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Prepared in cooperation with the Millennium Challenge Corporation

Groundwater Resources of Ribeira Paúl Basin, Island of Santo Antão, Cape Verde, West Africa

Overview of Cape Verde baseline groundwater study

Why was the study done?

Groundwater resources in Cape Verde provide water for agriculture, industry, and human consumption. These resources are limited and susceptible to contamination. Additional groundwater resources are needed for continued agricultural development, particularly during times of drought, but increased use and (or) climatic change may have adverse effects on the quantity and quality of freshwater available. In volcanic island aquifers such as those of Cape Verde, a lens of fresh groundwater typically "floats" upon a layer of brackish water at the freshwater/saltwater boundary, and increased pumping may cause salt water intrusion or other contamination. A recent U.S. Geological Survey study (Heilweil and others, 2006, 2009) assessed baseline groundwater conditions in watersheds on three islands of Cape Verde to provide the scientific basis for sustainably developing water resources and minimizing future groundwater depletion and contamination.

Figure 1. Location of study basins within Cape Verde, West Africa.

Setting and approach

Cape Verde is an archipelago of nine inhabited islands located about 750 kilometers off the west coast of Africa (fig. 1). Three watersheds were studied for the baseline groundwater study: Ribeira Paúl Basin on Santo Antão (this fact sheet), Mosteiros Basin on Fogo (Heilweil and others, 2010a), and Ribeira Fajã Basin on São Nicolau (Heilweil and others, 2010b). Rainfall in Cape Verde varies greatly from year to year and with elevation. Average annual rainfall ranges from less than 50 millimeters along the populated coastal areas up to 1,000 millimeters in the highlands. Most of the population resides in rural areas and derives its livelihood from rain-fed agriculture; the irregular rainfall makes farming extremely challenging in all but the wettest areas (Haagsma, 1995).

Very few streams are perennial because most rainfall rapidly runs to the ocean, evaporates, or is used by plants, with the remainder infiltrating through permeable rock to recharge the underlying aquifers. The groundwater moves downgradient from the upper elevations to the lower parts of each watershed, where it discharges to wells, springs, streams, tunnels, and to the ocean as submarine discharge (fig. 2). To assess groundwater resources in each basin, data were collected at many of these discharge points. The resulting groundwater levels, flow measurements, and water chemistry analyses were used to assess groundwater budgets, recharge sources, travel times, vulnerability to contamination, and sustainability of pumping.

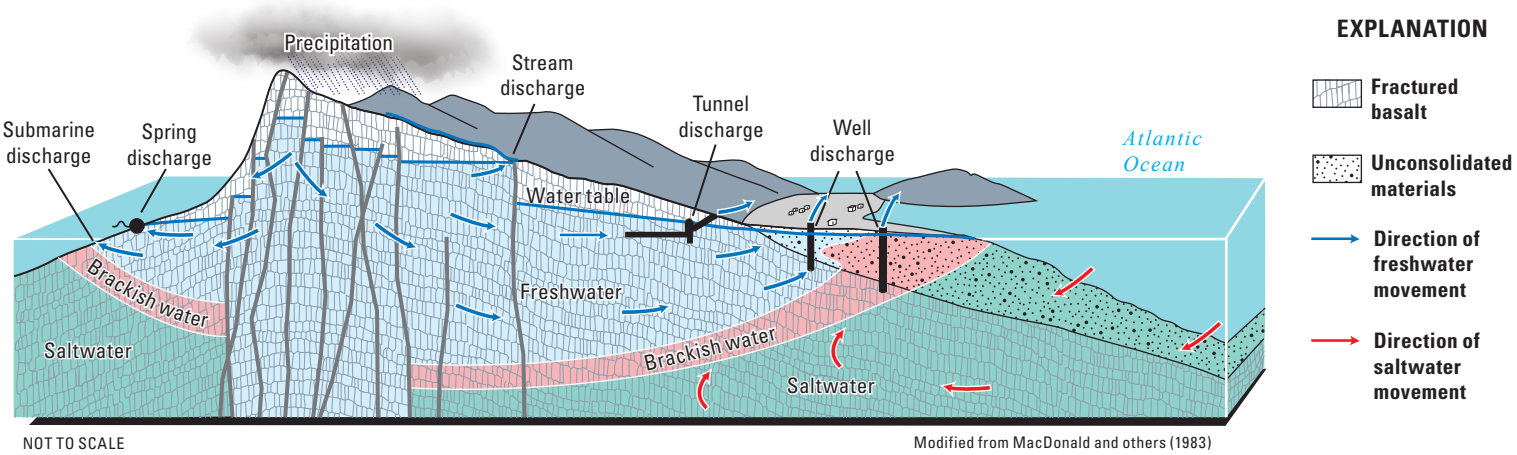


Figure 2. Generalized conceptual model of volcanic island hydrology.

