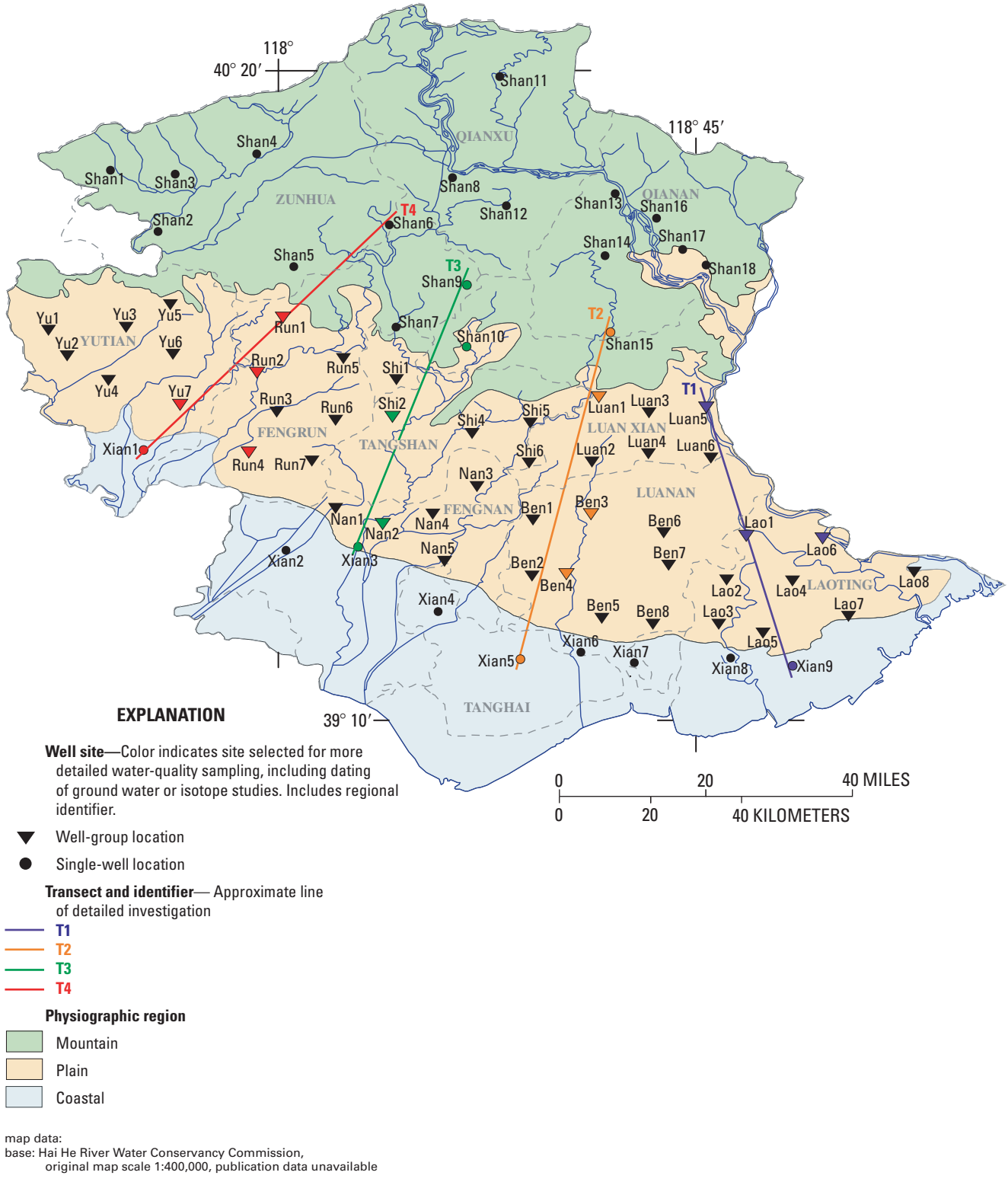
