Santa Clara Valley Water District Multi-Aquifer Monitoring-Well Site, Coyote Creek Outdoor Classroom, San Jose, California

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The U.S. Geological Survey (USGS), in cooperation with the Santa Clara Valley Water District (SCVWD), has completed the first of several multiple-aquifer monitoring-well sites in the Santa Clara Valley. This site monitors ground-water levels and chemistry in the one of the major historic subsidence regions south of San Jose, California, at the Coyote Creek Outdoor Classroom (CCOC) (fig. 1) and provides additional basic information about the geology, hydrology, geochemistry, and subsidence potential of the upper- and lower-aquifer systems that is a major source of public water supply in the Santa Clara Valley. The site also serves as a science education exhibit at the outdoor classroom operated by SCVWD.

Well Completion

Two boreholes were drilled at the CCOC site; one to a depth of 1,011 feet (ft) below land surface (bls) and the other to 100 ft bls. The first borehole contains four wells screened from 405 to 425, 520 to 540, 620 to 640, and 820 to 840 ft bls (fig. 2). The second borehole consists of a single well screened from 62 to 72 ft bls (fig. 2). Lithologic, geophysical (before and after drilling), and water-chemistry data were collected at the site. Additional geologic, geophysical, and geochemical data were obtained from the cores retrieved during drilling. Because multiple wells were installed in one of the single boreholes, depth-dependent hydrologic as well as isotopic- and inorganic-geochemical data were collected within the multiple-aquifer system. The data collected from the CCOC site can be used collectively with information from nearby wells to better understand the nature of the geology and water resources in the Santa Clara Valley.

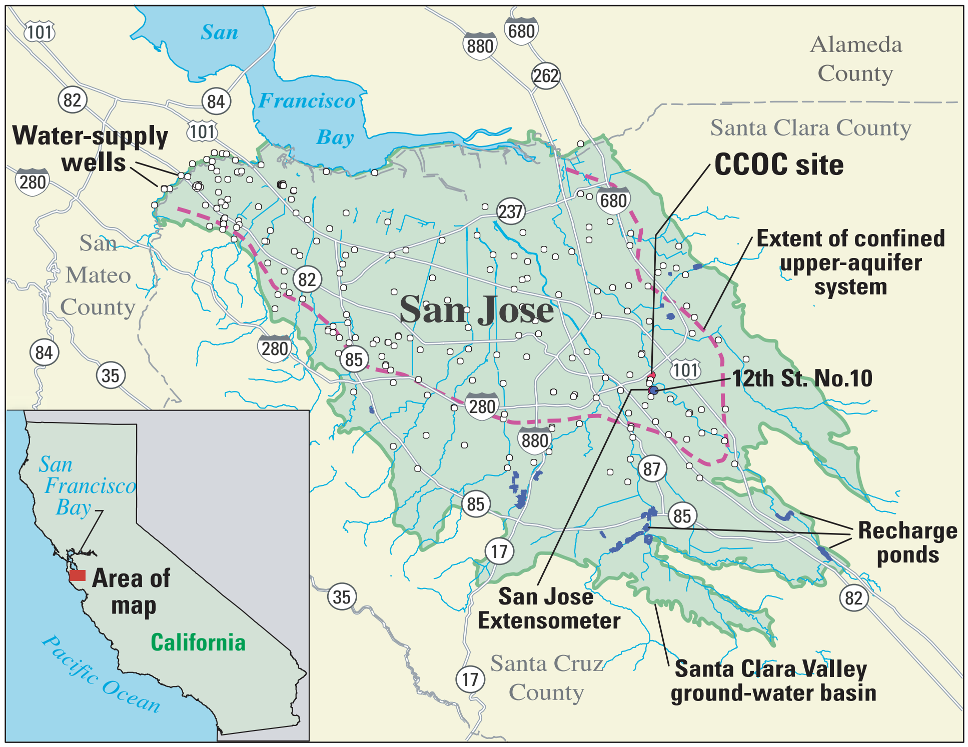

Figure 1. Location of multiple-aquifer monitoring-well sites, CCOC, Santa Clara Valley, California.

Geology

The deep borehole penetrated 1,011 feet of stream and alluvial fan sediments consisting of interlayered clay, silt, sand, and gravel (fig. 2). Drill cuttings, 202 ft of core, and borehole geophysical logs were used to define the aquifer system and bears upon local earthquake hazards. Composition, age, thermal disturbances from ground-water flow, and layering were determined from these data (fig. 2).

- A non-marine depositional environment is inferred from sedimentary features in the cores, including abundant molds of fine roots and a layer of peat at 1,006 ft.

