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FINAL

Pre Design Investigation Report for Remedial Alternatives to Mitigate Tetrachloroethylene Contamination (D1712508)

July 2019

Prepared for

South Tahoe Public Utilities District 1275 Meadow Crest Drive
South Lake Tahoe, CA 96150

KJ Project No. 1770027*00

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List of Abbreviations

Aquifer^{win32}	Software system used for analysis of aquifer test results.
Blaine	Blaine Technical Services, Sacramento, CA
BOS	Bottom of Screen
CAO	Cleanup and Abatement Order
Carson	Carson Pump Inc., Carson City, NV
Cascade	Cascade Drilling Services, Woodland, CA
CME	Construction Materials Engineers, Inc. Reno, NV
Cm/s	Centimeters per second
CPT	Cone Penetrometer Test
CPT/MIP	Cone Penetrometer Test/Membrane Interface Probe
CSLT	City of South Lake Tahoe
C_l	Lower part of Zone C
C_u	Upper part of Zone C
DCE	Dichloroethylene
District	South Tahoe Public Utility District
DO	Dissolved Oxygen
EC	Electrical Conductivity
EDC-EMD	El Dorado County Environmental Management Department
EPA	Environmental Protection Agency
FGL	FGL Environmental & Agricultural Analytical Chemists, Stockton, CA (Ca ELAP No. 1563)
Fox	Fox Capital Management Corporation
FS	Feasibility Study of Remedial Alternatives to mitigate Tetrachloroethylene Contamination (Agreement D1712508)
ft	feet
ft bgs	feet below ground surface
ft bmp	feet below measuring point (depth)
ft/d	feet per day
ft^2/d	square feet per day
ft/ft	feet per foot
ft/min	feet per minute
ft msl	feet above mean sea level (elevation)
GAC	Granular Activated Carbon
Gpd	Gallons per day
Gpd/ft	Gallons per day per foot
GPM	Gallons per minute
Gpm/ft dd	Gallons per minute per foot of drawdown
ihoriz	Horizontal gradient (groundwater)
in	Inches
K	Hydraulic Conductivity
KJ	Kennedy/Jenks Consultants, Inc.
lb	pound
lbs/d	pounds per day
LBWC	Lukins Brothers Water Company
LRWQCB	Lahontan Regional Water Quality Control Board
LTLW	Former Lake Tahoe Laundry Works site (1024 Lake Tahoe Boulevard)
Lumos	Lumos and Associates, Carson City, NV
MCL	Maximum Contaminant Level
MGD	Million gallons per day
mg/L	milligrams per liter (equivalent to parts per million)

$Mg.ft^2 d$	milligrams per square foot per day (Advective Flux)
MTBE	Methyl Tertiary Butyl Ether
m.y.	Million years
NAVD88	North American Vertical Datum of 1988
NNE	North northeast
NNW	North northwest
ORP	Oxidation-Reduction Potential
PCE	Tetrachloroethylene
PCF	Pounds per cubic foot
PDI	Pre-Design Investigation
PWS	Public Water System
QA/QC	Quality Assurance/Quality Control
QAPP	Quality Assurance Project Plan
SCH	Schedule
Seven Springs	Seven Springs Limited Partnerships
South “Y”	Intersection of Highway 50 and Highway 89, South Lake Tahoe, CA
SLTZ3	South Lake Tahoe Zone 3
SPT	Standard Penetration Test
TCE	Trichloroethylene
TD	Total Depth
TKPOA	Tahoe Keys Property Owners Association
TKWC	Tahoe Keys Water Company
TKWZ 1	Tahoe Keys Water Zone 1
TKWZ 2	Tahoe Keys Water Zone 2
TKWZ 3	Tahoe Keys Water Zone 3
TKWZ 4	Tahoe Keys Water Zone 4
TKWZ 5	Tahoe Keys Water Zone 5
TOS	Top of Screen
TVS Basin	Tahoe Valley South Subbasin (6-5.01)
USCS	Unified Soil Classification System
µg/L	Micrograms per liter (equivalent to parts per billion)
VOA	Volatile Organic Analysis
VOC	Volatile Organic Compound
WY	Water year

Section 1: Background

This section provides a summary of the area's site history, past investigations, and the purpose and scope of the recent investigation.

South Tahoe Public Utility District (District) contracted with Kennedy/Jenks Consultants, Inc. (KJ), to conduct a Pre-Design Investigation (PDI) and a Feasibility Study of Remedial Alternatives (FS) to address tetrachloroethylene (PCE) contamination found in groundwater within the South "Y" Area of the City of South Lake Tahoe, El Dorado County, California; herein referred to as the South "Y" Plume. The FS is detailed in the District's Proposition 1 Groundwater Grant Program Final Application (FAAST # 36772) submitted for review and evaluation by the State Water Resources Control Board Department of Financial Assistance (SWRCB-DOFA) in November 2016. The PDI was added to augment the existing hydrologic and groundwater quality data for use in the FS.

1.1 Purpose and Scope

The objective of the PDI is to collect specific capacity, aquifer characterization and water quality data that can be used to design strategies for the purpose of hydraulic control and/or removal of PCE contamination from groundwater. To meet these objectives, the PDI involved the drilling, installation, sampling, and pump testing of a new test well, for lithologic description, aquifer characterization, and vertical delineation of PCE contamination. The PDI included sampling and monitoring of existing wells neighboring the test well to calculate aquifer hydraulic properties; identify groundwater contaminant pathways; determine horizontal and vertical hydraulic gradients; and groundwater flow directions. These data will then be integrated and evaluated with the existing hydrologic and contaminant distribution data in the FS.

The components of the field implementation of the PDI, along with more extensive discussions of the area geology, hydrogeology, and historical contamination were presented in the *South Y Pre-Design Investigation Workplan* dated 23 March 2018 (the Workplan).

1.2 Site Area

The South "Y" Plume occurs within the west central portion of the Tahoe Valley South Sub-basin (6-5.01), herein referred to as the Tahoe Valley South Basin (TVS Basin). The TVS Basin has an area of approximately 23 square miles (14,814 acres) in El Dorado County, California as shown on Figure 1-1. The TVS Basin is roughly triangular in aerial extent and is bounded on the southwest by the Sierra Nevada, on the southeast by the Carson Range, and on the north by the southern shore of Lake Tahoe. The Basin generally conforms to the valleys of the Upper Truckee River and Trout Creek. The City of South Lake Tahoe (CSLT) overlies the northern portion of the TVS Basin. The southern boundary extends about three miles south of the town of Meyers in unincorporated El Dorado County. The northeast boundary of the TVS Basin is defined by the California-Nevada state line.

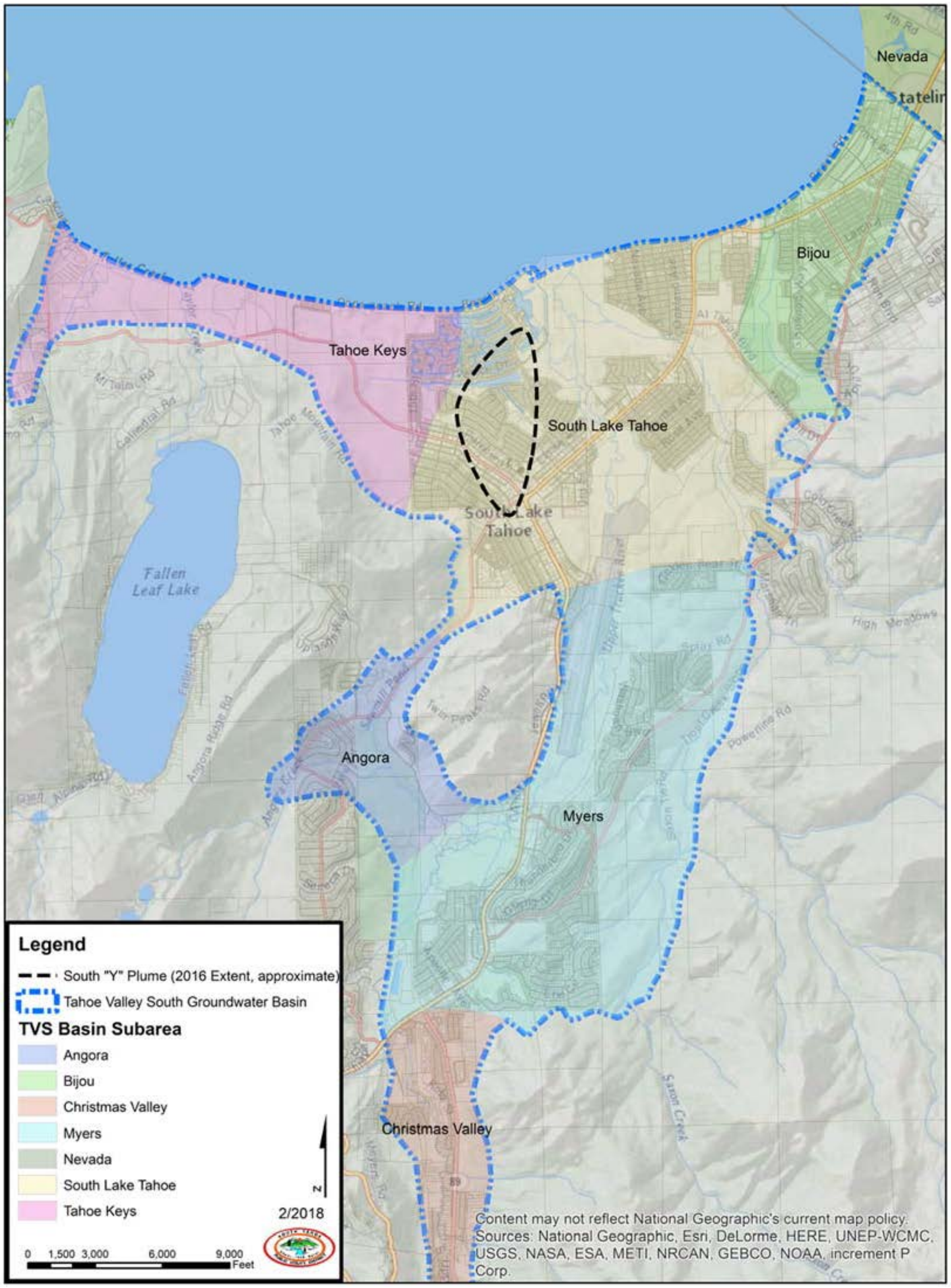

Figure 1-1: Regional location of the South "Y" Plume within the South Lake Tahoe subarea of the Tahoe Valley South Groundwater Basin.

As described in the Workplan, the new test boring (EW-1) and test wells (EW-1B and EW-1C) are located on a 1.1-acre parcel owned by the CSLT at 953 Eloise Avenue. This site is located in the northeast corner of the intersection of Eloise Avenue and 5^{th} Street and is the site of a CSLT storm water retention basin. Monitoring well cluster (MW-4) is located along the north shoulder of Eloise Avenue, in the southwest corner of the property. MW-4 consists of three 2-inch PVC monitoring wells installed at the following depth zones; MW-4A from 15– 25 feet; MW-4B from 35 -50 feet; and MW-4C from 59 – 79 feet. This well cluster was originally installed in 1999 as part of groundwater contamination assessment and remediation investigations for the Swiss Mart Gas Station Site (T0601700123). Monitoring Well MW-XA is located near the west bank of the retention basin. This shallow monitoring well was installed in 2003 as part of a hydrologic investigation of the retention basin and consists of a 2-inch PVC monitoring well screened from 5 to 15 feet below ground surface (ft bgs) (2nd Nature, 2006).

1.3 Hydrogeologic Setting

An extensive discussion of the geologic and hydrogeologic information pertinent to the Eloise Avenue project site is presented in the Workplan. Lithologic and well construction logs from South Y Area wells within the site area are also provided in the Workplan.

1.3.1 Geology

Figure 1-2 is a geologic map of the surficial deposits exposed in the South Y Area. The locations of cross-sections further discussed in this section are illustrated on Figure 1-2.

The Lake Tahoe Basin is a 2 m.y. structural graben formed by faulting and volcanism. The basin is filled with glacial, fluvial and lacustrine sediments deposited since the Pleistocene epoch. During the Pleistocene, glacial outwash deltas formed along the south, west and north shores of Lake Tahoe and prograded out into the lake. These outwash deltas formed during highstands in lake level caused by the damning of Lake Tahoe by valley glaciers at its outlet in the Truckee Canyon (Hyne et al, 1972). During these highstands, the bathymetric depth in the south shore area has been inferred to been as deep as 900 feet (USACOE, 2003).Thickest accumulations of these delta deposits are situated northeast of the South Y Area, underlying the Upper Truckee Marsh.

Within this setting, proximal sub-aqueous fans composed of coarse-grained glacio-fluvial sediments were deposited. Coarse-grained sediments from these sub-aqueous fans were transported as debris flows to the lake floor. Sand and silts are believed to have been transported further into the lake by density-driven underflows. Depending on rate of aggradation, coarse-grained materials transported to the lake floor are believed to have formed ice-contact fans or fan-delta deposits (USACOE, 2003).

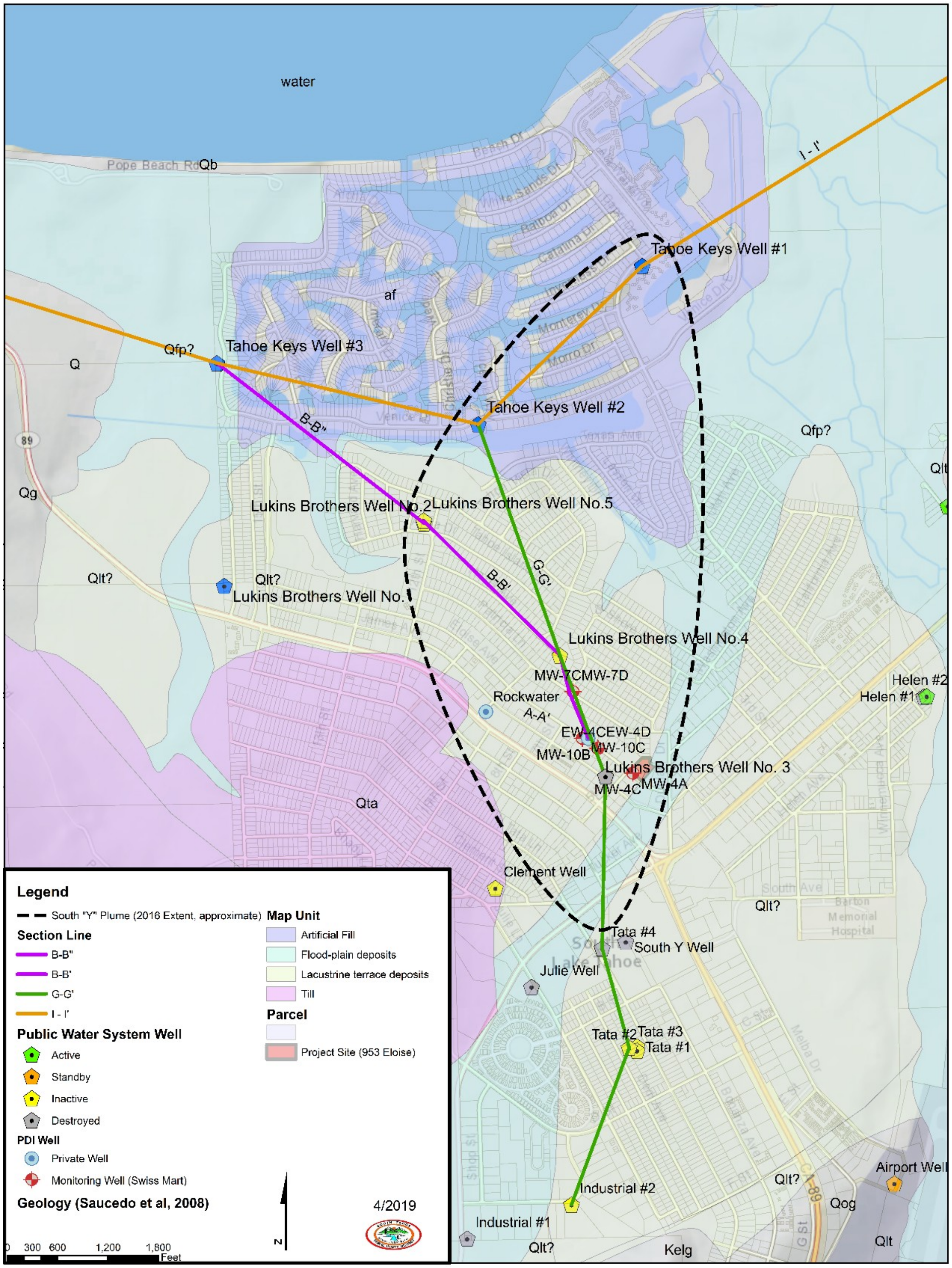

Figure 1-2: Geologic map units identified within the site area are from the California Geological Survey (Saucedo, 2008). Orientations of section lines provided in this report are also shown.

Figure 1-2 shows geologic map units exposed at the surface within the South Y Area. These units are predominantly lacustrine terrace deposits of Pleistocene age (Qlt?) and are generally described as consisting of poorly to moderately sorted silt, sand and gravel forming broad low terraces 5 - 10 meters above lake level. Till (Qta) occurs south of these terrace deposits, forming the north flank of Gardner Mountain and are described as unconsolidated boulder till with distinct yellow-brown weathered matrix; preserved as larger moraines with more rounded and broader crests. Flood-plain deposits of Holocene age (Qfp?) occur immediately north and east of the terrace deposits. These map units are described as consisting of gravelly to silty sand and sandy to clayey silt. Artificial Fill (af) occurs north of the floodplain deposits over the area of the Tahoe Keys. These are described as man-made deposits of varying composition. At the south end of the map, granitic rocks are exposed. These are older Cretaceous age igneous rocks which outcrop through the basin-fill sediments and are mapped as Echo Lake Granodiorite (Kelg) (Saucedo, 2008). Twin Peaks is the geographic name given to this outcrop of granitic basement.

The geology underlying the South Y Area is known from information gathered during the drilling and construction of Public Water System (PWS) wells located across the area, including lithologic and electrical spontaneous potential (SP) – single-point resistance logs. The deepest water wells drilled in the South Y Area provide subsurface information to depths of about 325 feet (South Y Well). Water wells situated north of this area in the Tahoe Keys provide subsurface information to depths of 495 feet (TKWC 2). Review of these data show that the stratigraphic sequence across the South Y Area is generally characterized as forming several sequences of medium to coarse gravel and sand deposits interlayered with fine-grained silts and clays (Figure 1-3).

Figure 1-3 is a subsurface section across the South Y area extending north from Industrial Well #2 to Tahoe Keys Well #2 (TKWC #2). Industrial Well #2 is located along the north flank of Twin Peaks. At the south end of the section, near its contact with the basin-fill, drilling logs indicate a thick section of boulder and coarse sand materials with clays that form a clastic wedge extending northward to at least to the area of Tata Lane Well #4. This is interpreted as scree resulting from erosion (glacial scour?) and deposited along the north flank of Twin Peaks. North of Tata Lane #4 the scree grades laterally to silts and clays. North of the Tata Lane Well #4, sands and gravels, penetrated at well depths of 85 to 135 ft bgs form a laterally extensive horizon that dips northward toward the TKWC #2 where it is correlated with sand and gravels penetrated at well depths of 134 to 190 ft bgs. These sand and gravels are not connected to the scree and are overlain by a laterally continuous silt and clay layer penetrated at well depths of 75 to 85 ft bgs at the Tata Lane Well #4; at well depths of 88 to 105 ft bgs at the Lukins Brothers Well #4; and at well depths of 98 to 134 ft bgs at the TKWC #2. Above this silt and clay layer is a much thicker accumulation of near-surface gravel and sand that is laterally continuous from the Industrial Well #2 to the TKWC #2. These sand and gravel deposits extend from ground surface to a depth of about 100 feet at the Industrial Well #2 to east of the Tata Well #3. The bottom of these sands are penetrated at a well depth of about 75 ft bgs in the Tata Well #4; at a well depth of about 88 ft bgs in the Lukins Brothers Well No. 4; and at a well depth of about 98 ft bgs in the TKWC #2.

1.3.1.1 Clay Lens

Subsurface sections showing the extent of the silt and clay layer are provided in Appendix A. Section G-G' shows the silt and clay layer forming a continuous horizon extending from the Tata Lane Well #4 to the TKWC #2. Section B – B" shows this layer pinching out in the area of LBWC #5, between LBWC #4 and TKWC #3. Driller logs from the Tahoe Valley Elementary School Well also show the silt and clay layer absent. The absence of this layer in the LBWC #5 and Tahoe Valley School wells constrains the east-west extent of this layer suggesting an elongated north-south oriented lens. The inferred subsurface extent of the clay lens is shown in Figure 1-4.

Information from drillers logs were used to construct a structure contour/isopach map of the silt and clay layer separating the sand and gravel horizon from the overlying near-surface sand and gravel deposits (Figure 1-5). Inspection of Figure 1-5 shows the strike along the top of the clay lens (north of the South Y) at N70E, slightly dipping to the north at 0.7 degrees. The isopach shows this lens less than 10 feet thick (EW-1C) near the South Y and more than 90 feet thick (TKWC #1) down-dip, north of the South Y.

1.3.1.2 Near-Surface Deposits

Numerous groundwater investigations have been conducted to characterize the type and extent of groundwater contaminants occurring within the South Y Area. Many of these investigations involved the drilling and construction of many soil borings and/or groundwater monitoring wells for the collection of soil and groundwater data. Information from these logs provides additional detail showing the subsurface arrangement of gravel, sand, silt and clay deposits to a depth of about 125 ft bgs. These include boring logs and subsurface sections developed by the District during PCE investigation at the Clement Well site, 912 Clement Street (Bergsohn, 1998); boring logs and subsurface sections developed by IT Corporation during methyl tertiary butyl ether (MtBE) contaminant investigation at the former USA Gas Station No. 7 site, 1140 Emerald Bay Road, (IT Corporation, 1999); and subsurface sections developed by E_2C Remediation during PCE contaminant investigation at the former Lake Tahoe Laundry Works site (LTLW), 1024 Lake Tahoe Boulevard (E_2C Remediation, 2008).

Groundwater investigation at the Clement Well was conducted north of Lake Tahoe Boulevard and west of the South "Y" site in order to identify contaminant pathways for the migration of PCE into this well. Lithologic logs from monitoring wells constructed at the site show the shallow stratigraphy to consist of a multi-layered sequence of silty fine sand and interbedded clayey fine sand and fine-medium sand from ground surface to a depth of about 45 ft bgs, medium and coarse sand from a depth of 53 to 84 ft bgs; and medium to coarse sand from 97 to 134 ft bgs. These sands are separated into three zones by intervening silty clay intervals occurring at depths of about 45 to 53 ft bgs and 84 to 97 ft bgs. Findings of this investigation suggested that PCE was migrating into the well through sand intervals occurring at depths below 48 ft bgs (Bergsohn, 1998).

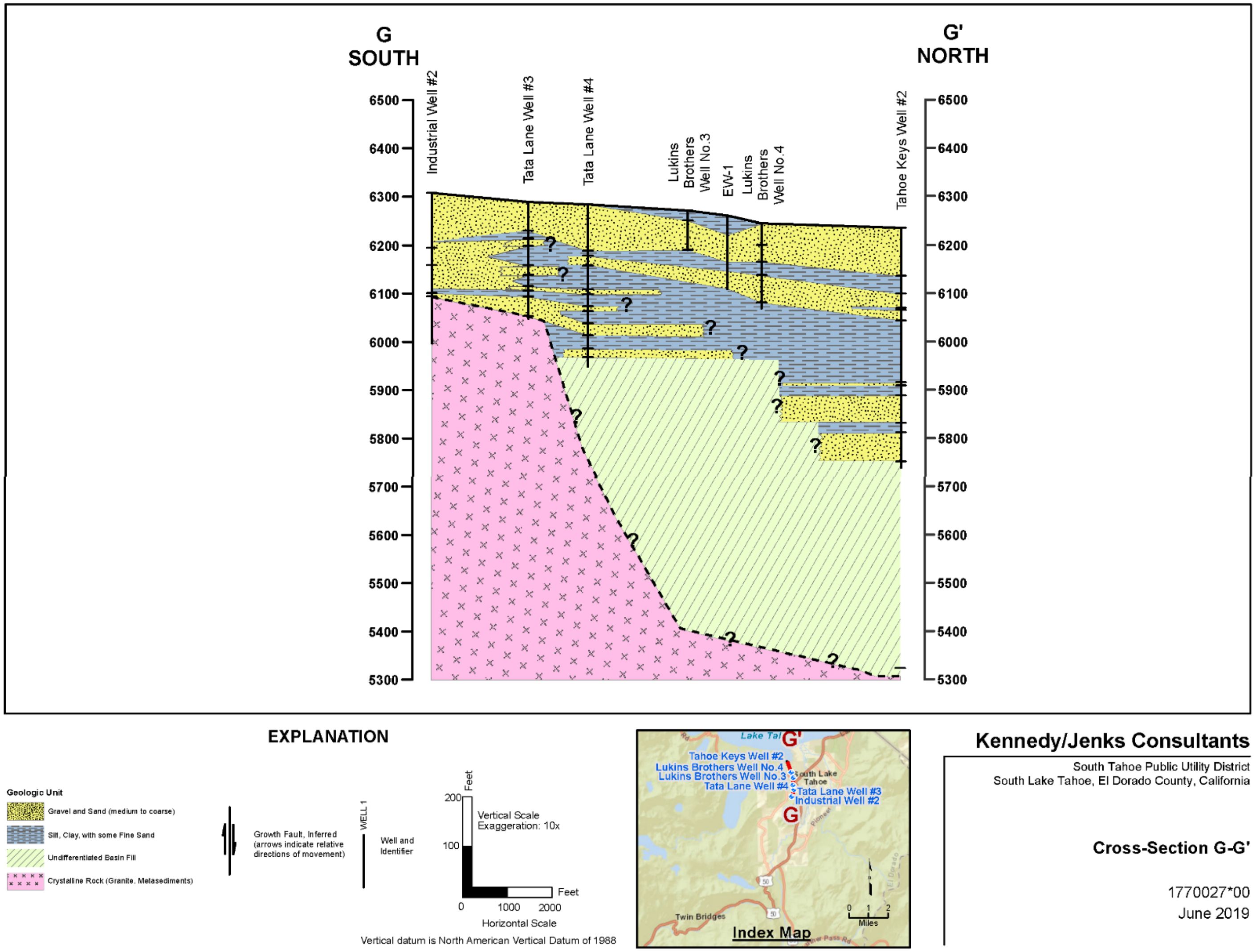

Figure 1-3: Subsurface Section G-G' showing the major gravel and sand units used for drinking water supply underlying the South "Y" area (Fogg et al, 2007). EW-1 is the test hole drilled at the project site projected into the section.

