U.S. Department of the Interior
U.S. Geological Survey

Source, Movement, and Age of Ground Water in a Coastal California Aquifer

This report is a summary of isotopic studies of ground-water source, movement, and age in aquifers underlying the Santa Clara-Calleguas basin, Ventura County, California. It is part of a series summarizing the results of the U.S. Geological Survey's Southern California Regional Aquifer-System Analysis (RASA) study of a southern California coastal ground-water basin. The geologic setting and hydrologic processes described in this report are similar to those in other coastal basins in southern California.

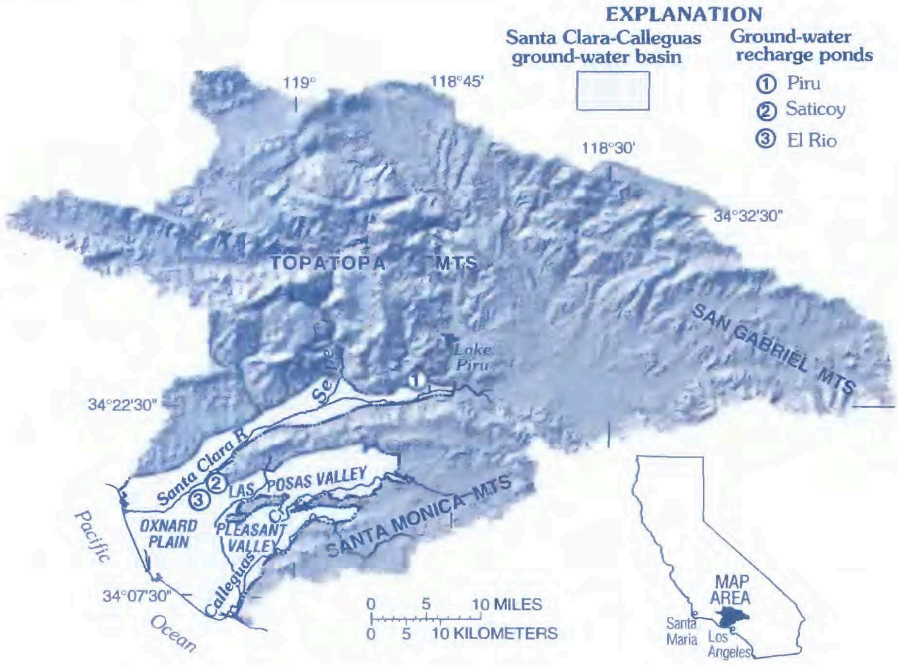

Figure 1. Santa Clara-Calleguas Hydrologic Unit.

Introduction

Understanding the contribution of recharge from different sources is important to the management of ground-water supply in coastal aquifers in California—especially where water-supply or water-quality problems have developed as a result of ground-water pumping. In areas where water levels have changed greatly as a result of pumping and no longer reflect predevelopment conditions, an analysis of isotopic data can provide information about the source, movement, and age of ground water that is not readily obtained from a more traditional analysis of ground-water data. This information can be used to develop management strategies that incorporate the availability of natural and artificial recharge to control water-level declines and water-quality degradation.

In this study, the ratios of the stable isotopes of oxygen and hydrogen were used to determine the source and trace the movement of ground water in the Santa Clara-Calleguas basin, Ventura County, California. Tritium and carbon-14 data were used to estimate the age (time since recharge) of ground water.

Hydrogeology

The 2,010-square-mile (mi^2) Santa Clara-Calleguas Hydrologic Unit, about 60 miles northwest of Los Angeles, has a Mediterranean climate characterized by warm, dry summers and cool, wet winters. Precipitation ranges from 14 inches near the coast to more than 40 inches at higher altitudes in the Topatopa and San Gabriel Mountains. Surface drainage is toward the Pacific Ocean through the Santa Clara River, which drains about 1,600 mi^2, and Calleguas Creek, which drains about 400 mi^2 (fig. 1). In most areas streamflow is intermittent and occurs only for brief periods after storms. However, streamflow is perennial in the larger tributaries to the Santa Clara River and in parts of the Santa Clara River where ground water discharges at land surface. In recent years, perennial flow has been maintained in some reaches within the Calleguas Creek drainage by the discharge of treated municipal sewage and irrigation return water.

The Santa Clara-Calleguas Hydrologic Unit includes the Santa Clara-Calleguas ground-water basin. The 310-mi^2 basin contains a complex system of aquifers that can be divided into an upper aquifer system and a lower aquifer system (see fig. 6, later in this report). The upper aquifer system consists of alluvial deposits and is generally about 400 feet thick. The lower aquifer system consists of alluvial deposits, which grade to marine deposits near the coast and with increasing depth, and is more than 1,000 feet thick in places. The deposits of the lower aquifer system are folded and faulted and crop out in some places along the flanks of the mountains and hills that surround the basin.

Previous researchers believed that natural recharge to both the upper and lower aquifer systems occurred primarily as infiltration of surface water from larger, perennial streams and that in areas where these streams are not present aquifers were readily recharged by infiltration of precipitation or infiltration of runoff in smaller, intermittent streams. Natural recharge is supplemented by diversion of surface water from Piru Creek near Piru and the Santa Clara River near Saticoy and El Rio (fig. 1). In other areas, natural recharge is supplemented (intentionally and unintentionally) by irrigation return water, discharge of treated municipal wastewater, and use of imported water.

The upper and lower aquifer systems are extensively developed for water supply. In many areas, ground-water pumping in excess of ground-water recharge has resulted in water-level declines greater than 200 feet. As a result, water supply and water-quality problems, such as seawater intrusion and brine invasion, are important concerns. Because of the large variability in seasonal and annual precipitation, runoff, and streamflow—and the geologic complexity of the aquifer system—there is uncertainty about the sources and amount of ground-water recharge, and about the movement of water within the aquifer systems.

Source and Movement of Ground Water

Oxygen-18 and deuterium are naturally occurring stable isotopes of oxygen and hydrogen. Oxygen-18 and deuterium abundances are expressed as ratios in delta notation (δ) as per mil (parts per thousand) differences relative to the standard known as Vienna Stan-