

Dissolved-solids in the Southwestern United States: Spatial Distribution

Preliminary results - subject to revision

By Nancy J. Bauch¹, David W. Anning², and Steven J. Gerner³

Introduction

In many areas of the Southwestern United States (Southwest), high concentrations of dissolved solids degrade a water supply's suitability for certain uses. While water naturally contains dissolved solids as a result of the weathering and dissolution of minerals in soils and geologic formations, human activities in municipal and agricultural areas also contribute to dissolved solids in water resources. In 2004, the U.S. Geological Survey (USGS) National Water-Quality Assessment (NAWQA) Program began a regional study to characterize dissolved-solids conditions in the basin-fill aquifers and major river systems of the Southwest, and to understand how natural and human factors affect the conditions. In particular, a primary objective of this study was to characterize the spatial distribution of dissolved-solids concentrations in basin-fill aquifers, and dissolved-solids concentrations, loads, and yields in major river systems of the Southwest. Important questions for this objective include:

What is the distribution of dissolved solids in basin-fill aquifers?

What percentage of area in basin-fill aquifers has dissolved solids in specifc concentration ranges?

What is the distribution of dissolved solids in major rivers systems? Do some areas have higher or lower dissolved-solids concentrations than other areas?

Approach

Dissolved-solids concentrations in ground water were compiled from previously published maps that illustrate concentrations in ground water within specified ranges: 0 to 500 milligrams per liter (mg/L), 501 to 1,000 mg/L, and so forth. Most of the maps were published in the 1980s. For areas that did not have dissolved-solids concentrations illustrated on maps, concentration ranges were manually delineated on the basis of dissolved-solids concentration and well-location data in the USGS National Water-Information System (NWIS) database.