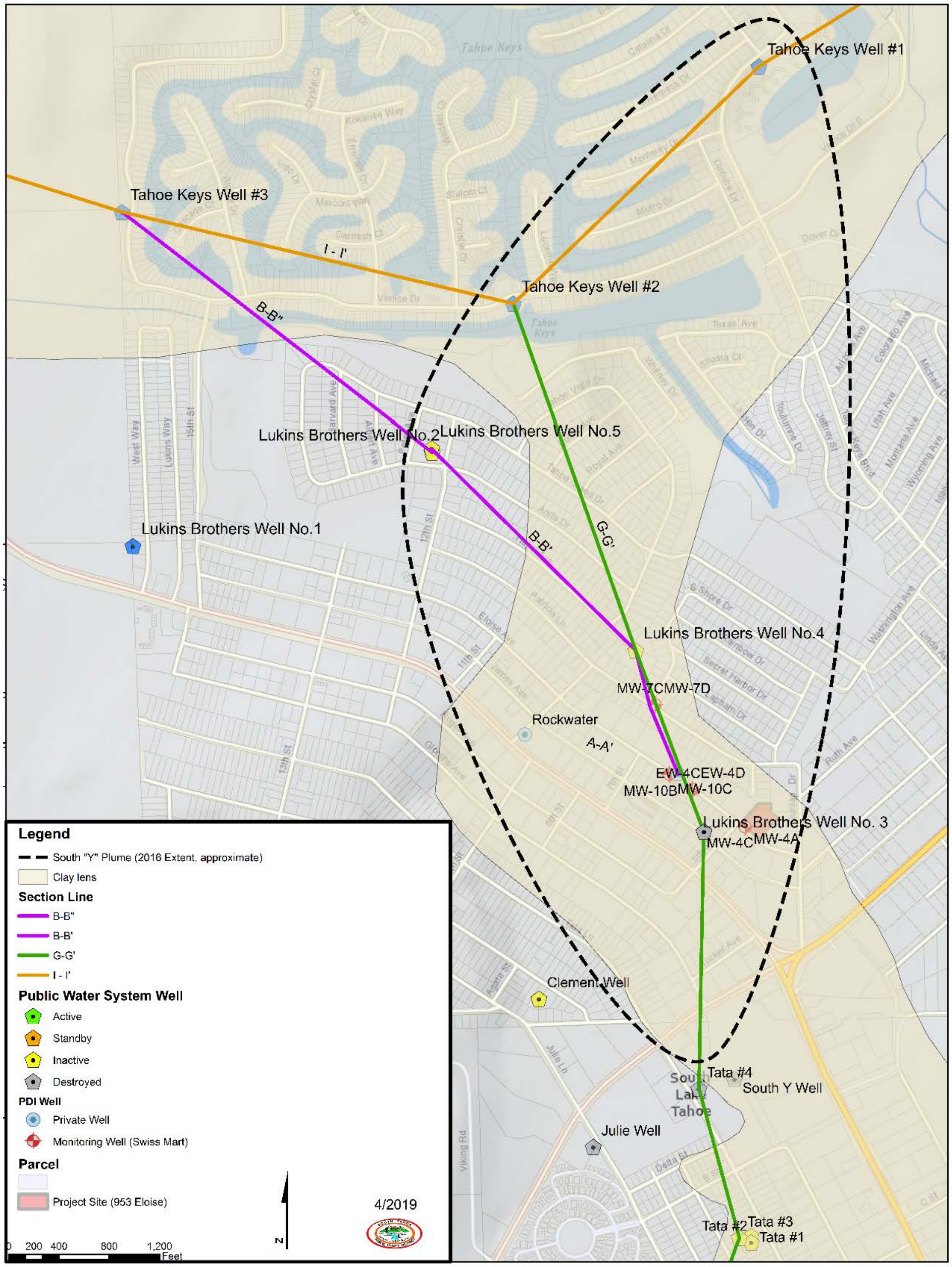

Figure 1-4: Inferred subsurface extent of the clay lens from the South Y to the Tahoe Keys.

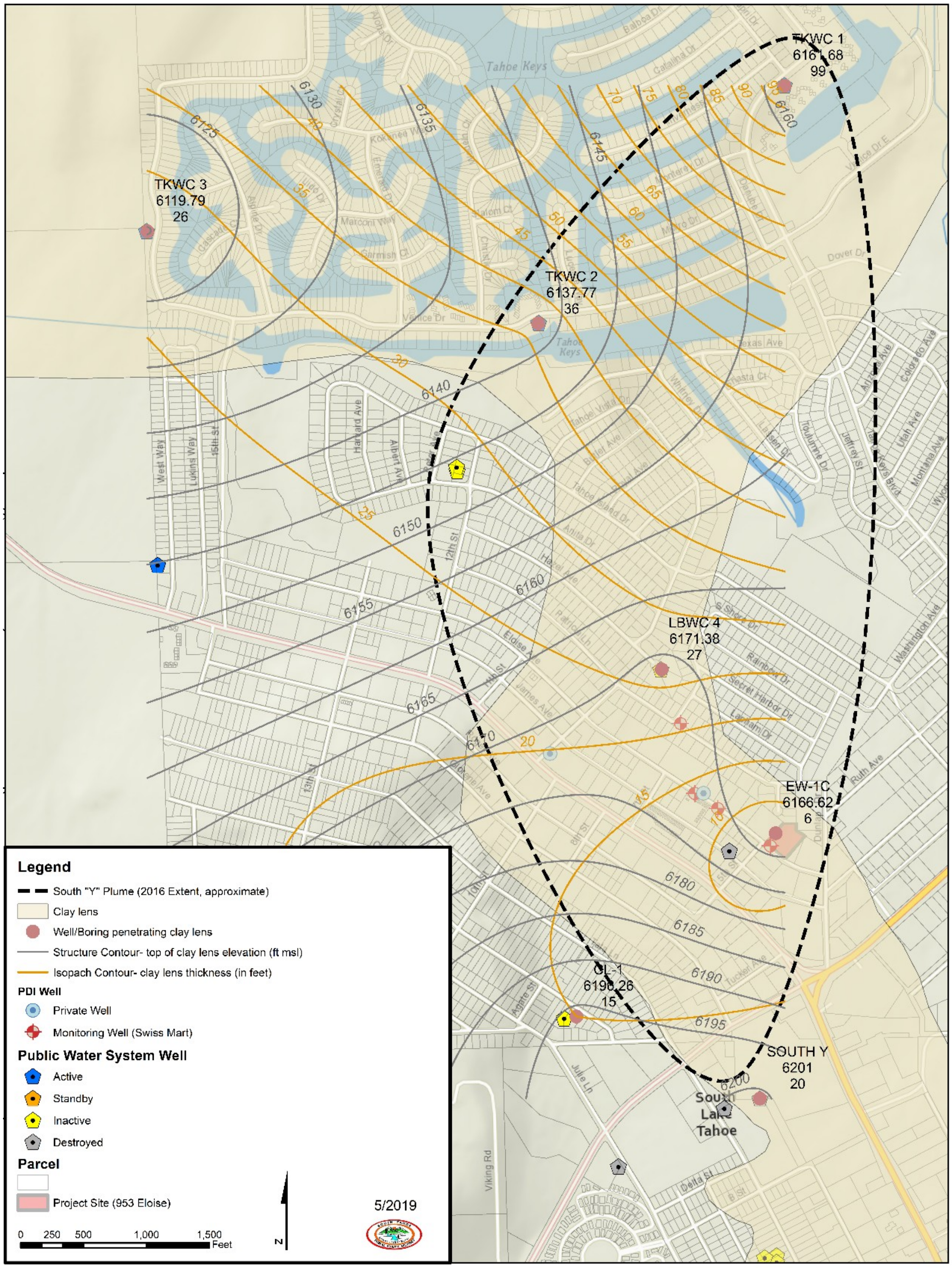

Figure 1-5: Structure contour and isopach map showing the orientation and thickness of the clay lens between Tata Lane Well #4 and TKWC #2. The clay lens occurs between the laterally extensive gravel and sand horizon and the near-surface gravel and sand deposits.

Copious amounts of subsurface data were collected south of Lake Tahoe Boulevard and west of the South "Y" at the former USA Gas Station No. 7 site (1140 Emerald Bay Road). Groundwater investigations at this site focused on delineating a methyl tertiary butyl ether (MtBE) contaminant plume associated with known petroleum hydrocarbon releases from this site. Geologic cross-sections constructed from numerous drilling logs across the South Y Area showed a similar multi-layered sequence of near surface granitic sands and silty sands from ground surface to a depth of about 30 ft bgs; a middle zone composed of interbedded sand and silty sand from 35 to approximately 55 to 75 ft bgs; and a deep zone composed of silty sand to sand with local gravel zones from depths of about 75 to about 125 ft bgs. These sands are separated by intervening silty clay intervals occurring at depths of about 30 to 35 ft bgs and from about 55 to 90 ft bgs (IT Corporation, 1999).

Site investigations performed immediately south and west of the South "Y" at the LTLW site (1024 Lake Tahoe Boulevard) were used to describe the occurrence of PCE contamination underlying this site. During a 2008 site investigation, well log data showed near surface poorly-graded and well-graded sands occurring below fill materials from about 5 to 15 ft bgs to about 30 to 40 ft bgs. A second zone of poorly-graded and well-graded sands is shown below the near-surface sands at depths below about 35 to 40 ft bgs. A thin silt layer (1 to 2.5 feet in thickness) separates these sand horizons where continuous along the west side of this site. This silt layer appears to be discontinuous along the east side of the site (E_2C Remediation, 2008).

In summary, review of the subsurface data shows the South Y Area underlain by several sequences of medium to coarse gravel and sand deposits interlayered with fine-grained silts and clays (Figure 1-3). These include scree at the south end of the South Y area nearest the north flank of Twin Peaks; a laterally extensive sand and gravel horizon between Tata Lane Well #4 to Tahoe Keys Well #2; and a thick accumulation of near-surface sand and gravels above the sand and gravel horizon from Industrial Well #2 north to TKWC #2. These near-surface deposits are separated from the underlying sand and gravel horizon by a laterally extensive clay lens extending north from Tata Well #4 to TKWC #2. Structure and isopach maps of the clay lens (Figure 1-4) show a north dipping lens that varies from less than10 to more than 90 feet in thickness. The isopach shows this lens is thinnest to the south near the South Y and thickens down-dip to the north and east of the South Y.

Near surface sand and gravel deposits are composed predominantly of sand, silty sand and silt. Locally the sands have been subdivided into three intervals or zones (e.g., Upper, Middle and Lower), where separated by intervening silty clay horizons. Upper silty clay horizons, from several feet in thickness, have ben correlated across a few hundred feet; while the lower silty clay intervals, from several to tens of feet in thickness, appear to be more extensive and have been correlated up to 1,100 feet in extent.

1.3.2 Hydrogeology

Based on review and evaluation of lithologic and SP logs from water wells drilled throughout the TVS Basin, the District has identified at least 26 water-bearing zones present within the basin-fill aquifer, of which 18 are actively used for drinking water supply. North and east of the South Y Area, glacial outwash delta deposits underlying the Upper Truckee Marsh, form the primary water zones used for drinking water supply in the TVS Basin.

Across the South Y Area, water zones generally correspond to the gravel and sand units illustrated in Figure 1-3. The water zones are separated from one another by interlayered silt and clays forming aquitards between water zones. The water zones correlated across the South "Y" Area are labeled on the subsurface sections provided in Appendix A. Review of these sections shows six water zones, from deep to shallow depths: Tahoe Keys Water Zone 1 (TKWZ1); Tahoe Keys Water Zone 2 (TKWZ2); Tahoe Keys Water Zone 3 (TKZ3); South Lake Tahoe Zone 3 (SLTZ3); Tahoe Keys Water Zone 4 (TKZ4); and Tahoe Keys Water Zone 5 (TKZ5). Each of these zones is actively used for drinking water supply with the exception of SLTZ3, which is not currently used for water production in the South Y Area.

PCE contamination in groundwater occurs predominantly in the two uppermost water zones (TKWZ4 and TKWZ5). The Federal and State drinking water standard maximum contaminant level (MCL) for this contaminant is 5 micrograms per liter (µg/L). PCE in groundwater above the MCL has impaired drinking water wells that historically have and or currently produce groundwater from both TKWZ5 and TKWZ4. The clay lens described in Section 1.3.1.1 and shown in Figure 1-4 forms an aquitard separating TKWZ4 (below the aquitard) from TKWZ5 (above the aquitard). This aquitard is believed to form a very low hydraulic conductivity layer that inhibits the vertical migration of PCE. However, this aquitard appears to pinch-out within the area of the contaminant plume, and the hydraulic influence of pumping wells along with well construction across this aquitard likely provide pathways for vertical migration of contaminants across this layer.

1.3.2.1 Groundwater Flow

Static water level elevation readings are collected annually from District PWS and observation wells during the spring and fall as part of the TVS Basin Monitoring Program. These readings through the South Y Area are from wells screened below the clay lens. Historical groundwater level readings from District PWS and monitoring wells indicate that the horizontal direction of groundwater flow across this area is generally to the north north-east toward Lake Tahoe.

The District has performed many aquifer tests characterizing aquifer parameters throughout the TVS Basin. A summary of the available aquifer test data for South Y Area wells is presented in the Workplan. From the available data, average groundwater flow velocity (Darcy velocity) is calculated at 0.26 feet/day; and the average linear (seepage) velocity is calculated at 1.30 feet/day These values are based on an average horizontal gradient of 0.01 ft/ft, derived from groundwater level readings collected during spring 2016 and fall 2017(KJ, 2018).

Vertical hydraulic gradients for the South Y Area are known from groundwater levels measured from a monitoring well cluster with wells screened above (CL-3) and below (CL-1) the clay lens. Vertical gradients from groundwater level readings measured in these wells are on the order of 0.10 ft/ft, which is an order of magnitude greater than the horizontal gradient.

During the baseline sampling conducted for the PDI and described in Section 3.4, additional groundwater elevation readings were collected from wells located directly within the South "Y" Plume screened above and below the clay lens. These readings provide interpretations of groundwater flow directions within the contaminant plume (see Section 3.4).

1.3.2.2 PCE Contamination

Groundwater in the TVS Basin is typically of excellent quality; however, there is a history of groundwater contamination from regulated industrial and commercial chemicals impairing drinking water sources within the basin. Chlorinated hydrocarbons have been detected in PWS wells, private wells and environmental monitoring wells within the South "Y" Area since 1989, when these compounds were required to be first tested in regulated drinking water sources. Many of these wells have since ceased operating due to PCE concentrations in these wells exceeding MCLs including: three District wells (Tata Lane Well # 4, Julie Well and South Y Well); and two Lukins Brothers Water Company (LBWC) wells (LBWC #3 and LBWC #4). A summary of PCE impacts to PWS wells in the South Y Area is provided in Section 1 of the PDI Workplan (KJ, 2018).

Currently, PCE above MCLs has impaired three PWS wells (LBWC #2, LBWC #5 and TKWC #2) with a combined source capacity of 3.25 million gallons per day (MGD). PCE below MCLs is detected in Tahoe Keys Water Company Well 1 (TKWC #1). Potential impairment of TKWC #1 would further reduce the total production capacity of area drinking water sources by an additional 1.44 MGD. Two other PWS wells (LBWC #1 and TKWC #3) west of the South Y plume are presently non-detect for PCE. The District has mutual aid and assistance agreements for the emergency provision of drinking water using inter-tie connections from its water distribution system to both the LBWC and TKWC water systems. During the 2018 WY, the District provided 7.54 million gallons through its inter-tie connection to LBWC, which is about 9% of LBWC's total water production for the 2018 WY (STPUD, 2018).

During the second half of 2016 through 2018, multiple parties have been engaged in the collection of water quality data to show the occurrence and distribution of PCE within the South "Y" Plume. In 2016, the Lahontan Regional Water Quality Control Board (LRWQCB) developed a cross-section to show the inferred vertical extent of PCE in groundwater (LRWQCB, 2016), provided as Figure 1-6. Environmental consultants retained by TKWC compiled available historical and current data to assess the spatial and temporal distribution PCE in soil and groundwater in the South Y Area. Using these data, the lateral extent of PCE contamination was generally defined, delineating the inferred lateral extent of the South Y Plume shown on Figure 1-7 (Alward and Peterson, 2016).

Further groundwater sampling has been performed by the water purveyors (District, LBWC and TKPOA); LRWQCB and environmental consultants retained by Seven Springs Limited Partnership (Seven Springs) and Fox Capital Management Corporation (Fox), referred to as the working parties. These sampling events and their results are summarized in the Workplan (KJ, 2018). Figure 1-6 is a map showing the distribution of PCE in groundwater based on samples collected during 2017. A map showing the distribution of PCE in groundwater based on samples collected during 2018 is provided in Section 3.7 of this report.

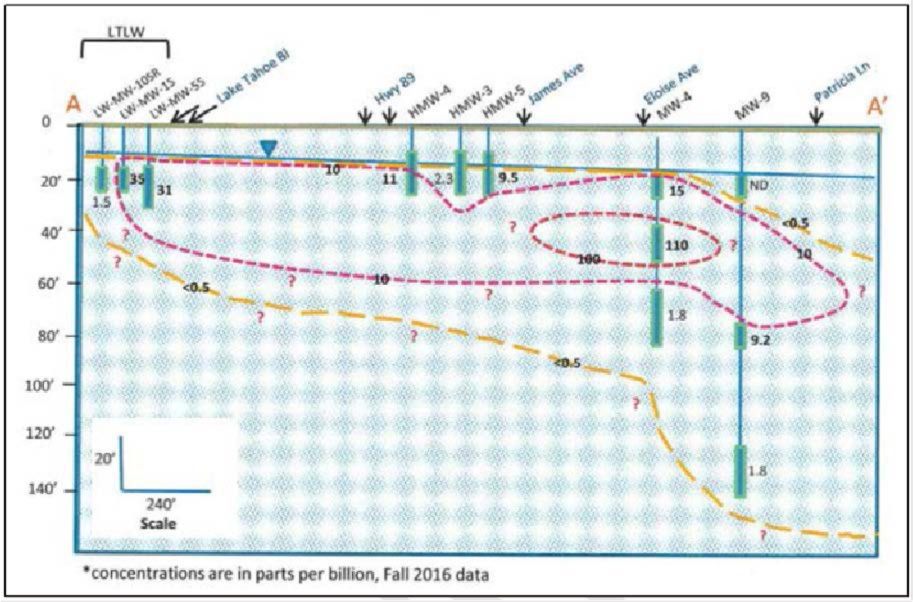

Figure 1-6: Vertical Extent of PCE Plume in fall 2016 (LRWQCB, 2016)

Groundwater samples collected by the LRWQCB and the working parties were collected from existing monitoring wells and cone penetrometer test/membrane interface probe (CPT/MIP) sample points. This effort identified groundwater quality in samples collected above the clay lens from sample depths less than 100 feet. Inspection of these results showed that south of the Y, highest PCE concentrations (56 – 72 µg/L) were found in groundwater samples collected at the former LTLW site from LW-MW-1S screened between 15 to 25 ft bgs. North of the Y, significantly higher PCE concentrations were detected in CPT/MIP samples collected from slightly deeper sample depths. High levels of PCE contamination (338 – 718 µg/L) were detected in CPT/MIP samples collected along James Street between 5th Street and Dunlap at sample depths between 35 to 39 ft bgs. Levels of PCE greater than 1,000 µg/L was found in one sample collected near the intersection of 5th Street and Eloise Avenue at sample depths between 45 to 49 ft bgs. PCE contamination less than MCLs (5 µg/L) was found in samples collected from this area at sample depths between 76 to 80 ft bgs. East of this area PCE contamination (5.47 – 9.58 µg/L) was detected in groundwater samples collected at sample depths between 70 to 74 ft bgs.

Along the west side of the plume, PCE contamination (22 – 99 µg/L) was found in CIP/MIP samples collected at sample depths between 69 to 73 ft bgs. The vertical extent of contamination along the west side of the South Y Plume was not defined.

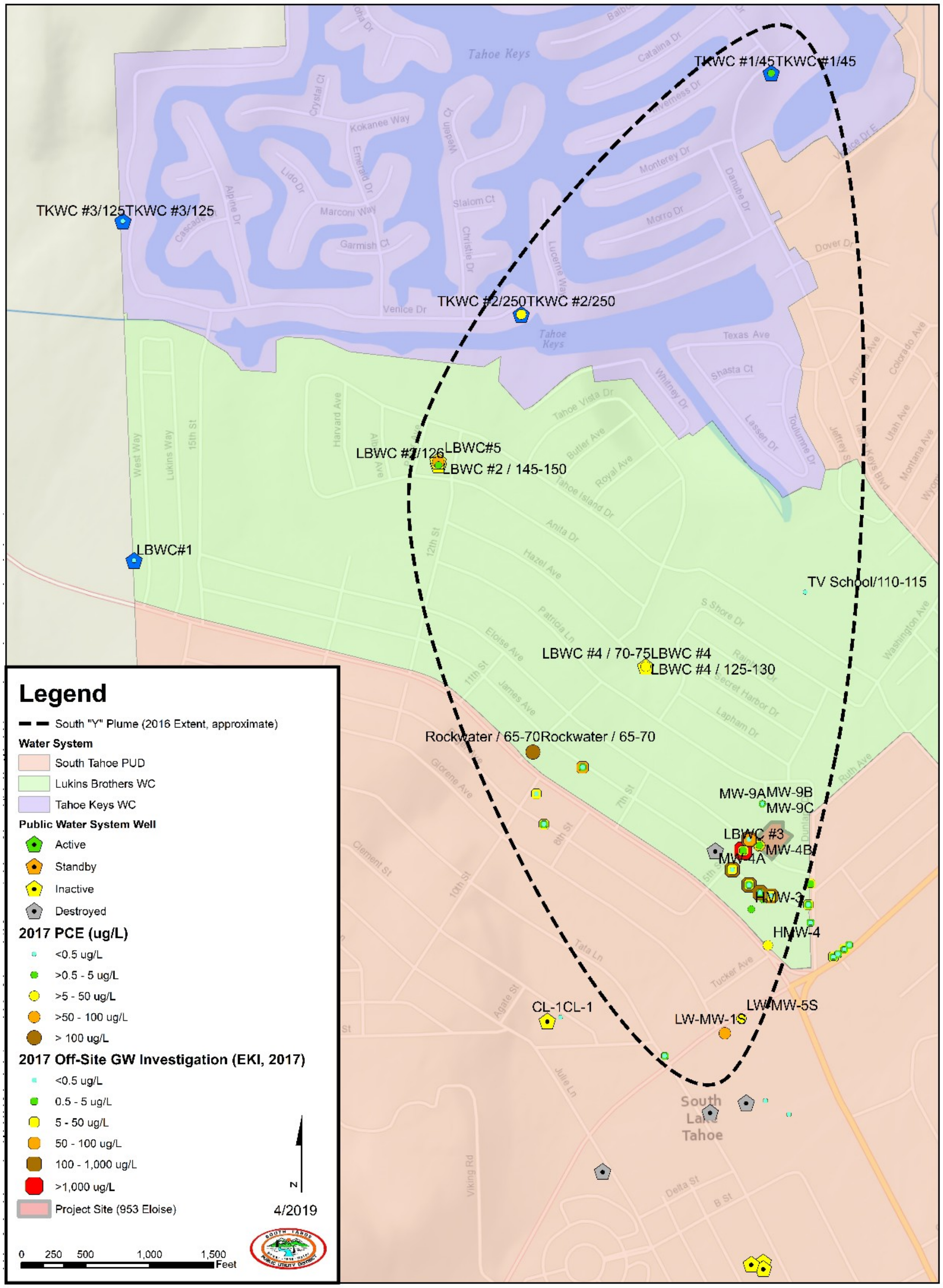

Figure 1-7: PCE distribution in groundwater from laboratory results of samples collected during 2017 by the water purveyors, the LRWQCB and consultants for the working parties. The inferred extent of the South Y Plume (from Alward and Peterson, 2016) is shown for reference.

With one exception, groundwater samples collected by the water purveyors were from below the clay lens at sample depths below 100 feet. This exception involved the collection of groundwater samples from an inactive private well (Rockwater Well) screened from between 70 to 99 ft bgs. Groundwater samples collected from this well found PCE concentrations above 100 µg/L. PCE was also detected in groundwater samples collected from LBWC #5 (67 µg/L), TKWC #2 (18 – 20 µg/L), TKWC #1 (1.8 – 2.1 µg/L). Grab samples collected from two depth discrete sample intervals from LBWC #4 ranged from 9 to 42 µg/L in groundwater samples collected from the upper screened interval (43-78 ft bgs) and was 26.7 µg/L in one sample collected from the lower screened interval (105- 132 ft bgs). PCE was not detected (< 0.5 µg/L) in groundwater samples collected from LBWC #1 , TKWC #3 and the TV School well.

Under Clean-up and Abatement Order R6T-2017-0022, the LRWQCB identified the former LTLW site as a source area contributing PCE contamination to the South Y Plume. A coin operated dry cleaning unit operated at this site between 1972 and 1979. Spills associated with deliveries of PCE dry-cleaning solvent are believed to have resulted in releases of PCE to shallow soil and groundwater. PCE used as a dry-cleaning grade solvent typically had a purity of 95% or more (ATSDR, 1997). The extent of PCE contamination from this site has not been fully defined; therefore LRWQCB is requiring the working parties to conduct further off-site investigation (LRWCB, 2017). In parallel with these efforts, the LRWQCB is also in the process of renewing site investigations to identify other contributing source areas of PCE contamination to the South Y Plume and is conducting a Regional Plume Investigation to further characterize the plume (LRWQCB, 2019). Figure 1-8 shows the locations of other potential PCE contributing source areas identified within the South Y Area.

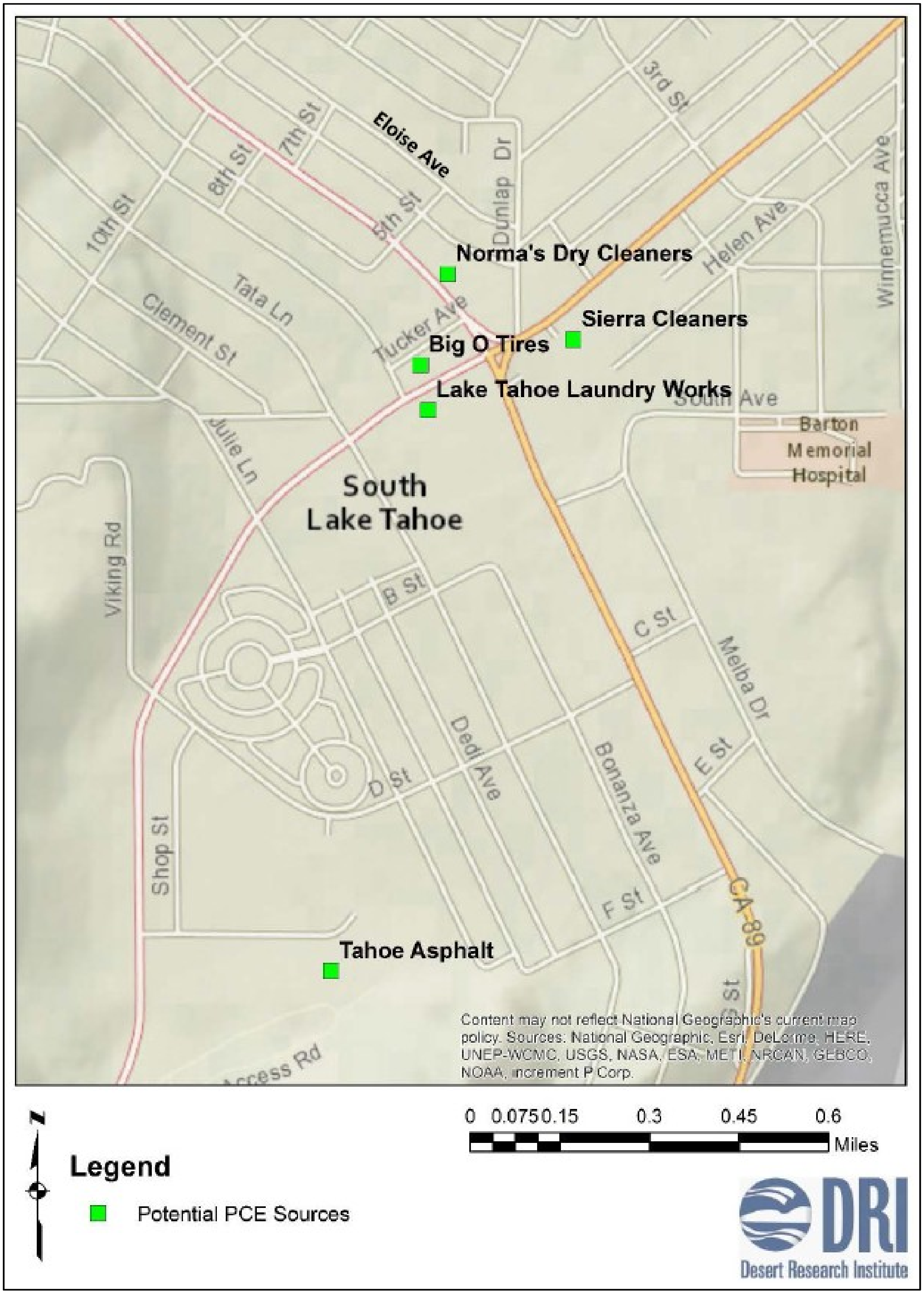

Figure 1-8: Potential Sources of PCE contamination in the South Y Area

Section 2: Field Investigation

This section describes the sampling, drilling, and well construction activities undertaken during the investigation.

