

APPENDIX A

SUPPORTING ANALYSIS FOR BASIN BOUNDARY FLOW

The Pleasant Valley Subbasin (Basin) is generally well bounded. The western Basin boundary is defined based on the surficial geologic contact between the Plio-Pleistocene continental deposits and the Tertiary and older marine sedimentary anticlinal features of the Alcalde, Jacalitos, and Kreyenhagen Hills (local sections of the Coast Range mountains; KDSA, 2016). The northern and eastern Basin boundary is similarly based on the surficial geologic contact between the Plio-Pleistocene continental deposits in the Basin and the Tertiary and older San Joaquin and Anticline Ridges on the north and northeast (KDSA, 2016). The Basin is bounded in the south by a groundwater divide with the Kettleman Subbasin. However, there is understood to be some outflow toward the Westside Subbasin. Specifically, there are two “gaps” in the regional anticline along the western boundary of the Basin (i.e., the Polvadero Gap in the south and the Pasajero Gap in the north; **Figure A-1**) (KDSA, 2016).

For the Polvadero Gap, the consensus among prior studies is that the anticline there leads to a groundwater divide and there is no exchange with the Westside Subbasin (HydroDevelopment, inc., 1967; Summers, 1985; KDSA, 2000).

For the Pasajero Gap, the most recent analysis available indicates that the flow conditions in 2019 resulted in approximately 1,700 acre-feet per year (AFY) of outflow from the Basin (KDSA, 2020b; **Appendix B**). The model developed for the Basin for the draft revised Groundwater Sustainability Plan (GSP; EKI, 2026) based upon the published Central Valley Hydrologic Model (Faunt et al., 2024), similarly estimates that cross boundary flows are approximately 2,000 AFY over the historical time period evaluated.

Preliminary review of Airborne Electromagnetic (AEM) Survey Data²¹, borehole lithologies, and groundwater contours confirms the plausibility for this small amount of flow to occur between the Pleasant Valley and Westside Subbasins, but additional data collection and analysis should be conducted to better refine the estimates.

AEM Data

The AEM data provide reference values to create lithologic profiles along each flight line. Resulting information can improve the understanding of large-scale aquifer structures and support the refinement of the Basin’s hydrogeologic conceptual model.

AEM Profiles

Figures A-1 through A-5 plot the available AEM flight lines, study areas, and the cross-sections. For each flight line, a profile figure was developed. Profiles along each flight line over the area of interest were created to examine subsurface conditions within each gap. The x-axis shows the distance from the beginning of the flight line to a given point on the flight line in thousands of feet (k) (i.e., 35k-45k = 35,000 feet to 45,000 feet). The California Department of Water Resources (DWR) interpretations of coarse fraction, created by converting the measure resistivity of soil types into a lithologic soil classification, were

²¹ AEM data were obtained from <https://data.cnra.ca.gov/dataset/aem>. Data were downloaded for Flight Line 2003001, which provides a longitudinal profile of the Basin, Flight Line 292001, which crosses through the Polvadero Gap, Flight Line 291901, which crosses through the Pasajero Gap, and Flight Line 200401, which provides a northwest-southeast transect along the anticlinal ridge that separates the Basin from the Main San Joaquin Valley and crosses both the Pasajero and Polvadero Gaps.

used directly. Coarse layers, composed of sand or gravel, support vertical and lateral flow of groundwater. Fine layers, composed of clays and silts, do not support groundwater flow, and may form anticlines through which groundwater does not pass. The orange regions show areas with low coarse fractions, suggestive of clays and silts, whereas blue areas show high coarse fractions, suggestive of sands and gravels. The bottom panel on each figure shows the original resistivity data.

Since AEM data has limited depth, the black line at the bottom of the AEM characterization shows the DWR-listed Depth of Investigation (DOI), below which AEM data cannot accurately characterize the subsurface. Also shown on **Figures A-2** through **A-5** are the lithologies from the AEM supporting data package, where available. Well completion reports and borehole logs provide important calibration data for AEM surveys. The coarse fractions, as interpreted by DWR from well completion reports or borehole logs, are shown as vertical profiles on the figures. Wells with known perforated intervals are also noted, as well as wells with known locations but no well completion or borehole information (see labels along the top of each profile). Wells within $\frac{1}{2}$ mile of the flight line were included in the profile.

Characteristic groundwater level surfaces were added to each profile. Groundwater level measurements within $\frac{1}{2}$ mile of the flight lines within several representative historical periods were incorporated into groundwater surfaces along each profile. Selected historical periods depend on significance and data availability. For example, Fall 2017 is both a historical low period for groundwater levels in some areas of the Basin and serves as a proxy for the SGMA baseline condition in the revised draft GSP. Fall 2025 and Spring 2026 represent recent seasonal lows and seasonal highs.

Pleasant Valley Longitudinal AEM Profile

The longitudinal profile for the Basin along section A to A' is shown in **Figure A-2**. The Pasajero Gap is generally aligned with the 35k-45k region of the profile x-axis. The Polvadero Gap is generally aligned with the 60k-70k region of the profile x-axis. **Figure A-2** contextualizes the typical coarse fractions within the Basin in the area near the Polvadero and Pasajero Gaps but does not directly characterize the aquifer materials because it does not cross either Polvadero or Pasajero Gap. A sequence of coarse materials (blue) extends to elevation of approximately 500 feet below sea level along the profile from 35k-45k (Pasajero Gap). That implies that there is a coarse-grained package of material with potentially higher transmissivity in the Basin near the boundary with the Pasajero Gap. In contrast, in the profile from 60k-70k along the x-axis (Polvadero Gap), a sequence of layered materials that are primary fine-grained is present with a few layers of more coarse material. This implies that there are some intermittent potential areas of higher transmissivity in that portion of the Basin.

Polvadero Gap AEM Profile

Section B-B' (**Figure A-3**) runs through Polvadero Gap from the Basin in the southwest (left side of profile) to Westside Subbasin in the northeast (right side of profile). The administrative boundary between the PVGSA and Westside Subbasin falls approximately ~5k into the profile (note that the mapped flight path passes from PVGSA into Westside Subbasin multiple times, see **Figure A-1**). The portion of the profile B-B' within PVGSA and the eastern portion of Westside Subbasin shows cones of depression that have been present in the Basin since at least 1967 (HydroDevelopment Inc., 1967). Groundwater levels rise to the east near well 11E-1N, where groundwater levels at several wells consistently exceed 300 feet (e.g., well 2R-1M, which has been measured between 306 feet above mean sea level [ft msl] and 338 ft msl since 1974). East of well 12D-1M, groundwater levels rapidly decline and Fall 2023 groundwater levels are consistently below 100 ft msl, and consistent with water levels within the main area of the Westside Subbasin (i.e., in the main San Joaquin Basin beyond the anticlinal restrictions of Polvadero Gap).

The rapid decline in groundwater levels east of well 12D-1M coincides with a profile section entirely characterized by a low coarse fraction. This impermeable section coincides with the area historically characterized as an anticlinal barrier to groundwater flow (see Section A-A' in Summers, 1985). East of the barrier, where the Polvadero Gap opens into the San Joaquin Valley, the barrier disappears as the lithology near the surfaces quickly transitions from a low coarse fraction to a high coarse fraction (near the D-D' intersection in **Figure A-3**). The well log for WCR2017-00810 shows that there is still heterogeneity and coarse fraction of approximately 40% down to an elevation of approximately 50 feet above sea level. This supports that there may be preferential flow paths. The low coarse fraction and associated low permeability and transmissivity of this intrusion steeply reduce the flow of groundwater through the Polvadero Gap. While the sedimentary nature of formations in this region and the presence of productive wells on both sides of the anticline preclude a fully impermeable barrier, the AEM data suggest that the volume of water flowing through the Polvadero Gap is likely to be minimal for the purposes of groundwater accounting in the Basin, as suggested in prior reports (HydroDevelopment, Inc., 1967; Summers, 1985).

Pasajero Gap AEM Profile

Section C-C' (**Figure A-4**) runs through Pasajero Gap from the Basin in the southwest (left side of profile) to Westside Subbasin in the northeast (right side of profile). Section D-D' crosses Section C-C' near 14k. Similar to the Polvadero Gap, Section C-C' shows a steep drop in groundwater elevations over a short lateral distance. In the Pasajero Gap, groundwater levels are consistent in the western portion of the gap (west of D-D', 14k) before a steep drop in groundwater elevations near the eastern end of the gap. The section of the gap with the steep gradient (near 14k) has intermingled coarse beds over several hundred feet of the aquifer. Coarse beds are present throughout Pasajero Gap; see construction information for well WCR0274955 near the PVGSA boundary and well WCR0288980 on **Figure A-4**, in addition to the coarse beds shown on the AEM Profile. The differences in coarse fraction between the AEM profile and the borehole lithologies, which may be away from the AEM flight line, show lateral (i.e., north-south) heterogeneity across the Pasajero Gap. For the purposes of groundwater accounting in the Basin, the AEM data suggest that there is likely some volume of water flowing through the Pasajero Gap as suggested in prior reports (**Appendix B**).