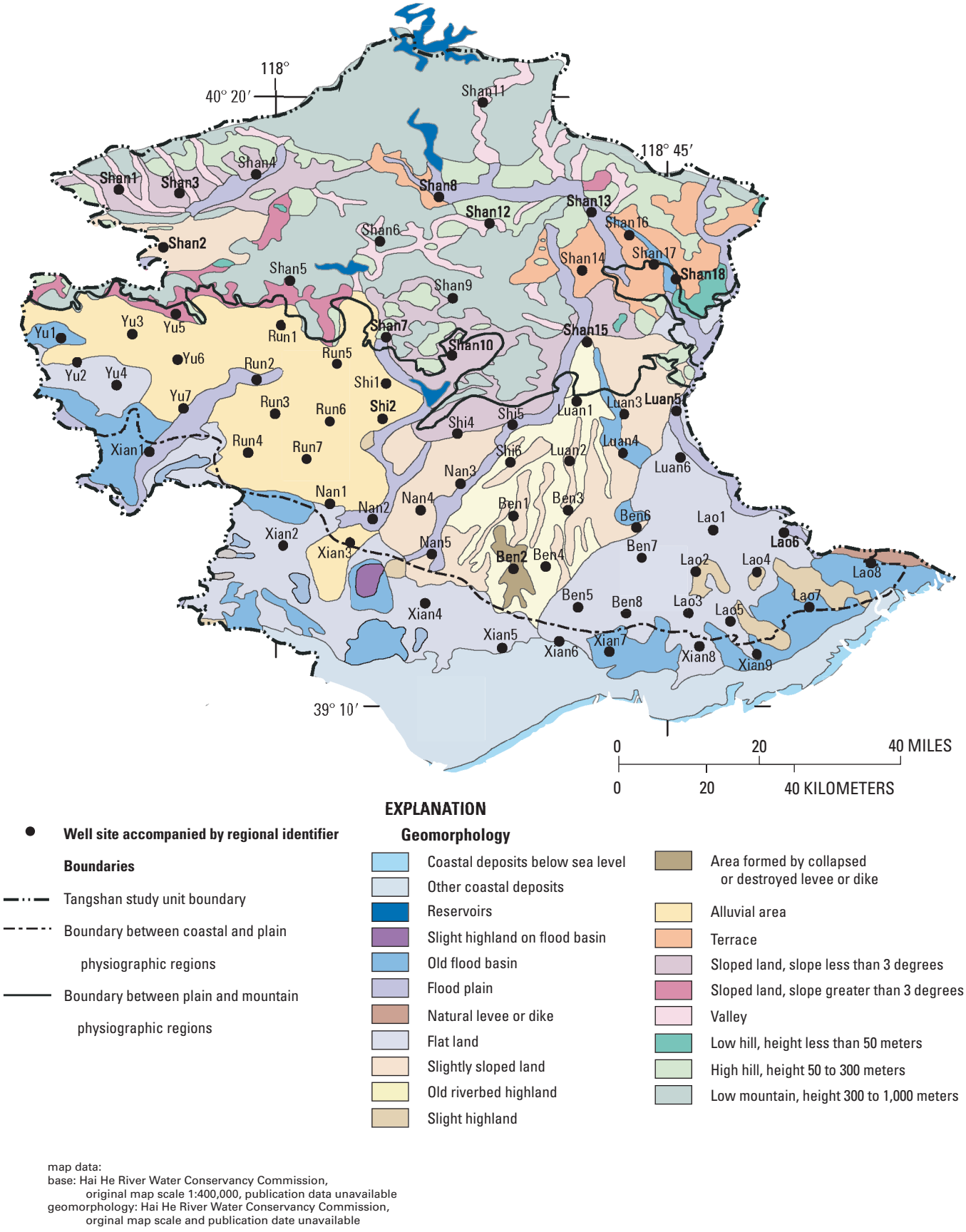