2.1 Permitting/Site Access Agreements

Permits included an access permit from Liberty Utilities, access and obstruction permits from the City of South Lake Tahoe and a well construction permit from El Dorado County. Copies of permits are included in Appendix B.

2.2 Baseline Sampling

Baseline groundwater sampling was conducted at the following ten wells, some of which are co-located: MW-4A, MW-4B, MW-4C, MW-7C, MW-7D, MW-10A, MW-10B, MW-10C, EW-4C, and EW-4D. Blaine Tech Services (Blaine) of Sacramento, California conducted the sampling on 2 May 2018. Blaine measured the water level in each well and purged three casing volumes of water while monitoring the parameters pH, electrical conductivity (EC), turbidity, dissolved oxygen (DO), and oxidation-reduction potential (ORP) for stabilization prior to collecting samples. After purging, Blaine collected the sample using a disposable bailer, decanting the water into containers provided by the District laboratory. Blaine delivered the samples under chain-of- custody to the District lab for analysis by an outside analytical laboratory. Blaine transferred the purge and decontamination water to the holding tank at the 953 Eloise for treatment through the onsite Granulated Activated Carbon (GAC) system and eventual discharge to the sanitary sewer. A summary of results is found on Figure 2-1 and Table 2-1. Blaine's field forms and copies of the laboratory reports are included in Appendix C.

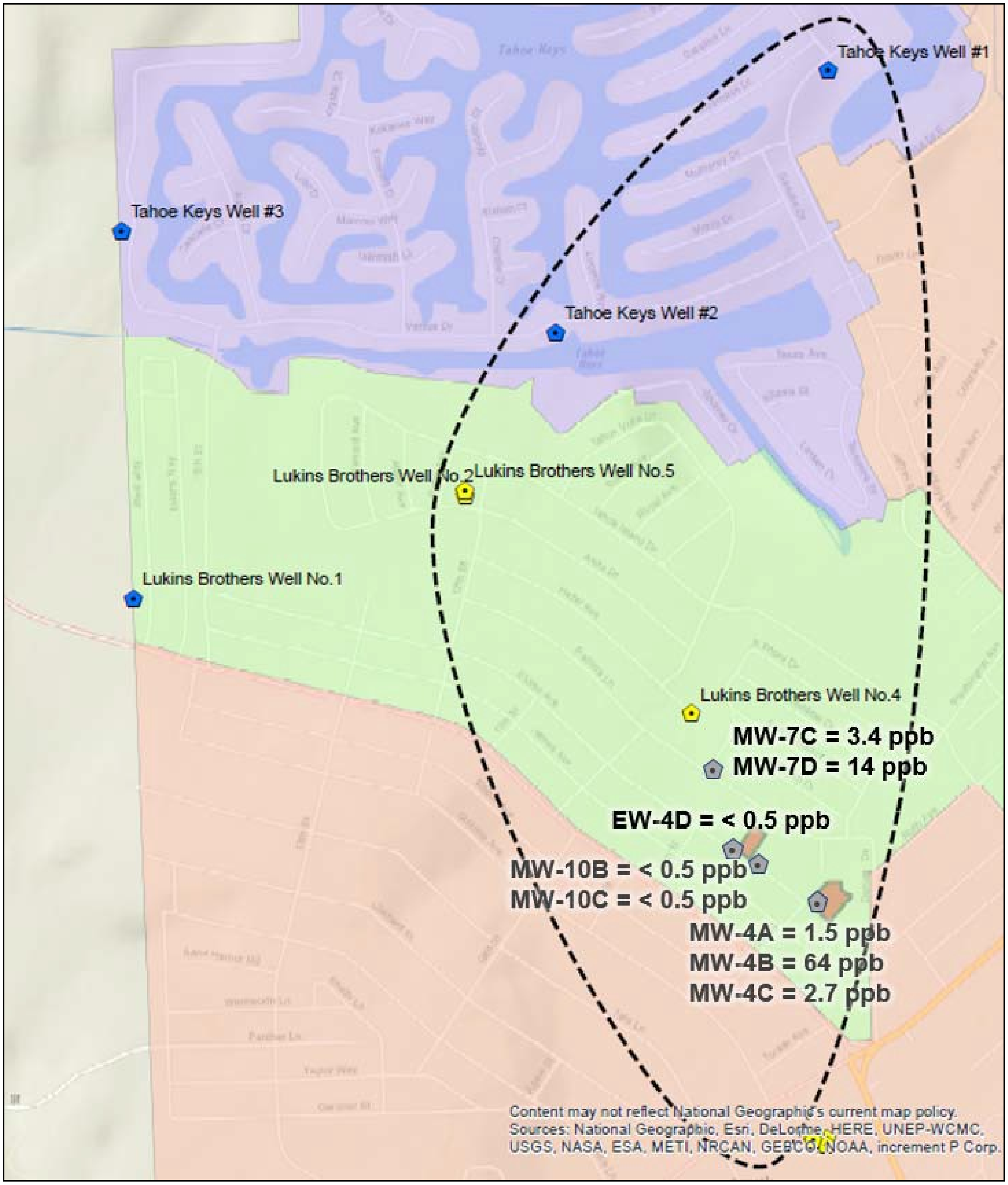

Figure 2-1: Baseline Groundwater Analytical Results Summary

2.3 Test Hole Drilling

The test hole and test wells were located on the 953 Eloise Street property. Drilling and well construction was done by Cascade Drilling, LP (Cascade). Water treatment system components (bag-type pre-filter and GAC filter) were supplied by Pure Effect, Inc. and plumbed together by Carson Pump, Inc. (Carson). Carson also provided and plumbed transfer pumps, discharge lines, fittings, and tanks for storing groundwater prior to discharge to the sanitary sewer.

2.3.1 Drilling Sequence

The drilling was conducted in two phases. In the first phase, between 29 April 2018 and 5 May 2018, Cascade installed the erosion and sediment control best management practices (BMPs), sound attenuation panels, and drilled the test hole. The sampling described in the Workplan was conducted, and samples of subsurface material were submitted for permeability and gradation testing. Cascade sealed the pilot borehole and the operation was demobilized while the samples were being analyzed. The water treatment system components were also demobilized.

The test wells were designed using the information obtained in the first phase. The completion intervals were based upon zone sample observations and analytical results and the observed stratigraphy. The well screen openings' size and filter pack were based upon the gradation results. The proposed well designs were discussed with and approved by the TAC prior to purchase and fabrication of the well components

After the wells were designed, Cascade ordered the well screen fabrication and purchased the filter pack, and the drilling operation remobilized for the extraction wells installation in the second phase. The extraction wells were constructed between 24 June 2018 and 28 June 2018. Carson Pump developed the wells on 29 June 2018. The step test and constant-rate aquifer tests were conducted in July 2018.

Boring and well construction logs (kept by the District and KJ) are included in Appendix C. Submittals regarding the extraction well materials are also included in Appendix D.

Table 2-1: Baseline Groundwater Analytical Results Summary

Source	Screen Depth feet bgs	Date	ID#	PCE ug/L	cis-1, 2-DCE ug/L	TCE ug/L	MTBE ug/L	TPH-DRO mg/L	Benzene ug/L	CCl_4 ug/L	Chloro-benzene ug/L	Chloro-form ug/L	1,4-Dichloro-benzene ug/L	1,2-Dichloro-ethane ug/L	1,1-Dichloro-ethylene ug/L	Vinyl chloride ug/L
Baseline Groundwater Samples																
MW-4A	**15-25**	05/02/18	AG61178	1.5	<0.5	<0.5	<0.2	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MW-4B	**35-50**	05/02/18	AG61179	64	0.8	2.3	<0.2	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MW-4C	**59-79**	05/02/18	AG61180	2.7	<0.5	<0.5	<0.2	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MW-7C	**70-80**	05/02/18	AG61181	3.4	0.6	<0.5	<0.2	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MW-7D	**120-140**	05/02/18	AG61182	14	<0.5	<0.5	<0.2	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MW-10B	**35-50**	05/02/18	AG61183	<0.5	<0.5	<0.5	<0.2	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
MW-10C	**65-80**	05/02/18	AG61184	<0.5	<0.5	<0.5	<0.2	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
EW-4D	**120-140**	05/02/18	AG61185	<0.5	<0.5	<0.5	<0.2	-	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

2.3.2 Drilling Method

The test hole and the two boreholes for the two extraction wells were drilled using the sonic drilling method. Using a sonic head, drill casing and rods are brought to a vibration frequency of 100 to 200 Hertz. These waves are transmitted through the drill string to the end of the casing and reflected, causing the casing to stretch and thin, and to shorten and thicken. This vibration causes a very thin layer of soil directly around the drill rods to fluidize, which reduces the friction between the drill rod and the surrounding formation, allowing very rapid penetration.

For continuous coring, the sonic drilling method uses a core barrel as a drill rod, which is encompassed by a larger diameter drill casing that enables the borehole to stay open and prevents collapse and cross-contamination. Upon completion of a core barrel run, the barrel is removed from the drill casing and the core sample is extruded from the barrel by means of vibration. The oversized casing is then advanced to seal off and support the borehole and prevent groundwater from shallow zones migrating into the deeper zones.

As shown on the test hole drilling log, specific intervals of fine-grained material were also sampled using the Standard Penetration Test (SPT) method (ASTM 1586-11). This measure of material density has been widely used for many years and has been correlated with properties measurable in cone penetrometer tests (CPT) conducted in the area. The SPT tests allow comparison and correlation with fine-grained zones encountered in CPT logs and with other borings in the basin. To conduct the SPT test, a 1.5-foot long split-spoon sampler is lowered to the bottom of the borehole and then advanced into the formation by repeatedly dropping a 140-pound hammer a distance of 30 inches onto the drive rod. The blows to drive the sampler a 6-inch interval are recorded, and are a function of the formation density. The split spoon sampler is fitted with 6-inch long metal tubes which can be submitted for a laboratory or geotechnical analysis.

The pilot boring was drilled with a 7-inch diameter barrel for coring and an 8-inch outer casing. The 7-inch-diameter boring was drilled to 150 ft bgs and continuously cored to log lithology. After coring and casing to the borehole's total depth and the final zone test conducted, the borehole was sealed with bentonite-cement grout. The borehole was open to 130 ft bgs after running the final zone test, so Cascade connected tremie pipe extending to slightly above 130 ft bgs.

2.3.3 Borehole Logging

The core was logged on a continual basis as described in the Workplan. Soil types were identified using the Unified Soil Classification System (USCS) group symbol and described in accordance with the 1990 American Society for Testing and Materials (ASTM) publication *D-2488-90 Standard Practice for Description and Identification of Soils (Visual-Manual Procedure)*. The log kept by the District and by KJ is presented in Appendix D.

2.3.4 Zone Testing Method

Aquifer zone test intervals were based upon the stratigraphy. After driving the outer casing to the interval's depth, Cascade connected a 5-foot or two 5-foot sections of 4-inch diameter, continuous wire-wound stainless steel well screen to 4-inch diameter SCH40 PVC blank casing and placed it in the borehole. Cascade then added gravel filter pack over the length of the screen and retracted the outer casing to expose the temporary well to the aquifer.

A 3-inch diameter, 1 horsepower Grundfos pump (model 30 SQE 130) connected to ¾" steel drop pipe was then suspended in the well screen and plumbed to a totalizing flow meter. The flow meter had a regulating valve and a sample port. Water was staged to a 500-gallon plastic holding tank then pumped through the GAC treatment system into the 500- barrel holding tank pending discharge to the sanitary sewer.

Each zone was pumped for two hours, at the end of which District staff collected a sample for chemical analysis. The District submitted the samples to FGL Laboratory (FGL) under chain-of-custody. After the zone test was completed, the piping, pump, and temporary well casing was removed and coring the pilot hole resumed.

The sample intervals and relevant chemical concentrations are summarized in Table 2-2. Forms with the interval depth, pumping rate, drawdown, and other details are included in Appendix E. Copies of the laboratory reports are included in Appendix F.

Table 2-2: Zone Test Summary

Zone Test	Test Date	Isolation Casing Depth	Screen[(a)] Depth Interval Ft. bgs	Pump Depth Ft. bgs	Final Pumping Rate Gallons per Minute	Comments
1	5/1/2018	27	31-36	33	2	-
2	5/2/2018	40	41-51	45.4	8.5	-
3	5/3/2018	57.5	59.5-69.5	60.7	8.7	-
5	5/5/2018	117	119-124	125	0.25	Pump set in sump below screen interval to maximize potential drawdown. Pumping rate possibly affected by mechanical problems.

(a) Screen section composed of 4-inch diameter stainless steel continuous wire-wound screen, 0.050-inch slot size. Temporary filter pack composed of Cemex #4/12 sand.
(b) Ft. bgs = feet below ground surface
(c) Pump: 3-inch Grundfos pump model 30 SQE 130.

2.3.5 Geotechnical Testing

Selected intervals were submitted to Construction Materials Engineers, Inc. (CME) for gradation testing and/or permeability testing. Gradation test results were used to design the test wells and the permeability test results were used in capture zone analysis to consider the potential areas of groundwater contribution for the planned test wells. Copies of the geotechnical tests are included in Appendix G.

The gradation data from the sieve analysis is summarized in Table 2-3. The soil data from the screened zones of EW-1 is graphed with file data for SRI #6 included in Appendix D. The moisture content, density, and permeability data is summarized in Table 2-4.

Table 2-3: Sieve Test Results Summary

Depth Interval Ft. bgs[(a)]	Dry Weight Grams	Sieve Size	Cumulative Weight Retained Grams	Percent Retained %	Percent Passing %
33-35	626.4	No. 4	8.8	1.4	98.6
33-35	626.4	No. 8	51	8.1	91.9
33-35	626.4	No. 10	74.6	11.9	88.1
33-35	626.4	No. 16	187.6	29.9	70.1
33-35	626.4	No. 30	391	62.4	37.6
33-35	626.4	No. 40	463.2	73.9	26.1
33-35	626.4	No. 50	522.2	83.4	16.6
33-35	626.4	No. 100	568.9	90.8	9.2
33-35	626.4	No. 200	591.2	94.4	5.6
35-37	760.5	1/2 inch	12	1.6	98.4
35-37	760.5	3/8 inch	21.2	2.8	97.2
35-37	760.5	No. 4	73	9.6	90.4
35-37	760.5	No. 8	170.9	22.5	77.5
35-37	760.5	No. 10	203.4	26.7	73.3
35-37	760.5	No. 16	300.2	39.5	60.5
35-37	760.5	No. 30	443.8	58.4	41.6
35-37	760.5	No. 40	532	70.0	30.0
35-37	760.5	No. 50	606.7	79.8	20.2
35-37	760.5	No. 100	676.9	89.0	11.0
35-37	760.5	No. 200	706.6	92.9	7.1
44-46	538.4	No. 4	1	0.2	99.8
44-46	538.4	No. 8	12.2	2.3	97.7
44-46	538.4	No. 10	20.9	3.9	96.1
44-46	538.4	No. 16	52.5	9.8	90.2
44-46	538.4	No. 30	143.2	26.6	73.4
44-46	538.4	No. 40	221	41.0	59.0
44-46	538.4	No. 50	326.6	60.7	39.3
44-46	538.4	No. 100	458.1	85.1	14.9
44-46	538.4	No. 200	494.9	91.9	8.1
46-48	540.3	No. 4	0.5	0.1	99.9
46-48	540.3	No. 8	12.4	2.3	97.7
46-48	540.3	No. 10	19.9	3.7	96.3
46-48	540.3	No. 16	51.2	9.5	90.5
46-48	540.3	No. 30	152.6	28.2	71.8
46-48	540.3	No. 40	229.5	42.5	57.5
46-48	540.3	No. 50	330	61.1	38.9
46-48	540.3	No. 100	449.1	83.1	16.9
46-48	540.3	No. 200	484.5	89.7	10.3
64-66	517.8	No. 8	4	0.8	99.2
64-66	517.8	No. 10	6	1.2	98.8
64-66	517.8	No. 16	18.6	3.6	96.4
64-66	517.8	No. 30	74.6	14.4	85.6
64-66	517.8	No. 40	165.4	31.9	68.1
64-66	517.8	No. 50	306.9	59.3	40.7
64-66	517.8	No. 100	454.8	87.8	12.2
64-66	517.8	No. 200	485.2	93.7	6.3
122-124	707.3	1/2 inch	9.6	1.4	98.6
122-124	707.3	3/8 inch	18.1	2.6	97.4
122-124	707.3	No. 4	44.6	6.3	93.7
122-124	707.3	No. 8	183.6	26.0	74.0
122-124	707.3	No. 10	221.9	31.4	68.6
122-124	707.3	No. 16	301	42.6	57.4
122-124	707.3	No. 30	428.5	60.6	39.4
122-124	707.3	No. 40	484.1	68.4	31.6
122-124	707.3	No. 50	541.3	76.5	23.5
122-124	707.3	No. 100	624.2	88.3	11.7
122-124	707.3	No. 200	653.7	92.4	7.6

(a) Ft. bgs = feet below ground surface
(b) All tests conducted by Construction Materials Engineers, Inc.

Table 2-4: Moisture and Permeameter Test Results Summary

MOISTURE TEST - ASTM D7263[(B)]

Depth Interval Ft. bgs[(a)]	Dry Density Pounds per Cubic Foot	Moisture Content %	Soil Classification Kennedy Jenks Log	 STPUD Log
24-24.5	119.1	11.7	Sandy Silt	Silt
38.5-39	109.2	18.9	Sandy Silt	Clayey Sand
39-39.5	110.2	16.3		
96-98	79.9	27.9	Clay	Clay
150	115	16.3	Silty Sand to Sandy Silt	Silt
Average	106.7	18.2		

33-35	87.4	10.4	Well Graded Sand	Poorly Graded Sand with Silt
35-37	78.2	8.4		
44-46	92.9	20.4	Poorly Graded sand	Poorly Graded Fine Sand with Silt
46-48	83.1	17.3		
64-66	79	17.4	Poorly Graded Sand	Poorly Graded Sand
122-124	104.4	15.5	Well Graded Sand	Well Graded Gravelly Sand
Average	87.5	14.9		

FIXED WALL HYDRAULIC CONDUCTIVITY TEST - USBR 5600-89

Depth Interval Ft. bgs	Hydraulic Conductivity Centimeters/Second	Soil Classification Kennedy Jenks Log	 STPUD Log
33-35	1.38E-03	Well Graded Sand	Poorly Graded Sand with Silt
35-37	4.12E-04		
44-46	1.82E-06	Poorly Graded Sand	Poorly Graded Fine Sand with Silt
46-48	1.06E-05		
46-48 Repeat	4.59E-06		
64-66	5.78E-05	Poorly Graded Sand	Poorly Graded Sand
122-124	7.42E-05	Well Graded Sand	Well Graded Gravelly Sand
Average:	2.77E-04		

FLEX WALL HYDRAULIC CONDUCTIVITY TEST - ASTM D5084

Depth Interval Ft. bgs	Hydraulic Conductivity Centimeters/Second	Soil Classification Kennedy Jenks Log	 STPUD Log
24-24.5, 25-25.5 Comb.	1.10E-04	Sandy Silt	Silt
38.5-39	3.50E-08	Sandy Silt	Clayey Sand
39-39.5	8.33E-05		
96-98	2.86E-07	Clay to Silty Clay	Clay
Average	4.84E-05		

(a) Ft. bgs = feet below ground surface
(b) All tests conducted by Geo-Logic Associates

2.4 Test Well Construction

The Workplan proposed completion of a single-completion, 8-inch-diameter test well in the pilot hole, with the final depths based upon stratigraphic findings and the zone groundwater sample results. Two potential alternatives were presented in the Workplan.

As described herein and shown on the boring logs, a thin fine-grained layer was encountered between 38 and 41 ft bgs. Elevated PCE concentrations were detected in Zone Sample 2 below this layer. PCE was detected at lower concentrations in Zone Sample 3 and Zone Sample 5. Based upon this stratigraphy, two test wells were constructed in two separate boreholes, with one well screened above the fine-grained layer (EW-1B) and one screened below this layer (EW-1C).

The boreholes for both test wells were drilled with 6-inch diameter core barrel and were cased with 10-1/2 inch diameter outer casing that was fitted with a 10-3/4 inch diameter drive shoe. The larger casing was driven to each borehole's total depth and retracted as the well was constructed.

2.4.1 Dimensions and Materials

Based upon flow rates observed during the zone tests, both wells were constructed with 6-inch diameter, stainless steel louvered well screen, and Schedule (SCH) 80 PVC blank riser, blank sump, and bottom caps. The lower flow observed in the zone tests indicated that a 6-inch well would be sufficient to accommodate a pump of adequate size needed to pump the aquifer at a sustainable rate. Stainless steel centralizers were placed at the top and bottom of the well screen and approximately every 40 feet above the well screen.

Based upon the stratigraphy the shallow well (EW-1B) was designed with a 7.5-foot long screen section, however due to the limits of well screen fabrication a 10-foot section of well screen was installed. Also based upon the stratigraphy the deeper well (EW-1C) was designed with a 15-foot long screen section.

The well screen opening size and filter pack selection was based upon the gradation test results. The gradation tests are included in Appendix D. The process followed the method in Driscoll (1986) and generated a result of 0.050-inch openings and a gravel pack corresponding to SRI Supreme gravel "#6".

The stainless steel well screen was fabricated by Roscoe Moss Company in Los Angeles, California with 0.050-inch louvered openings. The SRI Supreme gravel "#6" filter pack material was sorted and packaged by SRI Supreme in Marysville, California.

The bentonite transition seal consisted of Cetco brand Puregold medium-sized bentonite chips. The chips were dropped into the borehole and allowed to hydrate for at least one half hour prior to installing the grout seal. The grout was installed through a tremie pipe placed in the cased borehole a few feet above the bentonite seal. Cascade pumped the grout through a diaphragm pump, diverting the displaced water to a drum and then to the GAC filter and the holding tank. The casing was removed as the grout level rose to the ground surface. The grout consisted of approximately 2% ratio of powdered bentonite to cement by weight, mixed with no more than

6.5 gallons of water in conformance with the State of California Well standards. El Dorado County was informed of the grout times and approved the methods and materials in advance.

2.4.2 Depth Intervals

As shown on the boring logs, well EW-1B is completed in the zone between two silt layers occurring at 23 -26 ft bgs and 38 – 40 ft bgs. The borehole was drilled to 38 ft bgs, the well screen placed from 25.6 ft to 35.6 ft bgs and the bentonite transition seal was placed from 21 ft bgs to 24.8 ft bgs to coincide with a silt layer logged in the pilot hole. The bottom of the well was placed to coincide with the top of the underlying silt layer. Centralizers were placed on the sump; the top of the well screen; and at 15 ft bgs.

Well EW-1C was completed below the silt layer at 38-40 ft bgs. The borehole was drilled to 65 ft bgs, the well screen placed from 44.6 ft bgs to 59.6 ft bgs and the bentonite transition seal was placed from 36 ft bgs to 41 ft bgs. Centralizers were placed on the sump; the top of the well screen; and at 14 ft bgs.

The casing of both wells was extended above grade, and they were both completed with locking steel standpipes, a concrete pad, and bollards around each pad.

2.4.3 Well Development

Records from the 29 June 2018 swabbing and pumping development are included in Appendix G. Carson Pump developed the wells. The swab was a double-swab isolation tool with the swabs six feet apart. A Grundfos model 30 SQE 130 pump was set in the perforated pipe between the swabs to allow pumping from the 5-foot interval between the swabs. Carson line swabbed each well for 70 minutes using the double-swab isolation tool. Line swabbing was performed by repeatedly raising and lowering the swabbing tool at a rate of about 1 ft/s through a 10-foot stroke. After swabbing, the isolation tool was used to pump from 5-foot intervals of the well screen, from the bottom to the top of the well screen. Carson pumped a volume of 500 – 550 gallons from each 5-foot section. Development water was discharged through the GAC filtration system described above.

Carson pumped 1,050 gallons at an average rate of about 20 gpm from EW-1B and 1,550 gallons at an average rate of about 35 gpm from EW-1C. Each well was developed to the point of producing a visibly clear, sediment-free discharge.

2.4.4 Surveying

Well locations and elevations were surveyed by Lumos and Associates (Lumos) on 6 and 7 August 2018. Lumos used a Trimble S7 Robotic Total Station and TSC3 data collector. Lumos calculated the horizontal control for California State Plane Zone 2 NAD 83 to 0.01 foot resolution and vertical control by NAVD88 to 0.1 foot resolution. The surveyor report is included in Appendix I.

The report dated 7 September 2018 recorded the top of steel standpipe at well EW-1B and EW-1C. As shown on the boring logs, the top of the steel standpipe is 0.64 feet above TOC at EW-

1B and 0.63 feet above TOC at EW-1C. The steel standpipes were each completed at about 2.5 feet above existing ground at installation.

2.5 Investigation-derived Waste

Residuals consisted of soil cuttings and cement-related water, which were drummed; and formation water which was filtered and discharged. Documentation regarding disposal is included in Appendix J.

2.5.1 Soil

Samples of the soil core were submitted for chemical analysis and profiling. Laboratory reports and the profiling documents are included in Appendix I. Drums were removed from the Site on 4 September 2018 by Stericycle Environmental Solutions and transported to the Yuma Environmental Services facility in Yuma, AZ for disposal as non-hazardous waste. Laboratory reports, the profiling documents, bill of lading, and signed bill of lading are included in Appendix J.

2.5.2 Water

The water treatment system consisted of a bag-type pre-filter and a GAC filtration unit. The system capacity analysis is included in Appendix I and was based upon regional groundwater contamination data and the expected flow from the pilot boring and test well. Vendor specification sheets are included in Appendix J.

During the zone tests, water was pumped into a 500-gallon plastic holding tank then pumped through the bag filter, the GAC unit, and into a 500-barrel holding tank. The treated water in the tank was sampled on 7 May 2018 and analyzed for VOCs by EPA Method 8260B. The laboratory report is included in Appendix I and shows that no analytes were detected in the sample above the laboratory reporting limit. After the sample was analyzed, water was released from the holding tank to the sanitary sewer.

2.6 Aquifer Testing

Aquifer tests were performed to collect measurements needed to calculate the hydraulic characteristics of the aquifer. On July 8, 2018, a Test Pump was set into the pumping well. On July 9, 2018, a step-drawdown test was performed to establish an optimum pumping rate for the constant test. The constant test was performed on July 11 through July 14, 2018. For these tests, EW-1C was used as the pumping well. Observation wells used for the constant test included: the shallow Test Well (EW-1B); MW-XA; and the MW4 well cluster (MW-4A, MW-4B and MW-4C).

Figure 2-2 is a site image showing the relative locations of these wells. Figure 2-3 is an interpretive cross-section of the site showing the general arrangement of water-bearing zones and aquitards inferred from geologic logs from the Test Hole (EW-1) and MW-4C. The site is interpreted as a stratified aquifer occurring below the upper most silt layer (23-26 ft bgs) to the top of the bottom clay layer (94-100 ft bgs). The intervening silt layers are identified as aquitards which are relatively lower permeability layers which may inhibit vertical flow. These aquitards subdivide the aquifer into three water-bearing zones (A, B and C). Water-bearing Zone C is further sub-divided into upper (Cu) and lower (Cl) sub-zones using the thin silt layer penetrated at a depth of 52 – 52.5 ft bgs in the pilot hole, as the boundary between these two sub-zones.

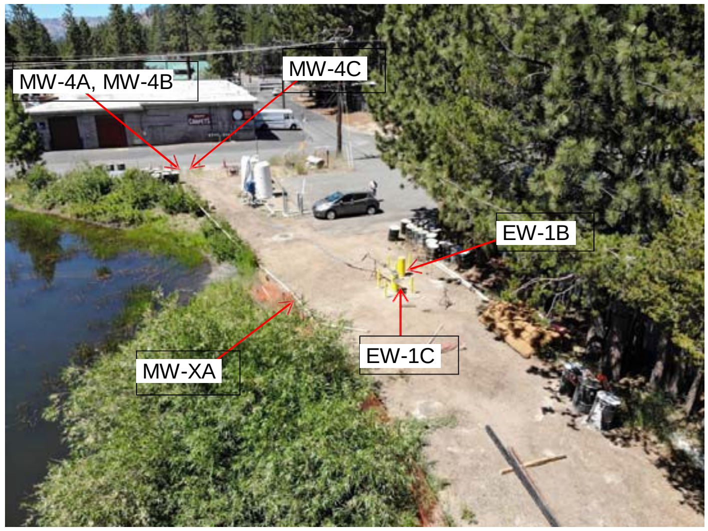

Figure 2-2: 953 Eloise Avenue Work Site

Note: Figure shows the general arrangement of pumping and observation wells used for aquifer testing.