Anticline Longitudinal Profile

Section D-D' (**Figure A-5**) bisects the Pasajero and Polvadero Gaps from north (Pasajero Gap) to south (Polvadero Gap). The northern end of Section D-D' shows a substantial package of coarse material from 0 to 3k on the x-axis of Profile D-D' that corresponds to the northern border of the Pasajero Gap. The coarse sediments are layered with finer sediments but range from approximately 150-300 feet in thickness. This implies that a portion of the interface between the Basin and Westside Subbasin is heterogenous with areas with higher transmissivity that could support preferential flow through the Pasajero Gap. The southern part of Pasajero Gap (see AEM Profile D-D' at approximately 5,000 ft and WCR 0037228) holds finer sediments. The Polvadero Gap (near 22k on the x-axis) shows consistently finer-grained materials at elevations less than 400 feet further supporting that inter-basin groundwater flow is likely much lower there.

Groundwater Contours

Groundwater level contours are shown for two periods; 2023 seasonal lows (**Figure A-6**) and 2024 seasonal highs (**Figure A-7**). The contours consistently show several features that have been noted previously (KDSA, 2020a; Provost and Pritchard, 2026). There is a consistent cone of depression in the southeastern area of the Basin near the Polvadero Gap, as well as a depression near the Coalinga Airport separated by an area of higher groundwater levels.

The contours also show a groundwater divide near the Polvadero Gap and a steep gradient toward the Westside subbasin through the Pasajero Gap, similar to what was shown in recent work to estimate Basin outflows (**Appendix B**). Data are sparse within the gap so there is uncertainty in the gradient. In addition, many of the groundwater level observations may be influenced by seasonal differences in pumping.

Contours indicate that the groundwater flow direction east of the Coalinga Airport (**Figures A-6 and A-7**) is generally toward the southeast and may intersect the coarse areas that were observed in the AEM profiles to flow through the Pasajero Gap. More discrete water level data in this region along with more information about subsurface properties will help improve the understanding of flow direction and volume within this eastern portion of the Pasajero Gap.

Data Gaps and Future Work

While the above information suggests that some groundwater outflow from the Basin is likely, additional groundwater level measurements, aquifer pumping tests, and model refinement would be needed to better confirm flow rates.

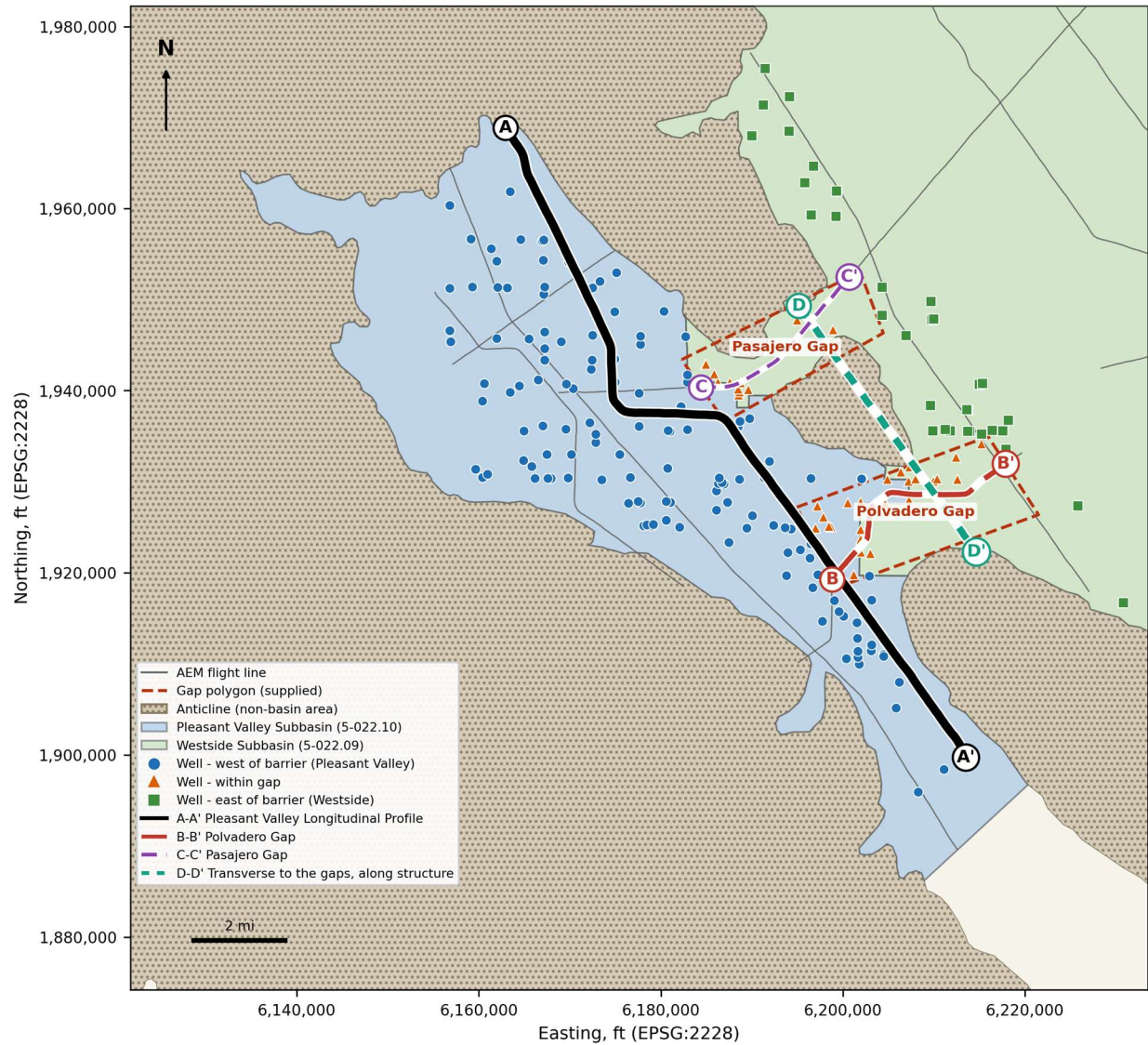


Figure A-1. Site map showing Pleasant Valley Subbasin, Pasajero and Polvadero Gaps, Aerial Electromagnetic Flight Lines, and Locations of Groundwater Wells.

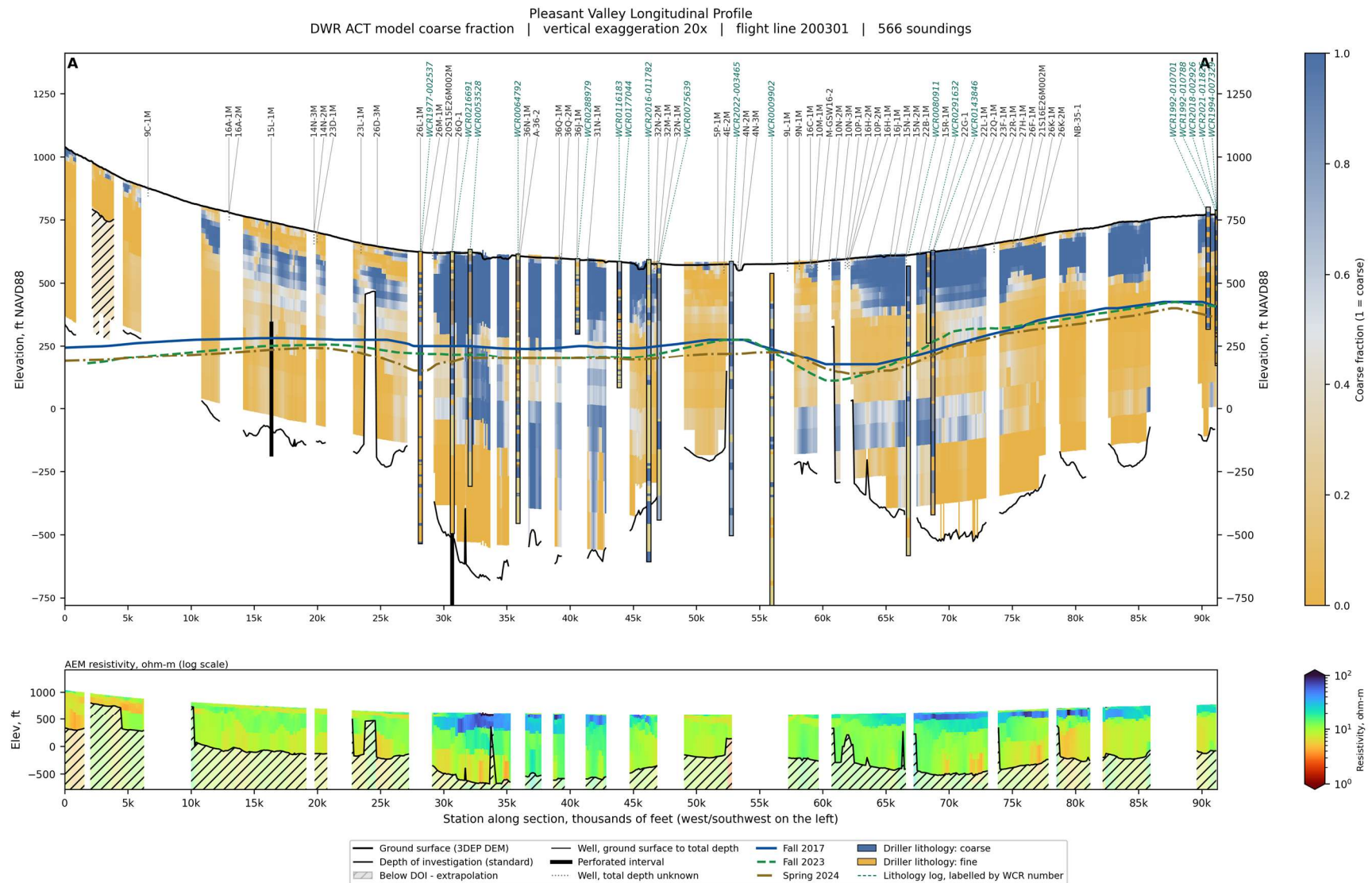


Figure A-2. Profile of Pleasant Valley Subbasin along A to A'