Ribeira Paúl Basin, Santo Antão

Results – What was learned?

Because of its leeward location with respect to the northeastern trade winds and equatorial monsoon, Ribeira Paúl Basin (15 square kilometers) receives almost 700 millimeters of rainfall annually, more than the other two basins, despite having an average altitude of only 620 meters (lower than that for Mosteiros Basin). This plentiful rain has endowed Ribeira Paúl Basin with some of the few perennial streams in Cape Verde. Infiltration of part of this rainfall is the primary source of groundwater recharge. The basin also likely receives recharge as subsurface inflow from the upgradient La Cova, a volcanic caldera with no surface-water outlet. More than 100 springs and spring-fed streams produce about 4,000 cubic meters per day of groundwater discharge, equal to about 15 percent of the estimated rainfall in Ribeira Paúl Basin. Water-level measurements in several wells indicate the depth to the water table adjacent to the main stream in Ribeira Paúl varies from about 1 to 20 meters and fluctuates seasonally according to flow in the stream. Water levels in the upper part of the basin, away from the stream, are likely much deeper.

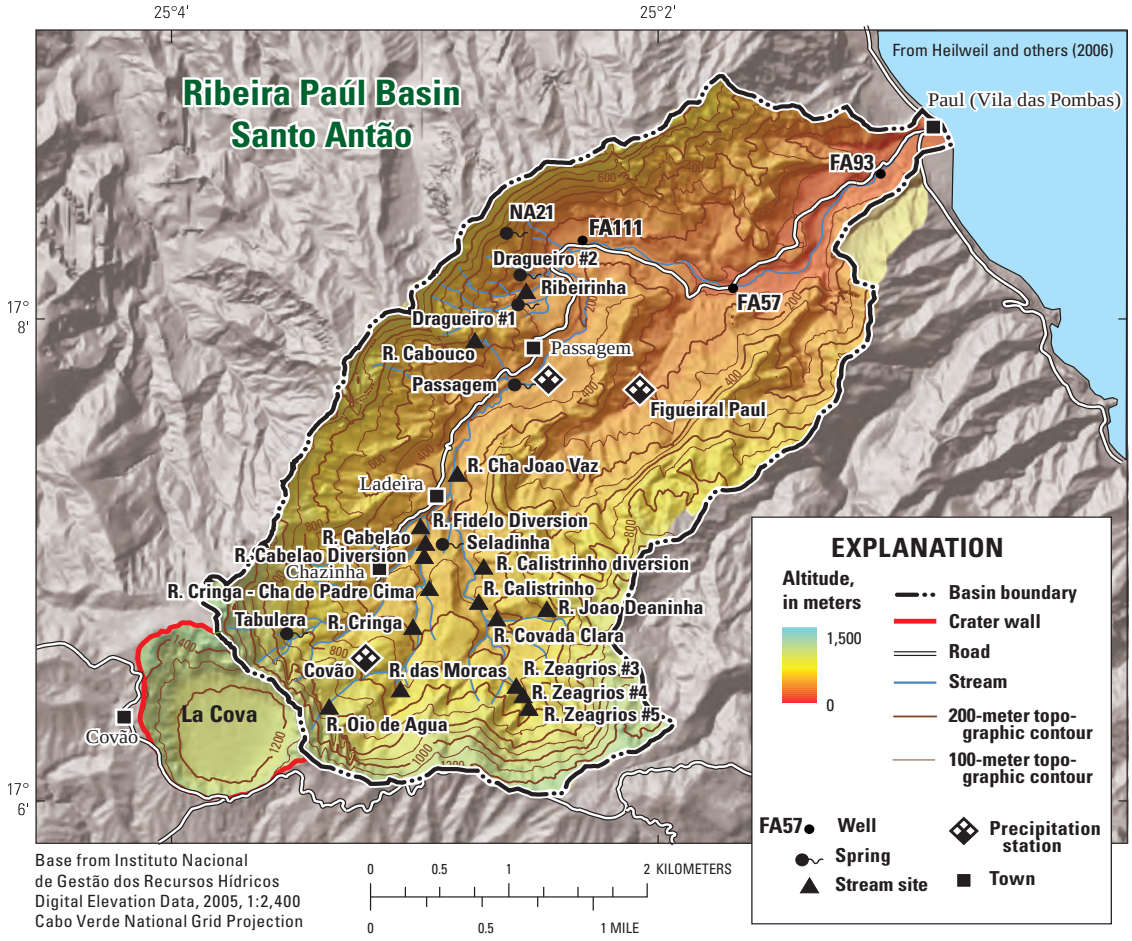


Figure 3. Hydrologic map of Ribera Paúl Basin, Island of Santo Antão.