On July 8, 2018 Carson Pump (Carson City, NV) installed 52 linear feet (lf) of 2-inch steel column pipe connected to a 4-inch, 5 horsepower submersible pump (Grundfos Model 40S50-12 and motor (Grundfos MS4000 79354509 Model B); and fifty feet (50 lf) of 1 ¼" Sch. 40 PVC sounding tube into EW-1C. The pump discharge head was set 3' above ground surface (ags), immediately above the top of the well cover. The top of the sounding tube was set next to the pump discharge head at 3.15 feet ags. All hand water level readings collected from the pumping well were measured in relation to the top of sounding tube reference point.

Discharge from the pumping well was measured using a Master Meter flow totalizer and a GPI Electronic Digital Meter (instantaneous flow) installed on the 2-inch pump discharge line. A 0-100 psi pressure gage was used to measure water pressure through the discharge line. A gate valve was used to regulate discharge from the pumping well.

During the step test, water level changes in the pumping well (EW-1C) were measured using an electronic water level indicator (Durham Geoslope Indicator). During the constant test, water level changes in the pumping well (EW-1C) and observation wells (EW-1B, MW-XA, MW-4A, MW-4B and MW-4C) were measured using dedicated pressure transmitter/data loggers (Solinst Levelogger LT) installed in each well. All Leveloggers were programmed to record water level readings at 2-minute intervals, starting on 7/6/2018 at 18:00. Atmospheric pressure readings were measured using a Solinst Barologger installed in EW-1B and was programmed to record atmospheric pressure at the same sampling interval and start time as the Leveloggers.

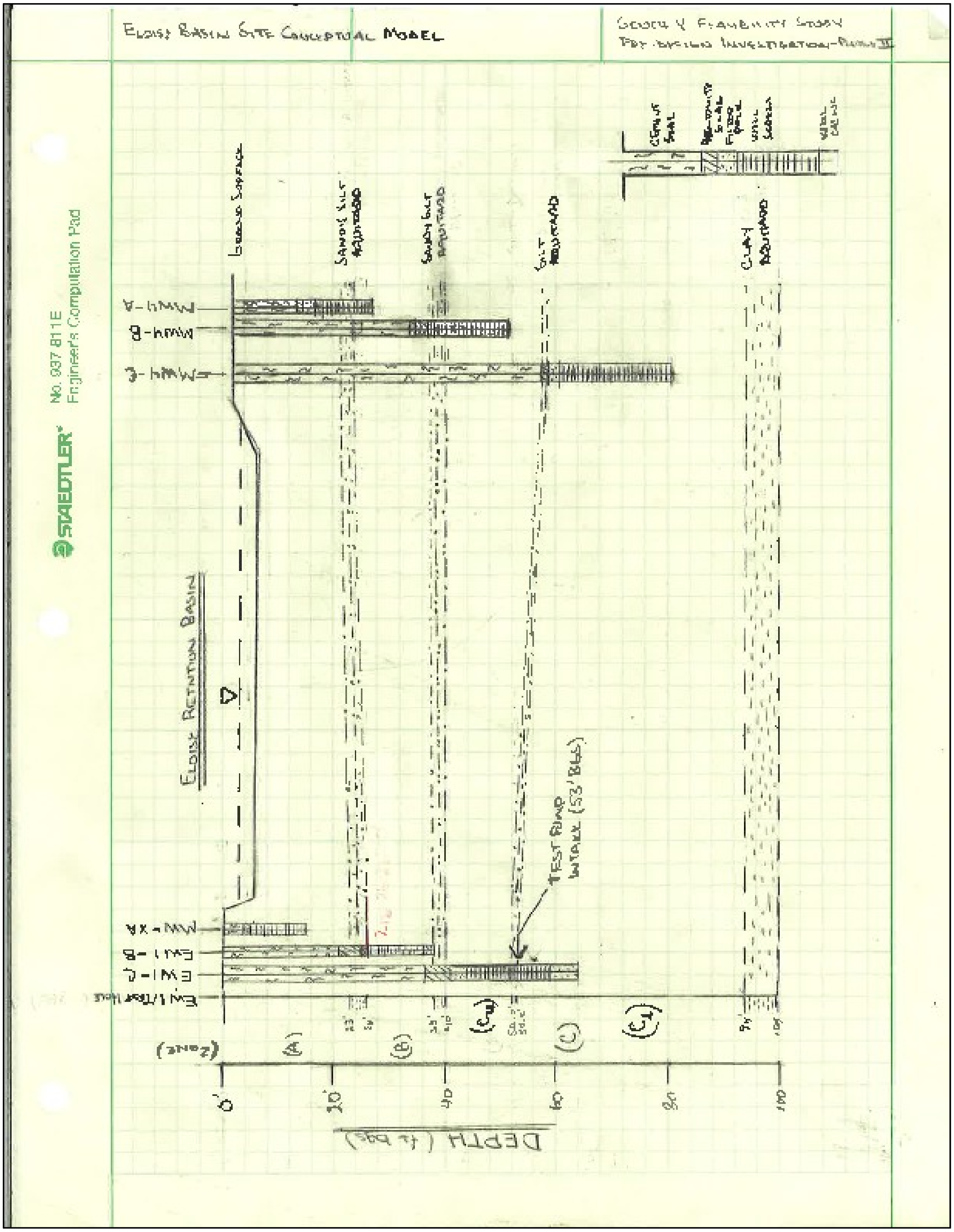

Figure 2-3: Interpretative Cross-Section

Note: Figure used to show the general arrangement of aquitards and water-bearing zones underlying the site area.

Table 2-5 lists the well details and pressure transducer settings used for aquifer testing.

Table 2-5: Aquifer test site details and pressure transducer settings.

Site ID	Distance/Direction from pumping well	Levelogger LT	Serial #	Sample Rate (minutes)	Start Time	Stop Time	Nominal Casing Diameter (in.)	Top of Screen (bgs)	Bottom of Screen (ft bgs)	Total Depth (ft bgs)	Depth to Water (ft bgs)	PXD Setting (ft bgs)	Head (ft H2O)
EW-1C	Pumping Well	F30	32011094	2	7/6/2018: 18:00	7/16/2018: 8:06	6	44	59	64	21.48	50	28.52
EW-1B	7'/south	F30	32011094	2	7/6/2018: 18:00	7/14/2018: 9:10	6	26	36	38	15.6	37.5	21.9
EW-1B atm	7'/south	F5	12044990	2	7/6/2018: 18:00	7/14/2018: 9:04	6	26	36	38	15.6	5	NA
MW-XA	16'/east	F5	12011448	2	7/6/2018: 18:00	7/14/2018: 9:28	2	5	15	15	4.98	9	4.02
MW-4A	106'/south	F30	112086766	2	7/6/2018: 18:00	7/14/2018: 9:50	2	15	25	25	4.88	20	15.12
MW-4B	106'/south	F30	112086772	2	7/6/2018: 18:00	7/14/2018: 9:34	2	35	50	50	9.33	35	25.67
MW-4C	105'/south	F30	112086777	2	7/6/2018: 18:00	7/14/2018: 9:42	2	59	79	79	12.13	35	22.87

2.6.1 Step- Drawdown Test

The step-drawdown test was performed on July 9, 2018 to determine the specific capacity for EW-1C and establish an optimum pumping rate for the Constant Test. The step test was performed using four 120-minute steps with the discharge rate (in gpm) increased at each successive step. The discharge rates and durations for each step are summarized below in Table 2-6.

Table 2-6: Step test pumping schedule.

Step	Discharge Rate (gpm)	Duration (minutes)
1	21	120
2	30	120
3	40	120
4a	54	20
4b	51	100

Figure 2-4 shows pumping water levels measured in EW-1C during the step test. The hydrograph shows that pumping water levels during Step 4 significantly declined at the 54 gpm discharge rate. In order to prevent pumping water levels falling below the Levelogger and pump intake, the control valve on the discharge line was adjusted (slightly closed) to complete the final step at 51 gpm. Hydrographs and data collected during the Step Test are provided in Appendix K.

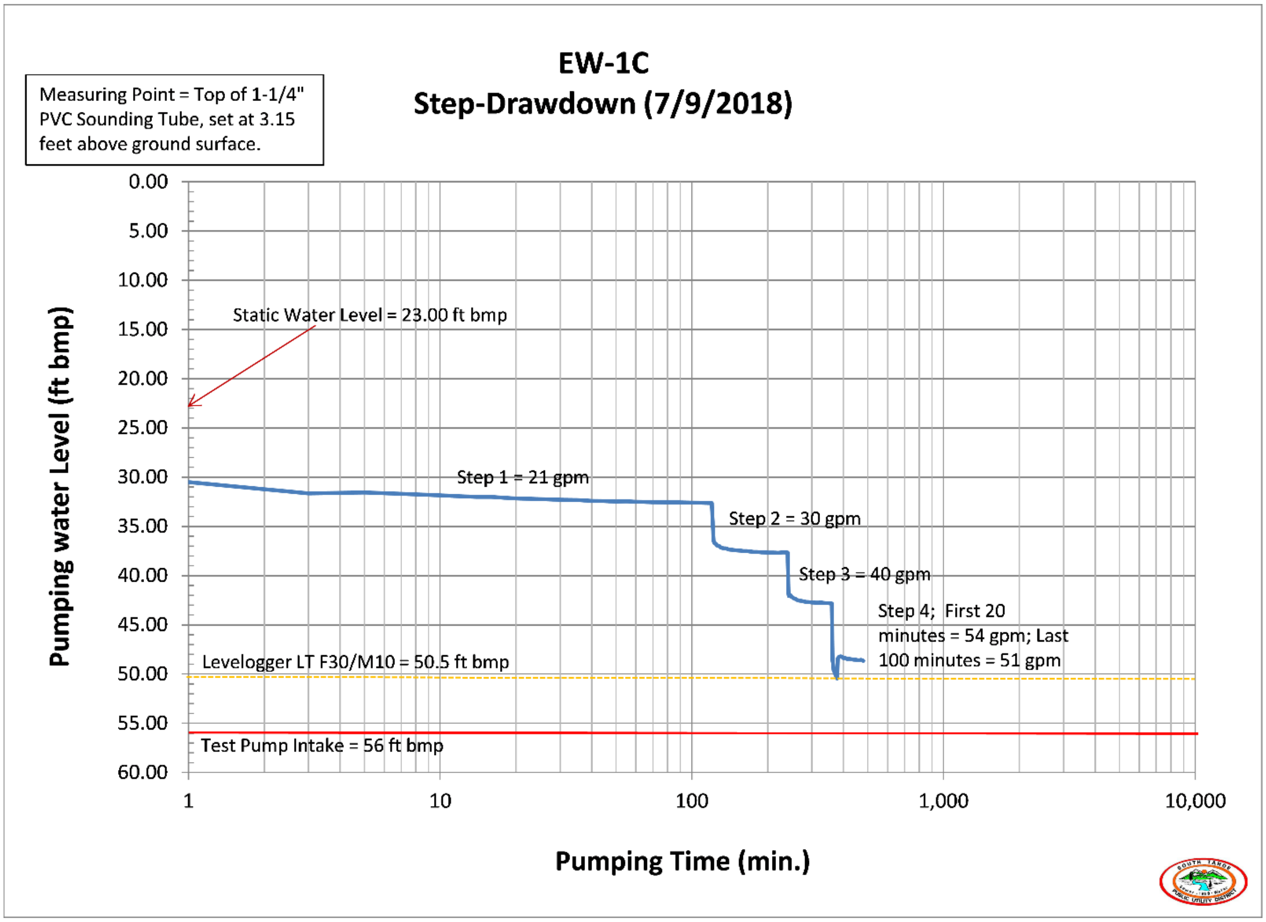

Figure 2-4: Pumping water levels measured in EW-1C during the step test.

2.6.2 Constant Test

A constant test was conducted from July 11 through July 14, 2018 to measure the discharge and drawdown from the pumping well (EW-1C) and the drawdown observed in the observation wells (EW-1B, MW-XA, MW-4A, MW-4B and MW-4C). These data were subsequently used to calculate the hydraulic characteristics of the aquifer. The constant test consisted of a 48-hour pumping period followed by a 24-hour recovery period. The pumping period started at 7:00 AM on July 11, 2018 and ended at 7:10 AM on July 13, 2018.

Hand readings were collected from the pumping well during the first 110 minutes after the pump was turned off and water levels had recovered to within 95% of static water level. The leveloggers were left in the well for more than 24-hours after the test pump was turned-off in order to record recovery readings from the pumping and observation wells. The leveloggers were removed from these wells and the data retrieved on July 14, 2018. Figure 2-5 shows the water level changes measured in EW-1C during the pumping and recovery periods of the constant test. Hydrographs from the observation wells are provided on Figure 2-6.

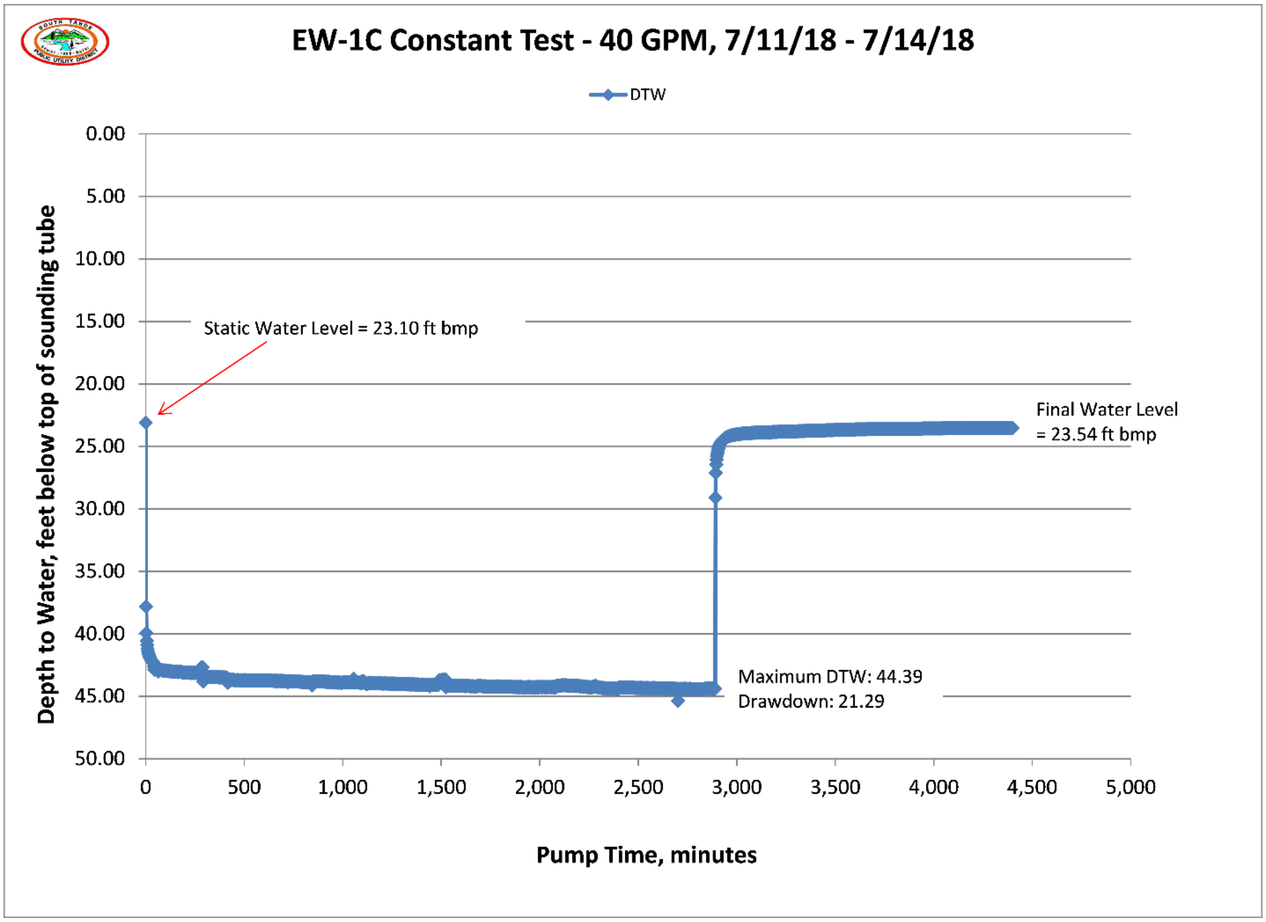

Figure 2-5: Hydrograph showing water level changes recorded in the pumping well during the constant test.

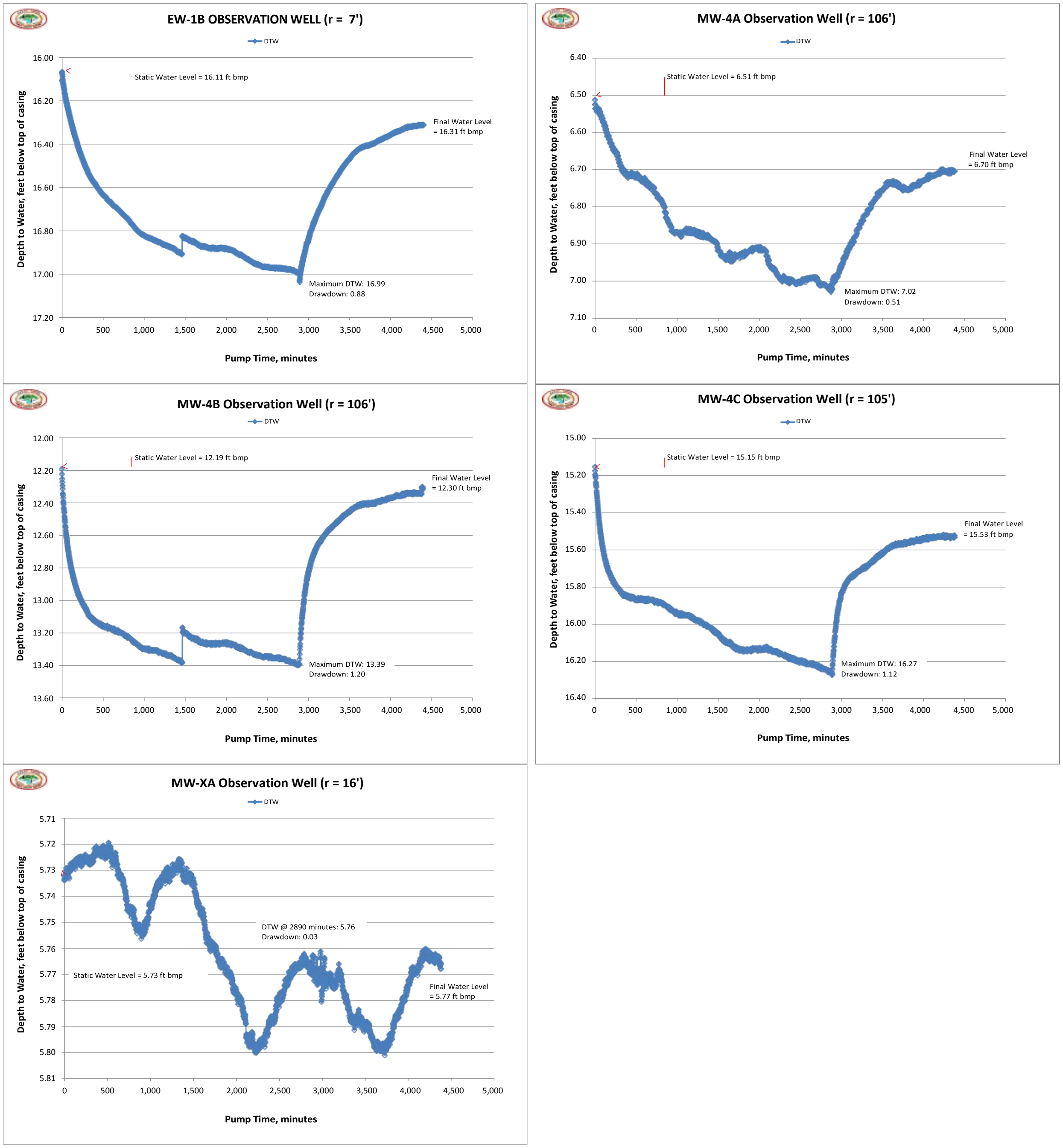

Figure 2-6: Hydrographs showing water level changes recorded in the observation wells during the constant test.

Note: The hydrographs for EW-1B and the MW-4 observation wells show a regular change in groundwater levels reflecting the change from pumping to non-pumping (recovery) conditions at the pumping well (see Figure 2-4). The hydrograph for observation well MW-XA shows rhythmic fluctuations in water level not attributed to the pumping well.

2.6.3 Time-Series Sampling

During the Constant Test groundwater samples were collected from the discharge of the pumping well (EW-1C) to ascertain whether any significant changes in VOC contaminant concentrations occurred during the test. A total of four water quality samples were collected from the sample tap on the well discharge line at the following times during the test as presented in Table 2-7.

Table 2-7: Water quality time-series sampling during the constant test.

Sample ID	Pumping Time (minutes)	Total Discharge (gallons)
AG62277	60	2,384
AG62282	720	29,009
AG62283	1440	58,039
AG62306	2880	116,379

All groundwater samples were collected by District laboratory personnel and delivered to the analytical laboratory under District chain-of-custody. Groundwater samples submitted to the analytical laboratory were analyzed for VOCs using EPA Method 524.2. Analytical results are provided in Table 3-1.

2.7 Deviations from PDI Workplan

The work described above was carried out as prescribed in the Workplan (KJ, 2018), with the following changes due to field conditions:

- One additional test well was constructed, EW-2, with EW-1, forming a well pair of two (2) test wells to prevent vertical movement of PCE contamination across the upper sandy silt aquitard.
- Aquifer zone groundwater sampling was conducted for four (4) zones instead of five (5).
- Zone test #4 was aborted due to sand filling the screen and pump.
- Within 30 hours of the start if the Constant Rate Testing of EW-1, the drawdown rate was less than 0.01 ft/minute. Therefore, the Constant Rate Test was concluded after 48 hours of pumping instead of 72 hours. The results of the Constant Rate Testing are discussed in Section 3.3.3 of this Report.
- At the end of the PDI, most of the GAC treatment capacity remained unused. Therefore, the GAC vessels were moved to LBWC 5, to enable the well to be purged and pumped for groundwater sample collection as part of the Baseline Sampling.

Section 3: Findings & Evaluation

This section describes findings of the investigation and supporting documentation which included:

- lithology (well logs and geologic and hydro-geologic cross-sections),
- analytical results (laboratory data sheets, chain-of-custody sheets, and analytical reports),
- aquifer characterization analysis,
- water levels (table including date of water level measurement, depths to groundwater, and groundwater elevations), and
- groundwater gradient and flow direction in comparison to regional gradient and flow direction (groundwater contour map, gradient calculation).

A more detailed evaluation of data collected by others in the Project area and an assessment of the nature and extent of contamination (contaminant plume maps, time-series plots for identified contaminants of concern) was discussed in the Workplan and will be discussed, as appropriate, in conjunction with these PDI results in the FS Report.

3.1 Subsurface Stratigraphy

The stratigraphy of the test boring based upon the sonic core and SPT samples is described on the log recorded by the District and KJ (Appendix D). A simplified graphic log showing the water-bearing zone designations and zone test intervals discussed in this report is presented as Figure 3-1. Permeability test and gradation test reports are included in Appendix G, and summarized on Table 2-2 and Table 2-3. Soil was not cored or logged during drilling for well construction.

Overall, the stratigraphy observed in the test borehole was consistent with regional characterization. As shown on the boring logs, the upper 23 feet was a mix of poorly graded sand, well graded sand with silt, well graded sand with gravel and possibly cobbles. A fine-grained layer of sandy silt was observed from 23 to 25 feet, underlain by well graded sand with highly weathered granitic cobbles. SPTs were conducted in the silty zone and Zone Test 1 was conducted in well graded sand below it. The silty material was very stiff and had no plasticity, and the permeability test indicated a hydraulic conductivity (K) of 1.14E-04 centimeters per second (cm/s), typical for fine material. The permeability test conducted on the sandy material from 33 to 35 ft bgs showed a K of 1.38E-03 cm/s.

Another thin sandy silt layer was present from 38.5 to 41 ft bgs, underlain by poorly graded, massive sand with thinner well-graded sand layers. The silty layer was expected at this depth based upon the nearby CPT-5E, so SPTs were conducted over this depth interval to capture geotechnical samples of it. Zone Test 2 was conducted just below this silty layer. Zone Test 3 was conducted in the massive poorly graded sand below 60 ft bgs.

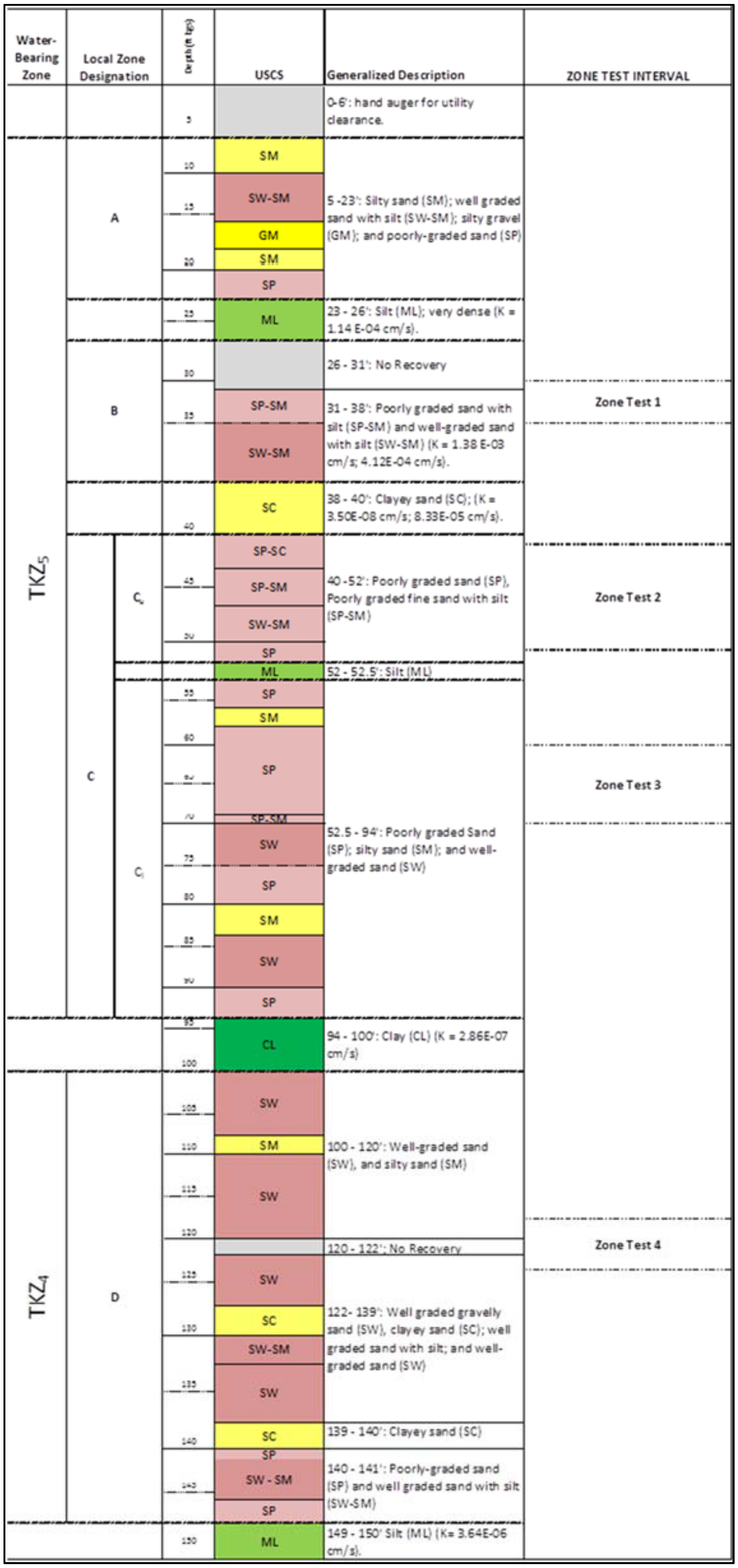

Figure 3-1: Simplified graphic log showing the water-bearing zone and zone test interval designations used in this report.

