U.S. DEPARTMENT OF THE INTERIOR
U.S. GEOLOGICAL SURVEY

Prepared in cooperation with the
COLORADO DEPARTMENT OF NATURAL RESOURCES,
DIVISION OF WATER RESOURCES, and the
COLORADO WATER CONSERVATION BOARD

HYDROLOGIC INVESTIGATIONS ATLAS HA–746C
Thickness of unconsolidated sediments—SHEET 1 of 5
Robson, S.G., and others, 2000, Geohydrology of the shallow aquifers in the Fort Lupton–Gilcrest area, Colorado

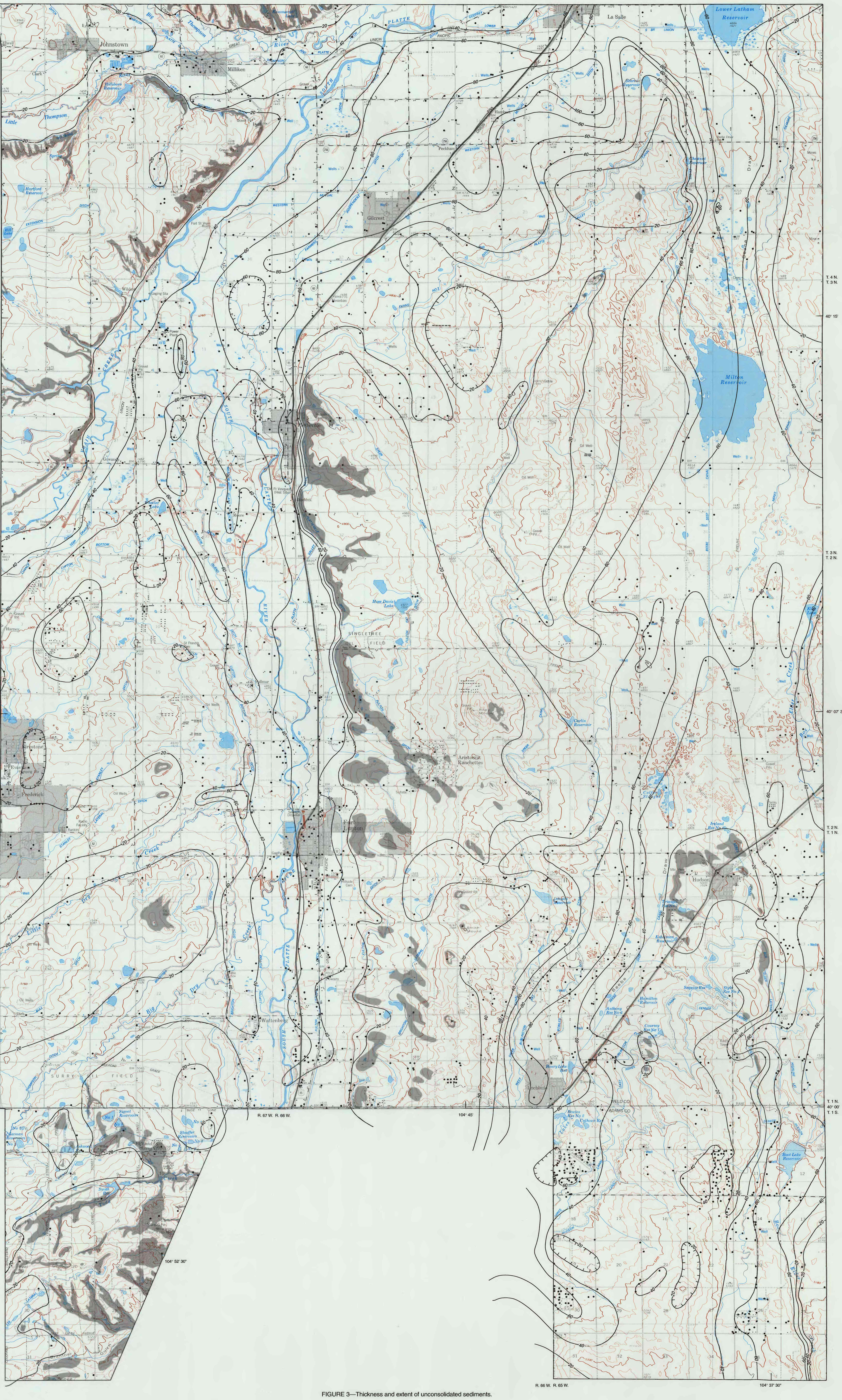

FIGURE 3—Thickness and extent of unconsolidated sediments.

