Mapping Groundwater Quality in a Coastal Southern California Aquifer System

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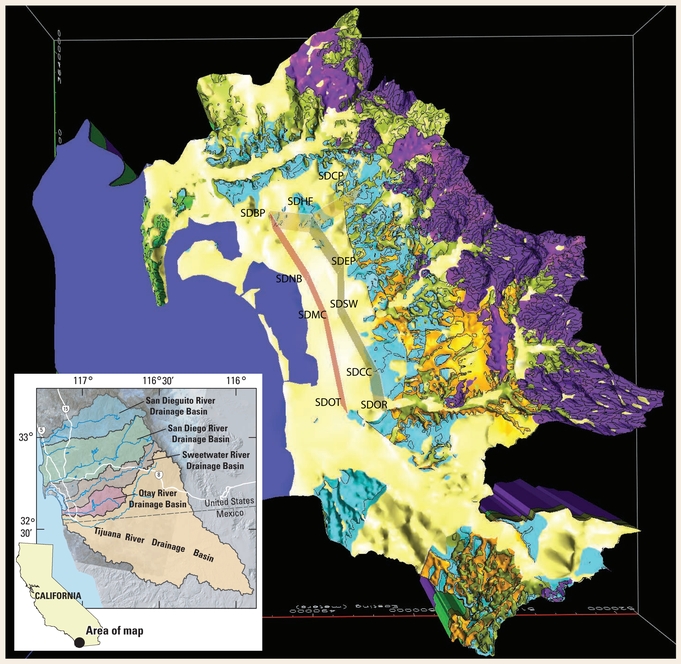
Abstract

Extensive data, including lithologic information, geophysical logs, and water quality data have been collected by the U.S. Geological Survey in the San Diego, California area to evaluate the suitability of the San Diego Formation and overlying alluvial deposits for use as a drinking water supply. *The lithologic information compiled from descriptions of drill cuttings collected during the installation of multiple-depth monitoring-well sites was combined with pre-existing GIS data sets, surface geologic maps, drillings and well logs, and various literature references to wells and outcroppings to generate a three-dimensional geologic framework model of the coastal San Diego area. The analytical protocol included selected major- and minor-ions, the stable isotopes of hydrogen, oxygen, and strontium, and the radiogenic isotope of carbon-14. Through the use of the water-quality data and cross sections derived from the 3D geologic framework model, it was possible to map the groundwater quality in the coastal southern California aquifer system.*

3D Geologic Framework Model

Over the past decade the USGS has been conducting a regional assessment of the groundwater resources in the San Diego area. An integral part of the regional assessment has been the installation of multiple-depth monitoring-well sites, each with as many as 6 monitoring wells to depths of more than 600 meters. Lithologic information was compiled from descriptions of drill cuttings collected at each borehole and from observations recorded during drilling. These observations provided direct, reliable data for the geologic boundaries of the subsurface. Additional data from wells, borings and seismic shot points provided age and depth information. These values were coupled with pre-existing GIS data sets, surface geologic maps, drillings and well logs, the aforementioned direct observations of lithology, and various literature references to wells and outcroppings to provide the input data used by RockWorks modeling software to generate a three-dimensional geologic framework model. Two north-south cross-sections were derived from the 3D geologic framework model, one located along the San Diego Bay (West) and the other one located along the coastal plain away from the bay (East). The East and West cross sections were used to map the groundwater quality in the coastal southern California aquifer system.

Additionally, the multiple-depth monitoring-well sites have been equipped with real-time, water-level recording equipment and the data is available via the project website. (For more information see—http://ca.water.usgs.gov/sandiego)



Significant Findings

1. **Sodium and chloride concentrations are quite high in many samples, showing poor water quality and potentially hiding other trends in the groundwater chemistry. Some of the Stiff diagrams have similar shapes to that of seawater; however, the SDNB wells suggest more than just seawater intrusion is affecting the ion concentration.**