- The borehole penetrated more gravel than had been anticipated from the records of nearby wells. The gravels are composed largely of sandstone, basaltic volcanics, and red chert eroded from Franciscan bedrock in the surrounding mountains. The abundance and coarseness of the gravel suggests that axial drainage through Santa Clara Valley, similar to the present Coyote and Guadalupe Creeks, has persisted while the sediment penetrated by the borehole was deposited.

- The deposits are less than 780,000 years old, based on a paleomagnetic study indicating that they formed after the last major reversal of the Earth's magnetic field (Mankinen, USGS, Menlo Park, oral commun., 2001). Knowing the age of the deposits aids in the reconstruction of the depositional history of the basin and in determining how

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recently nearby faults have been active.

•The base of the Holocene-aged sediments, which were deposited after the last continental glaciation, is marked at a depth of 75 ft by an increase in resistance to penetration using a cone penetrometer (CPT) (fig. 2) and is bracketed by the difference in radiocarbon dates of 10,700 and 28,100 radiocarbon years determined from small roots collected at 59 and 83 ft bls.

•A distinct layer of silty clay from 32-60 ft probably forms a local barrier to vertical movement of water and the potential for vertical recharge below the layer. The underlying Holocene-aged sand (basal aquifer) is part of the Recent aquifer within the upper-aquifer system (fig. 2).

•Gradients derived from detailed borehole temperature measurements indicate a linear conductive geothermal gradient from the bottom up to a depth of about 670 ft, above which the gradient is disturbed. Five zones in the upper-aquifer system (fig 2) are delineated by disturbances in the thermal gradient. These disturbances are likely due to lateral flow of water in the gravel layers, which are the major sources for nearby water-supply wells (fig. 1).

Hydrology

•The Recent aquifer is hydraulically distinct from the deeper aquifers within the upper-aquifer system, which is indicated by the more subdued fluctuation in water levels (CCOC-5) than that of the deeper wells (CCOC-1 to -4) (fig. 3).

•Water levels in the upper- and lower-aquifer system monitoring wells (CCOC-1, -2, -3, and –4) range from about 32 to 98 ft bls and show a seasonal variation of 40 to 60 ft for the period October 2000 to December 2001 (fig. 3). Differences in water levels between wells CCOC-2 through 4 vary seasonally, ranging from 8 to 24 ft during the period. These seasonal changes in water levels