EXPLANATION

Bedrock outcrop

—20— Line of equal thickness of unconsolidated sediments—Contour interval 20 feet. Hachures indicate enclosed thin interval

• Location of well or test hole with lithologic log

INTRODUCTION

Urban areas commonly rely on ground water for at least part of the municipal water supply, and as population increases, urban areas expand and require larger volumes of water. However, the expansion of an urban area can reduce ground-water availability. This may occur through processes of depletion (withdrawal of most of the available ground water), degradation (chemicals used in the urban area seep into the ground and contaminate the ground water), and preemption (cost or restrictions on pumping ground water from under extensively urbanized areas may be prohibitive). Thus, a vital natural resource needed to support the growth of an urban area and its infrastructure can become less available because of growth itself.

The diminished availability of natural resources caused by expansion of urban areas is not unique to water resources. For example, large volumes of aggregate (sand and gravel) are used in concrete and asphalt to build and maintain the infrastructure (buildings, roads, airports, and so forth) of an urban area. Yet, mining of aggregate commonly is preempted by urban expansion; for example, it cannot be mined from under a subdivision. Energy resources such as coal, oil, and natural gas likewise are critical to the growth and existence of an urban area but may become less available as an urban area expands and preempts mining and drilling.

In 1996, the U.S. Geological Survey began work on a national initiative designed to provide information on the availability of those natural resources (water, minerals, energy, and biota) that are critical to maintaining the Nation's infrastructure or that may become less available because of urban expansion. The initiative began with a 3-year demonstration project to develop procedures for assessing resources and methods for interpreting and publishing information in digital and traditional paper formats. The Front Range urban corridor of Colorado was chosen as the demonstration area (fig. 1), and the project was titled the Front Range Infrastructure Resources Project (FRIRP). This report and those of Robson (1996), Robson and others (1998), and Robson and others (2000a, 2000b, 2000d) are the results of FRIRP water-resources investigations; reports pertaining to geology, minerals, energy, biota, and cartography of the FRIRP are published separately. The water-resources studies of the FRIRP were undertaken in cooperation with the Colorado Department of Natural Resources, Division of Water Resources, and the Colorado Water Conservation Board.

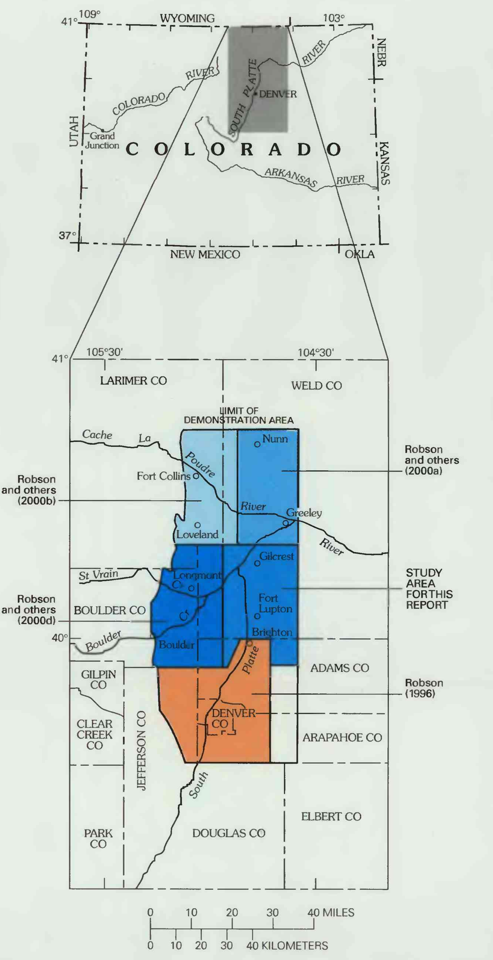

FIGURE 1—Location of demonstration area and study areas described in this and other U.S. Geological Survey reports.

