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

Prepared in cooperation with the
UNITED STATES AIR FORCE,
ARNOLD AIR FORCE BASE

WATER-RESOURCES INVESTIGATIONS
REPORT 93-4059

INTRODUCTION

Arnold Air Force Base (AAFB) occupies about 40,000 acres in Coffee and Franklin Counties, Tennessee (fig. 1). Near the center of the base is a 4,000-acre aerospace-system testing facility for the Air Force Material Command. This facility is the Arnold Engineering Development Center (AEDC). The base is underlain by gravel and limestone aquifers, the most productive of which is the Manchester aquifer. Ground-water contamination in this aquifer in and near the base has been documented in several ground-water investigations conducted as part of the U.S. Air Force Installation Restoration Program (IRP). These investigations include those conducted by Engineering Science (1984), Battelle Columbus Division (1988), Oak Ridge National Laboratory (1989), Post, Buckley, Schuh and Jernigan, Inc. (1989a, 1989b, 1989c), and Science Applications International Corporation (1990). Results of these investigations indicate that ground water in the Manchester aquifer has been contaminated locally by activities related to (1) aerospace-system testing at AEDC, (2) Air Force Base operations, (3) Coffee County landfill operation, and (4) historic military staging at the base.

Although the towns of Manchester and Tullahoma no longer use water from the Manchester aquifer to meet their water needs, rural wells in the area still obtain water for domestic and agricultural uses from this aquifer, and there is a need for a better understanding of the ground-water flow system within the Manchester aquifer in and near the base. To address this need, the U.S. Geological Survey, in cooperation with AAFB, is conducting an investigation of the hydrogeology of the base and surrounding area. As part of the investigation, water levels were measured in May 1991 in 92 wells completed in the Manchester aquifer. These measurements were used to map the potentiometric surface and to determine the general direction of the ground-water flow in the aquifer. This map report, which is based on those measurements, shows the altitude of the potentiometric surface of the Manchester aquifer in the area of the base and in surrounding areas extending outward to nearby major hydrologic and physiographic features important as boundaries to the regional ground-water system. These features include the Duck River, Normandy Lake, Elk River, and Woods Reservoir (fig. 2).

HYDROGEOLOGIC SETTING

The study area is located in the eastern Highland Rim physiographic province (Miller, 1974). Topography in and near the base ranges from relatively flat, poorly drained uplands to well-dissected, sloping escarpments. A broad topographic high transects the area. Surface drainage to the north and west of this terrain feature flows to the Duck River, impounded at Normandy Lake, whereas drainage to the east and south flows to the Elk River, impounded at Woods Reservoir.

The area is underlain by consolidated strata ranging in age from Ordovician to Mississippian. The principal geologic units are undifferentiated formations of Ordovician age, the Chattanooga Shale of Devonian age, and the Fort Payne Formation, Warsaw Limestone, and St. Louis Limestone, all of Mississippian age. Impure carbonate rock represents the predominant lithologic type, but shales, sandstones, and conglomerates also are present. In the AAFB area, the carbonate rock near land surface weathers to clay-rich regolith typically 10 to 90 feet thick. In stream valleys, alluvial deposits of Quaternary age overlie the consolidated rock.

The carbonate rock contains four aquifer units: the shallow aquifer, the Manchester aquifer, the Fort Payne aquifer, and the upper Central Basin aquifer system (fig. 3). The principal water-bearing unit is the Manchester aquifer (Burchett and Hollyday, 1974), in the upper Fort Payne Formation and overlying carbonate formations. Wells completed in the Manchester aquifer obtain water from cherty regolith and solution openings and fractures in rocks of the upper Fort Payne Formation. Ground-water flow in the lower part of the Manchester aquifer is largely through fractures. Recharge to the Manchester aquifer is through the shallow aquifer (fig. 3). The greatest amount of recharge is in the area of the topographic high.