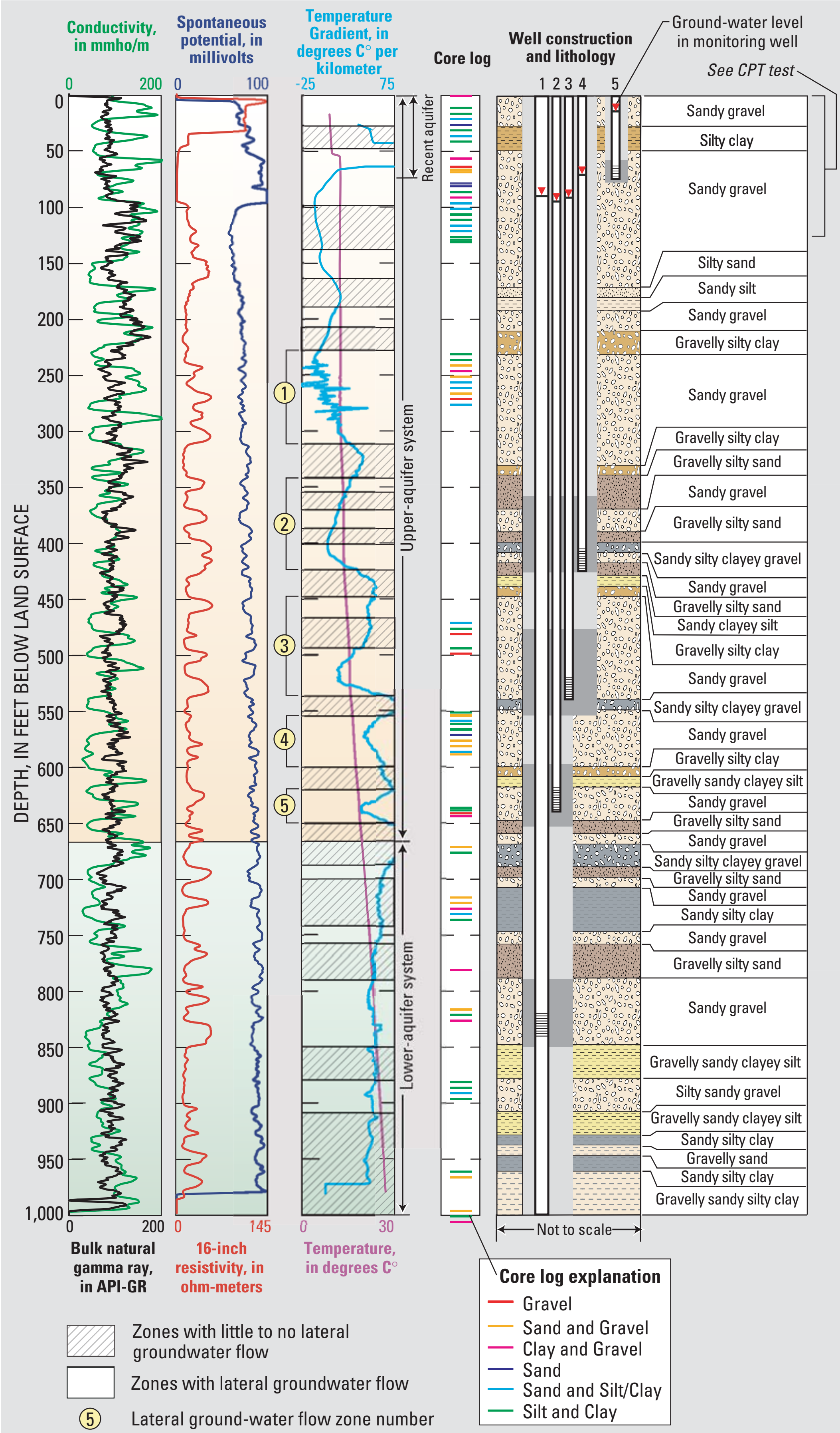

Figure 2. Well construction, well lithology, and geophysical data logs from CCOC site, Santa Clara Valley, California.

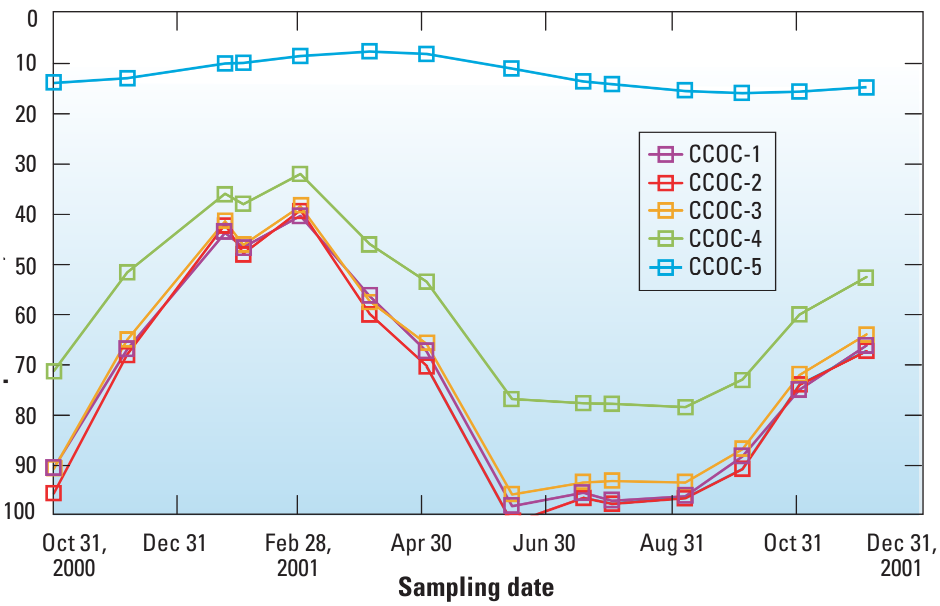

Figure 3. Water-level hydrograph, Coyote Creek Outdoor Classroom, from October 31, 2000 to December 31, 2001 (data from Santa Clara Valley Water District).

