PREPARED IN COOPERATION WITH THE
COLORADO DEPARTMENT OF NATURAL RESOURCES, DIVISION OF WATER RESOURCES,
OFFICE OF THE STATE ENGINEER; THE DENVER BOARD OF WATER COMMISSIONERS;
AND ADAMS, ARAPAHOE, DOUGLAS, ELBERT, AND EL PASO COUNTIES

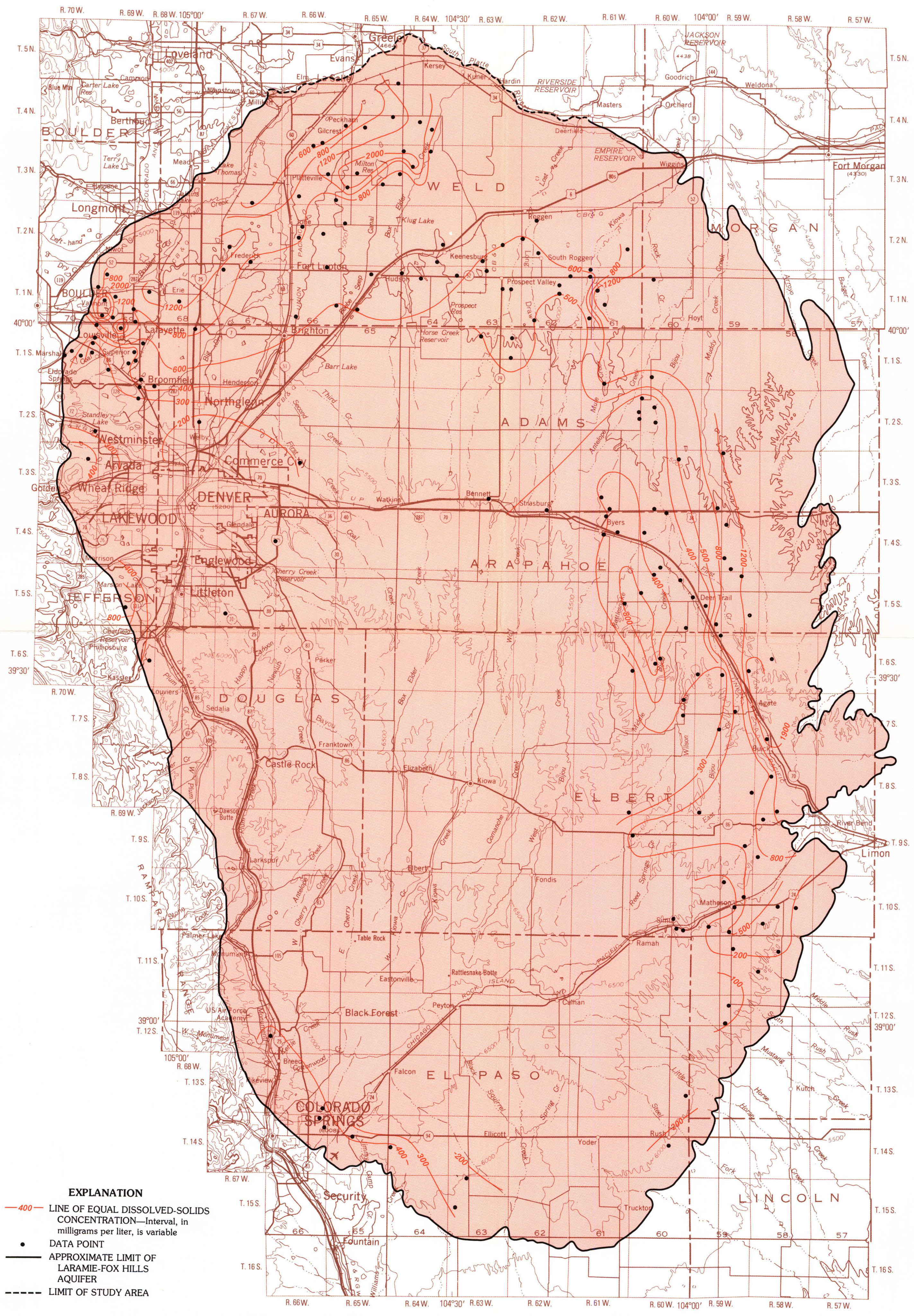


FIGURE 12.—MAP SHOWING DISSOLVED-SOLIDS CONCENTRATIONS OF WATER IN THE AQUIFER

WATER CHEMISTRY

Water in the Laramie-Fox Hills aquifer generally contains a preponderance of dissolved sodium and bicarbonate ions and is classified as a sodium bicarbonate type water. In the outcrop area along the margin of the aquifer, precipitation carries soluble minerals from the weathered soil and rock into the aquifer. This process produces the sodium sulfate type water found along the northern and eastern margins of the aquifer.

The concentration of dissolved solids in ground water is a measure of the total mineral content of the water. Dissolved-solids concentrations of water in the Laramie-Fox Hills aquifer appear to be less in the central part of the aquifer, possibly due to recharge from the overlying Arapahoe aquifer (fig. 12). The concentrations increase to more than 1,200 milligrams per liter in four areas near the northern and eastern margins of the aquifer. In each of these areas the Laramie-Fox Hills aquifer is overlain by the shaley upper part of the Laramie Formation and is beyond the extent of the Arapahoe aquifer. Considering the direction of ground-water movement, it seems that the more mineralized water in these areas is a result of soluble minerals being carried into the aquifer from surface sources or from sources within the upper part of the Laramie Formation.

Organic material present in the bedrock formations in the Denver basin alters the chemistry of the ground water by decreasing the availability of dissolved oxygen in the water. In an oxygen-deficient (reducing) environment, such as occurs in the Laramie-Fox Hills aquifer, iron, which is normally relatively insoluble, can be dissolved and transported by ground water. When this water is pumped from a well and exposed to oxygen in the air, the dissolved iron reverts to an insoluble form that is visible as a black to reddish-brown precipitate, which clouds and discolors the water and