The FRIRP demonstration area encompasses about 2,500 square miles and extends from the Arapahoe-Douglas County line on the south to the middle of Larimer and Weld Counties on the north, just north of the small town of Nunn (fig. 1). The western limit of the demonstration area is the approximate mountain front of the Front Range of the Rocky Mountains; the eastern limit is an arbitrary north-south line extending through a point about 4 miles east of Greeley.

This report presents the results of a systematic mapping of the extent, thickness, and water-table altitude of the shallow aquifers in the Fort Lupton-Gilcrest study area, a 490-square-mile area in the east-central part of the demonstration area (fig. 1). The shallow aquifers described in this report are present within unconsolidated sediments that form a discontinuous mantle overlying bedrock in the study area. However, where bedrock occurs at or near the land surface, the potentiometric surface of bedrock aquifers has been mapped as part of the water table of the shallow aquifers because at these locations, the bedrock aquifers generally are unconfined and have water-level conditions similar to those in the unconsolidated sediments. Figure 2 is a diagram showing the terms used to describe a shallow aquifer.

The five large maps in this report (figs. 3, 4, 7, 8, and 9) show (1) thickness and extent of the unconsolidated sediments that overlie bedrock formations in the area, (2) altitude and configuration of the bedrock surface, (3) altitude of the water table and direction of ground-water movement, (4) saturated thickness of the shallow aquifers, and (5) depth to the water table in the shallow aquifers. The maps primarily are intended to indicate the general altitude and thickness of the aquifers and are not intended to define conditions at specific sites.

The boundaries of the study area are the eastern edge of Range 65 West at Weld County Road 49 on the east, the southern edge of Township 1 South at 120th Avenue in Adams County on the south, the western edge of Range 67 West at Colorado Boulevard and Weld County Road 13 on the west, and the northern edge of Township 4 North at Weld County Road 50 on the north (fig. 3). The "notch" in the southern boundary near Brighton corresponds to the area mapped by Robson (1996). Most of the study area is rural. Fort Lupton and Platteville are the largest towns in the area and have about 1 square mile of urban area each. Several smaller towns have less than 1 square mile of urban area.

The southern boundary of this study area coincides with the northern boundary of the study area shown in Robson (1996) (fig. 1). Some of the shallow-aquifer mapping along the northern margin of the area mapped in Robson (1996) has been reexamined and revised as the result of the newer mapping to the north. The revised contours are shown in figures 3 and 7 as extensions beyond the southern boundary of the Fort Lupton-Gilcrest study area. These revisions have been incorporated into the coverages available through the project website.

Data used in this study consist of water-level measurements in wells and lithologic logs of wells and test holes. These data were obtained from records of wells and test holes constructed between about 1945 and 1997. Principal sources of data include the Colorado Division of Water Resources, the U.S. Geological Survey, the Colorado Department of Labor and Employment, the Colorado Geological Survey, and the Colorado Department of Transportation. Several other governmental agencies and private companies also provided data. Principal sources of lithologic data in published literature include Barb (1946), Colton and Fitch (1974), Gaggiani (1995), McConaghy and others (1964), Schneider (1962, 1983), and Trimble and Fitch (1974). Principal sources of water-level data in published literature include Brookman (1971), Code (1958); Gaggiani (1995); Hillier and others (1979); Hurr and Luckey (1972, 1973); Johncox and Gaggiani (1991); Major and others (1975); McConaghy and others (1964); Meinzer (1937); Meinzer and Wenzel (1936, 1938, 1939, 1940, 1941, 1942, 1944, 1946); Roberts (1995); Sayre (1947); Schneider (1962, 1983); Schneider and Hillier (1978); Trimble and Fitch (1974); U.S. Geological Survey (issued annually); and Wilson (1965). About 2,600 data points were compiled for use in mapping the geohydrology of the shallow aquifers in this study area.

