Prepared in cooperation with the Puerto Rico Department of Natural and Environmental Resources

Potentiometric Surface and Hydrologic Conditions of the South Coast Aquifer, Santa Isabel Area, Puerto Rico, March–April, 2014

Pamphlet to accompany
Scientific Investigations Map 3455

U.S. Department of the Interior
U.S. Geological Survey
Potentiometric Surface and Hydrologic Conditions of the South Coast Aquifer, Santa Isabel Area, Puerto Rico, March–April, 2014

By Félix A. Ramos and Alex A. Santiago

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Acknowledgments

The authors acknowledge the generous support of the farm owners in the Santa Isabel area who allowed access to their properties during the study period. The authors also thank U.S. Geological Survey (USGS) employees José M. Rodríguez, Sigfredo Torres-González and Coralis Conty for providing technical and editorial reviews of the manuscript and map; Marilyn Santiago, Xavier Marti, and Melissa Figueroa-Santos for the map development; Yaniré Martínez for the logistic support provided to conduct the streamflow measurements; and the entire crew of hydrologic technicians involved in data collection for this study. The authors also appreciate the editorial and technical reviews of USGS employees Kim H. Haag, Sandra Kinnaman, and Scott T. Prinos, whose substantive comments and suggestions greatly improved this document.
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Available for downloading from https://doi.org/10.3133/sim3455

1. Potentiometric surface and hydrologic conditions of the South Coast aquifer, Santa Isabel area, Puerto Rico, March–April, 2014

Figure

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1. Storage capacity of irrigation ponds in the Río Descalabrado to Río Jueyes area, Santa Isabel, Puerto Rico, March to April 2014.................................................................3
Conversion Factors
Inch/Pound to International System of Units

| Multiply            | By     | To obtain                  |
|---------------------|--------|---------------------------|
| Length              |        |                           |
| inch (in.)          | 2.54   | centimeter (cm)           |
| foot (ft)           | 0.3048 | meter (m)                 |
| Area                |        |                           |
| square foot (ft²)   | 0.0929 | square meter (m²)         |
| Volume              |        |                           |
| million gallons (Mgal) | 3,785 | cubic meter (m³)         |
| Flow rate           |        |                           |
| cubic foot per second (ft³/s) | 0.02832 | cubic meter per second (m³/s) |

Datum

Vertical coordinate information is referenced to local mean sea level.
Horizontal coordinate information is referenced to the North American Datum of 1927 (NAD 27).
Altitude, as used in this report, refers to distance above the vertical datum.
**Abstract**

A potentiometric surface map of the South Coast aquifer near Santa Isabel, Puerto Rico, was created from data collected during a synoptic survey of groundwater levels at 55 wells from March 31 to April 17, 2014. Measured groundwater level values ranged from −22.8 to 185.4 feet above mean sea level. During the study period, cumulative rainfall of 0.65 inch was recorded in the study area. Measurements of instantaneous streamflow at 15 locations in streams and irrigation canals, and locations of irrigation ponds, provide additional information about the hydrologic setting. Results of the study indicate a cone of depression was present near the center and eastern parts of the Santa Isabel area of southern Puerto Rico, and a small, deeper cone of depression existed west of Santa Isabel and Rio Coamo. These cones of depression represent areas where the potentiometric surface was below mean sea level. The long-term persistence of such conditions could result in seawater intrusion and an increase in concentrations of total dissolved solids within the South Coast aquifer.

**Methods of Investigation**

A synoptic survey of groundwater levels in 55 wells and a field reconnaissance of the hydrologic conditions in the Santa Isabel area of the South Coast aquifer were conducted from March 31 to April 17, 2014. Measurements of instantaneous streamflow were made at 15 selected sites along the Río Coamo, Río Descalabrado, Río Cañas, and the Canal de Juana Diaz to constrain the potentiometric surface. Data used to generate the potentiometric surface and the potentiometric contours are available online (U.S. Geological Survey, 2018; Ramos and Santiago, 2019).