The permeability test result from the 39 to 39.5 foot silt sample had a K of 3.5E-08 cm/s, and the sand from 46-48 ft bgs had a K of 1.06-E05 cm/s. The sand from 64-66 feet had a K of 5.78E-05 cm/s, similar to the sand sample collected from 46 to 48 feet.

Finer, silty sand layers with sub-horizontal lamination alternated with massive well graded sand layers from approximately 80 ft bgs to 89 ft bgs.

Clay forming the clay lens was encountered between 89 ft bgs and 100 ft bgs. The aquitard consisted of alternating sandy silt and silty sand from 89 ft bgs to 96 ft bgs, and a clay to silty clay from 96 ft bgs to 100 ft bgs. The clay was dark grayish brown, very stiff, low plasticity, and high toughness. The aquitard was noted on the cross sections presented in the Workplan (KJ, 2018), and was encountered at the depth predicted by projecting the pilot boring onto regional cross sections such as Figure 1-3. A remolded clay sample had a K of 2.86-E-07 cm/s.

The material below the clay was mainly gravel and sand to 127 feet, and a mix of finer sand and silty sand below 130 feet. A sample of the gravelly sand had a K of 7.42E-05 cm/s. Between 127 feet and 130 feet layers of silt and well graded sand were mixed and complexly deformed. The zone contained small, dark clasts that may be clasts of reduced organic matter. Well graded fine sand and clayey sand occurred below 130 feet. The bottom of the pilot borehole terminated at 150 feet in a 1-foot section of light brownish grey silt. This silt sample had a K of 3.64E-06 cm/s.

3.2 Analytical Results

3.2.1 Baseline

Laboratory reports and field purge forms are included in Appendix C, results are summarized in Table 2-1, and wells locations are shown on Figure 1-2. The baseline samples were collected on 2 and 3 May 2018.

3.2.2 Zone Tests

Laboratory reports are included in Appendix F and results for EW-1 are summarized in Table 3-1. PCE was detected in Zone 1, Zone 2, and Zone 3, and was not detected above the reporting limit in the Zone 5 sample. PCE concentrations in zone samples ranged from less than the reporting limit in Zone 5 to 66 µg/L in Zone 2.

Other compounds detected in the zone samples include Trichloroethylene (TCE) and benzene. TCE was detected at 0.8 µg/L in the Zone 1 sample, 2.8 µg/L in the Zone 2 sample, and slightly above the reporting limit at 0.6 µg/L in Zone 5. Benzene was detected in one sample – Zone 2 at 112 µg/L. Benzene was not detected in the baseline samples and was not detected in the samples collected from EW-1C during the constant rate test. The detection at this concentration is notable; however it was not detected in any of the baseline samples and was not repeated in the later sampling in EW-1C conducted during the constant-rate test.

Both the Zone 1 and Zone 2 sample depths are generally similar to nearby well MW-4B and the more distant well MW-10B. The PCE concentrations in the Zone 1 sample (30.7 µg/L) and Zone 2 sample (66 µg/L) are generally comparable to well MW-4B.

Figure 1-7 and 1-8 of the Workplan (KJ, 2018) show PCE concentrations versus bottom of screen sample depth for groundwater samples collected by the water purveyors, LRWQCB staff and recent PCE data available through Geotracker for the former Lake Tahoe Laundry Works (LTLW) site (SL0601754315). LTLW is one of the major PCE sources in the South Y and initiated source remediation using soil vapor extraction in around 2010.

Table 3-1: EW-1 Water Quality Data

Source	Screen Depth feet bgs	Date	ID#	Depth ft	Temp Deg. C	pH	EC uS/cm	D.O. mg/L	Turb NTU	PCE ug/L	cis-1,2-DCE ug/L	TCE ug/L	MTBE ug/L	TPH-DRO mg/L	Ben-zene ug/L	CCl_4 ug/L
Pilot Boring EW-1 Zone1	30-35	05/01/18	AG61161	26.2	11.0	5.08	522	3.23	26	30.7	<0.5	0.8	<0.2	<0.5	<0.5	<0.5
Pilot Boring EW-1 Zone 2	41-51	05/02/18	AG61175	37.9	11.9	5.03	558	2.38	26	66	<0.5	2.8	<0.2	<0.5	112	<0.5
Pilot Boring EW-1 Zone 3	60-70	05/03/18	AG61192	63.2	12.6	5.17	381	8.38	54	1.5	<0.5	<0.5	<0.2	<0.5	<0.5	<0.5
Pilot Boring EW-1 Zone 5	119-124	05/05/18	AG61207	25.3	16.0	7.42	228	2.04	299	<0.5	<0.5	0.6	<0.2	<0.5	<0.5	<0.5
Well EW-1C Constant Rate Test																
Well EW-1C: (1) at 1 hr	44.6-59.6	07/11/18	AG62277	-	12.0	6.00	566	-	-	64	1.1	3.9	<0.2	-	<0.5	<0.5
Well EW-1C: (2) at 12 hrs	44.6-59.6	07/11/18	AG62282	-	13.6	6.14	568	-	-	62	1.0	3.5	<0.2	-	<0.5	<0.5
Well EW-1C: (3) at 24 hrs	44.6-59.6	07/12/18	AG62283	-	12.3	6.17	585	-	-	62	1.0	3.8	<0.2	-	<0.5	<0.5
Well EW-1C: (4) at 72 hrs	44.6-59.6	07/13/18	AG62306	-	12.6	6.27	575	-	-	59	1.2	2.5	<0.2	<0.5	<0.5	<0.5

Source	Screen Depth feet bgs	Date	Chloro-benzene ug/L	Chloro-form ug/L	1,4-Dichloro-benzene ug/L	1,2-Dichloro-ethane ug/L	1,1-Dichloro-ethylene ug/L	Vinyl chloride ug/L	TDS mg/L	Chloride mg/L	NO_3-N mg/L	SO_4 mg/L
Pilot Boring EW-1 Zone1	30-35	05/01/18	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	328	123	1.08	6.90
Pilot Boring EW-1 Zone 2	41-51	05/02/18	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	430	149	1.36	6.43
Pilot Boring EW-1 Zone 3	60-70	05/03/18	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	278	87.8	0.456	3.91
Pilot Boring EW-1 Zone 5	119-124	05/05/18	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	154	25.1	0.109	8.45
Well EW-1C Constant Rate Test												
Well EW-1C: (1) at 1 hr	44.6-59.6	07/11/18	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	-
Well EW-1C: (2) at 12 hrs	44.6-59.6	07/11/18	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	-
Well EW-1C: (3) at 24 hrs	44.6-59.6	07/12/18	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	-	-	-	-
Well EW-1C: (4) at 72 hrs	44.6-59.6	07/13/18	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	400	136	2.28	5.76

			<--------Alkalinity------->																		
Source	Screen Depth feet bgs	Date	HCO_3 mg/L	CO_3 mg/L	OH mg/L	Total mg/L	Al pCi/L	As ug/L	Cd ug/L	Cr ug/L	Cu ug/L	Mn ug/L	Se ug/L	U ug/L	Zn ug/L	Boron mg/L	Ca mg/L	Fe ug/L	Mg mg/L	K mg/L	Na mg/L
Pilot Boring EW-1 Zone1	30-35	05/01/18	46.1	0	0	46.1	<20	<1	<0.5	<1	2.21	134	<5	-	111	<0.05	38.6	0.05	8.83	1.80	36.8
Pilot Boring EW-1 Zone 2	41-51	05/02/18	54.9	0	0	54.9	3000	1.34	<0.5	2.98	7.54	104	<5	-	71.6	<0.05	52.7	2.81	13.4	2.16	34.8
Pilot Boring EW-1 Zone 3	60-70	05/03/18	46.4	0	0	46.4	<20	<1	<0.5	<1	<2	35.1	<5	-	32.1	<0.05	31.6	0.08	7.15	1.44	25.2
Pilot Boring EW-1 Zone 5	119-124	05/05/18	69.1	1.98	0	71.1	90	3.28	<0.5	<1	<2	121	<5	-	<20	<0.05	12.0	0.11	4.83	2.14	25.5
Well EW-1C Constant Rate Test																					
Well EW-1C: (1) at 1 hr	44.6-59.6	07/11/18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Well EW-1C: (2) at 12 hrs	44.6-59.6	07/11/18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Well EW-1C: (3) at 24 hrs	44.6-59.6	07/12/18	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Well EW-1C: (4) at 72 hrs	44.6-59.6	07/13/18	50.5	0	0	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

Compared to data from water purveyors and the LRWQCB, the Zone 1 PCE result falls in a gap in the detected PCE concentration range of the shallow depth range, between a group of data points lower than about 15 µg/L and a group higher than about 50 µg/L. The Zone 2 sample falls near the lower end of a group of higher PCE concentration range in the 50-80 foot depth range, while the Zone 3 sample at 1.5 µg/L falls near the lower end of the 50-80 foot depth range data.

Compared to the LTLW data, the Zone 1 PCE result falls near the upper end of the detected PCE concentration range of the shallow depth range, and the Zone 2 sample falls near the lower end of the detected PCE concentration range in the 40-50 foot depth range. The Zone 3 sample at 1.5 µg/L falls in the near the middle of the 60-75 foot data.

3.2.3 Data Quality Assurance/Quality Control

To ensure consistency and thoroughness of the data generated from the PDI, the Quality Assurance/Quality Control (QA/QC) procedures prescribed in the Workplan Quality Assurance Project Plan (QAPP) were implemented for field data and water and soil sample collection, chain-of-custody form completion, analytical quality control, and data management.

According to the analytical laboratory reports, all water samples were:

- Received in acceptable condition within temperature requirements
- Prepared and analyzed within the method specified hold time
- Checked for pH is acid or base is required (except for VOAs)

For the water samples, analysis quality controls were within established criteria with the following exceptions:

- Chloromethane was above the acceptance range, but samples that were non-detect were accepted.
- Xylenes o, Trichloroethylene, Tetrachloroethylene, Hexachlorobutadiene, Chlorobenzene, Ethylbenzene, Dichlor, Naphthalene, trans-1,3-Dichloropropene may have been affected by the sample matrix, but data was accepted based on the Laboratory Control Standard/Sample or Continuing Calibration Verification recovery.
- Tetrachloroethane, 1,1,2-Trichloroethane, Trichlorotriflu may have been affected by the sample matrix, but data was accepted based on the Laboratory Control Standard/Sample or Continuing Calibration Verification recovery.

The analytical reports in Appendix F describes the sample preparation, analysis, and notes for the water samples collected for the PDI.

3.3 Aquifer Characterization

3.3.1 Zone Testing Results

Zone test pumping results are summarized in Table 2-1. In general, the pumping rates were lower than anticipated.

3.3.2 Geotechnical Testing Results

Geotechnical testing results are summarized in Table 2-2 and Table 2-3. Table 2-3 presents the density and moisture content results, the fixed-wall hydraulic conductivity test (used for permeable materials) results, the flex wall hydraulic conductivity test (used for finer, more impermeable materials) results along with the soil type logged. The coarser, more permeable material's density ranged from 78.2 pounds per cubic foot (pcf) to 104.4 pcf, with an average of 87.5 pcf. The density of the finer material ranged from 79.9 pcf to 115 pcf, with an average of 106.7 pcf.

The hydraulic conductivity of the coarser, more permeable material ranged from 4.59E-06 cm/s to 1.38 cm/s, with an average of 2.77E-04 cm/s. The hydraulic conductivity values of the finer, more impermeable material analyzed with the flex wall test ranged from 2.86E-07 cm/s to 1.10E-04 cm/s, with an average of 4.85E-05 cm/s. The tests indicate that the hydraulic conductivity values for the inferred aquitard materials are an order of magnitude lower than the inferred water-bearing zones.

Permeability tests were conducted on two samples in the silty zone between the EW-1B and EW-1C screened intervals. The two samples were split spoon liners from SPTs collected at 38.5 – 39 ft bgs and 39 – 39.5 ft bgs. The result from 38.5 – 39 ft bgs was 3.5E-08 cm/s, and hydraulic conductivity from the lower sample was 8.33E-05 cm/s.

3.3.3 Aquifer Test Results

Depth to water readings collected at the pumping well were tabulated for test analysis along with the well discharge totalizer readings and field water quality parameter readings. Automated pressure transducer readings were downloaded from the Solinst Leveloggers. All automated water level readings recorded in the pumping and observation wells were compensated for atmospheric pressure using the barometric pressure readings collected at EW-1B. The compensated dataset was used for calculating drawdowns during the constant test. These data were also used for analysis using Aquifer^{win32} (Version 5.04), a software program used for the analysis and display of aquifer test results (ESI, 2018). Use of Aquifer^{win32} allowed for the calculation of aquifer properties using a variety of hydraulic solutions which may approximate the aquifer test performed at the site (Table 3-2). Because the influence of the silt layers on groundwater flow was uncertain, hydraulic solutions used for aquifer test analysis included solutions for both nonleaky (confined) aquifer and leaky aquifer conditions. Because the aquifer was pumped by a partially penetrating well, Hantusch, 1964 was also used as this solution assumes that vertical flow in the aquifer is caused by partial penetration effects and not from leakage of water from an aquitard.

Table 3-2: Solutions used for aquifer test analysis of the constant test results.

Solution	Description
Cooper and Jacob, 1946	Generalized graphical method for evaluating formation constraints (Cooper Jacob Straight Line Method)
Theis, 1935	Constant Discharge from a fully penetrating well in a nonleaky aquifer.
Theis, 1946	Recovery test after constant discharge from a fully penetrating well in a nonleaky aquifer.
Hantush and Jacob, 1955	Constant Discharge from a fully penetrating well in a leaky aquifer.
Hantush, 1960	Constant Discharge from a well in a leaky aquifer with storage of water in the confining beds.
Hantush, 1964	Constant Discharge from a partially penetrating well in a leaky aquifer.

Well parameters and aquifer properties used in this analysis are tabulated in Table 3-3. An annotated cross-section showing the screen intervals used in the Aquifer^{win32} analysis is provided as Figure 3-2. For analysis purposes, the aquifer was assumed to have a total thickness of 68 feet and an anisotropy ratio (Kz/Kr) of 0.01.

Table 3-3: Well parameter and aquifer property inputs used for aquifer test analysis.

Well	Pumping Rate (gpm)	Radial Distance (feet)	Casing I.D. (feet)	Borehole O.D. (feet)	Screen Top Depth (Z in feet)	Screen Length (L, in feet)	Aquifer Thickness (D, in feet)	Kz/Kr
EW-1C	40	0	0.4688	0.8958	18	15	68	0.01
EW-1B	0	7	0.4688	0.8958	0	10	68	0.01
MW-4A	0	106	0.1667	1.00	0	3	68	0.01
MW-4B	0	106	0.1667	1.00	14	15	68	0.01
MW-4C	0	105	0.1667	0.667	37	20	68	0.01

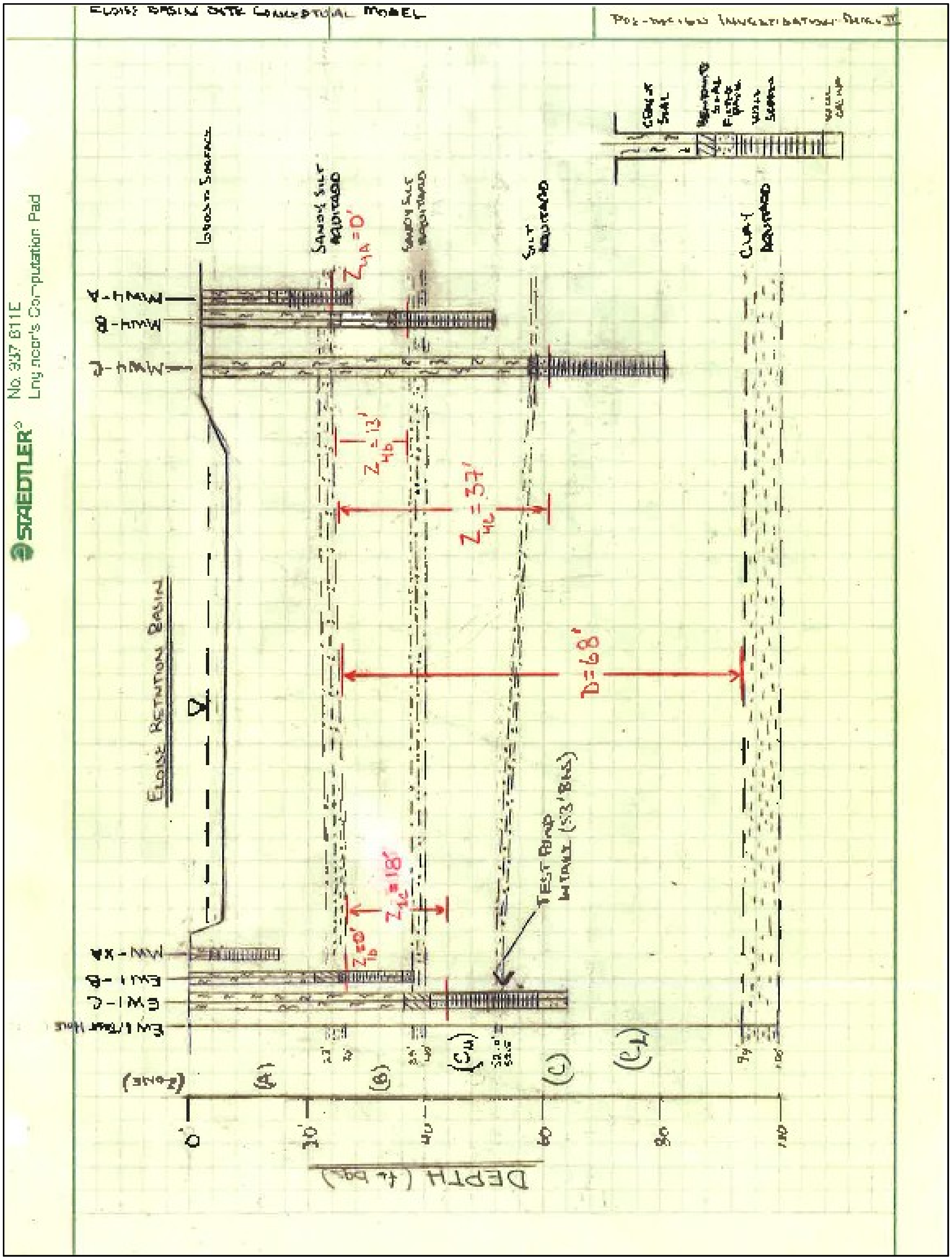

Figure 3-2: **Annotated cross-section used to show the arrangement of pumping and observation wells used for the Aquifer^{Win32} analysis.**

3.3.3.1 Step Test Results

The step test was used to determine the specific capacity for EW-1C and establish an optimum pumping rate for the constant test. Specific capacity is a measure of the amount of water that a well produces for a given unit of drawdown, typically in feet. The pumping rates and drawdowns calculated from the step test were used to generate a plot of specific capacity versus pumping time as shown on Figure 3-3. Specific capacity in a well typically decreases as either the pumping rate and/or pumping time increases. After the first step, the specific capacity of EW-1C reached an asymptotic value of about 2 gpm per foot of drawdown (gpm/ft dd).

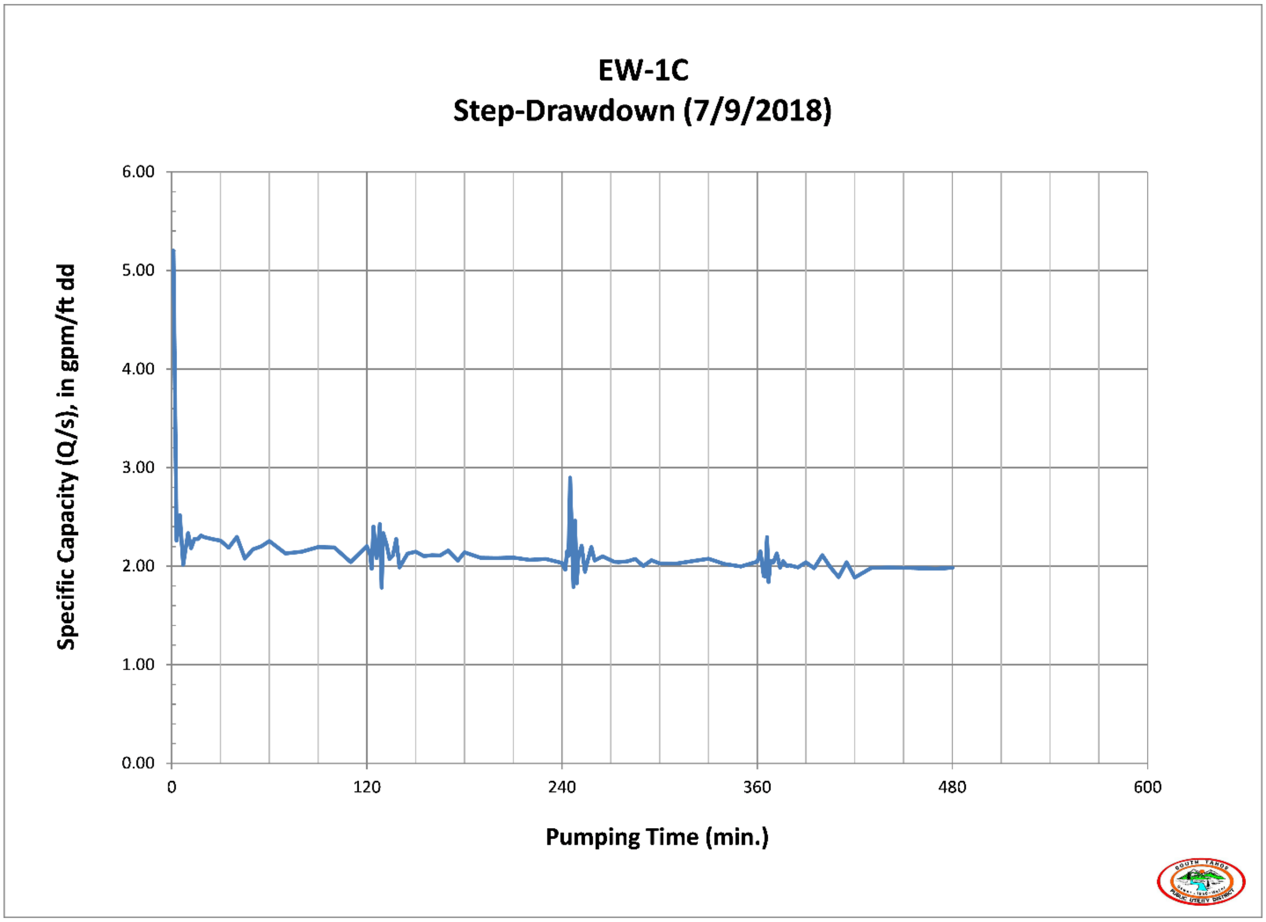

Figure 3-3: Specific capacity for EW-1C measured during the step test.

Based on the specific capacity measured for EW-1C and the drawdown constraints presented by the Levelogger and pump intake settings in the pumping well (see Section 2.6.1, Figure 2-4), a discharge rate of 40 gpm was selected for the constant test.

3.3.3.2 Constant Test Results

The constant test was performed to collect the data needed to calculate the hydraulic characteristics of the aquifer (i.e. aquifer properties). As noted in Section 3.3.3 varying solutions used for analyzing pumping test data from nonleaky (Confined) and from leaky aquifers were both used for analysis. Because the aquifer was pumped by a partially penetrating well, solutions which assume that vertical flow in the aquifer is caused by partial penetration effects and not from leakage of water from the aquitard were also used.

Aquifer properties for all wells that showed a pumping response were initially calculated from time-drawdown and recovery data plots using the straight-line method (Cooper and Jacob, 1946). Time-drawdown-data for the observation wells (EW-1C, MW-4A, MW-4B and MW-4C) were further analyzed using both nonlinear least squares statistical matching; and manual curve matching available through Aquifer^{win32}. All plots generated by this analysis are provided in Appendix L. Resulting aquifer properties are summarized below in Table 3-4.

The leaky aquifer solutions used for analysis include hydraulic parameters unique to these solutions. Hantusch's 1955 method estimates a parameter r/B which is the radial distance of the observation well from the pumping well divided by a leakage factor (B). As this parameter increases the type curves used for this analysis diverges from the type curve used for nonleaky (confined) aquifers. Qualifying conditions for this analysis were found to be valid for MW-4A and MW-4C and invalid for EW-1B and MW-4B. Review of Table 3-4 shows r/B values at 0 for the valid analysis. This suggests that vertical flow across aquitards is not significant.

Hantusch's 1960 method estimates a Beta (B) parameter which takes into account the storage changes in an aquitard. As this parameter increases the type curves used for this analysis diverges from the type curve used for nonleaky (confined) aquifers. Qualifying conditions for this analysis were found to be valid for MW-4A and MW-4C and invalid for EW-1B and MW-4B. Review of Table 3-4 shows B values at or near 0 for the valid analysis. This suggests that the amount of water supplied from storage in the aquitard is not significant.

Hantusch's 1964 method assumes that vertical flow in the aquifer is caused by partial penetration effects and not from leakage of water from an aquitard. Flow is 2-dimensional and radial in the aquifer and vertical in the confining bed. Qualifying conditions for this analysis were found to be valid for EW-1B, MW-4A and MW-4C and invalid for MW-4B.

Hydraulic conductivity (K) is a measure of a materials capacity to transmit water. Assuming that all the water extracted from the pumping well (EW-1C) is from the aquifer section occurring below the sandy silt aquitard separating water-bearing zones A and B; and the top of the clay aquitard at the bottom of water-bearing zone C, the average hydraulic conductivity of the aquifer is about 21 ft/d (7.3E-03 cm/s), which is representative of unconsolidated silty sand deposits. The hydraulic conductivities derived from the results analyzed at the observation wells are believed to be representative of the hydraulic conductivities for the materials occurring through the water-bearing zones, with the exception of MW-4A which has a screened interval that extends above the sandy silt aquitard forming the top of the tested aquifer. The hydraulic conductivity values for these observation wells (EW-1B, MW-4B and MW-4C) are slightly greater than the average value and generally range from about 26 ft/d (EW-1B, Leaky Aquifer Solution) to 60 ft/d (MW-4C, Theis Recovery Solution). Using the constant test results for the observation wells, the average hydraulic conductivities for the water-bearing zones are 41 ft/d

(1.4E-02 cm/s) for Zone B; 38 ft/d (1.3E-02 cm/s) for the upper portion of Zone C (Cu); and 49 ft/d (1.7E-02 cm/s) for the lower portion of Zone C (Cl). Average values of aquifer properties calculated from all of the valid solutions used for analysis are provided in Table 3-5.

Table 3-4: Constant Test results showing the aquifer properties calculated from the solutions applied for analysis.