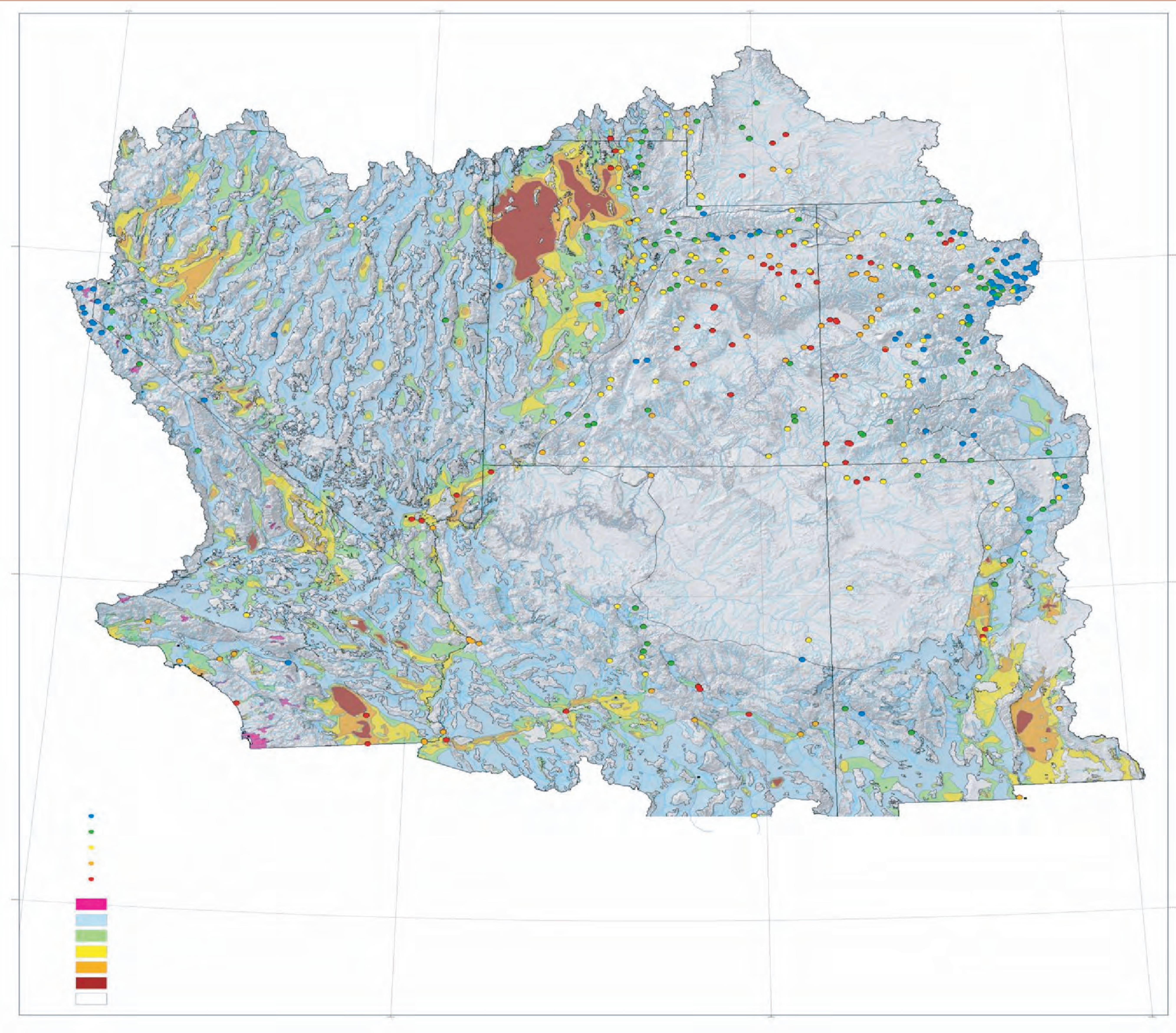
To determine dissolved-solids concentrations, loads, and yields in major river systems of the Southwest, surface-water-quality and streamflow data were compiled from the NWIS database for USGS stream-water-quality monitoring sites. Selected sites had at least 40 samples and 10 years of approximately quarterly or more frequent sample collection between water years 1974 and 2003. A total of 420 sites were included in the study. Dissolved-solids concentration and discharge data from routine sample collection were used to calibrate site-specific regression equations. For a given site, the regression equation and discharge data were used to estimate daily concentrations. Daily and annual loads were in turn estimated from daily concentrations. Summary statistics of median daily dissolved-solids concentrations, and median and annual loads and yields were used to characterize dissolved solids in the major river systems. This poster focuses on median daily dissolved-solids concentrations.

What is the distribution of dissolved solids in basin-fill aquifers?

The basin-fill aquifers pertinent to this study are the Basin and Range basin-fill aquifers (including Pacific Northwest basin-fill aquifers), Rio Grande aquifer system, and California coastal plain aquifers. ***Dissolved-solids concentrations in ground water of the basin-fill aquifers ranged from less than 500 mg/L near basin margins to more than 10,000 mg/L in topographically low areas of some basins or in areas adjacent to specific rivers in the Basin and Range and Rio Grande aquifer systems (fig. 1).*** In most basin-fill aquifers, dissolved-solids concentrations in ground water primarily were less than or equal to 1,000 mg/L. This includes central Nevada, much of Arizona except for area along the Gila and Salt Rivers, and southwestern New Mexico. Concentrations less than 1,000 mg/L are suitable most uses. The U.S. Environmental Protection Agency (USEPA) Secondary Drinking Water Regulation (SDWR) is 500 mg/L.

Dissolved-solids concentrations in ground water greater than 3,000 mg/L were found in topographically low areas with brackish or saline lakes, playas, and terminal basins (fig. 1). Most prominent are the Great Salt Lake and Desert in Utah; the Mohave Desert with its many playas, Death Valley and the Salton Sea area in California; the Black Rock Desert and Carson and Humboldt Sinks in Nevada; and the Tularosa Basin in New Mexico. Some concentrations in the Great Salt Lake and Mohave Deserts and Salton Sea area were greater than 300,000 mg/L. Other small areas in the Southwest with playas, brackish lakes and terminal basins had concentrations greater than 3,000 mg/L.