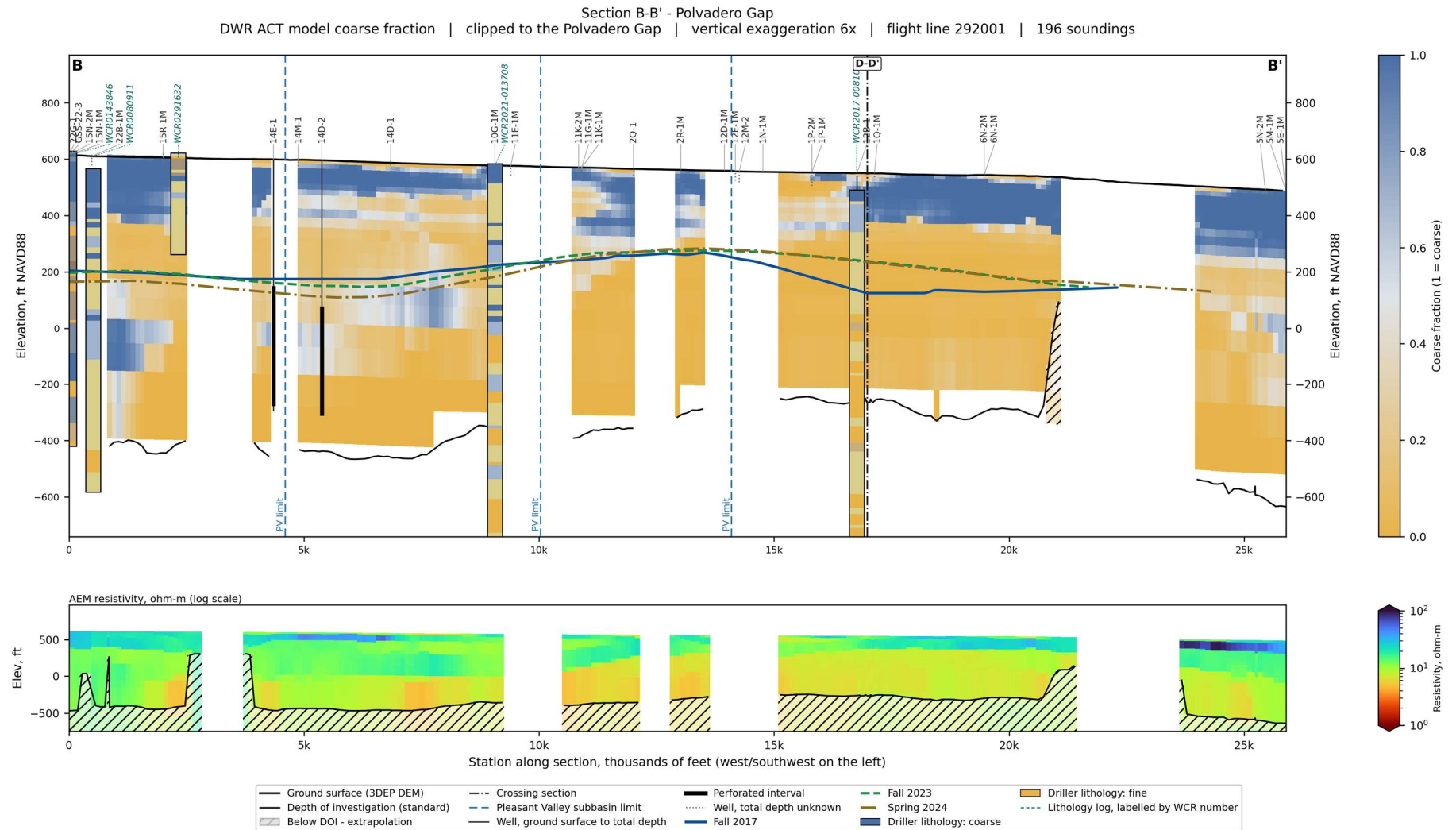


Figure A-3. Profile of Polvadero Gap Along B to B'

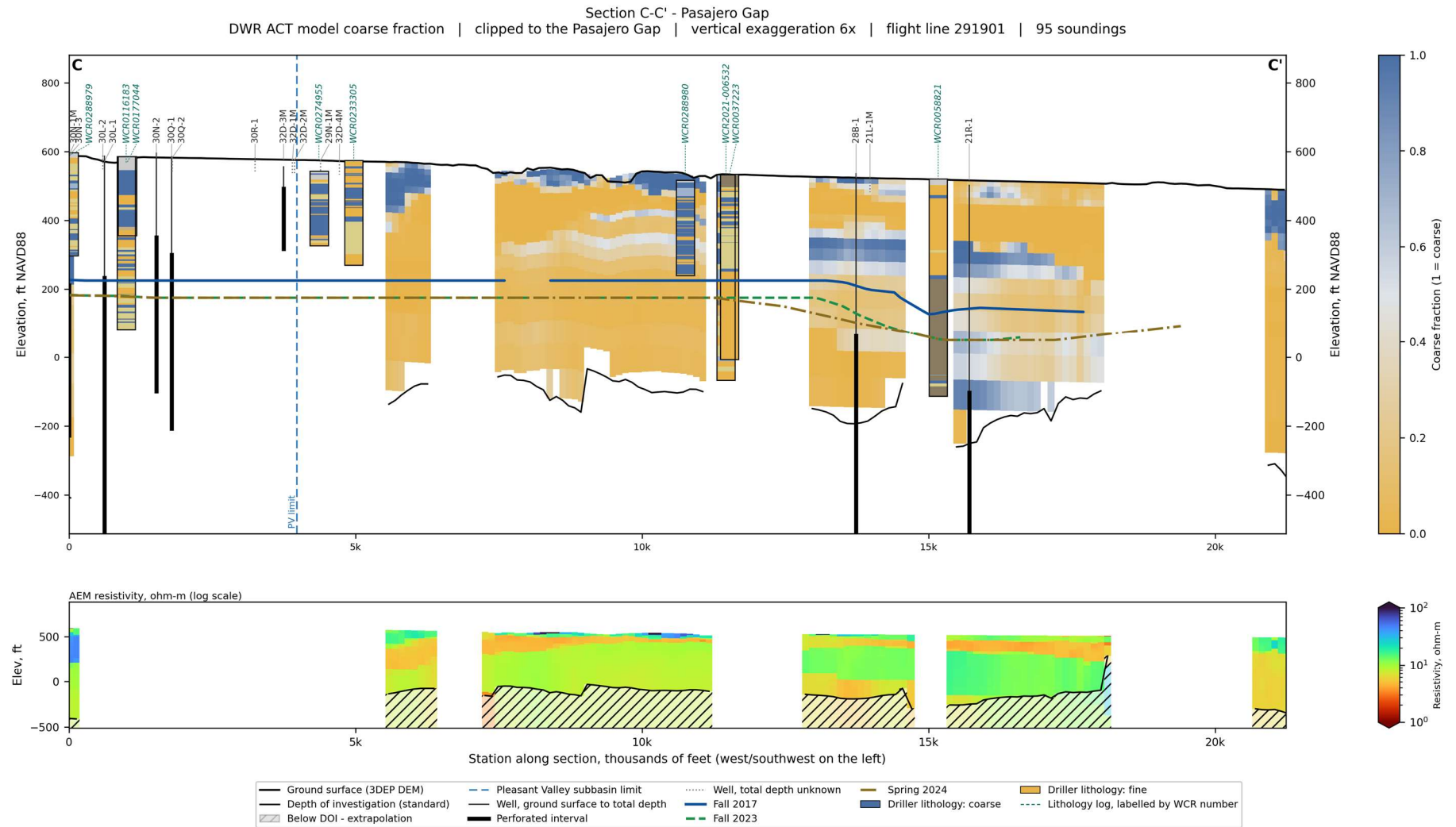


Figure A-4. Profile of Pasajero Gap along C to C'