Geospatial data consisting of ArcInfo[1] coverages of the geohydrologic contours and linework shown in figures 3, 4, 7, 8, and 9 of this report are available from the U.S. Geological Survey Colorado District Office and from the Front Range Infrastructure Resources Project website at http://rockyweb.cr.usgs.gov/frontrange. ArcInfo procedures used in preparing the maps are defined in the website metadata for each coverage. Digital data for well and test-hole locations and depths to bedrock and the water table also are available on the website.

This work could not have been completed without the cooperation and assistance of numerous individuals in governmental agencies and businesses who allowed access to their well and lithologic log information and geotechnical data bases. In addition, Sharon A. Rafferty and Stephen J. Char assisted with much of the digital map preparation. Thomas D. McCarthy and Gregory S. Danziger collected and compiled well data. Alene J. Brogan, Sharon P. Clendening, Alan M. Duran, Mary A. Kidd, Joy K. Monson, and Robert J. Olmstead aided in cartographic production, text editing, and manuscript preparation.

[1]The use of trade, product, industry, or firm names is for descriptive purposes only and does not imply endorsement by the U.S. Government.

MAP ACCURACY AND RESOLUTION

The geohydrologic mapping for this report was produced from three sets of initial data: (1) thickness of unconsolidated sediments measured from lithologic logs, (2) altitude of the water table in wells and, (3) altitude of the land surface as defined by 7.5-minute topographic quadrangles or their equivalent digital elevation models. Maps of the thickness of the unconsolidated sediments (fig. 3) and the altitude of the water table (fig. 7) were prepared at 1:24,000 scale by hand contouring data using 10- and 20-foot-interval contours. These maps were produced directly from data and herein are considered to be first-order maps with a vertical accuracy of about 10 feet. These maps were digitized for use with an ArcInfo-based geographic information system. The geographic information system was used to plot the maps at 1:50,000 scale and 20-foot contour intervals for use in figures 3 and 7. Digital elevation models and the equivalent topographic quadrangle maps with 10- or 20-foot contour intervals also are considered here to be first-order maps with vertical accuracy of 5 or 10 feet.

The map of the altitude of the bedrock surface (fig. 4) was computed by the geographic information system as the difference between the maps of the altitude of the land surface and the thickness of the unconsolidated sediments. The map of the depth to the water table (fig. 9) was computed as the difference between the maps of the altitude of the land surface and the altitude of the water table. The altitude of the bedrock surface and depth to water table maps herein are considered to be second-order maps because they are computed from two first-order maps. The second-order maps likely have vertical accuracies between 10 and 15 feet.

The map of the saturated thickness of the aquifers (fig. 8) was computed by the geographic information system as the difference between the maps of the altitude of the water table (a first-order map) and the altitude of the bedrock surface (a second-order map). The map of the saturated thickness is a third-order map because it is computed from a first- and a second-order map. The vertical accuracy of this map likely is about 20 feet.

The resolution of a map pertains to the minimum size of features that can be distinguished on the map. Geohydrologic mapping in this report has a resolution of about 0.02 square mile. Thus, the smallest geohydrologic feature that can be resolved on these maps is about 750 feet on a side.

GEOLOGY

Approximately the northwestern one-half of the study area is underlain by bedrock of Cretaceous age consisting of the Pierre Shale, Fox Hills Sandstone, and Laramie Formation. The southeastern one-half of the area is underlain by bedrock of the Arapahoe Formation of Cretaceous age and the Denver Formation of Tertiary and Cretaceous age. The Pierre Shale consists of shale and mudstone with localized beds of sandstone. The upper part of the Pierre Shale is transitional with the Fox Hills Sandstone and grades upward from predominantly shale to shale interbedded with siltstone and sandstone. The Fox Hills Sandstone consists of poorly to moderately consolidated, fine-grained sandstone interbedded with shale. The Laramie Formation consists of interbedded sandstone, mudstone, and shale with localized beds of lignite and coal. The Arapahoe and Denver Formations are composed of sandstone and mudstone with layers of conglomerate. Most of the bedrock outcrops in the area are weathered and poorly consolidated. The bedrock is extensively faulted near the town of Frederick. The Laramie-Fox Hills aquifer is a principal bedrock aquifer in eastern Colorado and primarily consists of water-yielding sandstones in the lower Laramie Formation and the Fox Hills Sandstone (Robson, 1987). The Laramie-Fox Hills aquifer directly underlies the alluvium along the South Platte valley between Platteville and Evans (north of the study area) and along the lower reaches of Saint Vrain Creek and Beebe Draw (Robson and others, 1998). In such areas, ground water may flow from alluvial to bedrock aquifers or from bedrock to alluvial aquifers depending on the relative water levels in the two aquifers.