WELL	SOLUTION	TYPE	Water-Bearing Zone	Saturated Thickness (D)	Distance from Pumping Well (r)	AQUIFER PROPERTIES TRANSMISSIVITY (T)			Storativity (S)	Hydraulic Conductivity (K)	r/B	B	Diffusivity (T/S)
				(ft)	(ft)		(gpd/ft)	(ft^2/d)		(ft/d)			(ft^2/d)
EW-1B	Straight Line	Pumping	B	68	7		19,556	2,614	4.15	38			
EW-1B	Straight Line	Recovery	B	68	7	T3	17,600	2,353		35			
EW-1C	Straight Line	Pumping	C	68	0	T1	5,770	771		11			
EW-1C	Straight Line	Pumping	C	68	0	T2	13,037	1,743		26			
EW-1C	Straight Line	Recovery	C	68	0	T1	4,310	576		8			
EW-1C	Straight Line	Recovery	C	68	0	T2	7,765	1,038		15			
EW-1C	Straight Line	Recovery	C	68	0	T3	22,000	2,941		43			
MW-4A	Straight Line	Pumping	A/B	68	106		37,714	5,042	0.0454	74			111,049
MW-4A	Straight Line	Recovery	A/B	68	106	T3	31,522	4,214		62			
MW-4B	Straight Line	Pumping	Cu	68	106		17,311	2,314	0.0038	34			608,985
MW-4B	Straight Line	Recovery	Cu	68	106	T2	20,706	2,768		41			
MW-4C	Straight Line	Pumping	Cl	68	105		22,468	3,004	0.0056	44			536,345
MW-4C	Straight Line	Recovery	Cl	68	105	T2	29,333	3,921		58			
EW-1B	Confined (Theis, 1935)	Pumping	B	68	7		18,915	2,529	4.94871	37			511
MW-4A	Confined (Theis, 1935)	Pumping	A/B	68	106		30,159	4,032	0.0601616	59			67,014
MW-4B	Confined (Theis, 1935)	Pumping	Cu	68	106		18,334	2,451	0.00347845	36			704,595
MW-4C	Confined (Theis, 1935)	Pumping	Cl	68	105		19,453	2,600	0.00587275	38			442,806
EW-1B	Recovery (Theis, 1946)	Recovery	B	68	7		23,784	3,179		47			
MW-4A	Recovery (Theis, 1946)	Recovery	A/B	68	106		49,672	6,640		98			
MW-4B	Recovery (Theis, 1946)	Recovery	Cu	68	106		21,234	2,839		42			

WELL	SOLUTION	TYPE	Water-Bearing Zone	Saturated Thickness (D) (ft)	Distance from Pumping Well (r) (ft)	AQUIFER PROPERTIES: TRANSMISSIVITY (T)	TRANSMISSIVITY (T) (gpd/ft)	TRANSMISSIVITY (T) (ft^2/d)	Storativity (S)	Hydraulic Conductivity (K) (ft/d)	r/B	B	Diffusivity (T/S) (ft^2/d)
MW-4C	Recovery (Theis, 1946)	Recovery	Cl	68	106		30,677	4,101		60			
EW-1B	Leaky Aquifer (Hantush & Jacob, 1955)	Pumping	B	68	7		14,708	1,966	5.61866	29	0.267486		350
W-4A	Leaky Aquifer (Hantush & Jacob, 1955)	Pumping	A/B	68	106		30,313	4,052	0.0645271	60	0		62,799
MW-4B	Leaky Aquifer (Hantush & Jacob, 1955)	Pumping	Cu	68	106		14,362	1,920	0.00436262	28	0.194438		440,084
MW-4C	Leaky Aquifer (Hantush & Jacob, 1955)	Pumping	Cl	68	105		19,571	2,616	0.00663122	38	0		394,537
EW-1B	Leaky Aquifer (Hantush, 1960)	Pumping	B	68	7		13,467	1,800	3.364832	26		0.11597	535
MW-4A	Leaky Aquifer (Hantush, 1960)	Pumping	A/B	68	106		29,592	3,956	0.0559575	58		0.00000	70,694
MW-4B	Leaky Aquifer (Hantush, 1960)	Pumping	Cu	68	106		20,709	2,768	0.00223725	41		0.00001	1,237,408
MW-4C	Leaky Aquifer (Hantush, 1960)	Pumping	Cl	68	106		21,195	2,833	0.00585924	42		0.00000	483,571
EW-1B	Partial Penetration (Hantush, 1964)	Pumping	B	68	7		23,882	3,193	0.0195286	47	0		163,481
MW-4A	Partial Penetration (Hantush, 1964)	Pumping	A/B	68	106		31,925	4,268	0.0930744	63	0.00001		45,853
MW-4B	Partial Penetration (Hantush, 1964)	Pumping	Cu	68	106		19,183	2,564	0.012836	38	0.24283		199,781
MW-4C	Partial Penetration (Hantush, 1964)	Pumping	Cl	68	105		32,460	4,339	0.00713064	64	0		608,539

Note: Shaded cells indicate solutions where qualifying conditions caused the solution to be deemed invalid; and which were not used in deriving average values for aquifer properties.

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Table 3-5: Average values of aquifer properties calculated for analyzed wells from the constant test.

WELL	Water-Bearing Zone	Saturated Thickness (D) (ft)	Distance from Pumping Well (r) (ft)	AVERAGE AQUIFER PROPERTIES: TRANSMISSIVITY (T) (ft^2/d)	STORATIVITY (S)	HYDRAULIC CONDUCTIVITY (K) (ft/d)	HYDRAULIC CONDUCTIVITY (K) (cm/s)
EW-1C	C	68	0	1,414		21	0.007335
EW-1B	B	68	7	2,519	3.0	41	0.014389
MW-4A	A/B	68	106	4,600	0.06382	68	0.023867
MW-4B	Cu	68	106	2,593	0.00364	38	0.013452
MW-4C	Cl	68	105	3,345	0.00622	49	0.017354

3.3.3.3 Time-Series Sampling Results

Water quality results for detected VOCS in time-series samples collected during the constant test is provided below in Table 3-6. A semi-log plot showing these time-series results in relation to pumping time and total discharge is provided as Figure 3-4. Inspection of these results does not show significant changes in detected VOC concentrations as the volumes of groundwater removed from the aquifer increased during the constant test. Although detected in samples collected during testing of Zone 2 (Section 3.2.2), benzene was not detected in any of the time-series samples, collected from this zone during the constant test.

Table 3-6: Water quality results for VOCs detected in time-series samples collected during the constant test.

Sample ID	Pumping Time (minutes)	Total Discharge (gallons)	PCE (µg/L)	TCE (µg/L)	DCE (µg/L)
AG62277	60	2,384	64	3.9	1.1
AG62282	720	29,009	62	3.5	1.0
AG62283	1440	58,039	62	3.8	1.0
AG62306	2880	116,379	59	2.5	1.2

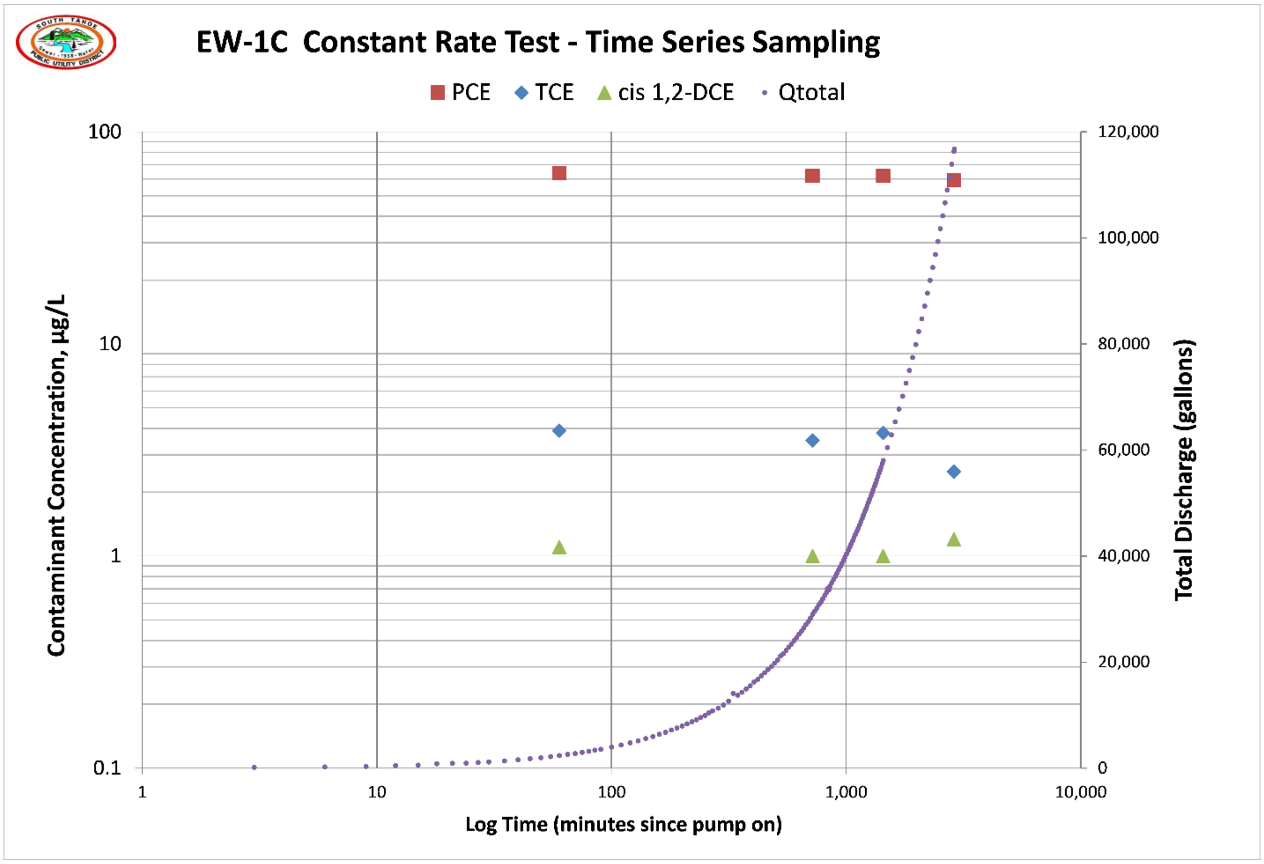

Figure 3-4: VOC concentrations detected in time-series samples collected during the constant test.

3.4 Groundwater Elevations and Gradients

Groundwater level elevation readings were collected from more than twenty (20) wells within and neighboring the South Y Area as part of the planning and performance of the Pre-Design Investigation. The locations of the wells used for groundwater level elevation readings are shown on Figure 3-5. The dates of measurement, water depths and corresponding groundwater level elevations are listed in Table 3-7. Review of Table 3-7 shows the most complete set of groundwater level measurements were collected on 10/25/2018 to show fall (seasonal low) and 5/23/2019 to show spring (seasonal high) groundwater conditions. These datasets were used to generate groundwater-level elevation contours, calculate average horizontal gradients and groundwater flow directions for two water-bearing zones above the clay lens (TKZ5: Zone B and TKZ5: Zone C_u) and a third deeper water-bearing zone (TKZ4) below the clay lens. Average horizontal gradients and flow directions for each water zone are summarized in Table 3-9. The TKZ4 data set was supplemented with groundwater level readings collected from the Tahoe Keys Wells on 11/2/2018 and 5/21-5/22/2019. Groundwater level readings collected from four well clusters, (Clement Well, MW-4, MW-7 and MW-10) were also used to calculate vertical gradients through the South Y Area. Groundwater elevation data and gradient and flow velocity calculations included in Section 3.4 are provided in Appendix M.

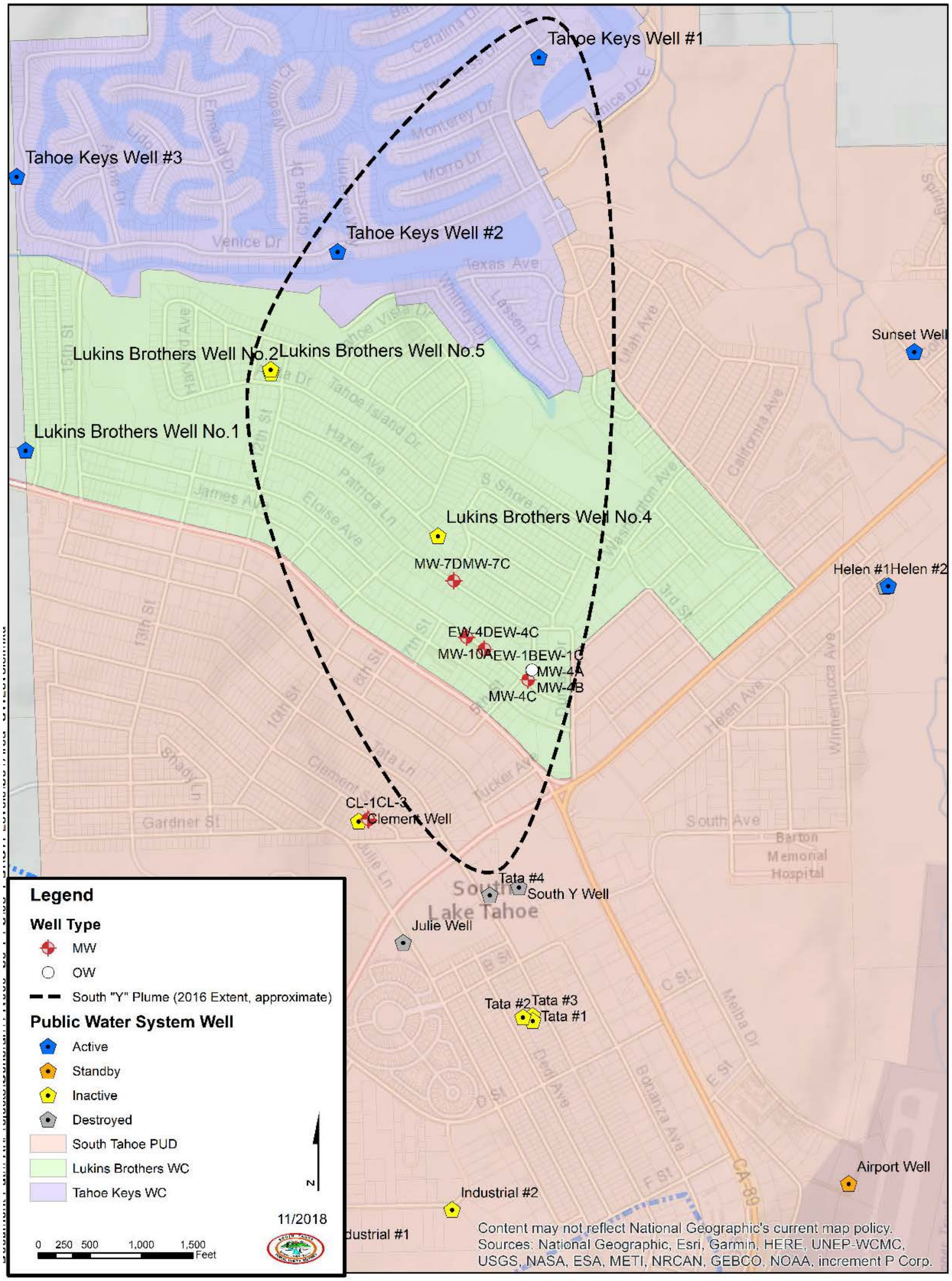

Figure 3-5: South Y area wells used for groundwater level elevation readings.

Table 3-7: Depth to water readings and corresponding groundwater level elevations collected from South Y Area wells.

Well	Measuring Point Elevation (NAVD88)	10/23/2017 DTW (ft bmp)	10/23/2017 GW Elev (ft msl)	1/17/2018 DTW (ft bmp)	1/17/2018 GW Elev (ft msl)	1/31/2018 DTW (ft bmp)	1/31/2018 GW Elev (ft msl)	5/2/2018 DTW (ft bmp)	5/2/2018 GW Elev (ft msl)	7/6/2018 DTW (ft bmp)	7/6/2018 GW Elev (ft msl)	7/14/2018 DTW (ft bmp)	7/14/2018 GW Elev (ft msl)	10/25/2018 DTW (ft bmp)	10/25/2018 GW Elev (ft msl)	11/2/2018 DTW (ft bmp)	11/2/2018 GW Elev (ft msl)	5/23/2019 DTW (ft bmp)	5/23/2019 GW Elev (ft msl)
Industrial Well #2	6306.82													28.36	6278.46			22.65	6284.17
Tata Well #2	6286.09													25.02	6261.07			20.53	6265.56
Clement Well	6282.58													34.09	6248.49			31.25	6251.33
CL-1	6278.12													30.44	6247.68			27.10	6251.02
CL-3	6278.34													22.98	6255.36			20.03	6258.31
MW-4B	6259.27			11.08	6248.19			9.44	6249.83	12.14	6247.13	12.52	6246.75	13.12	6246.15			9.15	6250.12
MW-4A	6259.11			6.39	6252.72			5.00	6254.11	6.47	6252.64	6.85	6252.26	7.92	6251.19			4.19	6254.92
MW-4C	6259.56			13.86	6245.70			12.27	6247.29	15.10	6244.46	15.57	6243.99	15.97	6243.59			12.00	6247.56
EW-1B	6262.24									15.98	6246.26	16.28	6245.96	16.96	6245.28			13.50	6248.74
EW-1C	6262.48									21.87	6240.61	23.55	6238.93	22.42	6240.06			18.81	6243.67
EW-4C	6265.04	22.28	6242.76					21.00	6244.04					24.13	6240.91			19.40	6245.64
EW-4D	6264.99	26.20	6238.79					25.20	6239.79					28.33	6236.66			25.45	6239.55
MW-10A	6264.54	15.57	6248.97					12.77	6251.77					16.65	6247.89			11.49	6253.05
MW-10B	6264.43	18.65	6245.78					16.54	6247.89					19.89	6244.54			16.32	6248.11
MW-10C	6264.56	23.90	6240.66					21.71	6242.85					24.96	6239.60			21.83	6242.73
Helen Well #2	6250.18													19.60	6230.58			15.59	6234.59
MW-7D	6254.65							15.76	6238.89					18.49	6236.16			16.35	6238.30
MW-7C	6254.53							13.83	6240.70					16.78	6237.75			14.16	6240.37
LBWC 4	6249.78													14.00	6235.78			12.33	6237.45
LBWC 1	6261.44													27.00	6234.44			26.00	6235.44
LBWC 2	6251.45													17.00	6234.45			15.17	6236.28
LBWC 5	6250.77													18.00	6232.77			16.83	6233.94
TKWC 2	6237.87					3.02	6234.85									8.30	6229.57	6.19	6231.68
TKWC 3	6238.79					4.54	6234.25									11.95	6226.84	6.45	6232.34
TKWC 1	6238.18					4.35	6233.83									8.67	6229.51	6.10	6232.08

3.4.1 Groundwater Elevation Contours

As noted in the Section 1.3.1.1 and described in the test hole (Section 3.1), the clay lens forms an aquitard separating the two upper-most water-bearing zones (TKZ5 and TKZ4) identified in the South Y Area. In order to differentiate water level readings collected from wells screened above and below the aquitard, a plot showing the top and bottom screen elevations for each of the wells was developed as shown on Figure 3-6. Using the bottom of screen (BOS) elevations, a cross-plot against the measured groundwater elevation for each well was generated as shown on Figure 3-7. By this method, and following review of the clay lens structure contour (Figure 1-4) wells with water level readings were differentiated by elevation head and water zone then grouped into three groundwater level sub-sets (Table 3-8). The Clement Well and CL-1 were excluded from the contoured data sets for the TKZ5 Zone C_u group as the BOS elevations for these wells occur with TKZ4. The resultant groundwater level contours for each sub-set are provided below as Figures 3-8, 3-9 and 3-10.

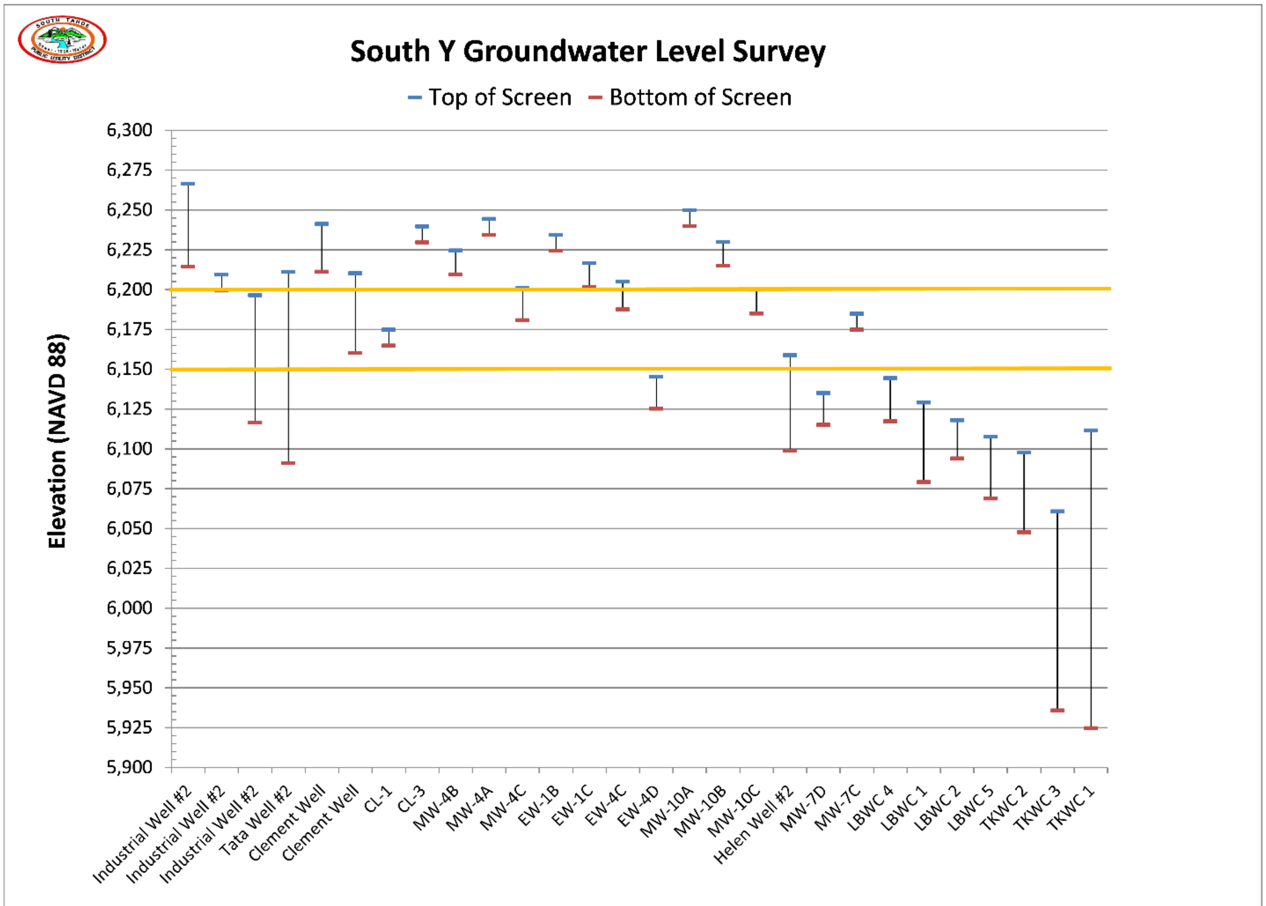

Figure 3-6: Elevation ranges of well screen intervals used for groundwater level elevation survey through the South Y Area.

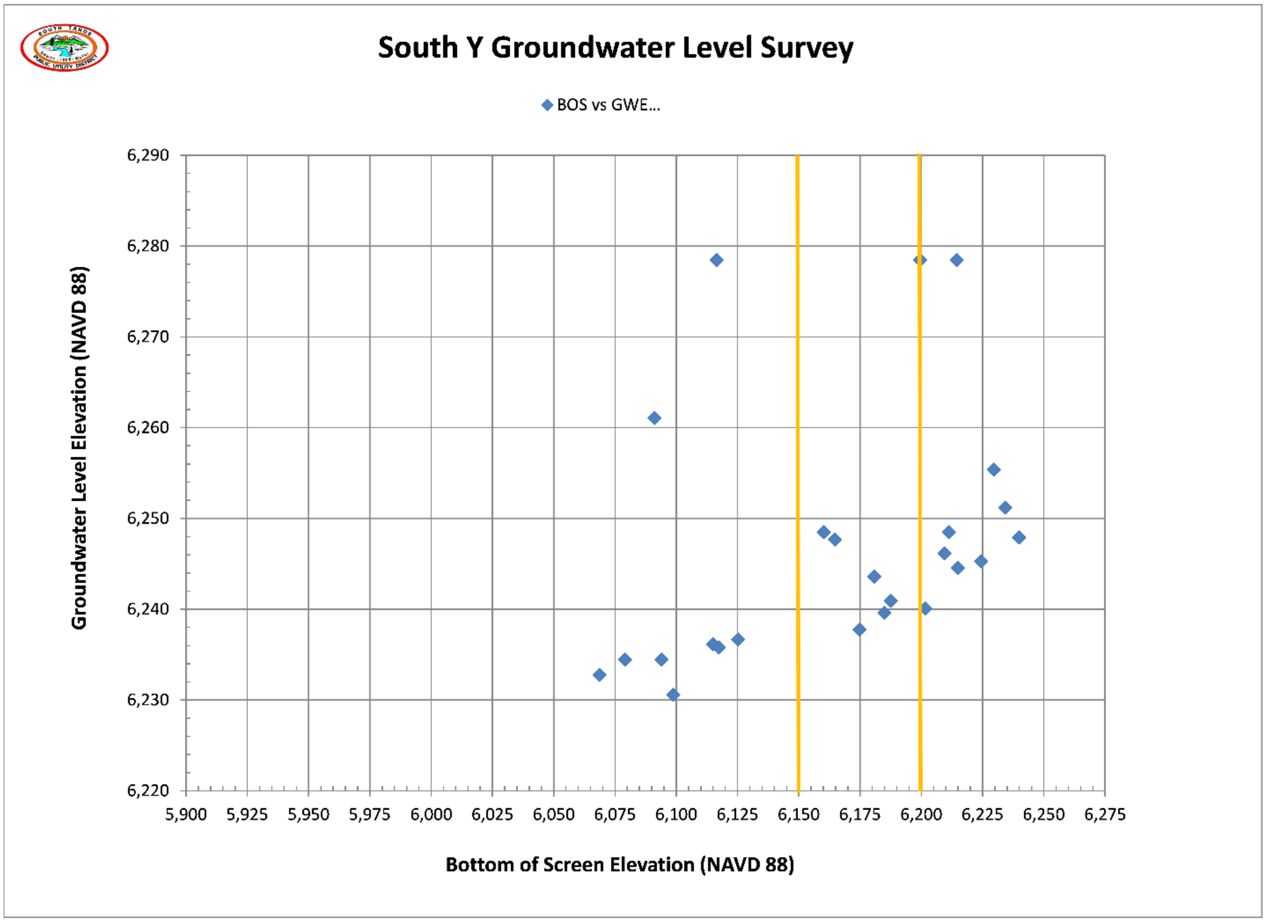

Figure 3-7: Groundwater elevation/bottom of screen elevation cross plot used to differentiate well groundwater level elevations by elevation head.

Table 3-8: Zone interpretations and bottom of screen depths and elevations used for groundwater level contours.

ZONE	BOS Depth (ft)	BOS Elevation (ft msl)
TKZ5; Zone B	< 50	> 6200 ft msl
TKZ5: Zone Cu	78 < BOS <80	6150 ft msl < BOS < 6200 ft msl
TKZ4	BOS >132	BOS < 6150 ft msl

Average horizontal gradient and flow direction across contoured areas were calculated using 3-point problem solutions (Table 3-9.) Review of these data show average horizontal gradients are relatively low (<0.01 ft/ft) for each Zone. Seasonal changes in average groundwater flow directions do not appear to be significant. However, average direction of groundwater flow does appears to change with depth rotating from NE in TKZ5, Zone B to NW in the underlying TKZ5 Cu and TKZ4 Zones.

Table 3-9: Horizontal gradients (ihoriz) and flow directions derived from three point problem solutions.