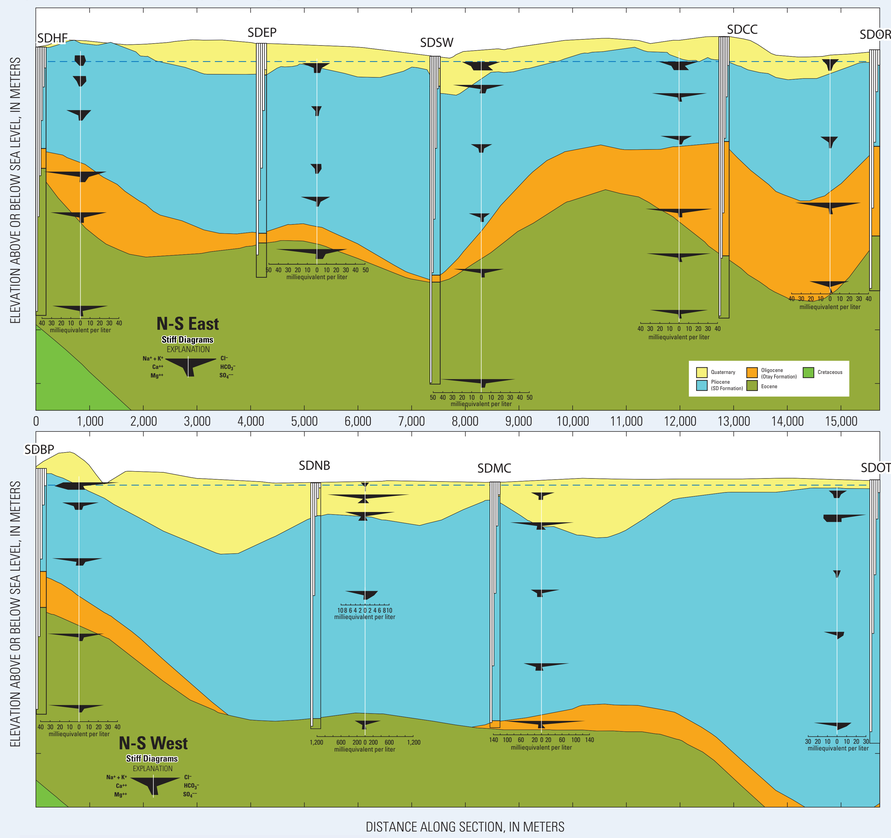
2. **The stable isotopes of hydrogen and oxygen indicate the groundwater in the Sweetwater and Otay River basins likely originates in the fractured crystalline rock more than 20 km east and upgradient from the coastline.**

3. **The $^{87}Sr/^{86}Sr$ ratios in the shallow part of the aquifer system reflect the isotopic composition of Sr in the rocks and minerals that are present. In contrast, $^{87}Sr/^{86}Sr$ ratios approach the value of seawater at about the time of deposition of the geologic formation in the deeper part of the aquifer system.**

4. **The age of groundwater in the coastal aquifer system generally correlates with depth. Water in the Quaternary layer appears to be less than 10,000 years old; water in the San Diego formation is generally less than 20,000 years old; and water in the lower formations (Otay and the Eocene layer) is between 25,000 and 45,000 years old.**