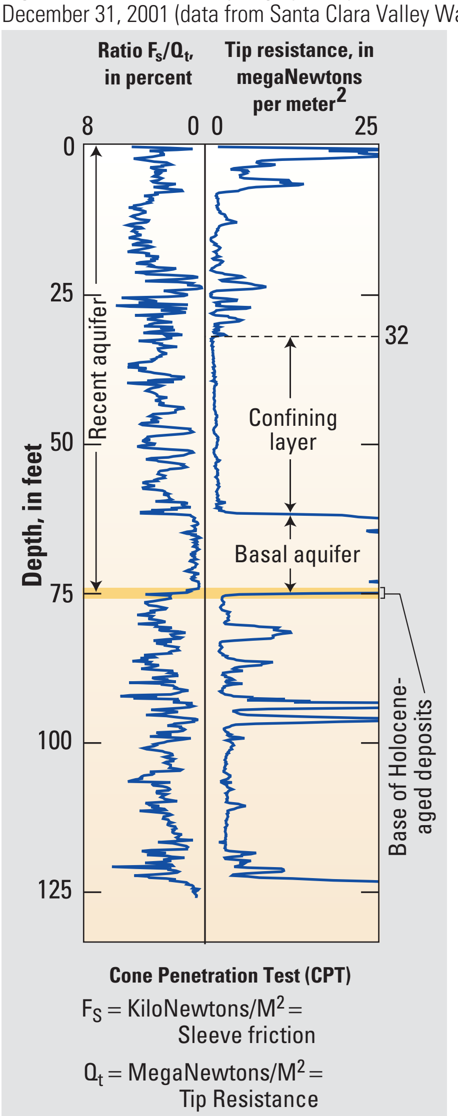

Figure 2. Well construction, well lithology, and geophysical data logs from CCOC site, Santa Clara Valley, California—Continued.

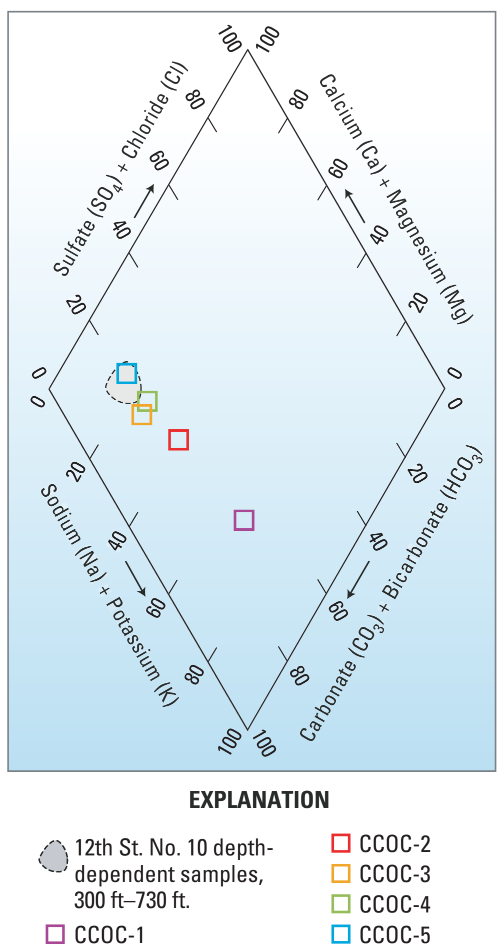

Figure 4. Chemical composition of major ions in groundwater from five wells at CCOC and 12th Street No. 10, Santa Clara Valley, California.

and water-level differences between aquifers contribute to the seasonal elastic compaction and expansion of fine-grained sediments that is measured by SCVWD at the nearby San Jose Extensometer (fig. 1) and quantified regionally in Interferometric Synthetic Aperture Radar images (Ikehara and others, 1998).

•Water levels in well CCOC-1, which is screened in the lower-aquifer system, vary with water levels from monitoring wells screened in the upper-aquifer system. This suggests that the lower-aquifer system may contribute some water to pumpage from nearby water-supply wells.

Geochemistry

Major-ion chemistry (fig. 4), tritium, carbon-14, and stable isotopes of hydrogen and oxygen (table 1 and fig. 5) were used to delineate the type, age, origin, and movement of ground water.

Upper Aquifer System

•Total dissolved solids in water from the upper-aquifer wells CCOC (2-5) ranges from 345 to 658 mg/L (table 1). Percentages of major cations and anions from CCOC–3 through 5 are chemically similar to samples from nearby water-supply well 12th St. No. 10 (fig. 4).

•Water from the upper-aquifer wells (CCOC-2 through -5) contain tritium ranging from 9.8 to 11.9 pCi/L and have uncorrected carbon-14 ages that range from 1,500 and 2,500 years old. The presence of tritium in older water suggest a mixture of older ground water and ground water recharged within the last 50 years, probably from nearby local streamflow, precipitation, and water imported water from northern California (table 1).