Section D-D' - Transverse to the gaps, along structure
DWR ACT model coarse fraction | vertical exaggeration 10x | flight line 200401 | 235 soundings

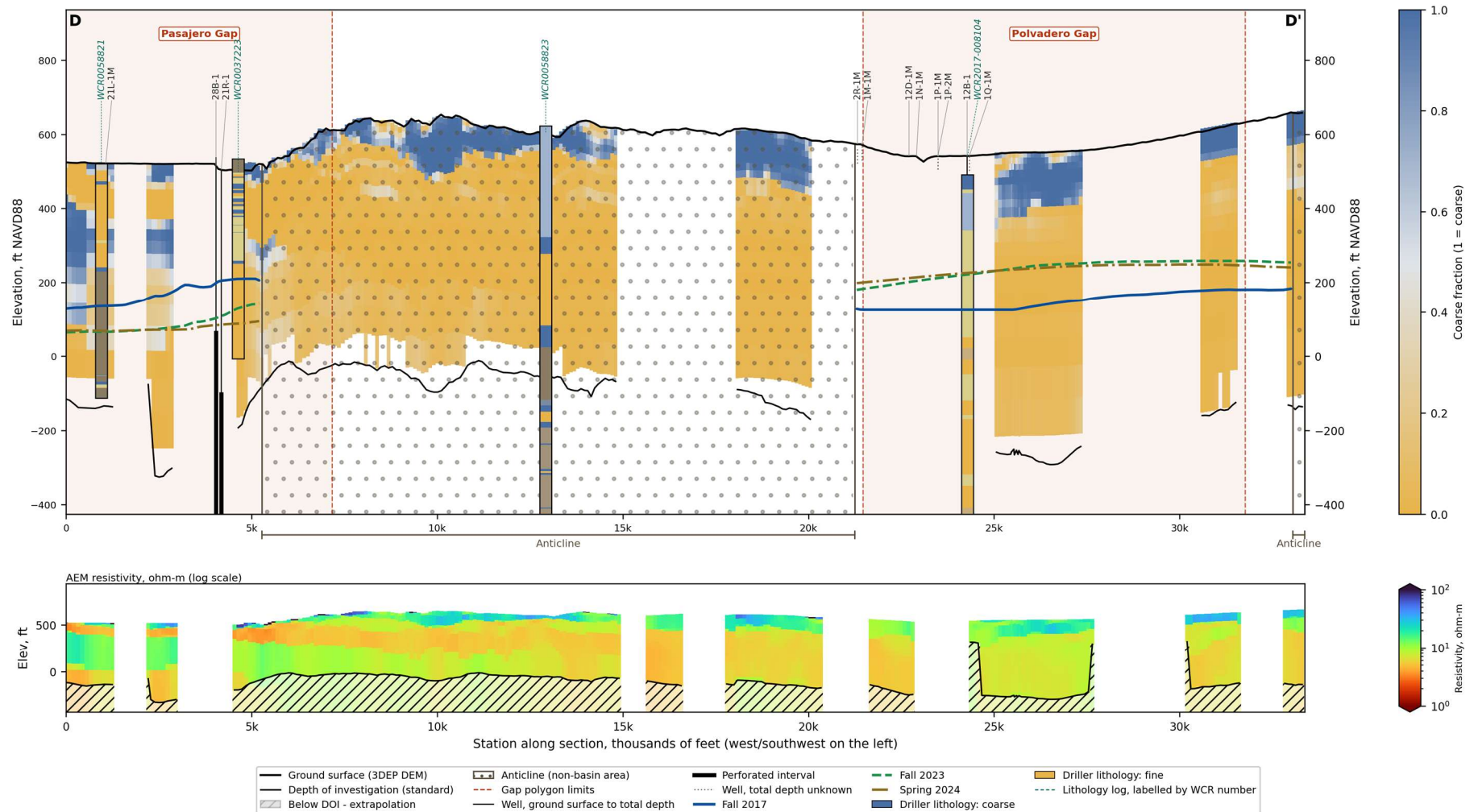


Figure A-5. Profile of Regional Anticline Along D to D'

