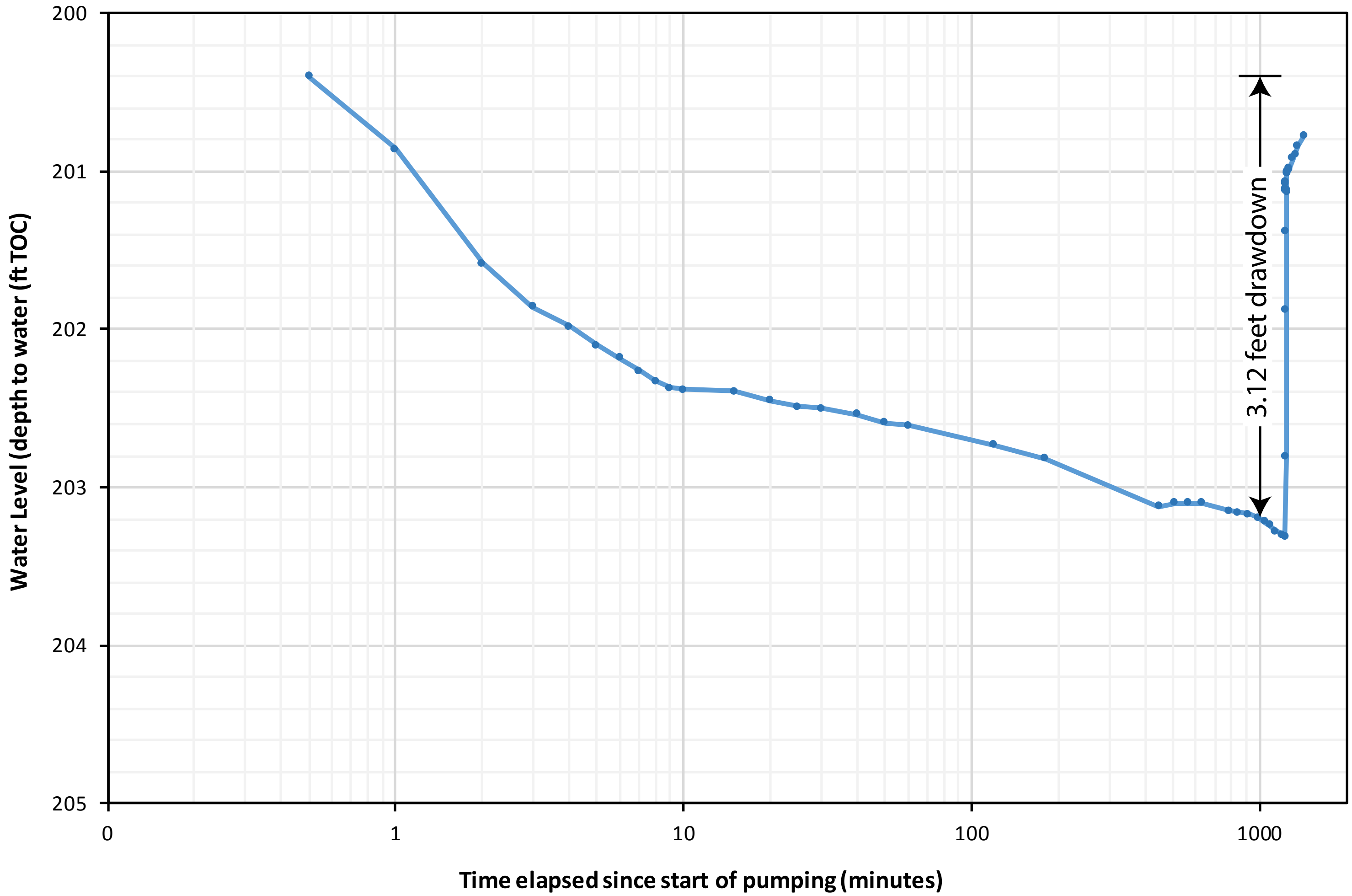
Figure 10
Well 3 Hydrograph
Constant-Rate Pumping
and Recovery Test