TKZ5: Zone B				
Date	**dh (ft)**	**dl (ft)**	**ihoriz**	**Flow Direction**
10/25/18	9.21	1630	0.006	N12E
05/23/19	8.19	1490	0.005	N5E
TKZ5: Zone C_u				
Date	**dh (ft)**	**dl (ft)**	**ihoriz**	**Flow Direction**
10/25/18	1.85	330	0.006	N67W
05/23/19	2.36	355	0.007	N63W
TKZ4				
Date	**dh (ft)**	**dl (ft)**	**ihoriz**	**Flow Direction**
10/25/18	44.02	8025	0.005	N9W
05/23/19	48.73	8040	0.006	N12W

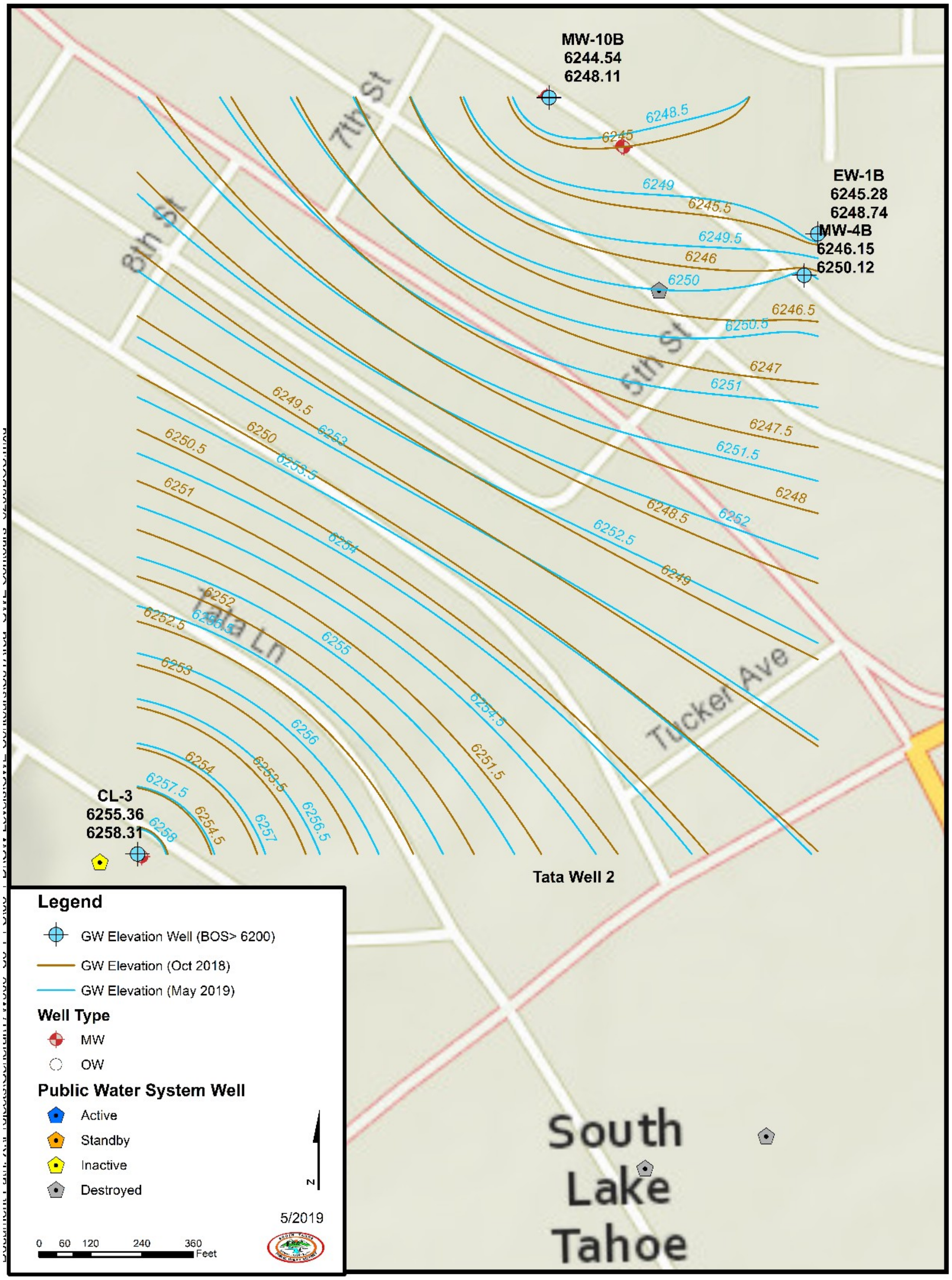

Figure 3-8: Fall 2018 and spring 2019 groundwater level elevation contours for TKZ5: Zone B.

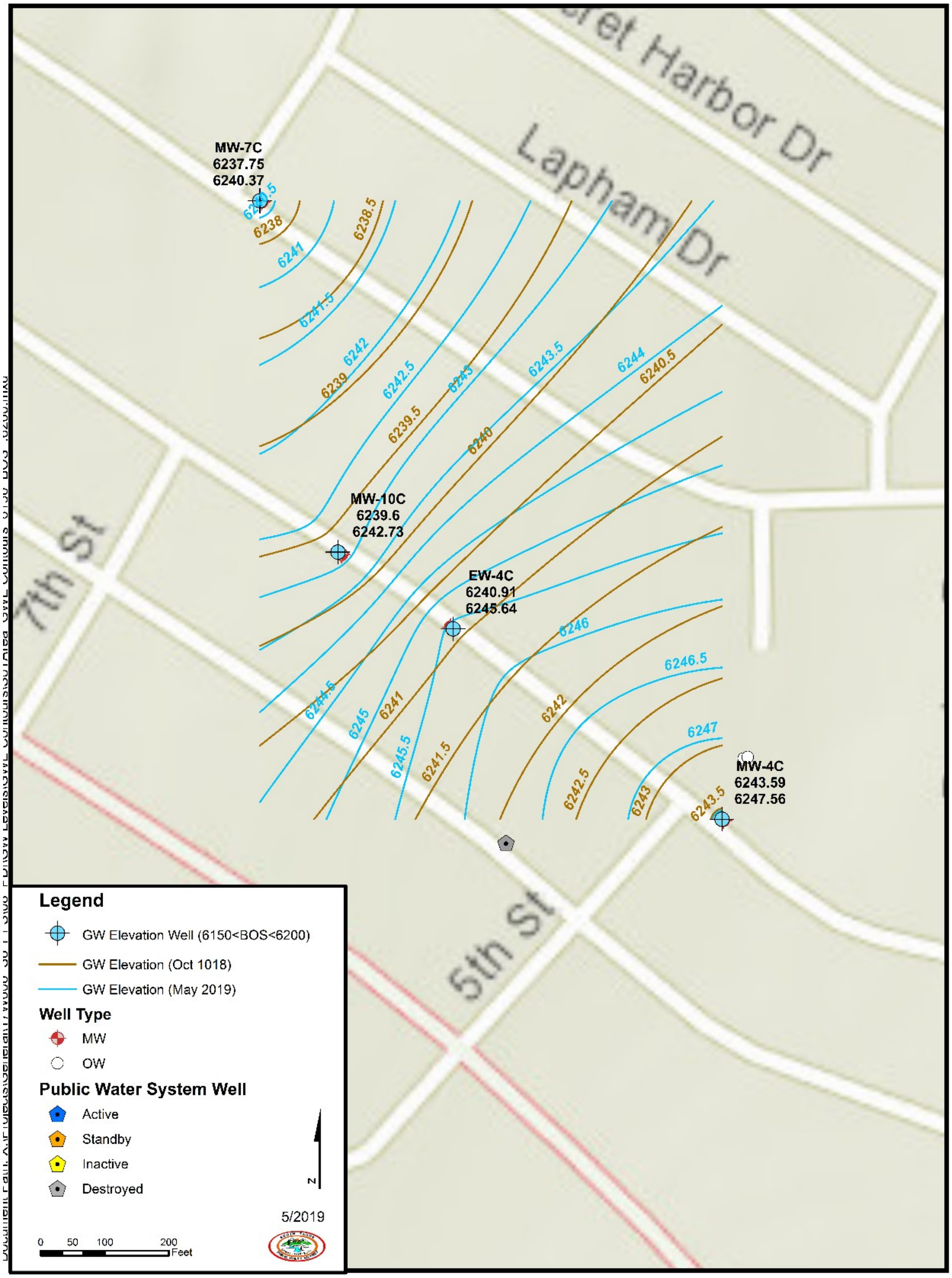

Figure 3-9: Fall 2018 and spring 2019 groundwater level elevation contours for TKZ5: Zone C_u.

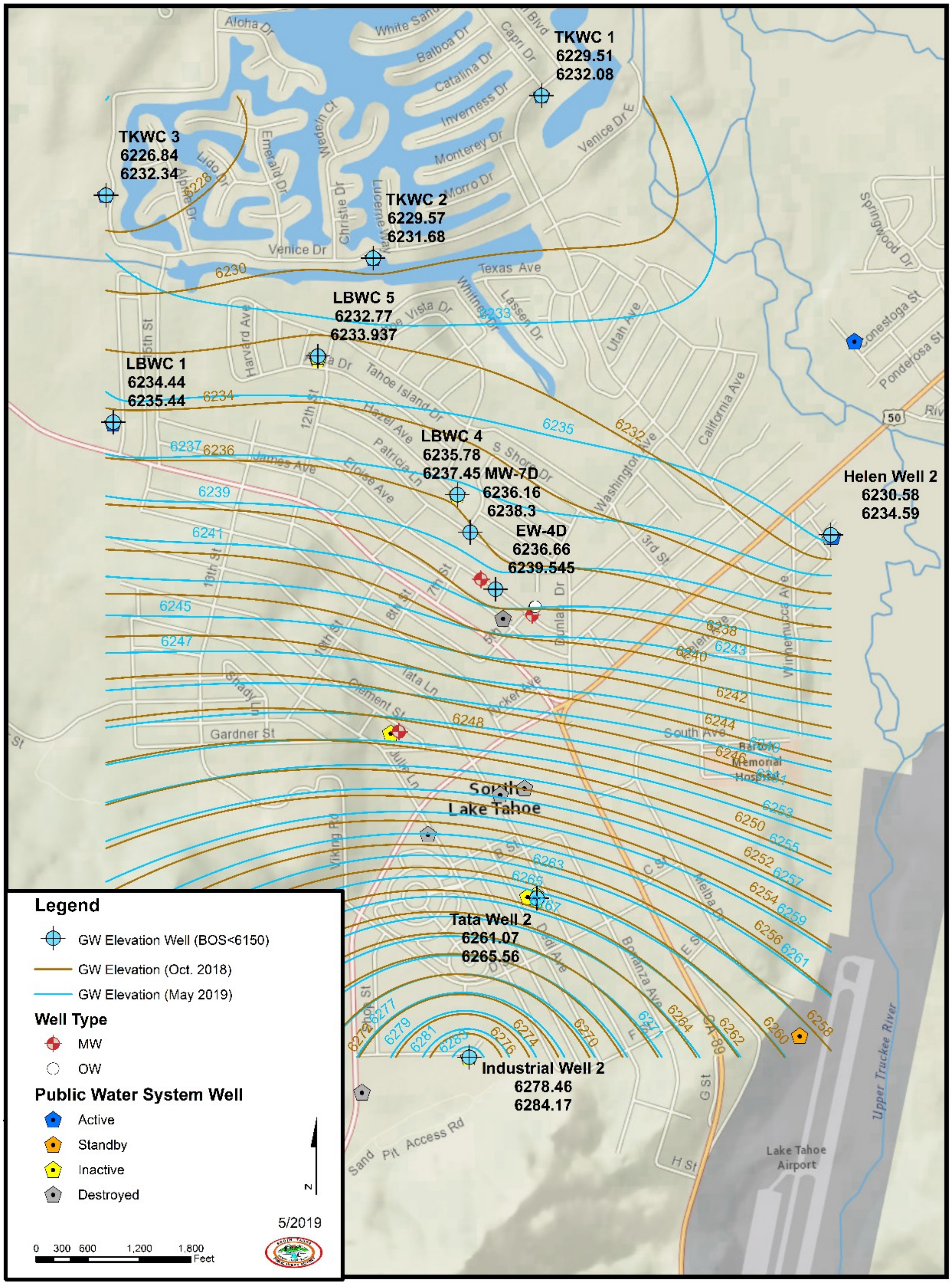

Figure 3-10: Fall 2018 and spring 2019 groundwater level elevation contours for TKZ4.

3.4.2 Vertical Gradients

Vertical gradients were calculated from groundwater level readings collected at four well clusters within the South Y Area (Clement Well, MW-4, MW-7 and MW-10). The BOS elevations for all of the wells included in these well clusters are above the clay lens, with the exception of the Clement well cluster which includes a well pair with screened intervals above (CL-3) and below (CL-1) the clay lens.

Since 2001, the District has collected measurements of groundwater levels in the Clement Well Cluster (CL-1 and CL-3) as part of its Basin Monitoring Program for the Tahoe Valley South Basin. These readings are augmented by groundwater level readings collected from well clusters during the PDI (MW-4, MW-7 and MW-10). A hydrograph showing the vertical gradients calculated from level measurements in these wells is provided below in Figure 3-11. Worksheets showing the water level and screen elevations used for these calculations are included in Appendix M. In general, the vertical gradients for each of the well clusters wells are an order of magnitude greater than the average horizontal gradients calculated from the groundwater level contours. Relatively high gradients at the Clement Well Cluster suggest a significant vertical component of downward directed groundwater flow across the clay lens from TKZ5 to TKZ4.

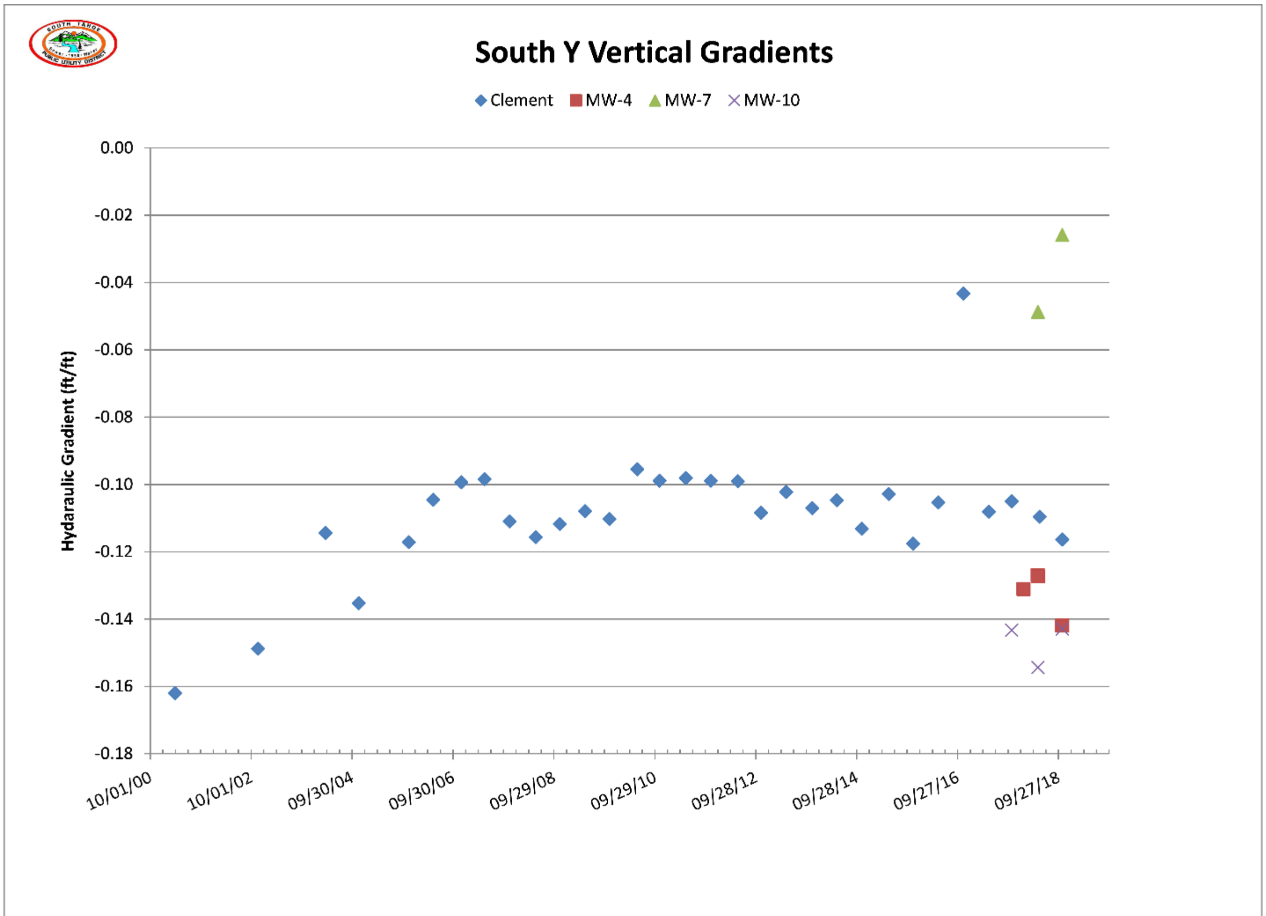

Figure 3-11: Vertical gradients measured in well clusters within the South Y Area.

3.4.3 Groundwater Velocity

Using the average hydraulic conductivity values derived from the aquifer test and the average horizontal gradients calculated from the groundwater level contours, the average groundwater velocity (Darcy velocity), pore seepage velocity and travel time required for contaminants to move by advection along the estimated length of the plume were calculated. The PCE concentrations detected in the zone test samples can then be used along with the Darcy velocity calculations to derive the rate at which the PCE mass moves by advection in the direction of groundwater flow. Worksheets showing these calculations for Zones B and Zones C are included in Appendix M.

Using the hydraulic gradient values derived from the fall 2018 and spring 2019 groundwater elevation readings, groundwater velocities for Zone B (26 – 38 ft bgs) range from 0.21 ft/d (fall 2018) to 0.25 ft/d (spring 2019). While the average pore seepage velocities for Zone B range from 0.89 ft/d (fall 2018) to 0.75 ft/d (spring 2019). Groundwater velocities for Zone C (40 – 94 ft bgs) range from 0.22 ft/d (fall 2018) to 0.26 ft/d (spring 2019). While the average pore seepage velocities for Zone C range from 0.79 ft/d (fall 2018) to 0.95 ft/d (spring 2019).

Assuming a plume length of 8,150 feet the travel time for groundwater to move by advection along this plume length is estimated to range from 25 to 30 years for Zone B. Travel times for Zone C are estimated to range from 23.5 to 28.2 years.

The advective flux density is the rate per unit area at which mass is transported with groundwater across an imaginary plane oriented perpendicular to the direction of groundwater flow. Using the PCE concentrations detected in the zone test samples, the advective flux densities for the PCE mass in groundwater were calculated for Zone B and the upper part of Zone C (Cu). The advective flux density for Zone B is 0.196 milligrams per square foot per day ($mg/ft^2 \cdot d$). The advective flux density for Zone C_u is 0.391 $mg/ft^2 \cdot d$. These calculations show that the PCE contaminant mass is moving at about twice the rate in Zone C_u than in Zone B.

3.5 Extraction Well Capture Zone and Contaminant Mass Recovery

Test wells EW-1B and EW-1C were designed and constructed for possible use as shallow extraction wells. Information collected during the Pre-Design Investigation were used to calculate single well capture zones and contaminant mass recovery rates for these wells and are presented below for consideration during preliminary engineering design.

3.5.1 Capture Zone Analysis

A capture zone is a 2-dimensional representation showing the area contributing groundwater to a pumping well. Capture zone analysis is often used during preliminary engineering design to ascertain the appropriate number and spacing of shallow extractions wells needed to contain and/or remove dissolved contaminants from a groundwater plume.

Capture zones for both test wells were calculated using the single well capture zone equation (Javenadl & Tsang, 1986). Input values and results of these computations are provided below in

Table 3-9. Figure 3-12 shows the graphical representations of the calculated capture zones for EW-1B and EW-1C.

Table 3-10: Inputs values and results from computations using the capture zone equation (Javendal & Tsang, 1986).

Parameter	Description	Units	EW-1B	EW-1C
Q	Discharge Rate	Gpm	20	40
Kh	Hydraulic Conductivity	ft/d	41	43.5
I	Hydraulic Gradient	ft/ft	0.006	0.005
D	Aquifer Thickness	Ft	12	54
v	Groundwater Velocity	ft/min	1.71E-04	1.51E-04
Q/(Dv)	Capture Zone- Maximum upgradient width	Ft	1,304	656
Q/(2*(Dv))	Capture Zone- width perpendicular to pumping well	Ft	652	328
Q/(2*pi*Dv)	Capture Zone- Down-gradient distance to Stagnation Point	Ft	208	104
0.32Q/Dv	Optimal distance between two extraction wells along a line	Ft	417	210
0.4Q/Dv	Optimal distance between three or more extraction wells along a line	Ft	522	262

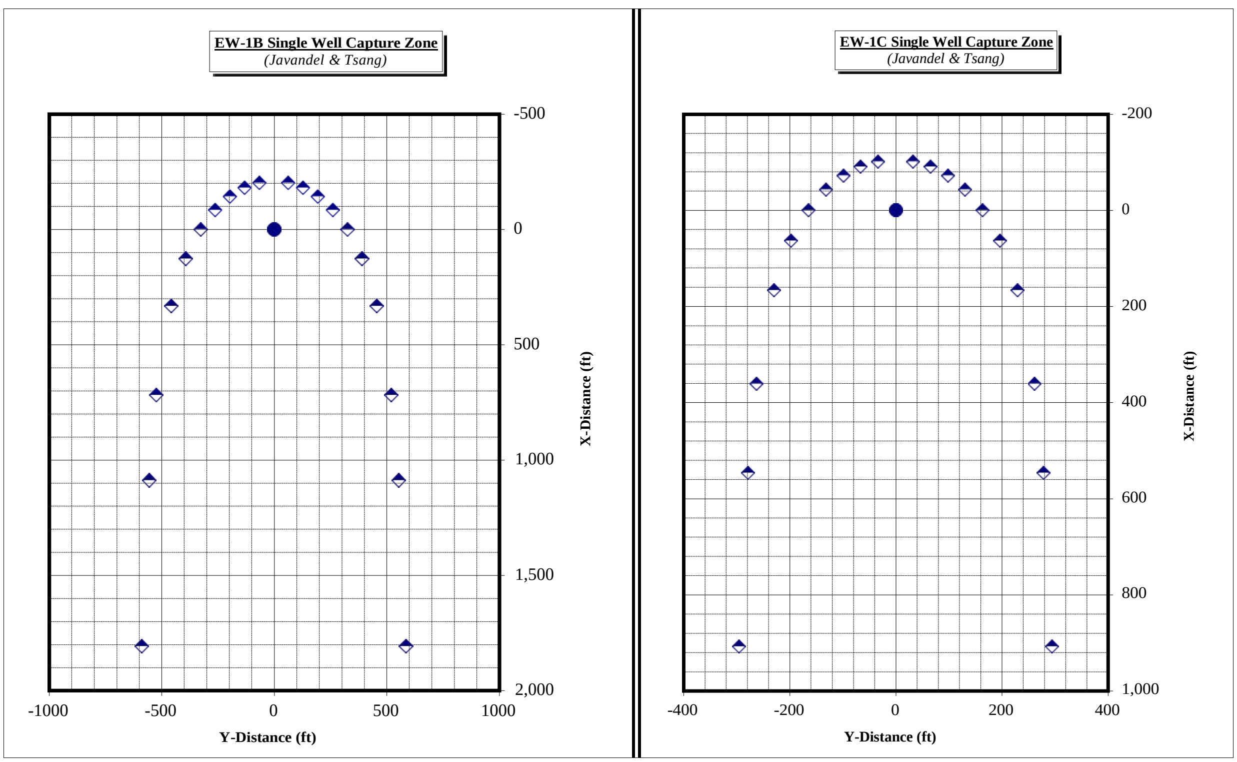

Figure 3-12: Capture zone areas calculated for EW-1B and EW-1C.

3.5.2 Contaminant Mass Recovery

Using the average concentrations of the VOCs detected during the constant test, the contaminant mass removal rates were calculated for EW-1C. The calculated extraction rates for these contaminants are provided below in Table 3-10. At these extraction rates it would require about a 100 days of continuous pumping at 40 gpm to remove: 3 lbs of PCE; 0.2 lbs of TCE and 0.1 lb of DCE from groundwater.

Table 3-11: Contaminant mass extraction rates for EW-1C.

Contaminant	Average Concentration (µg/L)	Pumping Rate (gpm)	Mass Extraction Rate (lbs/d)
PCE	62	40	0.03
TCE	3.4	40	0.002
DCE	1.1	40	0.001

3.6 South Y Well Survey

The South Y Area is made up of a variety of existing land uses, including commercial, residential, public and open space. The residential subdivisions within the area date from the 1960s to the 1990s (TRPA, 2015). Many of the commercial and residential properties include wells that are owned and operated privately for drinking water supply. A number of these wells have been impaired by PCE contamination and are no longer used or have been destroyed. In order to better understand the possible use of groundwater by private wells in the South Y Area a well survey was performed based on a review of District and El Dorado County Environmental Management Department (EDC-EMD) records.

Results from this file review indicate a total of twenty-four (24) private wells and fourteen (14) small community water system (SCWS) wells may be located within or neighboring the South Y Plume as shown on Figure 3-13. Inspection of Figure 3-13 shows that nineteen of these wells are; situated within or are in very close proximity to the inferred extent of the South Y Plume; constructed over the clay lens; and are greater than 80 feet in depth or construction information for these wells could not be found. Identification of these wells is important to help identify all potential users of groundwater within the South Y Area and to determine whether these wells may also serve as vertical conduits for the movement of contaminants into TKZ4. Well information gathered during the well survey is provided in Appendix N.

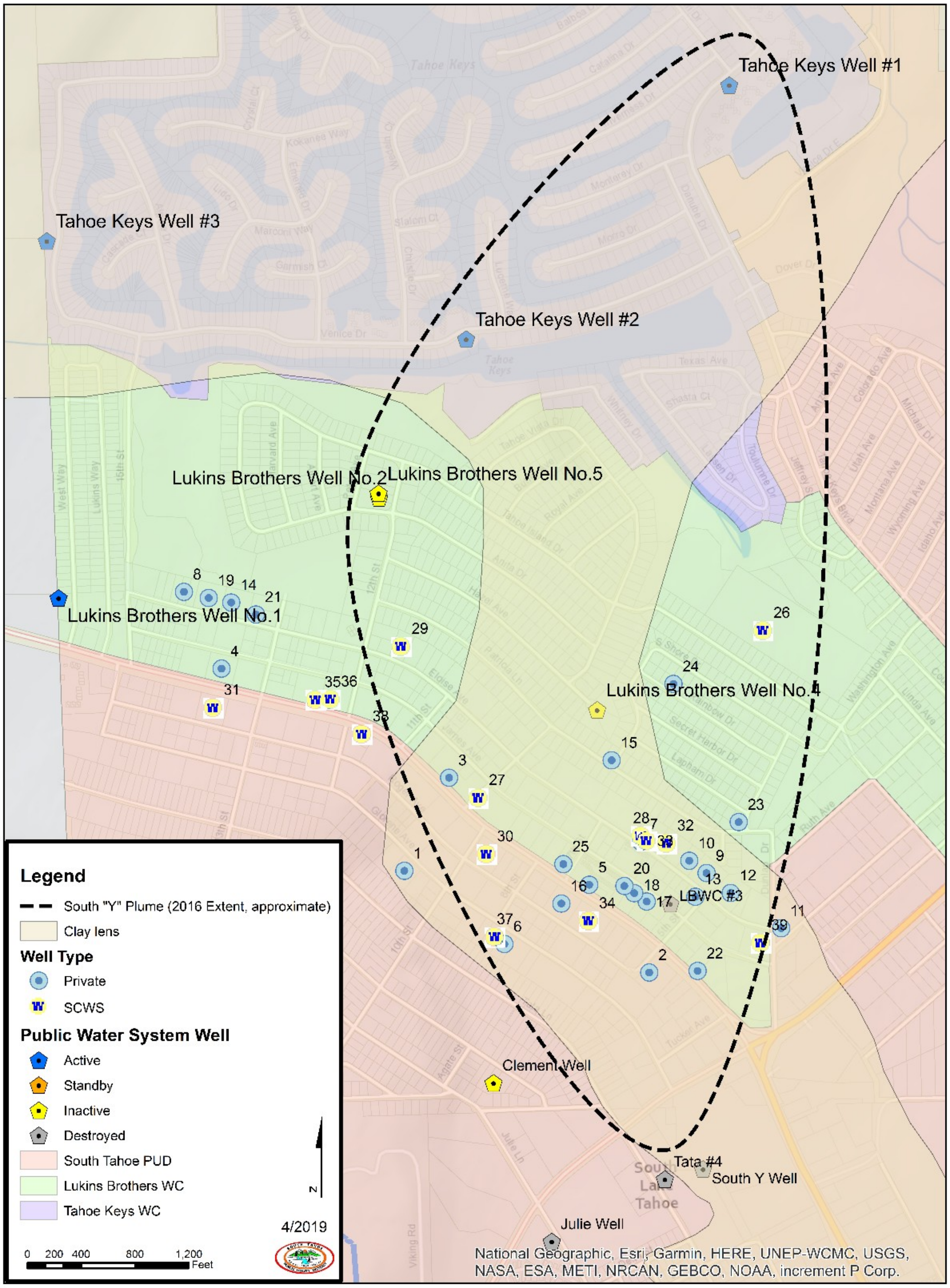

Figure 3-13: Private and small community water system wells located within the South Y Area.