stains porcelain fixtures and laundry. Although iron is present in the water throughout the aquifer, the severity of the problem varies considerably from well to well, apparently in response to the chemical environment in the local area. Dissolved-iron concentrations generally range from 20 to 200 micrograms per liter, which is less than the limit of 300 micrograms per liter recommended for public water supplies (U.S. Environmental Protection Agency, 1977). Dissolved-iron concentrations of 42,000 and 79,000 micrograms per liter were determined in water from two wells near Colorado Springs and concentrations of about 1,000 micrograms per liter were determined in water from a few other widely scattered wells. In areas of strong reducing conditions in the aquifer, sulfate minerals and organic material may be reduced to hydrogen sulfide and methane gases. When these gases are present in significant concentrations, water pumped from the aquifer may effervesce, have a putrid odor, and be of marginal value for many uses.

Dissolved-sulfate concentrations in excess of 250 milligrams per liter occur in six areas near the northern, eastern, and southern margins of the aquifer (fig. 13). The U.S. Environmental Protection Agency (1976, 1977) and the Colorado Department of Health (1978) recommend that dissolved-sulfate concentrations not exceed 250 milligrams per liter in public water supplies in part because of the laxative effect this compound can have on people unaccustomed to drinking the water. Dissolved-sulfate concentrations ranged from less than 2 milligrams per liter south of Denver to more than 1,200 milligrams per liter near Fredrick.

Hardness also may affect the acceptability of water for domestic use. Hard water is objectionable because it leaves scaly deposits on the inside of pipes, steam boilers, and hot water heaters, requires more soap to make a good lather, and roughens washed clothes and hands. The U.S. Geological Survey classifies hardness in terms of calcium carbonate, as shown on the explanation of the map of ground-water hardness (fig. 14). Soft water occurs in the central part of the aquifer with hard to very hard water occurring in a few areas near the northern, eastern, and southern margins of the aquifer.