Author contact information:
¹USGS Colorado Water Science Center, Denver Federal Center, Box 26046, MS-415, Lakewood, CO 80225, njbauch@usgs.gov
²USGS Arizona Water Science Center, 2255 N. Gemini Drive, Flagstaff, AZ 86001, dwanning@usgs.gov
³USGS Utah Water Science Center, 2329 W. Orton Circle, Salt Lake City, UT 84119, sjgerner@usgs.gov



What percentage of area in basin-fill aquifers has dissolved solids in specific concentration ranges?

Basin-fill aquifer	Area of basin-fill aquifer with dissolved solids in specific concentration ranges (percent)				
	Dissolved-solids concentration range (mg/L)				
	0-500	501-1,000	1,001-3,000	3,001-10,000	> 10,000
Basin and Range	62	17	10	4	7
Rio Grande	57	14	19	9	1
California coastal plain	44	43	10	3	< 1

Table 1. Percent area of basin-fill aquifers with dissolved-solids concentrations in specific concentration ranges

Greater than one-half the area of the Basin and Range and Rio Grande basin-fill aquifers systems and almost one-half of the California coastal plain basin-fill aquifers had dissolved-solids concentrations that were less than or equal to 500 mg/L (table 1), the USEPA SDWR. Greater than 70 percent of the area of each aquifer system had concentrations that were less than or equal to 1,000 mg/L and were suitable for most uses. Only the Basin and Range had more than one percent of its area with dissolved-solids concentrations greater than 10,000 mg/L. These elevated concentrations were in areas near the Great Salt Lake and in the Great Salt Lake Desert.

What is the distribution of dissolved solids in major river systems? Do some areas have higher or lower dissolved-solids concentrations than other areas?

Dissolved solids data were available for a large part of the Southwest, but large spatial gaps in the distribution of data were present in some areas (fig. 1). Data were sparse for desert areas and closed drainages due to the small number of stream-water-quality monitoring sites. An extensive distribution of dissolved-solids data were available for headwater areas of the Colorado and San Juan Rivers in Colorado, the White-Yampa Rivers, and the lower Green River.

Median daily dissolved-solids concentrations in major river systems in the Southwest varied though-out the region (fig. 1), ranging between 22 and 13,189 mg/L. Dilute concentrations (those less than 100 mg/L) were found in the headwaters of the Colorado, Green, San Juan, Truckee, Carson, and Rio Grande Rivers. These areas are underlain by non-soluble igneous and metamorphic rocks. Concentrations typically increased in a downstream direction (fig. 2)

Slightly saline to saline median daily concentrations (those greater than or equal to 500 mg/L) were found in the Middle and Upper Colorado River basins upstream from Lees Ferry, Arizona, the Gila River in Arizona, rivers and streams in southern California, the lower Colorado-Lake Mead river basin, and the lower Rio Grande. Streams in these areas are in contact with more soluble sedimentary rocks and (or) are affected by other natural or human factors.

Median daily dissolved-solids concentrations varied in the eight physiographic provinces covered by this study (table 2). ***Concentrations were at a minimum in the Southern Rocky Mountain physiographic province and at a maximum in the Colorado Plateau physiographic province.***