The potentiometric surface was delineated by measuring water-level altitudes in USGS observation wells in the study area and in pumping wells that were either not operating during the survey period or shut down briefly so that water-level measurements could be made. In the latter case, measurements were made after a recovery period of 30 minutes so that drawdown in the wellbore achieved a near-static-level
representation of the aquifer at the measurement point (Rodríguez and others, 2005). The water-surface altitude was referenced to the mean sea level datum from USGS 1:20,000-scale maps for Santa Isabel, Rio Descalabrado, Coamo, and Salinas quadrangles (Doyle and Smith, 2012).

The aquifer in the study area is heterogeneous, being composed of unconfined, semiconfined, and confined zones; however, well-depth and construction data are insufficient to adequately distinguish the vertical zones penetrated by the majority of wells. Thus, the potentiometric surface map is presented as a planar, two-dimensional feature, assuming hydrologic connectivity between zones of variable confinement (Prinos, 2005). The potentiometric-surface contours were delineated using water-level data, and more qualitatively informed by surface hydrologic features such as irrigation ponds, canals, drainage ditches, and saturated intermittent streams, as well as topographic settings (Rodríguez, 2013).

Hydrologic Conditions and the Estimated Potentiometric Surface

The potentiometric surface map (sheet 1) and hydrologic conditions presented herein represent dry-season conditions in the study area, which typically occur during the months of December through April (Kuniansky and others, 2004), as well as conditions during a multiyear drought. Drought conditions during 2014 were indicated by substantial rainfall deficits, relative to the 30-year moving average, starting in 2012, at multiple, long-term rainfall National Oceanic and Atmospheric Administration monitoring stations in the area overlying the South Coast aquifer (Torres-Gonzalez and Rodríguez, 2016). During March and April 2014, groundwater levels and streamflow were seasonally low, and agricultural irrigation withdrawals were assumed to be high to meet crop demands during these extremely dry conditions. The mean annual rainfall at the Santa Isabel rain gage 50106100 is 36.27 inches (in.) (National Weather Service, 2010). Two separate rainfall events (April 3 and April 9, 2014) occurred during the study period, and a total rainfall of 0.65 in. was recorded for those dates at Alomar Oeste observation well (USGS station number 175734066233300, fig. 1). Rainfall on April 3, 2014, corresponds with a 0.54-ft increase in groundwater levels at the Alomar Oeste observation well; rainfall accumulation on April 9, 2014, also corresponds with an increase in groundwater levels at this well (fig. 1).

Measured groundwater level values collected during the study period ranged from −22.8 to 185.4 feet above mean sea level. Groundwater-level data indicate that a large cone of depression was present near the center and eastern parts of the Santa Isabel area of southern Puerto Rico, and a smaller, deeper cone of depression existed west of Santa Isabel and

![Figure 1](image_url)  
**Figure 1.** Groundwater levels and rainfall at Alomar Oeste observation well (station 175734066233300), Santa Isabel, Puerto Rico, March 31 to April 17, 2014.
Rio Coamo (sheet 1). These cones of depression represent areas where the potentiometric surface was below mean sea level. Long-term persistence of groundwater levels in the South Coast aquifer below sea level could lead to saline-water intrusion and an increase in concentrations of total dissolved solids in groundwater.

The potentiometric surface that represents conditions in the aquifer during March–April 2014 can be compared to that determined from data collected in March 1987 (Rodríguez-del-Río and Gómez-Gómez, 1990). The comparison of these potentiometric surfaces indicates that groundwater levels in the aquifer were about 39 ft lower on average during March–April 2014 than during March 1987. During and prior to 1987, sugarcane was the main crop harvested in the area, and farmers used furrow irrigation techniques (Rodríguez-del-Río and Gómez-Gómez, 1990). During the early 1990s, furrow irrigation was replaced by drip irrigation, which is a more efficient irrigation method. The change to drip irrigation reduced the aquifer recharge, because most of the irrigation water applied is used by the crops or returned to the atmosphere by evapotranspiration. As a result, no appreciable amounts of water are returned to the aquifer as recharge under current irrigation methods (Kuniansky and others, 2004).