If specific water-quality information is required at a particular well site, it commonly is necessary to make a chemical analysis of a water sample. Because this can be time consuming and costly, it is helpful to be able to estimate the concentrations of some dissolved constituents from the value of one easily measured constituent. Chemical analyses of water samples from about 40 wells indicate that reasonable estimates of dissolved-solids, alkalinity, bicarbonate, chloride, fluoride, potassium, sodium, and sulfate concentrations can be made when the specific conductance of the water sample is measured. These relations are shown in the adjacent graphs (fig. 15). The graph showing the specific conductance versus dissolved-solids relation applies to all water types in the Laramie-Fox Hills aquifer, while the two remaining graphs apply only to sulfate type water or bicarbonate type water as indicated. Sulfate type water generally occurs in those areas where the water contains more than 250 milligrams per liter of dissolved sulfate, as shown on the map of sulfate concentrations (fig. 13). In areas where the water contains less than 250 milligrams per liter of dissolved sulfate, the water generally is a bicarbonate type.

As an example of how these graphs can be used, water from a well completed in the Laramie-Fox Hills aquifer at Keenesburg would have a dissolved-solids concentration of about 650 milligrams per liter and would be of a bicarbonate type, as is shown on the maps of dissolved-solids and sulfate concentrations. Using the graph for bicarbonate type water, a vertical line drawn at 650 milligrams per liter dissolved solids indicates the water would have about 600 milligrams per liter of bicarbonate, 490 milligrams per liter of alkalinity, and 2.4 milligrams per liter of fluoride.