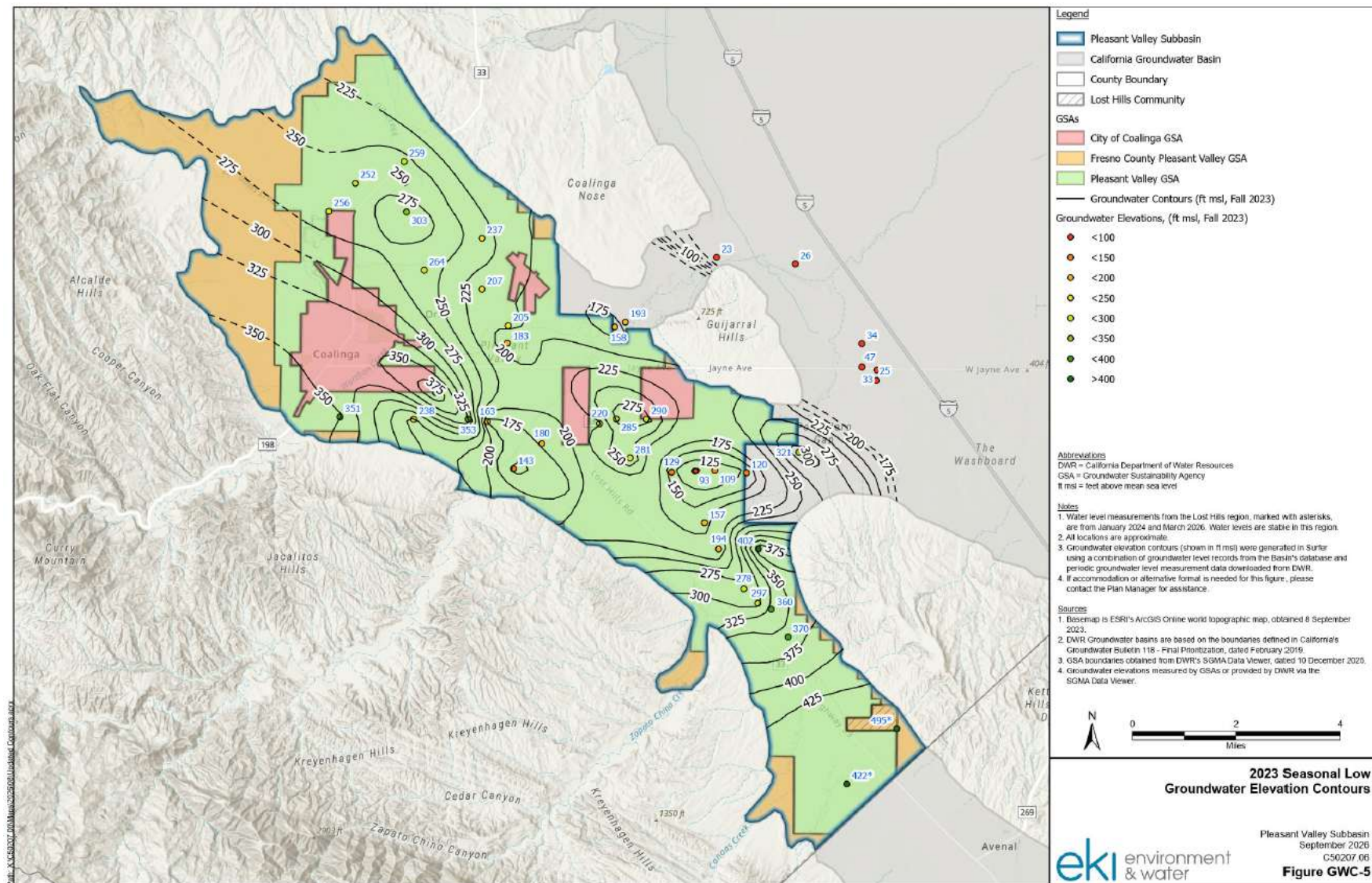


Figure A-6. Groundwater Level Contours for 2023 Seasonal Low

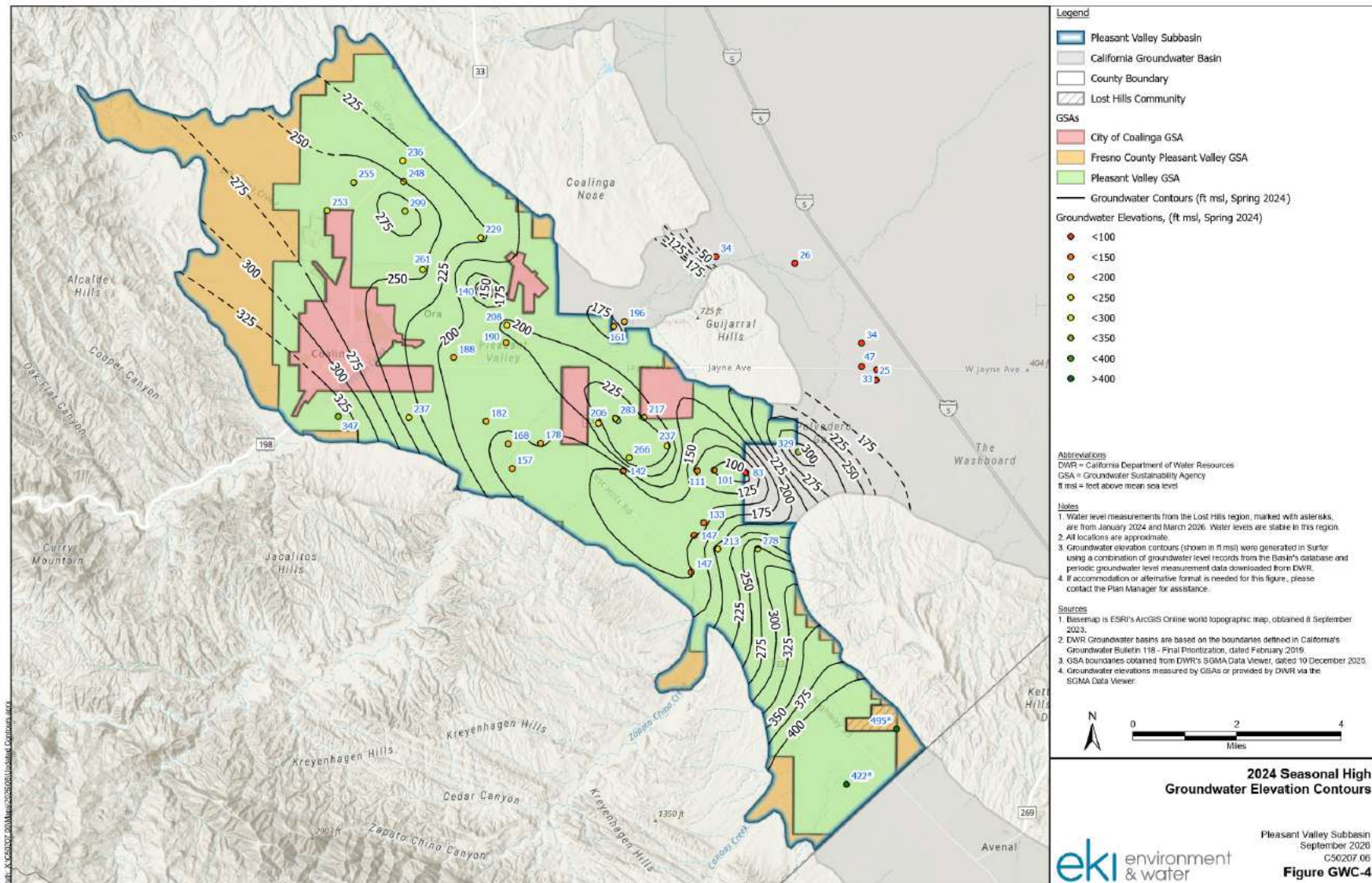


Figure A-7. Groundwater Level Contours for 2024 Seasonal High

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Faunt, C.C.; Traum, J.A.; Boyce, S.E.; Seymour, W.A.; Jachens, E.R.; Brandt, J.T.; Sneed, M.; Bond, S.; Marcelli, M.F. (2024) Groundwater Sustainability and Land Subsidence in California's Central Valley. *Water*, 16, 1189. <https://doi.org/10.3390/w16081189>

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Summers Engineering, Inc., 1985. Pleasant Valley Water District, Coalinga, California, Groundwater Information.

APPENDIX B

SUBSURFACE GEOLOGIC CONDITIONS NEAR PASAJERO AND POLVADERO GAPS

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GROUNDWATER FLOW THROUGH PASAJERO GAP

Kenneth D. Schmidt and Associates, 2020

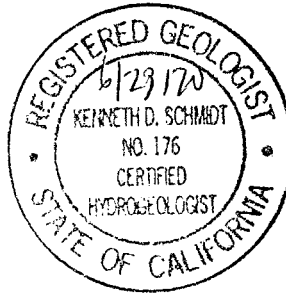
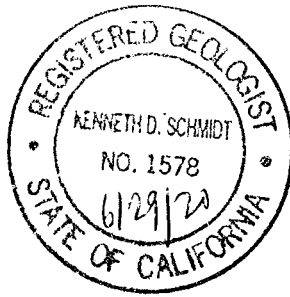
SUBSURFACE GEOLOGIC CONDITIONS NEAR PASAJERO AND POLVADERO GAPS

The possible easterly movement of groundwater from Pleasant Valley through two gaps in the Guijarral Hills has been of interest. The north gap is termed the Pasajero Gap, through which Arroyo Pasajero flows. The south gap is termed the Polvadero Gap, through which Zapato Chino Creek flows. Besides groundwater elevations on both sides of each gap, an important issue is the depth to the base of the unconsolidated alluvium (the top of consolidated sedimentary rocks) beneath each gap. In order to evaluate groundwater conditions near the gaps, two previously prepared subsurface geologic cross sections by KDSA were extended. Cross Section A-A' extended along Los Gatos Creek west of the Pasajero Gap. Cross Section B-B' extended along Zapato Chino Creek, and the north end was near Polvadero Gap.

Cross Section A-A' was extended to the northeast and east through three additional wells, so as to extend east of the Pasajero Gap and into the San Joaquin Valley (Figure 2). Along the extension of Cross Section A-A', the logs for the three additional wells extend from 1,240 to 1,885 feet in depth. The Pasajero Gap is essentially in the area near Well 21Q1. The unconsolidated alluvial deposits at Wells 28D and 21Q1 extend to a depth of at least 1,200 feet, and the cross section indicates that the alluvial deposits are thick beneath the gap. In addition, the Spring 2019 water levels are plotted along this section. These water-level elevations are higher to the southwest and lower to the northeast, indicating that groundwater flows from Pleasant Valley, through the Pasajero Gap, and into the San Joaquin Valley. West of the gap in Pleasant Valley, water-level elevations ranged from about 210 feet above MSL to the southwest to about 80 feet near the gap. East of the gap, water-level elevations decreased to less than 30 feet above MSL in the San Joaquin Valley.

Cross Section B-B' was extended to the northeast through two wells and a test hole to also extend into the San Joaquin Valley (Figure 3). For the extension of Cross Section B-B', the depths of the two wells and test hole extend from 1,530 to more than 1,800 feet. Unconsolidated alluvial deposits extend to a depth of at least 1,240 feet near Polvadero Gap and to depths exceeding 1,500 feet to the northeast in the San Joaquin Valley. Water-level elevations along Cross Section B-B' (extended) indicate a cone of depression in Pleasant Valley and a groundwater divide near Polvadero Gap. Therefore no groundwater flow is indicated

through the gap. The reason for this is attributed to little pumping near the gap and heavy pumping on both sides of it, in Pleasant Valley and in the San Joaquin Valley.

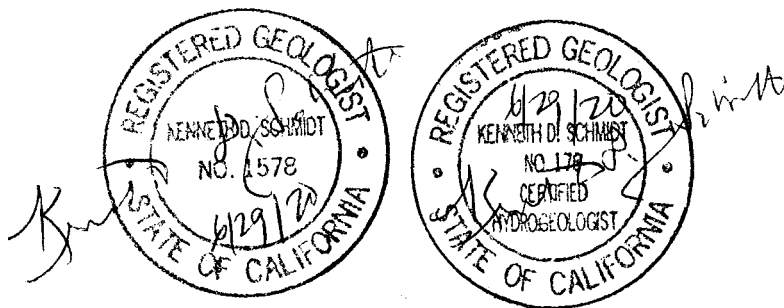


DEEP SUBSURFACE GEOLOGIC CROSS
SECTIONS IN PLEASANT VALLEY

Two deep subsurface geologic cross sections were developed as part of this evaluation (Figure 1). Cross Section C-C' extends from the northwest near Highway 33 and Tornado Avenue to the southeast and east to near Phelps Avenue and Amador Avenue. Cross Section D-D' extends from the west near San Joaquin Avenue and Firestone Avenue to the east to near Sutter Avenue and Goodrich Avenue.

Figure 4 shows Subsurface Geologic Cross Section C-C'. Depths of most wells or holes along the section exceed 1,400 feet, and depths of four exceed 2,000 feet. Stream channel deposits (coarser than sand) were primarily present above the water level as of Spring 2019, except near Los Gatos Creek at Wells 27G and 27J, where they extended to depths of about 900 to 1,100 feet. A few other localized deep streambed deposits were indicated along the northwest part of the cross section. Clay was predominant below a depth of about 1,000 feet and above a depth of about 1,600 feet along the northwest part of the cross section and below a depth of about 600 feet and above a depth of about 1,600 feet along the east part. Deep sands are common along the section below a depth of about 1,600 feet. Most of the deep wells along the section also tap shallow coarse-grained layers above the clay unit. The thickest deeper sands were indicated at Wells 22P and 30N.