Figure 4. Tangshan study area, or "study unit," and locations of wells, transects (T1 through T4) for detailed investigations, county boundaries, and physiographic regions, People's Republic of China. A well group consists of two or more wells. Well sites show the regional identifier (Ben1, Lao1, Nan1, etc.), which corresponds to the Chinese naming convention.



map data:
base: Hai He River Water Conservancy Commission,
original map scale 1:400,000, publication data unavailable
geomorphology: Hai He River Water Conservancy Commission,
orginal map scale and publication date unavailable

Figure 5. Geomorphic regions of the Tangshan study unit, People's Republic of China. Well sites show the regional identifier (for example, Ben1, Lao1, and Nan1), which corresponds to the Chinese naming convention.

Mississippian, and Pennsylvanian Periods and tuffs of the Tertiary Period. The western parts of the study unit also include Ordovician limestone. The southern part of the study unit includes primarily coastal deposits. The surficial deposits of the plain area are composed of primarily Quaternary deposits, including gravels, sands, clayey sands, and clays.

Four aquifer systems are recognized in the Tangshan study unit, Aquifers 1–4. Aquifers 1 and 2 are shallow and have good recharge characteristics, whereas aquifers 3 and 4 are deeper and separated from the overlying aquifers by clayey sand or clay layers, although those layers are probably not continuous (Zhang, Suo Zhu, Hai He River Water Conservancy Commission, written commun., 1996). Aquifer 1 is not continually saturated under the present conditions of recharge and water use and has generally been lost as a water-producing unit. The thickness of Aquifer 1 is 20–140 m. The thickness of Aquifer 2 is 40 to 240 m. The sediments are alluvial, diluvial, or lacustrine. Aquifer 3 is about 20 to 140 m thick. The sediments are composed of alluvial, diluvial, and marine sediments. Aquifer 4 is about 10 to 20 m thick. All of the upper sedimentary material is from the Quaternary period and is composed mainly of alluvial, diluvial, or lacustrine sediments. Information on the saturated thickness of these aquifers was provided by the Hai He River Water Conservancy Commission (Lin Chao, Hai He River Water Conservancy Commission, written commun., 1998).

Delmarva Peninsula

The general environmental setting of the Delmarva Peninsula has been described in Hamilton and others (1993). The Peninsula has an oval shape that extends about 241 km north to south and about 113 km east to west at its widest point and its physiography consists mostly of the Coastal Plain with a small amount of the Piedmont upland in the north (fig. 6). The Delmarva Peninsula is a flat to gently rolling upland, which is flanked by low plains that slope toward the Chesapeake Bay, the Delaware Bay, and the Atlantic Ocean. Tidal wetlands are located close to the coastline.

A wedge of unconsolidated sediments, which thickens to the south and east, underlies the Delmarva Peninsula. The thickness of the sediment varies considerably: it is more than 2,400 m along the Atlantic Coast of Maryland, whereas no sediment is located along the boundary of the Coastal Plain and Piedmont upland physiographic regions (fig. 6). The sediments range from Cretaceous to Quaternary (Holocene) in age and are comprised primarily of sand, clay, silt, gravel, and variable amounts of shells. The wedge of sediments is underlain by Precambrian igneous and metamorphic rocks, and sedimentary rocks of the Cretaceous Period. Previous studies in Cushing and others (1973) identified a series of nine confined aquifers and associated confining units, whereas Harsh and Laczniak (1990) identified only six confined aquifers and associated confining units. In either case, the series of confined aquifers is overlain by an extensive surficial aquifer that is under unconfined conditions in most of the study unit. This surficial aquifer is the focus of the water-quality studies for this study unit because it supplies water to the confined underlying aquifers and also because it is used extensively. About one half of the 643,000 m^3 of water that is pumped daily from wells is withdrawn from the surficial aquifer.