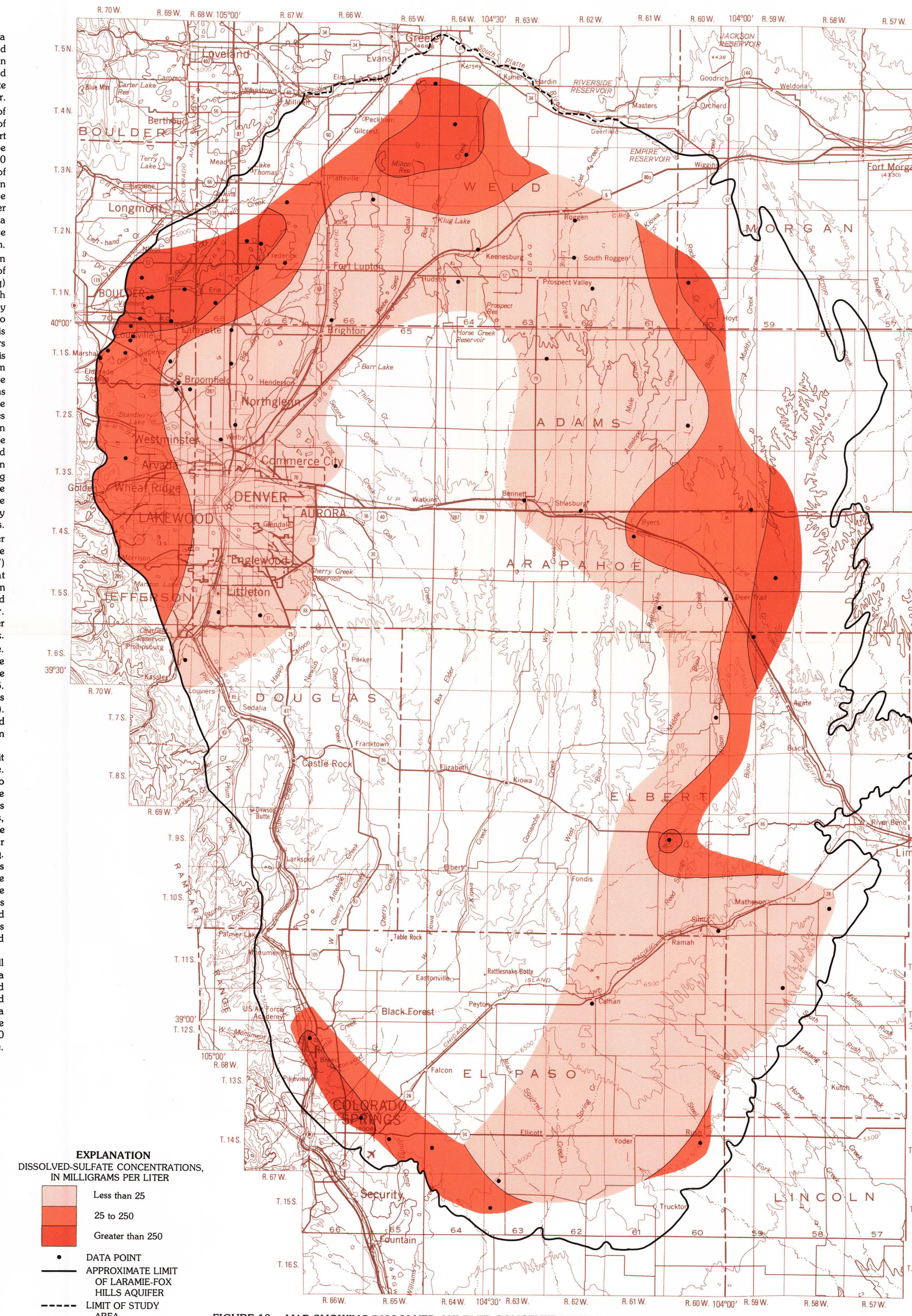


FIGURE 13.—MAP SHOWING DISSOLVED-SULFATE CONCENTRATIONS OF WATER IN THE AQUIFER

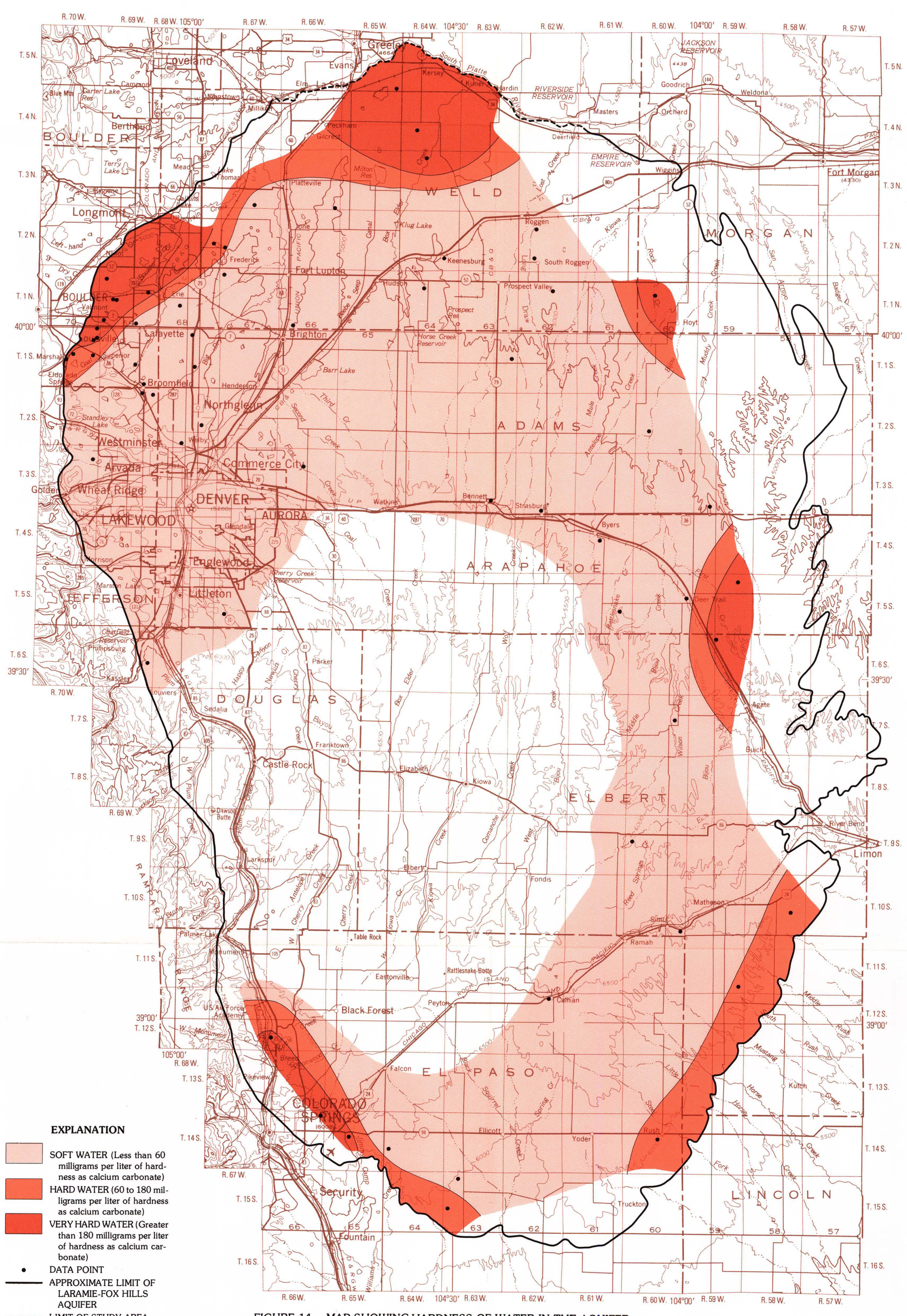


FIGURE 14.—MAP SHOWING HARDNESS OF WATER IN THE AQUIFER

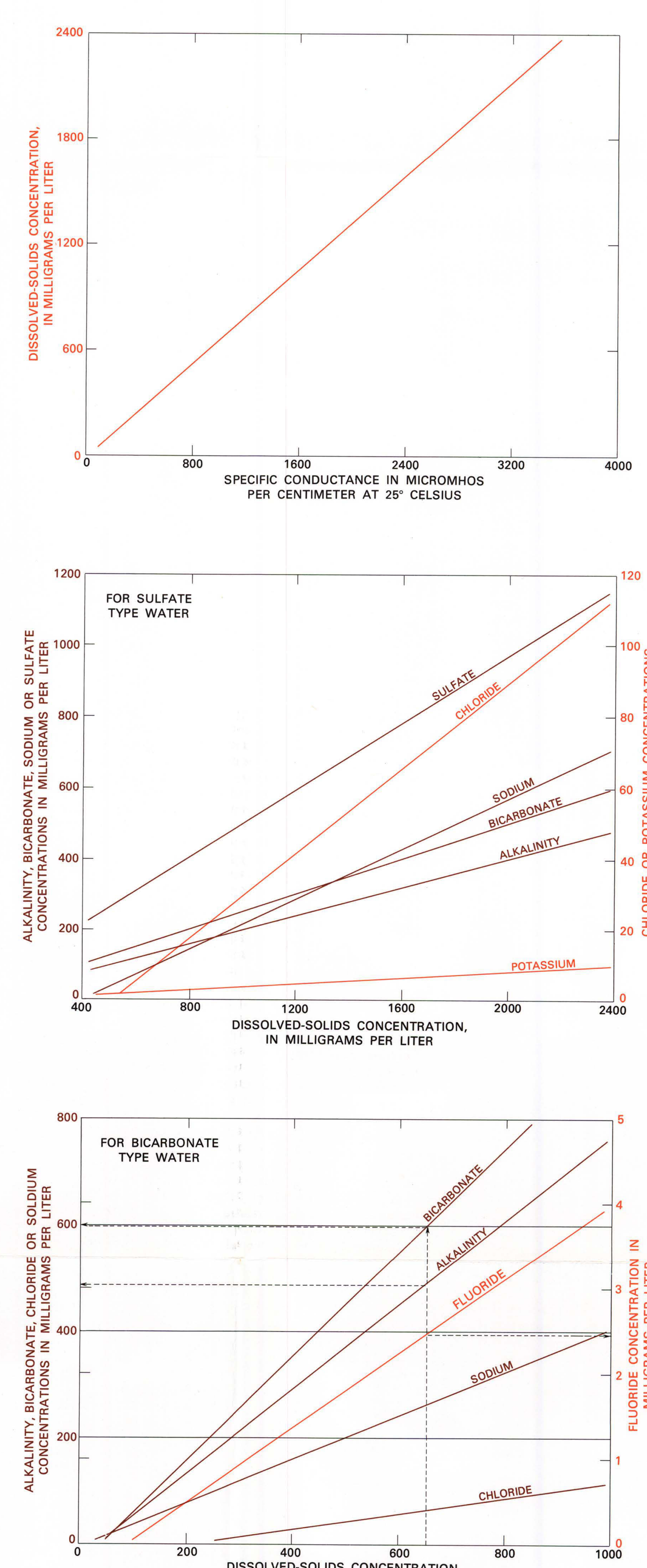


FIGURE 15.—GRAPHS SHOWING WATER-QUALITY RELATIONS

USE OF THE MAPS

The maps presented in this report are intended to provide a general understanding of the hydrologic and geologic conditions in the Laramie-Fox Hills aquifer and to provide specific information useful in developing and using the water. Those readers who may be unfamiliar with hydrologic and geologic maps may wish to consider the following examples that illustrate how the maps can be used to evaluate the water supply in different areas of the Laramie-Fox Hills aquifer. In addition to comparing areas within the same aquifer, it also is possible to use these maps with other data (Robson and Romero, 1981a, 1981b; Robson and others, 1981) to compare the water-supply potential in different aquifers. The