Environmental tracers[1] indicate that groundwater throughout Ribeira Paúl Basin is generally less than 50 years old, except in some locations where it is mixed with older water. The younger groundwater in Ribeira Paúl Basin, compared with the other study basins, is consistent with its higher precipitation and recharge. The quality of groundwater within the basin is generally very good. The higher recharge rates, however, indicate the susceptibility of the aquifer to contamination from agriculture and septic systems, particularly because of the shallow depth to groundwater adjacent to the main stream, where human activity is greatest. This was confirmed by measured groundwater nitrate concentrations approaching 5 mg/L as nitrogen, in compliance with the World Health Organization drinking water standards, but indicating the presence of some nitrate contamination. Although freshwater is plentiful in this basin, additional urban and agricultural development should be carefully planned to avoid groundwater contamination.

[1] Environmental tracers used to determine age were tritium (^3H), tritiogenic helium ($^3He_{trit}$), and chlorofluorocarbons (CFCs). Unlike the other two study basins, groundwater dating using the tritium/helium method was successful and not hampered by high concentrations of helium associated with volcanism or gases derived from the mantle.

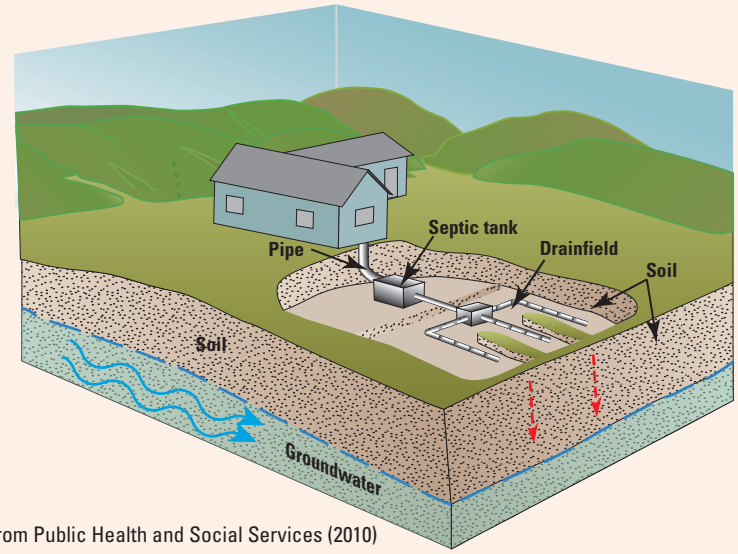
Challenges for future water-resources development and management in Ribeira Paúl Basin

- Groundwater resources in Ribeira Paúl Basin are plentiful, as indicated by the large amount of groundwater discharge to springs, streams, and wells. The quality of groundwater in the basin is generally very good, but high recharge rates and young groundwater ages indicate the susceptibility of the aquifer to surface infiltration of septic effluent and agricultural chemicals.
- Most of the villages and agriculture are located near the main stream in Ribeira Paúl. Because of its hydraulic connection with the stream, pumping from the aquifer may induce poorer-quality stream water into the ground-water system.
- Although most production wells in Ribeira Paúl Basin are away from the ocean, pumping should be monitored to protect groundwater in the lower part of the basin from saltwater intrusion.
- Because of the water-quality and water-quantity concerns in Ribeira Paúl Basin, careful stewardship and management practices will be essential for protecting water resources for future generations.

By frequently monitoring groundwater chemistry (salinity, nitrates), spring and streamflow, rainfall, pumping rates, and water-level changes, scientifically based metrics can be established to ensure sustainable future groundwater and agricultural development in Ribeira Paúl Basin.

What is groundwater contamination from surface pollution?

- Groundwater in shallow, unconfined aquifers, such as those typically found in the volcanic-rock aquifers of Cape Verde, is susceptible to contamination from surface pollution. It is particularly vulnerable in areas where human activities are within recharge zones of the aquifer. Contaminants may include septic or animal waste, agricultural nutrients and pesticides, and industrial chemicals.
- These contaminants may be flushed into the aquifer, particularly in areas that have permeable soils or fractured bedrock.



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By Victor M. Heilweil, Stephen B. Gingerich, L. Niel Plummer, and Ingrid M. Verstraeten

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Additional resources

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For more information, contact:
International Water Resources Branch
U.S. Geological Survey
12201 Sunrise Valley Drive
Reston, Virginia 20192
703-648-5230

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