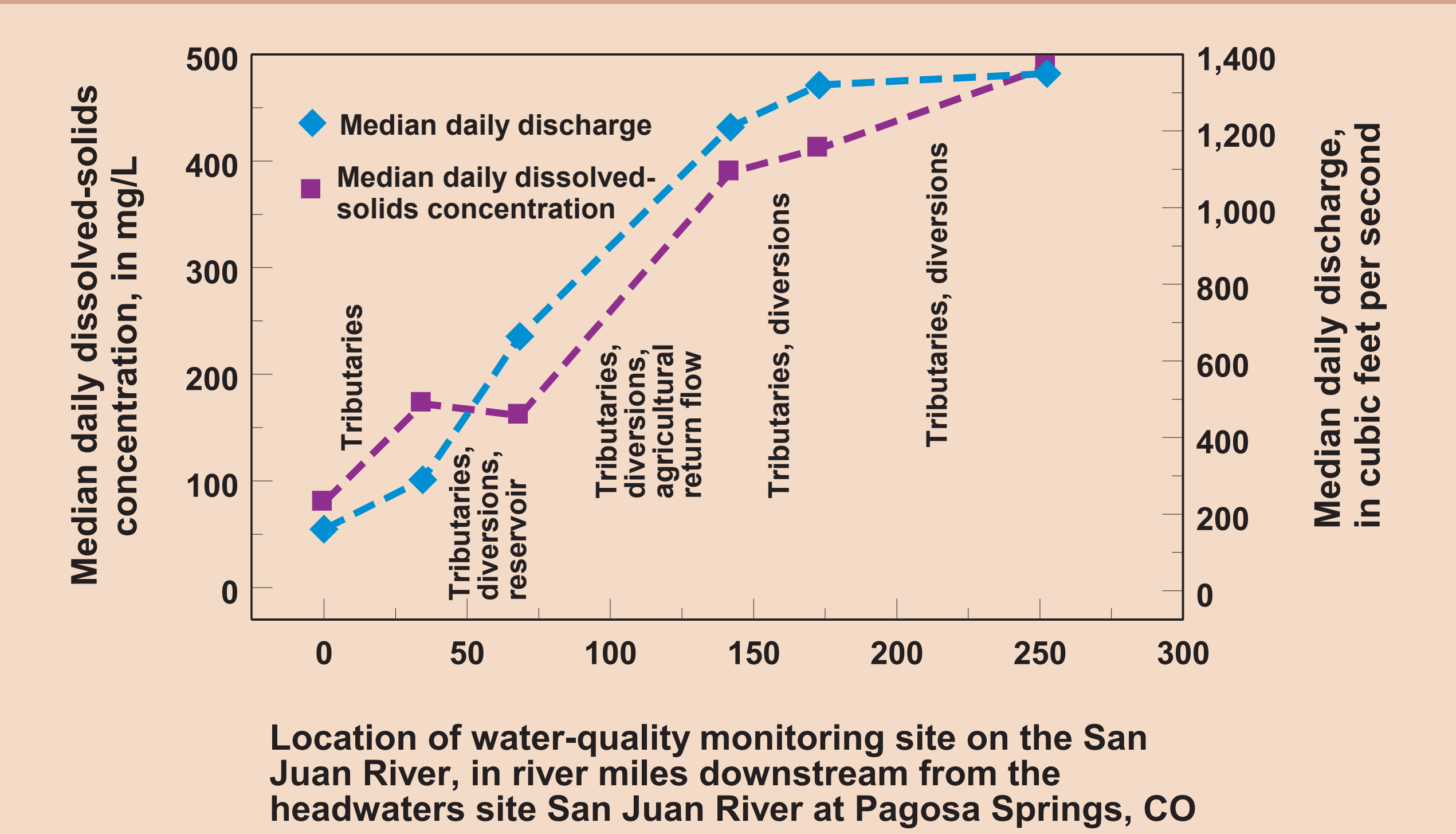


Figure 2. Median daily dissolved-solids concentrations and discharge, San Juan River mainstem sites, and factors that affect concentrations of dissolved solids in streams.

Physiographic province	Number of sites	Dissolved-solids concentration (mg/L)			
		Minimum	Median	Maximum	Standard deviation
Basin and Range	93	45	387	3,891	839
Colorado Plateau	130	39	461	13,819	1,491
Cascade-Sierra Mountains	15	25	57	142	30
Lower Californian	1	1,341	1,341	1,341	--
Middle Rocky Mountains	43	44	213	615	134
Pacific Border	5	81	580	994	328
Southern Rocky Mountains	103	22	93	612	111
Wyoming Basin	30	26	245	2,543	654

Table 2. Statistical summary of median daily dissolved-solids concentrations by physiographic province for stream-water-quality sites in the Southwestern United States