calculated values are referenced by letter to the corresponding letter shown on the accompanying diagram (fig. 16) and the computations are shown in table 1. Two sites are considered as examples—one at Northglenn, the other at Platteville. The land-surface elevations can be estimated from the topographic contours shown on the adjacent maps or from U.S. Geological Survey 7½-minute topographic quadrangle maps. The land-surface elevation is about 5,350 feet at Northglenn and is about 4,810 feet at Platteville.

A. The depth to the base of the aquifer is the difference between the land-surface elevation and the elevation of the base of the aquifer. The depth to the base of the Laramie-Fox Hills aquifer is 1,530 feet at Northglenn and 390 feet at Platteville. These values are in reasonable agreement with the general values shown on the map of depth to the base of the aquifer.

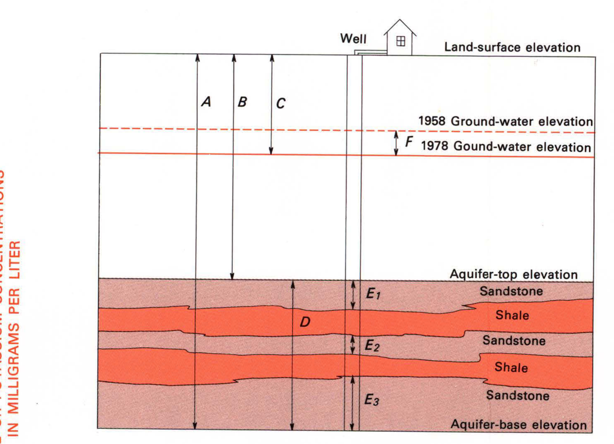
B. The depth to the top of the aquifer is calculated in one of two ways depending on the location of the site. Northglenn is not located in the partially saturated zone, so the depth to the top of the aquifer is the difference between the land-surface elevation and the elevation of the top of the aquifer. Platteville, however, is located in the partially saturated zone, so the depth to the top of the aquifer here is the difference between the land-surface elevation and the elevation of the potentiometric surface. It also should be noted that Platteville is located in an area occupied by an alluvial aquifer, so the depth to the top of the Laramie-Fox Hills aquifer is the distance from the land surface to the potentiometric surface plus the thickness of the alluvial aquifer. The depth to the top of the Laramie-Fox Hills aquifer is 1,250 feet at Northglenn and 70 to 150 feet at Platteville.

C. The depth to water in a fully penetrating well is the difference between the land-surface elevation and the elevation of the potentiometric surface. At Northglenn the 1978 depth to water was 440 feet and at Platteville it was 50 feet.