Figure 5 shows Subsurface Geologic Cross Section D-D'. Information on subsurface conditions below a depth of 1,200 feet along this section is only available east of Well 8E. Stream channel deposits extend to a depth of about 1,000 feet along the central part of the section. In contrast to Section C-C', a number of these layers were below the water level as of Spring 2019. Most of the shallow wells along Section D-D' tap stream channel deposits. Substantial clays are indicated along the cross section below a depth of about 1,000 feet and above a depth of about 1,600 feet. Where data are available, thick sand layers extend to at least 2,300 to 2,700 feet in depth.



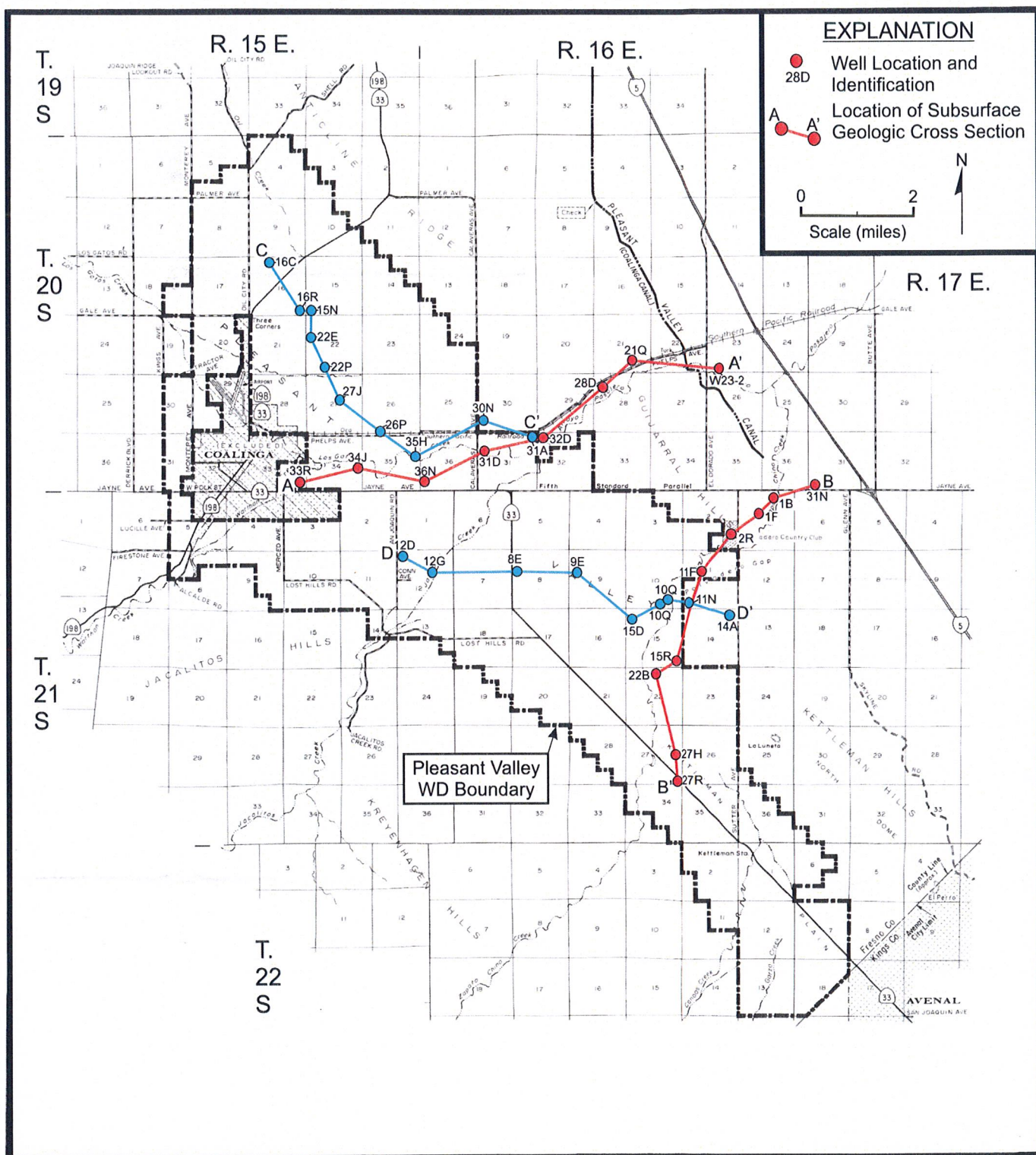


FIGURE 1 - LOCATION OF SUBSURFACE GEOLOGIC CROSS SECTIONS

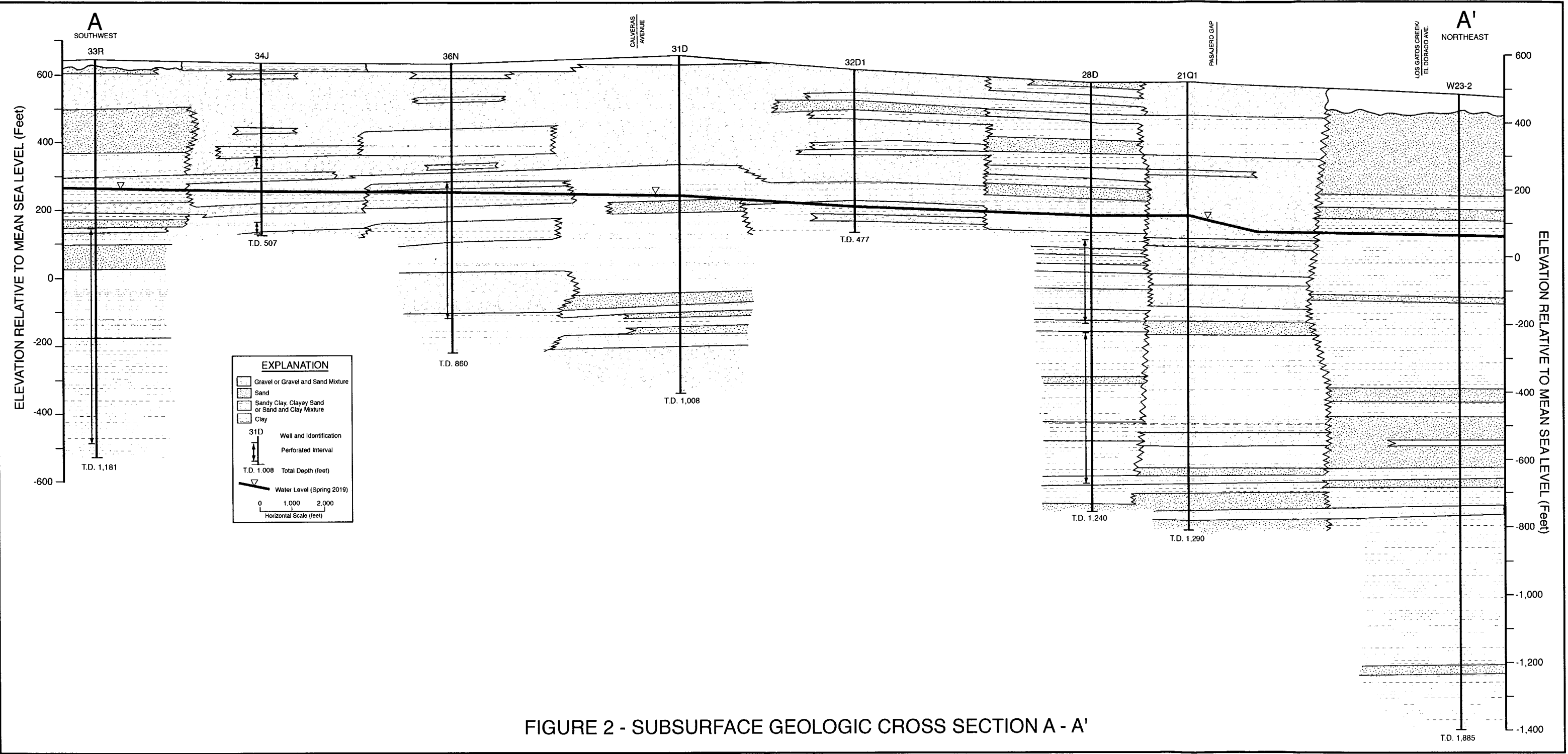
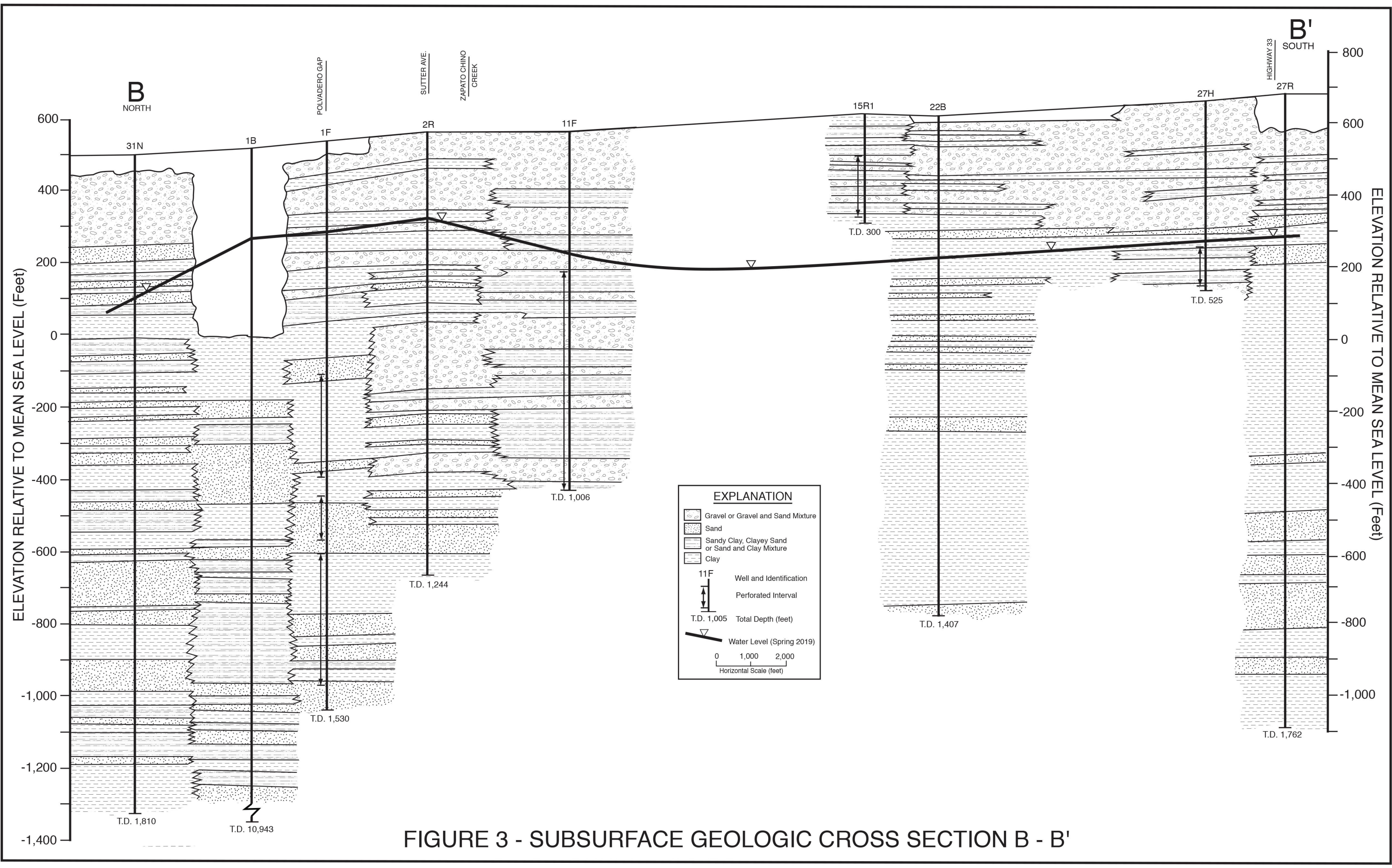