3.7 2018 PCE Distribution

During 2018, the Phase I and Phase II Off-site Groundwater Investigations conducted for the former LTLW site generated additional data showing PCE in groundwater within the South Y Area (EKI, 2019). Groundwater data from these investigations were reviewed and combined with the groundwater quality data collected during the PDI to provide a more complete picture of the current PCE distribution in groundwater (see Figure 3-14). A brief summary of findings from review of these data is provided in the following section.

The Phase I and Phase II investigations involved the collection of multi-depth grab groundwater samples using CPT/MIP sample points along two transects. The Phase I transect was along Lake Tahoe Boulevard and the Phase II transect was along Tucker Avenue. Both transects were located immediately north of the LTLW site, and neighbor the Tucker Avenue Stormwater Retention Basin. Both transects were used to sample groundwater from depths generally ranging from about 14 to 76 ft bgs. Three monitoring well pairs were also constructed as part of the Phase II investigation down-gradient of the stormwater basin. For each well pair, a shallow zone well was constructed with screened intervals varying from between 8 to 24 ft bgs and a middle zone well was constructed with screened intervals varying from between 33 to 48 ft bgs.

Water quality results from the CPT/MIP sampling show PCE concentrations were generally highest in groundwater samples collected along Tucker Avenue, from between 30 to 50 ft bgs. Groundwater samples from this depth interval had reported PCE concentrations ranging from 145 to 1,680 µg/L. High PCE concentrations (290 µg/L) were found at one CPT/MIP location in a sample collected below this depth interval at 61 ft bgs. PCE was not detected in the deepest CPT/MIP samples collected across this transect suggesting a maximum vertical extent for this contamination at about 71 to 76 ft bgs.

Water quality results from the monitoring well sampling show PCE concentrations were highest (163 – 1,580 µg/L) in samples collected from the middle zone well for each well pair. Highest concentrations in samples collected from the shallow zone wells was found in the well pair (OS-2S/2M) neighboring the stormwater basin.

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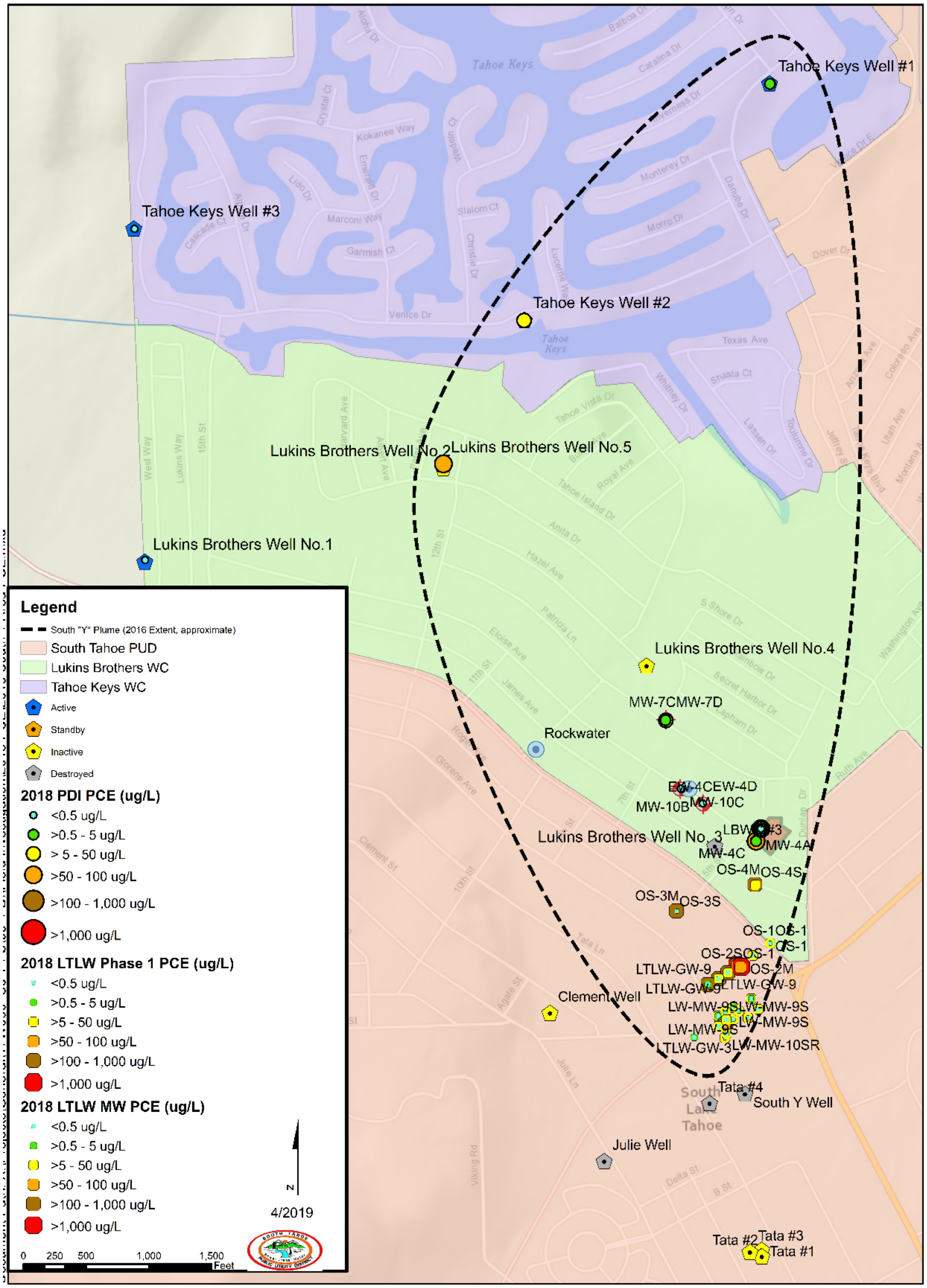

Figure 3-14: 2018 PCE distribution in groundwater from data collected during this Pre-Design Investigation and Phase I and Phase II of the Off-Site Groundwater Investigation for the former LTLW site (SL0601754315).

Considered along with the findings of the 2018 PDI, PCE water quality results from the Off-Site Groundwater Investigation suggests that the Tucker Avenue Stormwater Basin likely provided a vertical pathway for the infiltration of PCE contamination to depth intervals corresponding to Zone B (26 – 38 ft bgs) and Zone C_u (40 -52 ft bgs) described at the PDI site (953 Eloise Avenue). PCE groundwater distributions identified from sampling completed in both 2017 and 2018 identifies these depth intervals as a preferential pathway for the horizontal movement of PCE in groundwater across the up-gradient half of the South Y Plume to at least LBWC 4. Detections of PCE in groundwater samples collected from the upper screened interval of LBWC 4 (43 – 78 ft bgs) show that PCE contamination entered this well from the Zone C_u depth interval. The construction of LBWC 4 enables the vertical movement of PCE contamination into TKZ4 underlying the clay lens. There are nineteen other wells that are situated within or are in very close proximity to the inferred extent of the South Y Plume which are constructed over the clay lens and are greater than 80 feet in depth or well construction information for these wells could not be found. It is likely that the hydraulic influence from many of these wells, when active, may have also drawn PCE contamination into deeper portions of TKZ5 and /or served as vertical conduits for the movement of PCE into TKZ4. Flow directions from groundwater elevation contours for TKZ5 Zone B (Figure 3-8 and Table 3-9) show these wells situated down-gradient, in terms of groundwater flow, with respect to the Tucker Avenue Stormwater Basin. However, groundwater flow directions in TKZ5 Zone C_u suggests a NW component of groundwater flow (Figure 3-8 and Table 3-9) lower in this depth interval.

3.7.1 Stormwater System

The CSLT stormwater system includes a complex network of drain inlets, interceptors, retention basins, channels and drainage pipes used for stormwater management. The spatial relationship of these features to the distribution of PCE contamination in groundwater was reviewed at a cursory level to consider this system as another possible pathway for leading to the distribution of PCE contamination observed across the South Y Area (Figure 3 -15). Historical evidence inferring the introduction of PCE from the LTLW site into the stormwater system is presented in groundwater investigation workplan comments provided by environmental consultants retained by TKPOA (GZA, 2017).

Drain inlets, interceptors and open channels are located near possible PCE source areas as indicated by the locations of PCE detected in soil samples collected in the South Y Area. At the former Hurzel property an interceptor is located immediately on the property. Construction of this interceptor should be reviewed to consider this stormwater collector as a potential source and/or vertical pathway for infiltration of PCE contamination. Stormwater channels and drainage pipes convey collected stormwater toward retention basins located north of Roger Avenue and west of Seventh Street hydraulically upgradient from LBWC #4 and retention basins north of Eloise Avenue and west of 12th Street hydraulically upgradient of LBWC #5. The identification of the Tucker Stormwater Basin as a pathway for the infiltration of PCE contamination warrants that these retention basins also be considered for investigation.

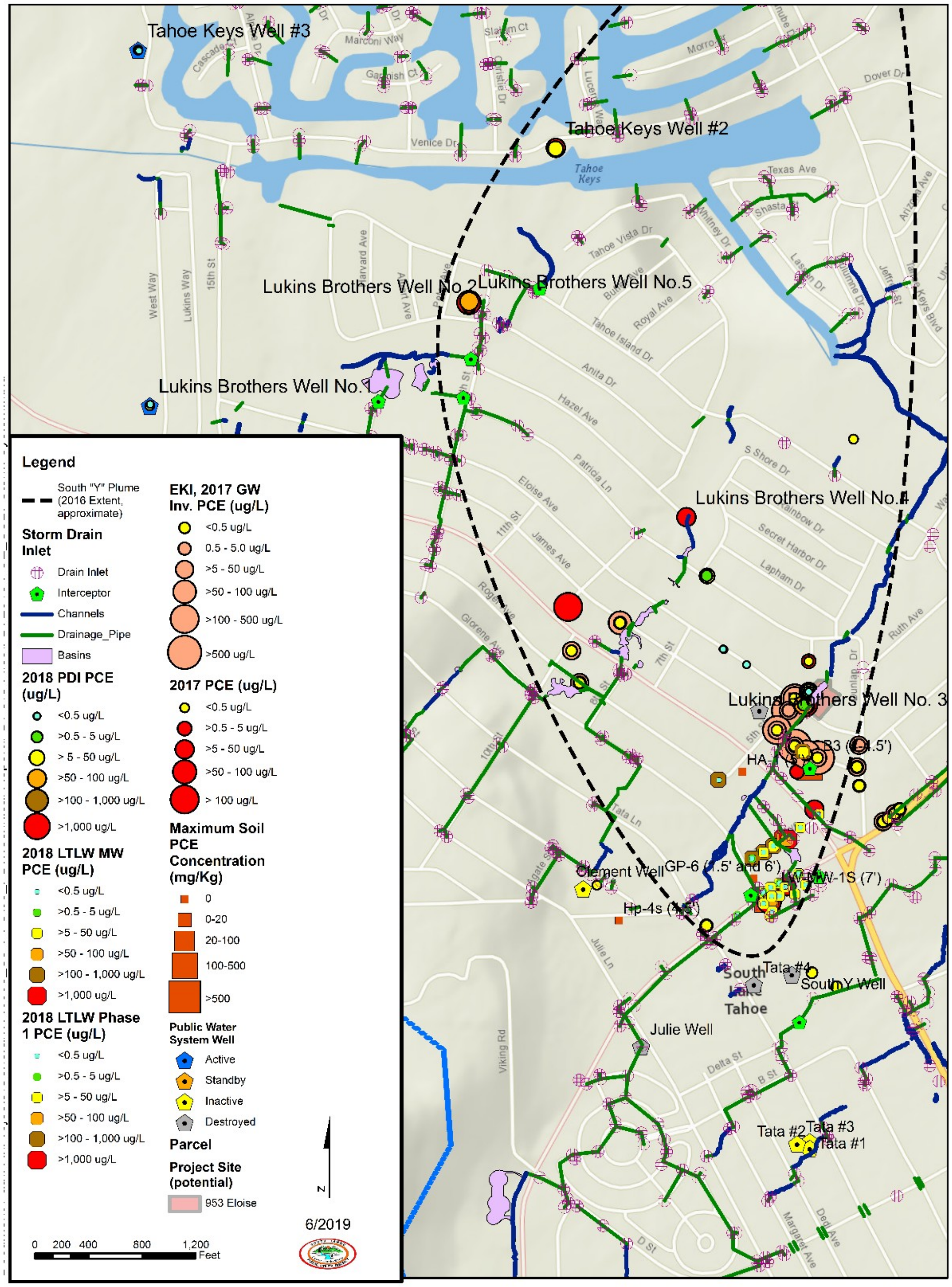

Figure 3-15: CSLT Stormwater System and the distribution of PCE in groundwater through the South Y Area

Section 4: Conclusions

1. The South Y Area is underlain by several sequences of medium to coarse gravel and sand deposits interlayered with fine-grained silts and clays to a depth of more than 300 feet. The gravel and sand deposits are interpreted as scree deposited along the north flank of Twin Peaks and glacial outwash deposits related to the progradation of glacial outwash deltas, east of the South Y Area, during the Pleistocene. The interlayered silts and clays represent lacustrine sediments deposited during inter-glacial periods. The gravel and sand units generally correspond to water zones recognized by the District within the basin-fill aquifer. The interlayered silts and clays generally form aquitards between water zones. Five water zones are recognized by the District through the South Y Area; of these four (TKZ1, TKZ2, TKZ4 and TKZ5) are actively used for drinking water supply. A clay lens striking N70E and dipping north 0.7 degrees forms an aquitard between TKZ4 and TKZ5. The clay lens varies from less than 10 feet in thickness near the South Y to more than 90 feet in thickness down-dip, north of the South Y in the area of the Tahoe Keys.

2. PCE contamination in groundwater through the South Y Area occurs predominantly in the two uppermost water zones (TKZ4 and TKZ5). PCE has been detected in PWS and private drinking water wells and environmental monitoring wells through this area since 1989, when PCE was first required to be tested in regulated drinking water sources. Currently PCE above MCLs has impaired three PWS wells (LBWC #2, LBWC #5 and TKWC #2) with a combined source capacity of 3.25 MGD. Two PWS wells west of the South Y Plume (LBWC #1 and TKWC #3) are presently non-detect for PCE.

3. The inferred vertical and lateral extents of PCE in groundwater were initially delineated in 2016 (Alward and Peterson, 2016; LRWQCB, 2016). The South Y Plume is believed to extend from the South Y north toward the Tahoe Keys along the south shore of Lake Tahoe. The vertical extent of the South Y Plume is believed to be inhibited by the clay lens aquitard occurring between TKZ4 and TKZ5.

4. Multiple sources areas may be contributing PCE contamination to the South Y Plume. Currently, the LRWQCB has only identified the former LTLW site (SL0601754315) as a contributing source area. Results from recent Off-Site Groundwater Investigations completed in 2018 for this site indicates that the Tucker Avenue Stormwater Basin likely served as a pathway for the infiltration of PCE contamination to depths of about 71 to 76 ft bgs.

5. As part of the South Y Feasibility Study, a Pre-Design Investigation (PDI) was performed at 953 Eloise Avenue, South Lake Tahoe, CA. This site is located about 1,200 feet north of the Tucker Avenue Stormwater Basin. The PDI was used to collect water quality information needed to define the vertical extent of groundwater contamination and collect aquifer property information useful for engineering design. The data collected as part of the PDI represents a snapshot in time of the aquifer and its stratigraphy in the vicinity and depth of EW-1, the wells sampled as part of the baseline sampling, and LBWC 5 using the remaining GAC from EW-1. The PDI also confirmed the presence and allowed description of the clay lens inhibiting the vertical movement of PCE contamination into TKZ4. The flow test

conducted as part of the PDI provided a real-world flow rate for use in the regional groundwater model to evaluate PCE remediation alternatives.

6. Sonic drilling was used to complete a test hole to a depth of 150 ft bgs. Logging of continuous core showed the site stratigraphy generally consistent with regional characterization. The uppermost water-bearing zone (TKZ5) extended from water table depth to the top of the clay lens between 89 to 100 ft bgs. A lower water-bearing zone (TKZ4) occurs below this aquitard and extends to a depth of at least 150 ft bgs Thin silt horizons subdivide TKZ5 into three local zones designated Zones A (0 – 24 ft bgs); Zone B (26 – 38 ft bgs); and Zone C (40 -89 ft bgs). Zone D (100 – 150 ft bgs) occurs in TKZ4 below the clay lens.

7. Geotechnical testing on soil samples collected during test hole drilling included dry density, moisture content and both fixed-wall and flex wall hydraulic conductivity tests. Laboratory K values for the sample collected from the clay lens was reported at 2.86E-07 cm/s equivalent to 8.11E-04 ft/d. In general, laboratory K values were lower in the samples collected from fine-grained interlayers than the K values for the coarse materials.

8. Laboratory analytical results from zone test sampling show the vertical distribution of chlorinated hydrocarbons (PCE, TCE and DCE) at the site. PCE concentrations above MCLs were found in groundwater samples collected to a depth of at least 51 feet within the upper part of TKZ5 in Zone B (26 -38' bgs) and in Zone C_u (40-52 'bgs). The majority of PCE mass is believed to have migrated to the site through these two zones, within the 26 to 52 foot depth interval. PCE was detected below MCLs in Zone C_l (53' – 89' bgs) and was not detected in Zone D below the clay lens within TKZ4. TCE was detected below MCLs in samples collected from each test zone, with the exception of the Zone C_l. TCE in these samples are interpreted as daughter products resulting from biodecay of PCE. Significant levels of benzene were detected in the zone test sample collected from Zone C_u. However, benzene was not detected in any of the time-series samples collected from EW-1C during the constant rate test. The source of the benzene detected in Zone C_u is presently unknown.

9. Aquifer testing completed during the PDI included an 8-hour step test followed by a 48-hour constant rate test. Data from the constant rate test was used to determine aquifer properties for wells which showed a pumping response. These data were analyzed using Aquifer^{win32}, a software system developed for the analysis and display of aquifer test results. Aquifer properties were calculated using a variety of hydraulic solutions including nonleaky (confined) and leaky aquifer conditions and partially penetrating well solutions. For analysis purposes the tested aquifer included Zones B and C with a total thickness of 68 feet. Aquifer test K values from valid hydraulic solutions averaged 41 ft/d (0.0144 cm/s) for Zone B; 38 ft/d (0.0135 cm/s) for Zone C_u and 49 ft/d (0.0174 cm/s) for Zone C_l. Storativity (S) estimates for these zones were 3.0 for Zone B; 0.00364 for Zone C_u and 0.00622 for Zone C_l. The high S estimated for Zone B may indicate short circuiting of groundwater across the upper sandy silt horizon, separating Zone B from Zone A (the overlying unconfined portion of the aquifer).

10. Static groundwater level readings collected during the fall of 2018 and the spring of 2019 were used to determine horizontal gradients and flow directions under seasonal low and seasonal high groundwater conditions for two zones in TKZ5 (Zone B and Zone C_u) and TK4. Horizontal gradients were relatively low (<0.01 ft/ft) for each zone. Groundwater flow directions varied by depth rotating from NE in TKZ5 Zone B to NW in the underlying Zones

TKZ5 Cu and TKZ4. Vertical gradients calculated from static groundwater level readings were an order of magnitude greater than horizontal gradients. Relatively high gradients at the Clement Well Cluster show a significant vertical component of downward directed groundwater flow across the clay lens from TKZ5 to TKZ4.

11. Groundwater velocities were calculated for Zone B (26 – 38 ft bgs) and Zone C (40 – 89 ft bgs) using average K derived from the aquifer tests and horizontal hydraulic gradients from static groundwater level readings. Comparison of these readings show that average groundwater velocity (Darcy velocity) and pore seepage velocity were relatively similar between the two zones, with average groundwater velocities on the order of 0.25 ft/d and pore seepage velocities on the order of 0.85 ft/d. Travel times for the movement of groundwater by advection along the length of the plume (8,150 feet) were also similar on the order of about 25 to 30 years for Zone B and 23.5 to 28.2 years for Zone C. However, because the highest levels of PCE were found in Zone C_u the advective flux density for PCE is two times the rate in Zone C_u than in Zone B.

12. Using average K values derived from the aquifer test, the areas contributing groundwater to EW-1B and EW-1C were computed, as a basis for design for shallow groundwater extraction wells. At an assumed pumping rate of 20 gpm, the area contributing groundwater to EW-1B has a capture width of about 652 ft perpendicular to the pumping well, 1,304 feet at its maximum upgradient width and a down gradient distance of 208 ft to the stagnation point. At an assumed pumping rate of 40 gpm, the area contributing groundwater to EW-1C has a capture width of 328 ft perpendicular to the pumping well, 656 feet at its maximum upgradient width and a down gradient distance of 104 ft to the stagnation point.

13. The optimal spacing between three or more shallow extraction wells installed along a line is estimated at about 520 feet for Zone B and at about 260 feet for Zone C. The relatively greater aquifer thickness of Zone C compared to Zone B results in the smaller contributing area and derived optimal spacing from the pumping of EW-1C compared to EW-1B.

14. Time-series VOC samples were collected during the 48-hour pumping period used for the constant test. Mass extraction rates for VOCs detected during the constant test are as follows: PCE 0.03 lbs/d; TCE 0.002 lbs/d; and DCE 0.001 lbs/d. At these extraction rates it would require about 100 days of continuous pumping at 40 gpm to remove 3 lbs of PCE; 0.2 lbs of TCE; and 0.1 lbs of DCE from groundwater.

15. District and EDC-EMD records search identified a total of 38 private wells possibly situated within or near the South Y Plume. Of these, 19 wells are; situated within or are in very close proximity to the inferred extent of the South Y Plume; constructed over the clay lens; and are greater than 80 feet in depth or construction information for these wells could not be found. Identification of these wells is important to help identify all potential users of groundwater within the South Y Area and to determine whether these wells may also serve as vertical conduits for the movement of PCE contamination into TKZ4.

16. Integration of PCE water quality results collected during 2017 and 2018 suggests that the Tucker Avenue Stormwater Basin provided a vertical pathway for the infiltration of PCE contamination to depth intervals corresponding to Zone B and Zone C_u at the PDI project site. Maximum concentrations of PCE have been detected at depth intervals between 30 to 50 ft bgs at multiple sites through the South Y Area. These data suggests this depth interval

serves as a preferential pathway for the horizontal movement of PCE across the up-gradient half of the South Y Plume to at least LBWC 4. Detections of PCE in groundwater samples collected from LBWC 4 show that PCE entered the well from this shallow depth interval and likely served as a vertical pathway for the further movement of PCE contamination from TKZ5 into TKZ4. It is likely that the hydraulic influence from many wells, located within the South Y Area may have also drawn PCE contamination into deeper portions of TKZ5 and /or served as vertical conduits for the movement of PCE across the clay lens into TKZ4.

17. Comparison of the greater CSLT Stormwater Collection System to the distribution of PCE in groundwater suggest a causal relationship between components that warrant further investigation. Drain inlets, drainage pipes and channels collect stormwater near possible PCE source areas and convey this water toward retention basins located hydraulically upgradient from LBWC #4 and LBWC #5. Engineering details for drain inlets and stormwater interceptors located near potential source areas of PCE contamination need to be reviewed for potential to vertically infiltrate PCE contaminated groundwater. The identification of the Tucker Stormwater Basin as a vertical pathway for the infiltration of PCE contamination warrants that these other retention basins also be considered for investigation.

Section 5: Recommendations for Alternatives Development

The results of this Pre-Design Investigation are a geographically limited effort to collect site specific water quality and aquifer characteristics in the mid-plume area to augment the current body of information associated with the LTLW site. Other efforts are underway by the Regional Water Quality Control Board to define the lateral and vertical extent of the PCE plume adjacent to the LTLW site. Data collection will be an ongoing effort and are inherently limited by financial resources; i.e. there will always be data gaps and/or there are insufficient resources to collect data that will reduce uncertainty to zero.

5.1 Additional Data Collection to Fill Data Gaps

Continuing effort will be needed to fill data gaps that may inform future decisions regarding actions such as:

- Potential sources of PCE, contaminant types, and source area concentrations. Four potential source areas of PCE contamination have been identified in the South Y Area (Figure 1-8). Of these, only the Lake Tahoe Laundry Works site is currently under investigation. Further investigation is required to determine the vertical and lateral extents of PCE in soil and groundwater at the other three potential source areas.

- Regional aquitard characteristics such as spatial extent and influence on plume migration. Subsurface information reviewed during the PDI identified a clay lens of significant areal extent occurring within the South Y Area (Section 1.3.1.1). This clay lens forms an aquitard between the two upper-most water zones (TKWZ4 and TKWZ5) used for drinking water production in the South Y area. As an aquitard this clay lens has a significant bearing on groundwater flow and inhibits the vertical migration of PCE. The lateral extent of the clay lens is believed to be limited in an east-west direction across the inferred extent of the South Y Plume. Additional test borings should be drilled between the Rockwater Well and LBWC 1; and the LBWC 1 and LBWC 5 to better define the western extent of this clay lens. Additional test borings should be drilled between the LBWC 4 and TV School Well; and the TV School Well and TKWC1 to better define the eastern extent of this clay lens. Internal plume geometry including single vs. multiple plumes and characterization. Contaminant distribution data suggests that majority of PCE contamination is moving in in groundwater through water –bearing zones generally occurring between depths of 25 to 50 ft bgs (Sections 3.3, 3.4, 3.5 and 3.7). Samples collected from these depths should be regarded as target intervals for any future investigations to discern between single vs. multiple plumes occurring within the South Y Area. Vertical extent of PCE contamination should be characterized below 50 ft bgs to the top of the clay lens aquitard, where present, or to sample depths with PCE concentrations below laboratory method detection limits (0.5 µg/L), whichever is encountered first.

- Uncertainty in permeability horizon. Aquifer characterization data for water-bearing zones serving as preferential pathways for the movement of PCE contamination in groundwater is sparse. Additional short-term zones tests and longer term aquifer tests should be performed using test borings and/or existing monitoring wells to build on the aquifer characterization data collected during the PDI. These data should then be used to map the hydraulic conductivity distribution in water-bearing zones occurring between depths of 25 to 50 ft bgs; and from 50 to about 89 ft bgs (top of clay lens). These data can then be used to better understand the movement of PCE in groundwater within the South Y area and provide information needed to develop strategies for the containment and removal of PCE from groundwater. Priority for performance of these zone and/or aquifer tests should be given to those areas immediately neighboring identified source areas.

5.2 Additional Data Collection to Inform Alternative Development

Refinement of alternatives prior to implementation maybe supplemented with further investigations in the Project area to address critical data gaps. Specific data gaps for an alternative will be identified during development of the Feasibility Study alternatives. Such information will likely be limited to the effective geographic area of each alternative, including:

- Preferential pathways: underground utilities such as storm water collection/infiltration systems or sanitary sewers, target zones for plume migration, distribution of local confining layers and aquitards.
- Private well information and contributions to vertical migration of the PCE plume.
- Influence of alternative on plume migration.

5.3 PDI and Alternatives Development

The information derived from this predesign investigation will be used to inform alternatives and the Feasibility Study as follows:

1. The baseline water quality samples collected at the four nearby monitoring wells at varying depths when combined with the samples collected during drilling of EW-1 provide a current snapshot of the PCE concentrations, when combined with historic information, will be used to inform estimates of PCE removal in the extraction alternatives and to evaluate the feasibility and efficacy of various remediation alternatives in these locations.
2. The aquifer tests at EW-1C and the adjacent wells, as summarized in Table 3-5, when combined with the well specific screened interval, will inform the potential rate of extraction and capture zone for extraction well alternatives in the feasibility study and can be used to refine the groundwater model.
3. The time series sampling during the constant rate test indicate that PCE concentrations within the capture zone of EW-1C are quite constant and can inform the estimate of PCE mass removal for extraction at this location. The presence of daughter products TCE and cis 1,2-DCE indicate some degradation.

4. Other data such as groundwater elevations using topographic survey results, boring logs, aquifer and laboratory tests, can be useful in verifying groundwater model results and estimating flow directions.

5. The boring logs provide additional information in refining the regional geologic cross-section.

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