Unconsolidated sediments overlie most of the bedrock in the study area. These sediments tend to be thinner in upland areas between stream valleys and thicker in the valleys and paleovalleys (ancient valleys) of major streams. The unconsolidated sediments are of Quaternary age and are composed of alluvium, colluvium, and eolian deposits.

The oldest alluvium (Pleistocene age) in the study area consists of the pre-Rocky Flats Alluvium, Rocky Flats Alluvium, Verdos Alluvium, and Slocum Alluvium (Colton, 1978; Trimble and Machette, 1979). This alluvium consists of poorly sorted gravel, sand, and clay containing caliche. The alluvium is present in only a few of the upland areas between stream valleys and is most prevalent in the southwestern corner of the study area. Younger alluvium (late Pleistocene age) consists of the Louviers Alluvium and Broadway Alluvium. These deposits are composed of well-stratified gravel, sand, and silt and are present on terraces along the margins of the principal stream valleys. The youngest alluvium (Holocene age) in the area consists of Piney Creek and post-Piney Creek Alluvium, which are composed of gravel, sand, silt, and clay along the valleys and flood plains of the principal streams and tributaries. This alluvium is highly variable in composition and contains organic matter. In general, all alluvium in the study area decreases in grain size with increasing distance downstream, has moderate to large hydraulic conductivity, and readily yields water to wells where it is saturated. The thickness and extent of the alluvium make it a good source of ground water.

Colluvium consists of bouldery to pebbly, sandy silt and clay primarily deposited by gravity and sheetwash on slopes. Colluvium overlies the bedrock in many areas of steep topography, particularly along the steeper flanks of stream valleys. These deposits are Pleistocene to Holocene in age and commonly are derived from nearby or underlying bedrock. Hydraulic conductivity of the colluvium is small where it consists of clay derived from weathered shale and is moderate to large where it consists of coarser sediments derived from weathered sandstone or conglomerate. Because the colluvium is limited in both thickness and areal extent, it generally is not a good source of ground water.

Eolian deposits of sand and silt cover most of the land surface outside the principal stream valleys. These deposits are Pleistocene to Holocene in age and primarily take the form of sand dunes, although loess also is common downwind from flood plains and weathered bedrock. The eolian deposits have moderate to large hydraulic conductivity and readily yield water to wells where saturated. However, because the saturated thickness of the deposits generally is small, the deposits provide only a limited supply of ground water.

The contact between bedrock and unconsolidated sediments is distinct and easily identified in lithologic logs of wells in many areas, but the contact is transitional and difficult to identify in logs in other areas. Along valleys and paleovalleys of principal streams, gravel and cobbles commonly are present at the base of the unconsolidated sediments, and the contact with the underlying shale bedrock is distinct. In other parts of the study area, however, the contact is difficult to identify because the upper part of the bedrock is weathered to form a transitional zone, the upper part of which sometimes is nearly indistinguishable from overlying unconsolidated sediments. In such cases, differences in grain size, color, consolidation, rate of drill penetration, and degree of fracturing are used to estimate the position of the contact. Because of the indistinct contact, unconsolidated weathered bedrock likely has been mapped as part of the unconsolidated sediments.

Bedrock is present at or near land surface along the margins of the principal valleys in the western and southern parts of the study area (fig. 3). The locations of the outcrops are based on geologic mapping at 1:24,000 scale in Soister (1965a, 1965b, 1965c); at 1:100,000 scale in Colton (1978) and Trimble and Machette (1979); and at 1:250,000 scale in Braddock and Cole (1978). The previously published shapes of a few outcrops were modified on the basis of new information from lithologic logs of wells and test holes in or near the outcrops.