•Imported water from northern California that is artificially recharged into the aquifer systems by SCVWD is relatively enriched in lighter isotopes of hydrogen (-74 per mil) and oxygen (-10.2 per mil) (Muir and Coplen, 1981). The differences in isotopic composition allows for a direct comparison with native ground water (-41 per mil d-D and –6.1 per mil d-O18) and potential natural recharge from local surface

Local well No.	Screened interval (feet below land surface)	Total dissolved solids (mg/L)	Delta-deuterium (δ-D per mil)	Delta-oxygen-18 (δ-D per mil)	Tritium (pCi/L)	Uncorrected carbon-14 age (years before present)
7S/1E-9L4 (CCOC-1)	820–840	345	-49.6	-7.25	0.4	17,300
7S/1E-9L5 (CCOC-2)	620–640	406	-44.3	-6.46	10.7	2,500
7S/1E-9L6 (CCOC-3)	520–540	492	-42.2	-6.13	9.8	2,100
7S/1E-9L7 (CCOC-4)	405–425	528	-41.8	-6.20	10.5	1,700
7S/1E-9L8 (CCOC-5)	62–72	658	-42.4	-6.08	11.9	1,900
7S/1E-16C8 (12th St. No. 10)	265–774	504	-43.3	-6.13	13.0	1,500

Table 1. Selected water-chemistry constituents for the CCOC monitoring site and a nearby water-supply well, Santa Clara Valley, California

water (-40 per mil d-D and –6.0 per mil d-O18), such as Coyote Creek streamflow that is isotopically heavier than imported water (Muir and Coplen, 1981). As local and imported water is recharged and mixes with native ground water, a directly proportional change in isotopic composition occurs and the percentage of artificial recharge can be estimated using simple fractions of isotopic data (Muir and Coplen, 1981). Assuming a binary mixture, following the method from Muir and Coplen (1981), and using the isotopic values for local and imported-water recharge and the well values (table 1), samples from CCOC yield estimated mixtures of 2 percent (CCOC-4) to 10 percent (CCOC-2) of imported-recharge water. Mixtures from CCOC are similar to depth-dependent samples from nearby water-supply well (12th St. No. 10) (fig. 5).

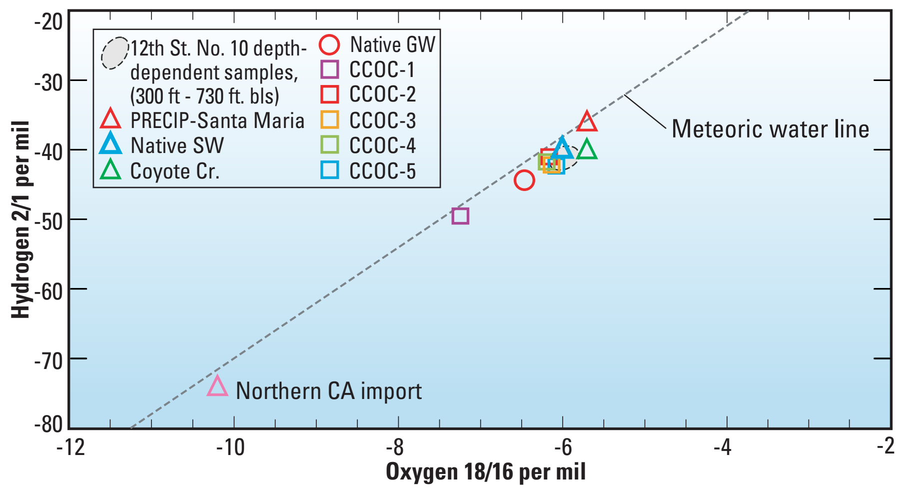

Figure 5. Santa Clara Valley oxygen vs. deuterium isotopes.

Lower-Aquifer System

•Water samples from the lower-aquifer system well CCOC-1 are chemically (fig. 4) and isotopically (fig. 5) distinct from water samples from the upper-aquifer system (CCOC-2–5). Combined with the temperature gradient data, (fig. 2) this difference suggests there is little to no vertical flow between upper- and lower-aquifer systems through the layered sediments.

•The absence of tritium and the uncorrected carbon-14 age of 17,300 years before present in samples from well CCOC-1 indicate that no recent recharge is present in the deepest aquifers penetrated at the monitoring-sell site. Corrected carbon-14 ages (not shown) can be as much as 30 percent younger due to the addition of inorganic carbon to ground water (Davis and Bentley, 1982). However, the uncorrected carbon-14 age indicates that this ground water represents recharge that occurred thousands of years before present.

•Water sampled from CCOC-1 was probably recharged prior to the Holocene age, when the prevailing colder climate of the ice ages changed the isotopic composition of local recharge to more closely resemble the isotopic composition of water currently imported from northern California (Muir and Coplen, 1981).

Coyote Creek outdoor classroom

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