D. The aquifer thickness also is calculated in one of two ways depending on the location of the site. At Northglenn (not in the partially saturated zone) the aquifer thickness is the difference between the elevation of the top of the aquifer and the elevation of the base of the aquifer. At Platteville (in the partially saturated zone) the thickness is the difference between the elevation of the potentiometric surface and the elevation of the base of the aquifer with a 20 to 100-foot correction for the thickness of the alluvial aquifer. At Northglenn the Laramie-Fox Hills aquifer is 280 feet thick and at Platteville it is 240 to 320 feet thick.

E. The total thickness of sandstone and siltstone in the aquifer at each site is shown on the total sandstone and siltstone thickness map. At Northglenn about 170 feet of sandstone and siltstone is present and about 150 feet of sandstone and siltstone occurs at Platteville.

F. The water-level change between 1958 and 1978 is shown on the water-level change map. At Northglenn the water level in the aquifer has declined 200 feet in 20 years, while at Platteville minimal decline has occurred.



EXPLANATION
A. Depth to base of aquifer
B. Depth to top of aquifer
C. Depth to water in 1978
D. Aquifer thickness
E. Sandstone thickness, total$=E_1+E_2+E_3$
F. 1958 to 1978 water-level change

FIGURE 16.—DIAGRAM SHOWING COMPUTED QUANTITIES

The information summarized in table 1 can be used to evaluate the water supply available from the aquifer at each site. The Laramie-Fox Hills aquifer at Northglenn has a much greater depth to water and is more deeply buried than the aquifer at Platteville. The total sandstone and siltstone thickness is about the same at the two sites; however, about 200 feet of water-level decline has occurred at Northglenn between 1958 and 1978. As a result, the cost of constructing a deeper well at Northglenn will be much greater than the cost of a shallow well at Platteville. The greater depth to water at Northglenn will require more energy to lift the water to the land surface and pumping costs consequently will be greater here. The rate of water-level decline of 10 feet per year at Northglenn also will add to the future cost of pumping if water-level declines continue in this area. The water level in a well at Platteville could be drawn down only about 20 to 100 feet during pumping without reaching the top of the aquifer. At Northglenn about 810 feet of drawdown would be possible. If the aquifer has similar characteristics at the two sites, a well at Northglenn would yield more water than a well at Platteville.

Water in the Laramie-Fox Hills aquifer is of better chemical quality at Northglenn than at Platteville. Dissolved-soilds concentrations are about 300 milligrams per liter at Northglenn and 650 milligrams per liter at Platteville and sulfate concentrations are less than 25 milligrams per liter at Northglenn and 25 to 250 milligrams per liter at Platteville. Water at Northglenn is soft while that near Platteville can range from soft to hard.

Table 1.—Summary of computations (in feet)

	Northglenn	Platteville
A. Depth to base of aquifer:		
Land-surface elevation	5,350	4,810
Aquifer-base elevation	3,820	4,420
Difference	1.530	390
B. Depth to top of aquifer:		
Land-surface elevation	5,350	4,810
Potentiometric-surface elevation ...		4,760
Aquifer-top elevation	4,100	
Difference	1,250	50
Plus alluvial-aquifer thickness		20–100
		70–150
C. Depth to water:		
Land-surface elevation	5,350	4,810
Potentiometric-surface elevation ...	4,910	4,760
Difference	440	50
D. Aquifer thickness:		
Potentiometric-surface elevation ...		4,760
Aquifer-top elevation	4,100	
Aquifer-base elevation	3,820	4,420
Difference	280	340
Minus alluvial-aquifer thickness ..		20–100
		240–320
E. Sandstone and siltstone thickness read directly from map	170	150
F. Water-level change, from 1958 to 1978, read directly from map	200 (decline)	0

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Base from U.S. Geological Survey State base map, 1969

INTERIOR—GEOLOGICAL SURVEY, RESTON, VA—1981—W81146

SCALE 1:500 000
CONTOUR INTERVAL 500 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

GEOLOGIC STRUCTURE, HYDROLOGY, AND WATER QUALITY OF THE LARAMIE-FOX HILLS AQUIFER IN THE DENVER BASIN, COLORADO

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and Andrew Wacinski, Stanley Zawistowski, and John C. Romero,
Division of Water Resources, Office of the State Engineer
1981