POTENTIOMETRIC-SURFACE MAP

The potentiometric-surface map for the Manchester aquifer was prepared from water-level measurements made in 92 wells in the AAFB area (fig. 2). These measurements were made in May 1991 when water levels were near or slightly higher than average (fig. 2). Altitudes of the water surface in wells ranged from about 1,090 to 940 feet above sea level in May 1991. The configuration of the potentiometric surface of the Manchester aquifer based on these water-level measurements, generally follows topographic trends in the area. The altitude of the potentiometric surface is greatest near the topographic divide and least near the major drainage features. Potentiometric gradients indicate that ground water generally moves from the area of topographic highs toward the northwest, or toward the south and southeast to discharge to the principal streams and reservoirs. Water in the Manchester aquifer occurs under water-table conditions in some areas and under confined conditions in other areas. The major man-induced stress on the ground-water system at the AEDC is dewatering of the aquifers at the J4 test cell (a deep excavation in which rocket engines are tested) where a cone of depression has formed within the potentiometric surface of the Manchester aquifer (fig. 2). Approximately 160 gal/min of ground water are pumped from a collection system surrounding the J4 test cell. The wells used in dewatering are open to all four aquifers (fig. 3) at the AEDC.

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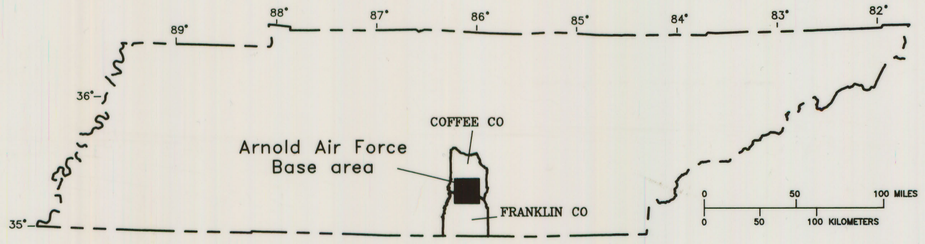
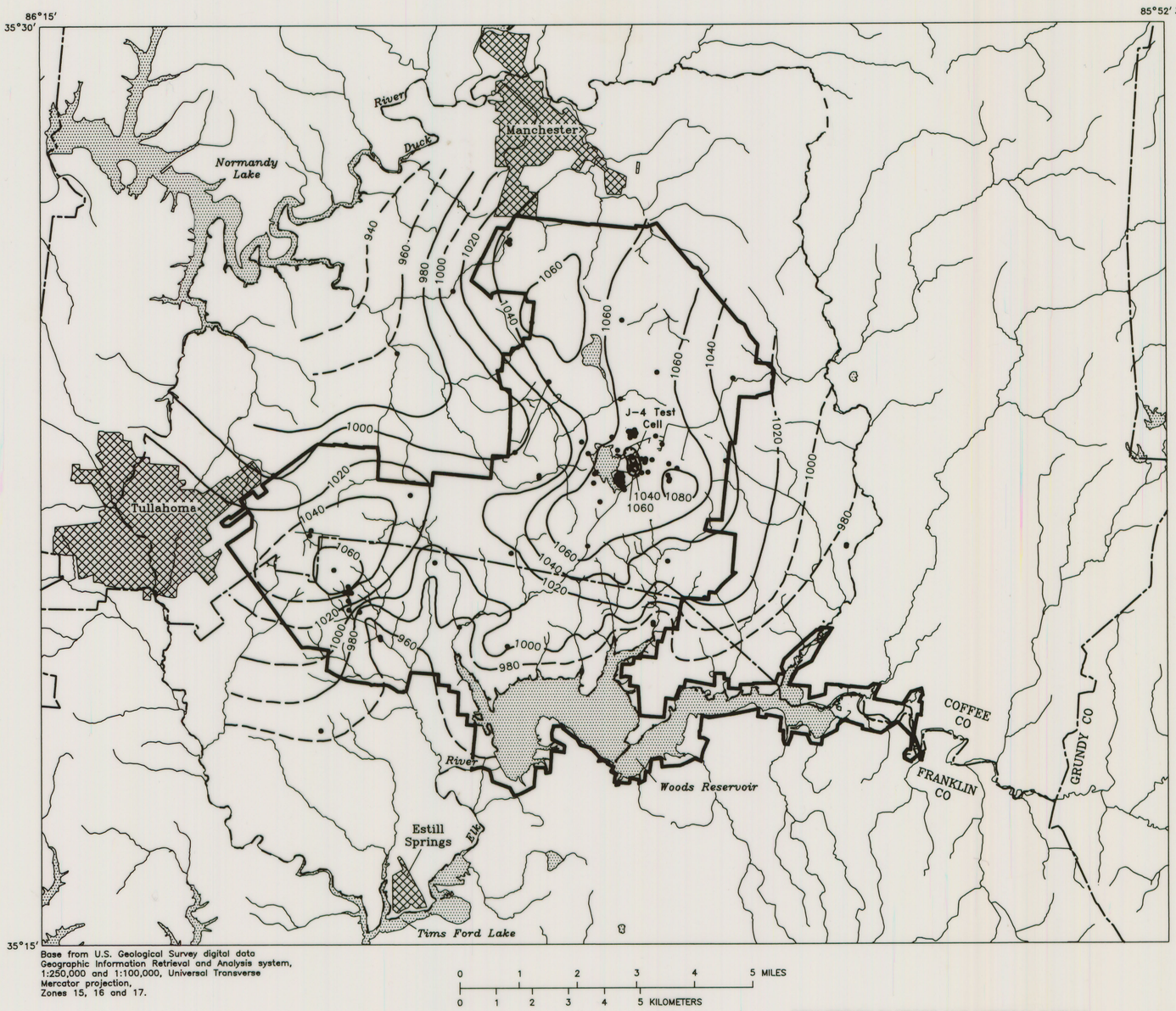