Instantaneous streamflow was measured at selected sites along the Rio Coamo, Rio Descalabrado, Rio Cañas, and the Canal de Juana Diaz and used to qualitatively constrain the potentiometric surface during the timeframe of the synoptic survey. Where streamflow was present, the potentiometric surface was assumed to intersect the streambed; where streamflow was zero, the stream was dry, and the potentiometric surface was assumed to not intersect the streambed. During the study, the Rio Coamo, Rio Descalabrado, and Rio Jueyes were flowing along their upstream reaches, north of Puerto Rico Highway 52; flow in the downstream reaches along the south coastal plain diminished southward until it was intermittent or absent. Streamflow measured in the Canal de Juana Diaz between the Rio Cañas and Rio Jueyes on March 19, 2014, ranged from 20.4 to 7.3 cubic feet per second. Streamflow in the Canal de Juana Diaz decreased substantially in the reach between the Rio Coamo, and Rio Jueyes area, most likely because of the diversion of surface water to irrigation ponds in this area.

Water diversion from the Canal de Juana Diaz replenishes 11 irrigation ponds within the study area that were in operation during the survey. These 11 irrigation ponds are used to complement and reduce continued groundwater withdrawals in the area. Irrigation ponds represent areas where recharge to the aquifer, and associated potentiometric mounding, may be occurring. This information was used to qualitatively guide placement of the potentiometric contours. The surface area of the irrigation ponds was calculated using the original engineering drawings provided by the U.S. Department of Agriculture and verified with satellite-georeferenced photographs. The corresponding areas and volumes of the irrigation ponds are summarized in Table 1.

### Table 1. Storage capacity of irrigation ponds in the Río Descalabrado to Río Jueyes area, Santa Isabel, Puerto Rico, March to April 2014.

| Pond name       | Latitude / longitude (NAD 27) | Area (ft²) | Volume (Mgal) |
|-----------------|--------------------------------|------------|---------------|
| Doble A Pond    | 175835.80 / 662343.96          | 142,148.1  | 7.21          |
| Doble B Pond    | 175837.64 / 662343.26          | 37,027.8   | 2.73          |
| Celso Pond      | 175911.44 / 662319.67          | 94,765.4   | 5.12          |
| La Guancha Pond | 175955.58 / 662247.05          | 116,336.2  | 6.26          |
| Portalatín Pond | 175836.43 / 662249.21          | 105,755.3  | 6.31          |
| La Muerta Pond  | 175900.63 / 662230.32          | 113,376.2  | 6.57          |
| Cardona Pond    | 175936.77 / 662221.37          | 115,485.9  | 6.65          |
| Sergio Pond     | 175839.86 / 662206.10          | 76,143.8   | 4.02          |
| Grande Pond     | 175940.35 / 662156.14          | 201,349.5  | 14.83         |
| Paso Seco Pond 1| 180055.17 / 662441.80          | 140,285.9  | 10.33         |
| Paso Seco Pond 2| 180102.28 / 662456.53          | 107,326.8  | 7.90          |
| **Total**       | **1,250,001**                  | **77.93**   |               |

### Summary and Conclusions

Groundwater-level data collected during the study period from March to April 2014 indicate that a large cone of depression, where the potentiometric surface was below mean sea level, existed near the center and eastern parts of the Santa Isabel area of southern Puerto Rico, and a small, deeper cone of depression existed west of Santa Isabel and Rio Coamo. The presence of groundwater levels in the South Coast aquifer below sea level for extended periods of time could lead to seawater intrusion and an increase in concentrations of total dissolved solids in groundwater.

Instantaneous streamflow measurements were made at selected sites along the Rio Coamo, Rio Descalabrado, Rio Cañas, and the Canal de Juana Diaz. The Rio Coamo, Rio Descalabrado, and Rio Jueyes were flowing along their upstream reaches north of Puerto Rico Highway 52, but flow in the downstream reaches on the south coastal plain diminished southward until it was intermittent or absent. Streamflow measured in the Canal de Juana Diaz between the Rio Cañas and Rio Jueyes ranged from 20.4 to 7.3 cubic feet per second. A substantial decrease in streamflow along the Canal de Juana Diaz occurred in the reach between the Rio Coamo and Rio Jueyes, most likely caused by the diversion of surface water to irrigation ponds in this area. These irrigation ponds are used as an alternative to continued groundwater withdrawals in the area and may provide recharge to the aquifer.
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