Thickness and Extent of Unconsolidated Sediments

Thickness data from lithologic logs of wells and test holes and the zero thickness associated with mapped bedrock outcrops were used to define the thickness of the unconsolidated sediments in the study area. The map of the thickness and extent of the unconsolidated sediments (fig. 3) was prepared by a combination of hand contouring and plotting using the geographic information system. Hand contouring was used to better interpret the varied and inconsistent data values that sometimes resulted from local irregularities in the bedrock surface, the imprecise bedrock contact, mislocated data points, or conflicting data. Thickness contours generally were drawn using the preponderance of data in a local area and do not necessarily agree with each individual data value. Small topographic features and large earthen structures such as dams, gravel pits, and highway embankments generally were disregarded when constructing the contours. Ancient stream channels (paleochannels) and larger ancient stream valleys (paleovalleys) are common features of the area. The general thickness and extent of the unconsolidated sediments in the study area are shown in figure 3.

Unconsolidated sediments range in thickness from zero at bedrock outcrops in upland areas to about 100 feet in the South Platte River valley near Gilcrest. The present location of the South Platte River generally does not correspond to the thickest part of the alluvial valley because the ancestral South Platte River has migrated across the valley bottom and cut paleochannels in the underlying bedrock at various locations. For example, a paleochannel trending northeast-southwest through Gilcrest has 80 to 100 feet of sediment, whereas 2 to 3 miles northwest, at the present location of the South Platte River, sediments are 20 to 40 feet thick. At one time, the river probably flowed northeast through the Gilcrest area, but it has subsequently abandoned that channel and migrated to the northwest where the river now is eroding the bedrock margin of the valley and has created the steep valley-margin topography near Wildcat Mound. Paleochannels are near the eastern and western margins of the valley between Platteville and Wattenberg. The South Platte River currently flows approximately between the two paleochannels. Sediment thickness in the eastern paleochannel ranges from 40 to 60 feet; thickness in the western paleochannel ranges from 40 to 80 feet.

Sediment thickness generally is 20–40 feet in the valleys of Big and Little Dry Creeks, Saint Vrain Creek, and the Big and Little Thompson Rivers. As much as 60 to 70 feet of sediment is present in the Box Elder Creek valley in the southeastern part of the study area. Unconsolidated sediments are 70 to 90 feet thick in the trend of the South Platte River paleovalley along Beebe Draw in the northern part of the study area.

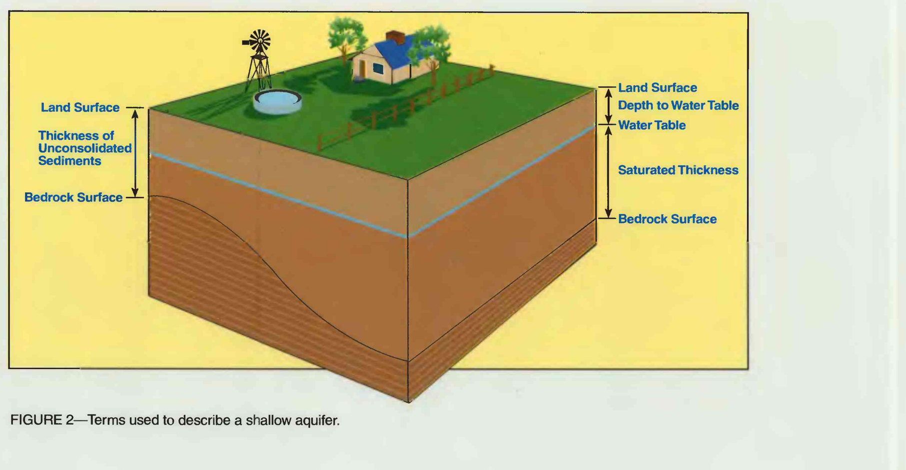

FIGURE 2—Terms used to describe a shallow aquifer.

Base from U.S. Geological Survey
1:50,000 Adams and Weld Counties

SCALE 1:50,000

CONTOUR INTERVAL 20 FEET
NATIONAL GEODETIC VERTICAL DATUM OF 1929

GEOHYDROLOGY OF THE SHALLOW AQUIFERS IN THE FORT LUPTON–GILCREST AREA, COLORADO

By
S.G. Robson, J.S. Heiny, and L.R. Arnold

2000