Pumping test performed on August 27-28, 2018
ft TOC - feet below top of well casing

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Figure 11
Well 1 Hydrograph
Constant-Rate Pumping and Recovery Test

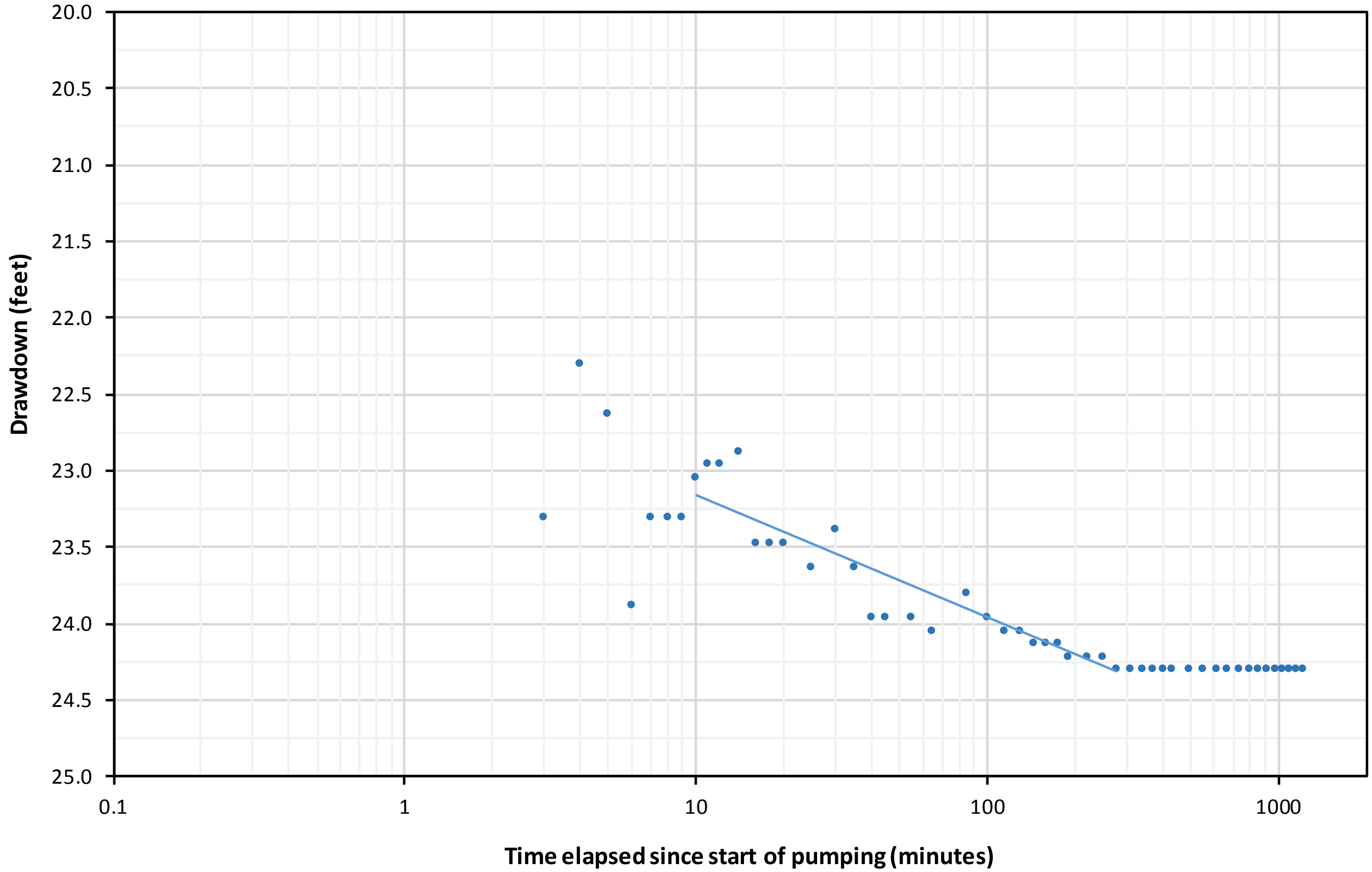

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Figure 12
Well 3 Drawdown
Constant-Rate
Pumping Test