Figure 1. Map showing location of the Arnold Air Force Base area in Coffee and Franklin Counties, Tennessee.



EXPLANATION

- BOUNDARY OF ARNOLD AIR FORCE BASE
- STUDY AREA BOUNDARY
- 980 — POTENTIOMETRIC-SURFACE CONTOUR — Shows altitude at which water level would have stood in tightly cased wells. Dashed where approximately located. Contour interval 20 feet. Datum is sea level
- WELL AT WHICH WATER-LEVEL MEASUREMENT MADE IN MAY 1991 WAS USED FOR CONTROL

Figure 2. Map showing altitude of the potentiometric surface of the Manchester aquifer in the area of Arnold Air Force Base.

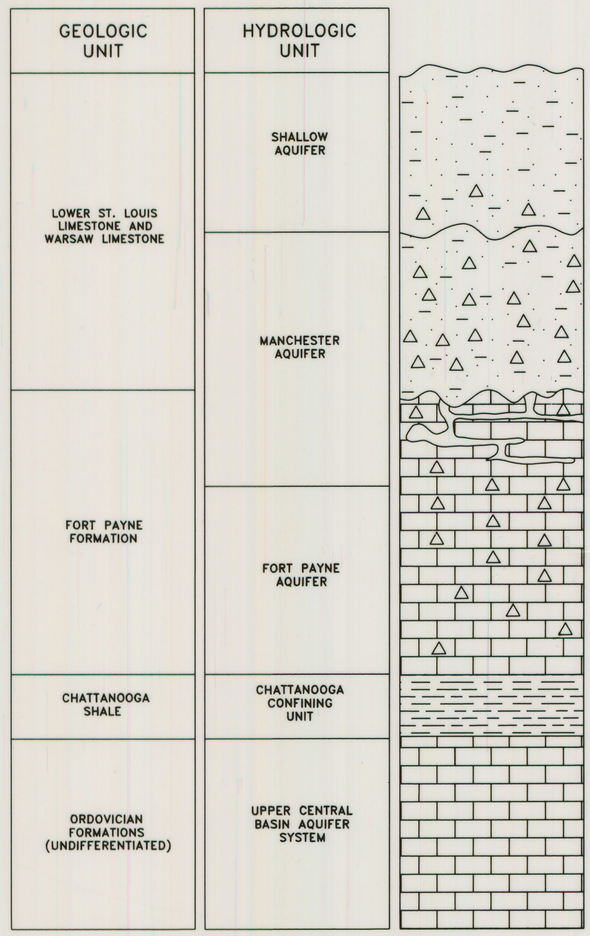


Figure 3. Diagram showing the relation between the geologic units, hydrologic units, and lithology in the area of Arnold Air Force Base.

CONVERSION FACTORS AND VERTICAL DATUM

Multiply	By	To obtain
foot (ft)	0.3048	meter
acre	4,047	square meter
acre	0.4047	hectare
gallon per minute (gal/min)	0.06309	liter per second

SEA LEVEL: In this report "sea level" refers to the National Geodetic Vertical Datum of 1929 -- a geodetic datum derived from general adjustment of the first-order level nets of the United States and Canada, formerly called Sea Level Datum of 1929.

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ALTITUDE OF THE POTENTIOMETRIC SURFACE IN THE MANCHESTER AQUIFER AT ARNOLD AIR FORCE BASE, MAY 1991, COFFEE AND FRANKLIN COUNTIES, TENNESSEE

by
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1993