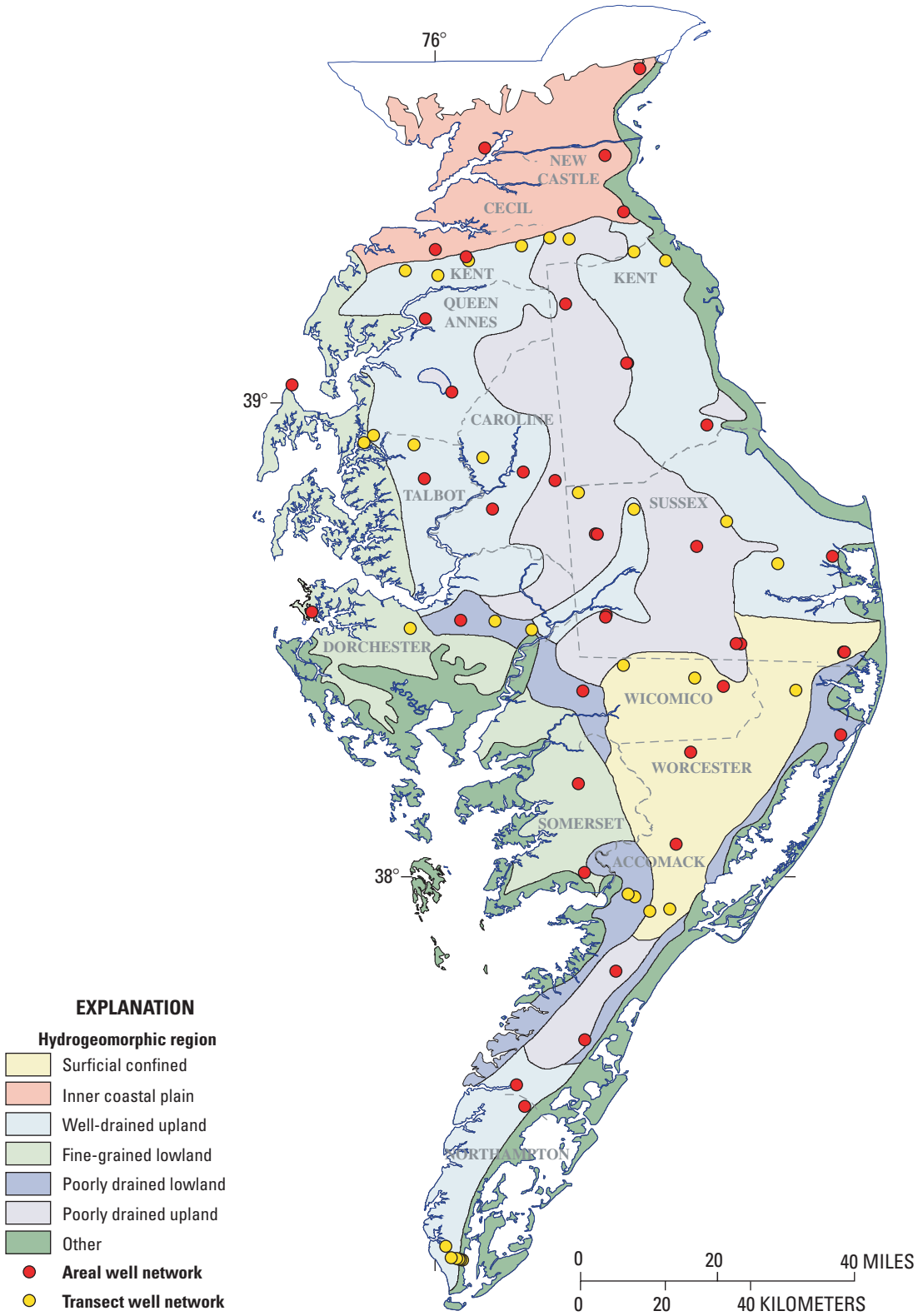
A description of the surficial aquifer of the Delmarva Peninsula has been provided in Hamilton and others (1993). Previous authors who also have reported on this aquifer include Rasmussen and others (1955), Jordan (1962, 1964), Hansen (1966), Cushing and others (1973), Owens and Denny (1978, 1979a,b), Denny and others (1979), Owens and Minard (1979), Hansen (1981), Bachman (1984), Owens and Denny (1984), Mixon (1985), and Andres (1986). Briefly, the sediments that compose the surficial aquifer represent several time-stratigraphic units, and those sediments were deposited in fluvial, estuarine, and marine and marginal marine environments. Most investigators consider the deposits to be from the Pleistocene Epoch. The mineralogy of these sediments consists of quartz sand and varying amounts of plagioclase, orthoclase, feldspars, and glauconitic sand. Minor amounts of heavy minerals are also present.

The Delmarva peninsula includes primarily one major physiographic region, the coastal plain, but comprises seven hydrogeomorphic regions within the plains (described in Hamilton and others, 1993): the poorly drained upland, the well-drained upland, the surficial confined region, the poorly drained lowland, the fine-grained lowland, the inner coastal plain, and "other" (fig. 7). Knowledge of these hydrogeomorphic regions is critical in understanding major element chemistry and contaminant transport. The surficial aquifer has been described as "under water table conditions throughout most of the study unit" (Hamilton and others, 1993, p. 8). The shallow water table is about 0–3 m below land surface in the central uplands. The water table is deeper in the well-drained uplands (as deep as 12 m below land surface). The flow in the surficial aquifer is from local water-table highs to streams and the coast. The ground-water flow paths are generally shorter than a few kilometers (Hamilton and others, 1993). Within these regions, agriculture is the major land use, woodlands constitute about 31 percent of the land area, and residential or urban development constitutes about 13 percent.

The average annual precipitation for the Delmarva Peninsula is 1,143 mm/yr. More than half of

map data: U.S. Geological Survey, 1981a,b; 1983 c,e,f,g; 1984a,b,e,i; 1999

Figure 6. Physiographic regions of the Delmarva Peninsula, United States. Includes state and county boundaries.



map data: Hamilton and others, 1993.
U.S. Geological Survey, 1981a,b; 1983c,e,f,g; 1984a,b,e,i; 1999

Figure 7. Hydrogeomorphic regions and locations of well networks of the Delmarva Peninsula, United States. Includes county boundaries.

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