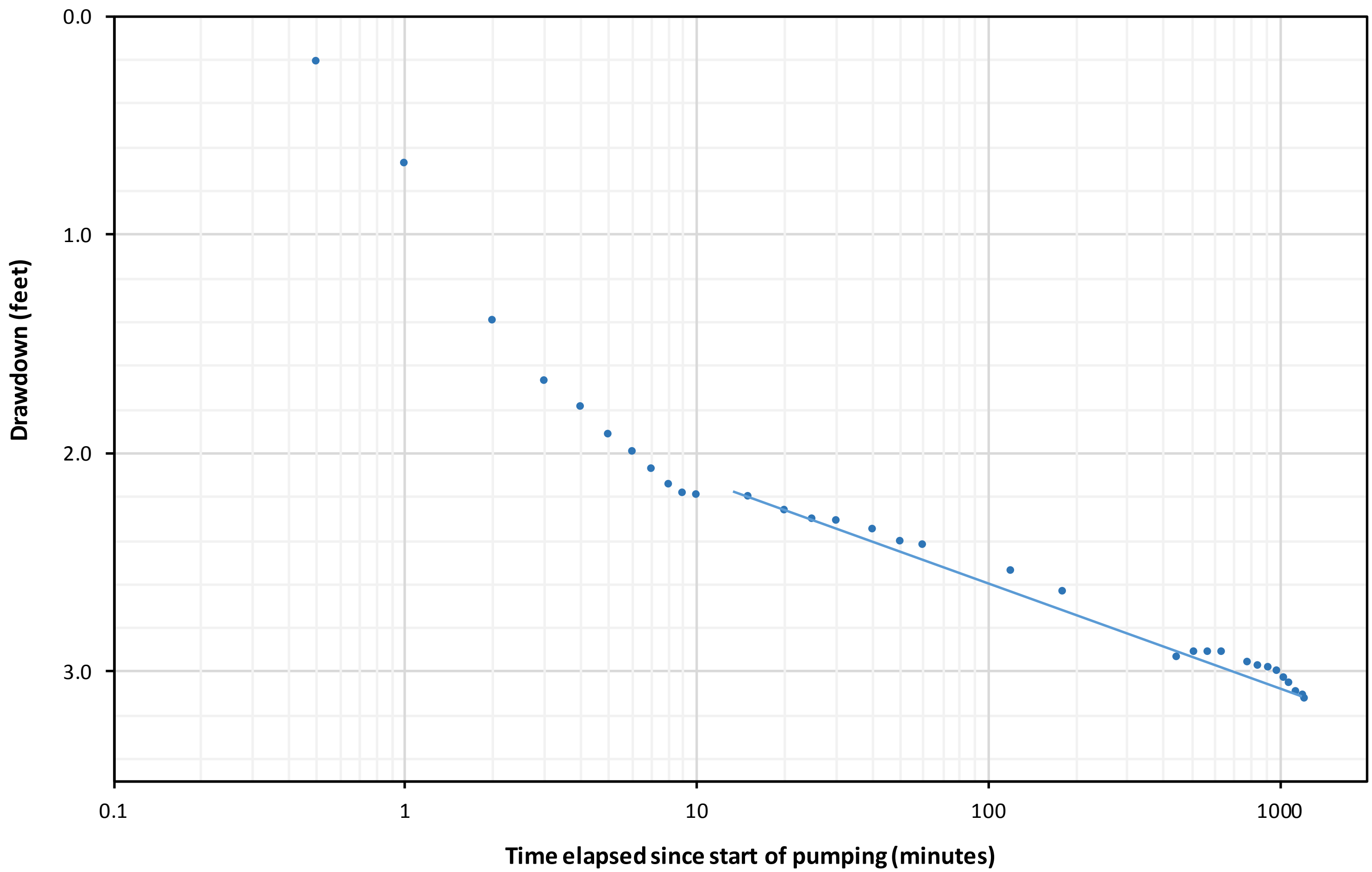

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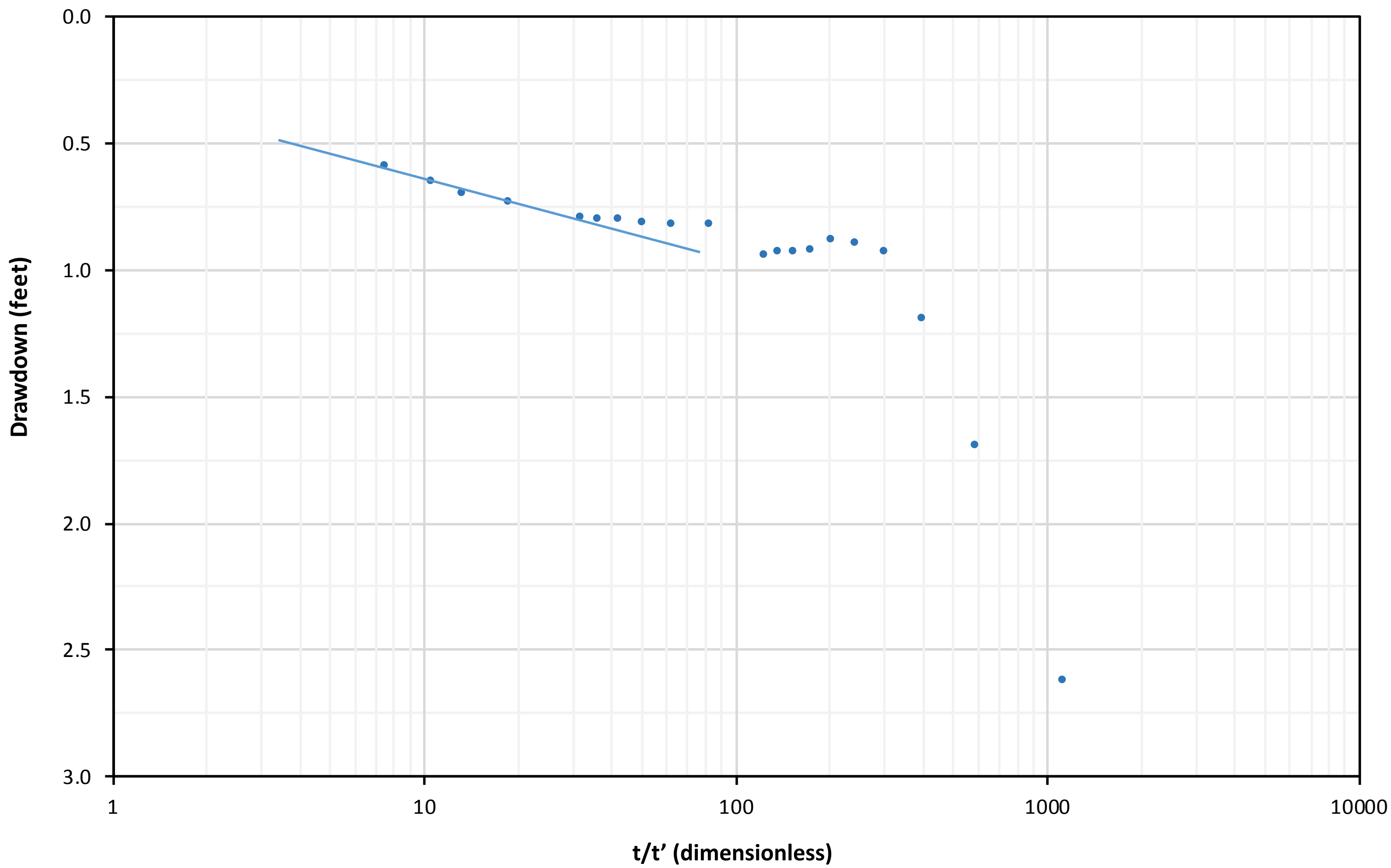
Figure 13
Well 1 Drawdown
Constant-Rate
Pumping Test



Recovery test performed on August 28, 2018

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Figure 14
Well 1 Residual Drawdown Recovery Test