FIGURE 2 - SUBSURFACE GEOLOGIC CROSS SECTION A - A'



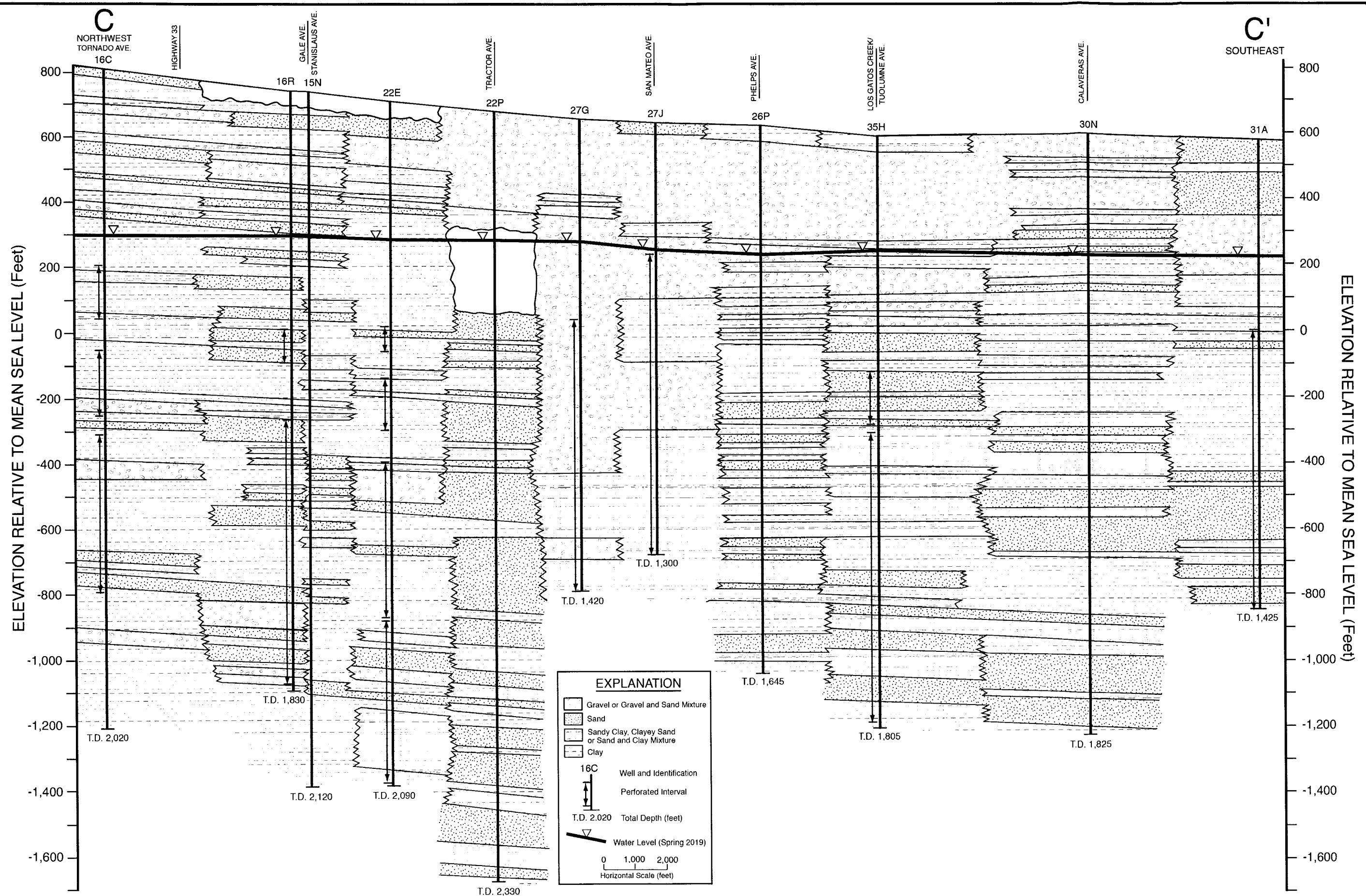


FIGURE 4 - SUBSURFACE GEOLOGIC CROSS SECTION C - C'