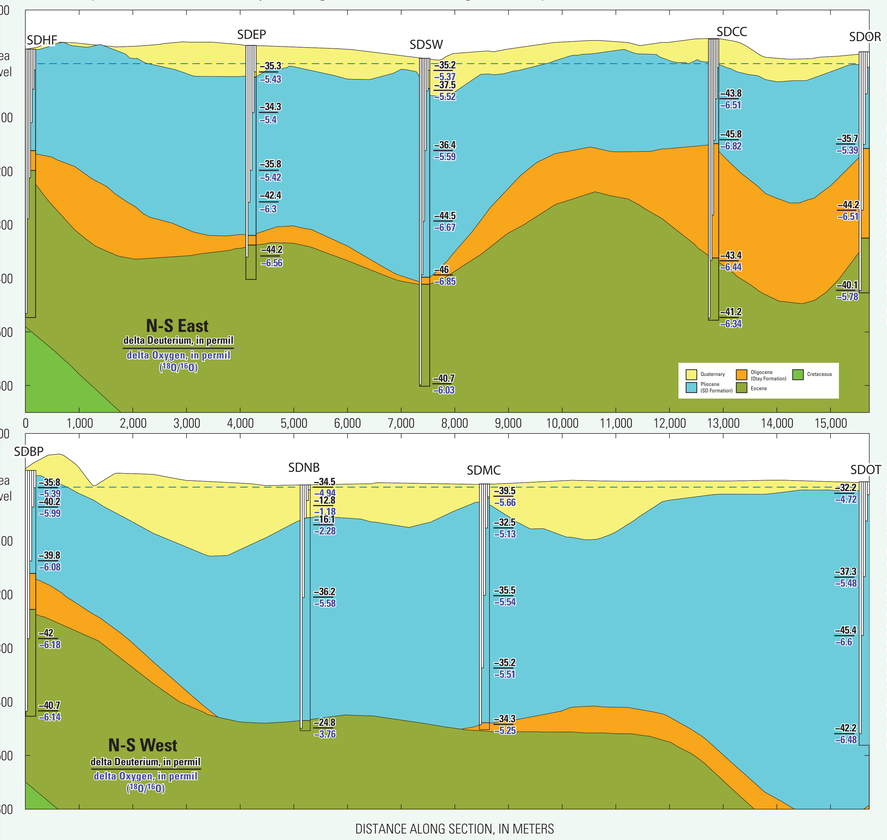
Major-ion Chemistry

Major-ion composition of groundwater samples collected from 9 multiple-depth monitoring-well sites located in coastal San Diego are presented here using Stiff diagrams. As seen in both the West and East cross sections, much of the groundwater in the coastal southern California aquifer system is of poor quality, having high sodium and chloride concentrations. SDMC and SDNB have particularly poor quality water, requiring scale increases of 50% and 200%, respectively, in order to depict the high concentrations of sodium and chloride at these sites.



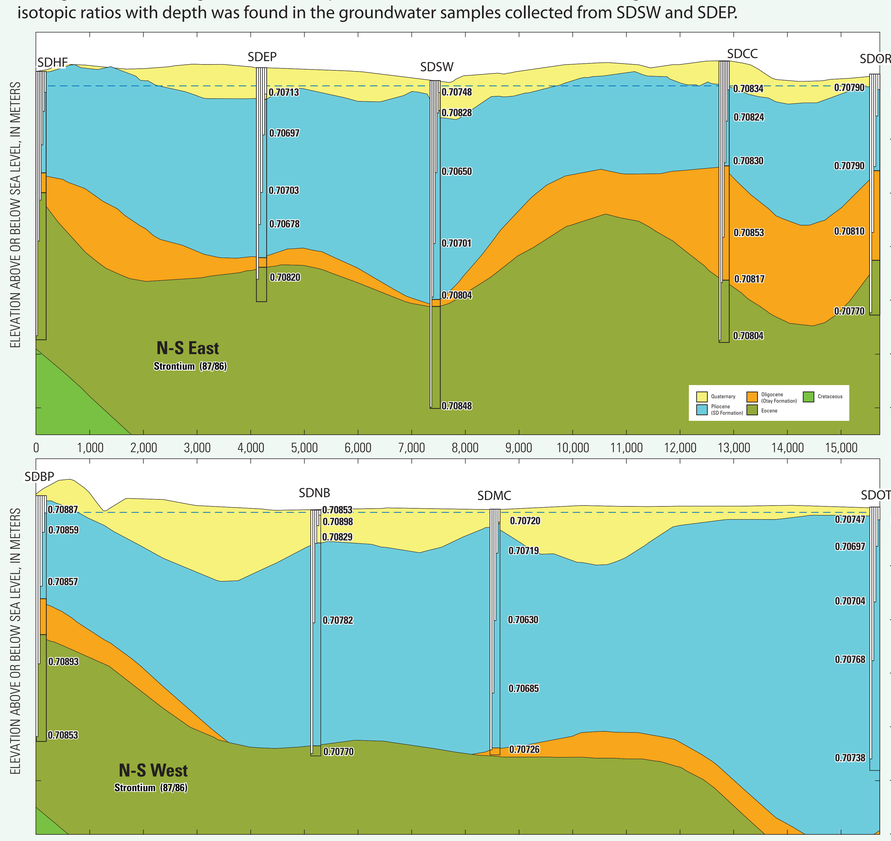
Stable Isotopes of H and O

The stable isotopes of hydrogen and oxygen can be used to identify the different sources of recharge throughout the region. The lighter isotopic values are characteristic of recharge from the mountains in eastern San Diego County, while the heavier isotopic values are characteristic of local precipitation as the source of recharge. The different sources of recharge are distinguishable in general terms, with more locally recharged water being found at shallower depths and more distantly recharged water found at greater depths.



$^{87}Sr/^{86}Sr$ Isotopic Ratios

Strontium isotopes are useful in detecting mixing among waters of different sources and histories, as well as in characterizing the effects of water-rock interaction. The $^{87}Sr/^{86}Sr$ isotopic ratios for coastal San Diego groundwater ranged from about 0.7060 to 0.7090, with the lowest values from groundwater samples collected from SDMC and the highest values from groundwater samples collected from SDNB and SDBP. The greatest variation of $^{87}Sr/^{86}Sr$ isotopic ratios with depth was found in the groundwater samples collected from SDSW and SDEP.



Uncorrected Groundwater Age

Carbon-14 was used to derive the uncorrected groundwater ages from calculations using the percent modern carbon measured in the various samples. The cross sections show a general trend which depicts groundwater in the Quaternary layer as less than 10,000 years before present, water in the San Diego Formation as generally less than 20,000 years before present, and water in the lower formations (Otay and the Eocene layer) as between 25,000 and 45,000 years before present.