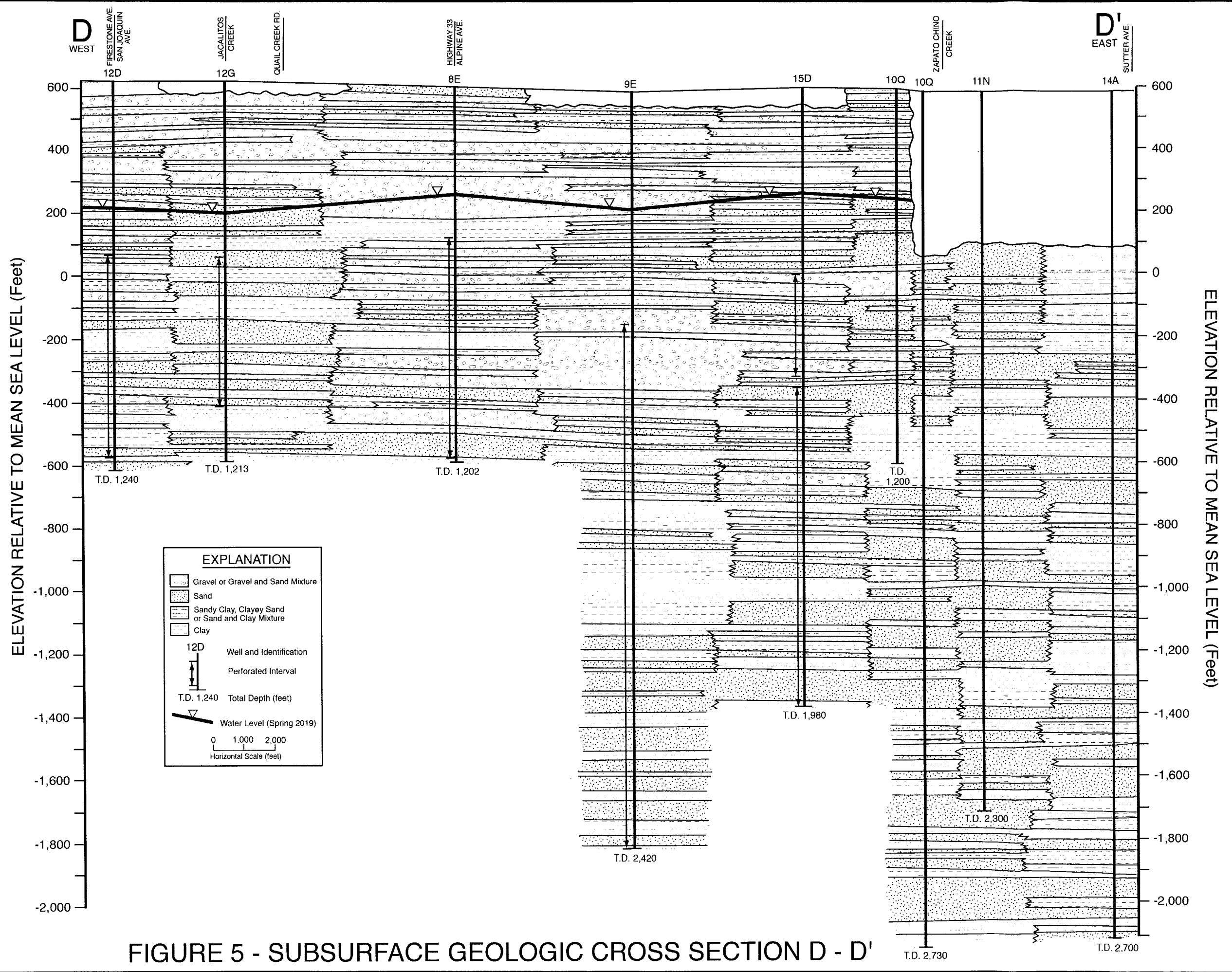


FIGURE 5 - SUBSURFACE GEOLOGIC CROSS SECTION D - D'

MEMO

To: Brian Ehlers
From: Ken Schmidt
Topic: Groundwater Flow Through
Pasajero Gap
Date: July 17, 2020

Pursuant to our discussion, I have estimated the amount of groundwater flow from Pleasant Valley through the Pasajero Gap into the San Joaquin Valley. This is considered a preliminary estimate that can be refined later, if desired. Darcy's Law was used, where:

$Q = TIL$,
where Q = groundwater flow (gpd)
 T = transmissivity (gpd per foot)
 I = water-level slope (feet per mile)
 L = width of flow in miles.

In terms of the width of flow, we have evaluated logs of wells in and near the Pasajero Gap. The topographic contours on the U.S. Geological Survey Gujarral Hills 7.5-minute quadrangle map provide additional information. The steeper contours in the Gujarral Hills south of Los Gatos Creek and north of Pleasant Valley Ranch, just south of Anticline Ridge indicate the edges of the gap. The average width of flow is about 1.25 miles.

We did not have a transmissivity value for in or near the gap. However, we have specific capacities for three wells in Sections 30 and 32 of T20S/R16E. These values ranged from 14 to 29 gpm per foot and averaged 21 gpm per foot. Using the conversion factor of 2,000, this results in an estimated transmissivity of 42,000 gpd per foot.

Attached is part of a revised Spring 2019 water-level map for the area north of Jayne Avenue. There was a difference in water-level elevation of 210 minus 130 feet, or 80 feet, between two wells that were 2.75 miles apart. The average water-level slope southwest of the gap was 29 feet per mile to the north-east. Using Darcy's Law:

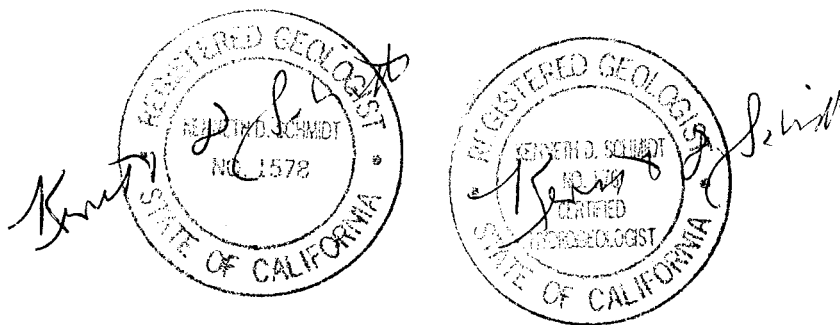
$$Q = 42,000 \text{ gpd/ft} \times 29 \text{ feet/mile} \times 1.25 \text{ miles}$$

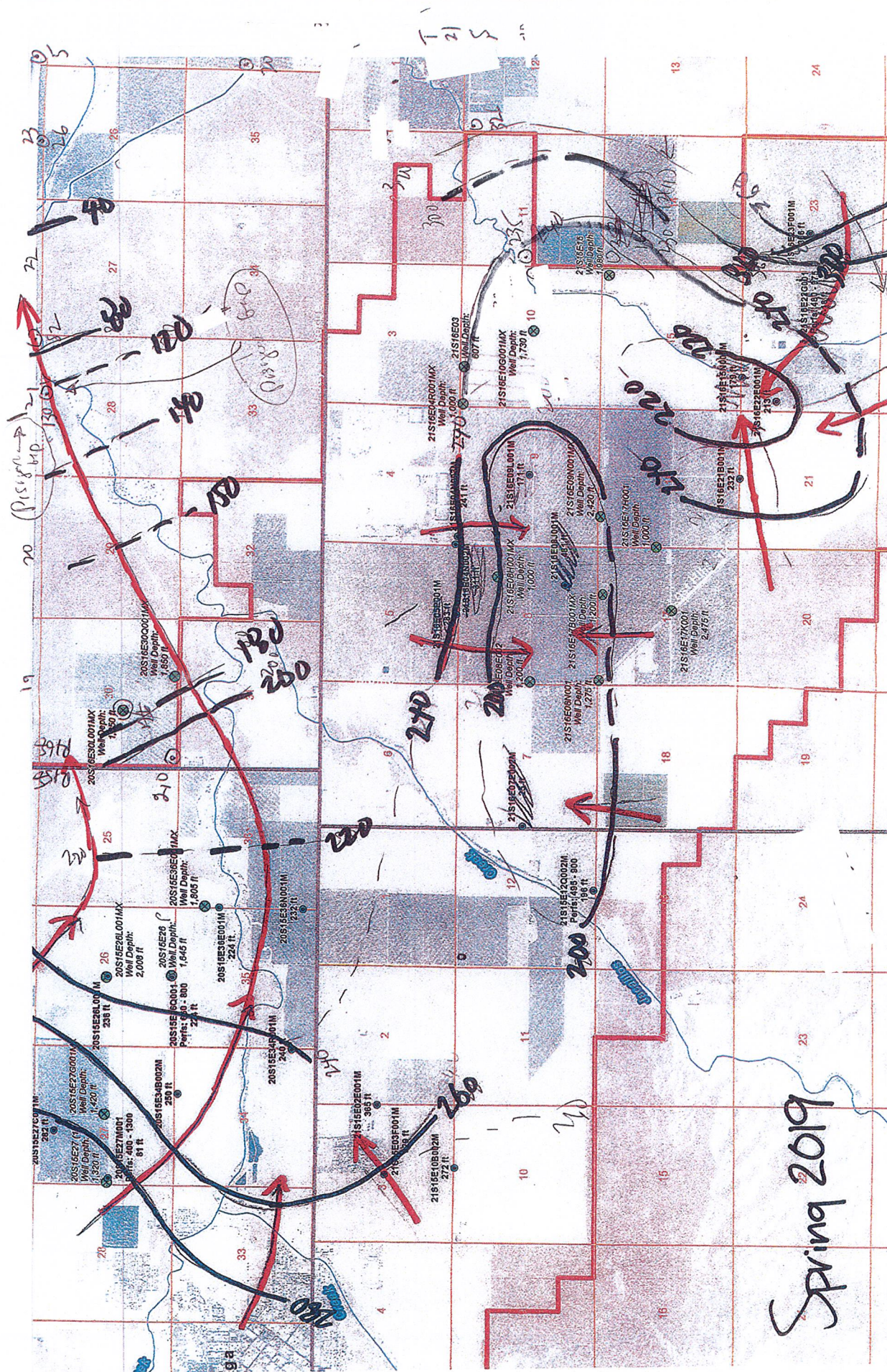
$$Q = 1,523,000 \text{ gpd, or } 4.68 \text{ acre-feet per day}$$

$$Q = 1,700 \text{ acre-feet per year.}$$

For the future, it would be useful to extend Pleasant Valley WD water-level elevation and direction of groundwater flow maps into the southwest quarter of T20S/R16E. In addition, an aquifer test could be done on a well southwest of the Pasajero Gap to determine the aquifer transmissivity.

Please call me if you have any questions.





Spring 2019