Kirkwood - Cohansey Water-table Aquifer

Location

The Kirkwood-Cohansey water-table aquifer is present throughout nearly the entire New Jersey Coastal Plain. The aquifer covers approximately 3000 square miles (fig. 1). It is thickest and most productive in the central and southern part of its extent.

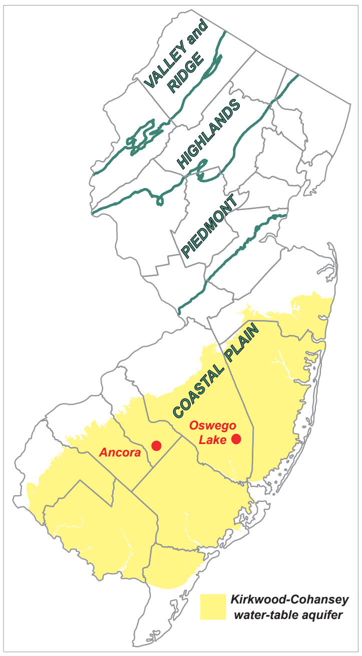

Figure 1. Location of Kirkwood-Cohansey water-table aquifer.

Description of the Aquifer

The Kirkwood-Cohansey water-table aquifer is made up of the Kirkwood and Cohansey Formations, which are geologic units. The Cohansey Formation is mostly sand, with minor lenses of silt and clay and some gravel, while the Kirwood Formation contains both sand and clay beds. In places younger surficial sediments are part of the aquifer. Ground water is stored in and transmitted through pores between sand grains and is typically well connected to surface water bodies. Some ground water leaks to deeper confined aquifers.

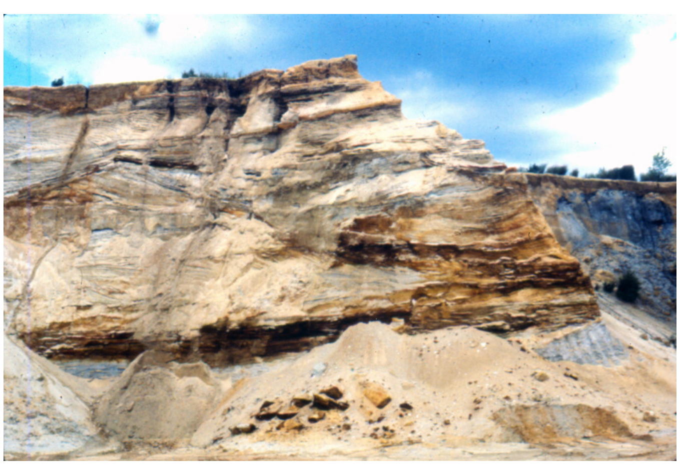

Figure 2. Cross-bedded barrier island sand deposits of the Cohansey Formation, two miles east of Farmingdale, Monmouth County.

The Cohansey Formation is made up of white to yellow, cross-bedded, primarily medium to coarse sand, with gravel and clay occurring locally (fig. 2). In places the formation is stained red or orange-brown by iron oxides and is sometimes cemented into large blocks of ironstone. Clay may be dark gray where unweathered, but is usually white where interbedded with ironstone. The Kirkwood Formation is made up of fine- to medium-grained micaceous sand with clay (fig. 3). Less commonly it contains coarse-to-fine gravelly sand. Dark gray to gray-brown clay and silty micaceous clay with plant debris occurs throughout the formation. It is extensively stained by iron oxides near the surface.

Figure 3. Fine-grained shallow marine shelf sand deposits of the Kirkwood Formation in Howell Township, Monmouth County.

The Kirkwood-Cohansey water-table aquifer varies in thickness and lithology throughout the New Jersey Coastal Plain. At the Ancora bore hole (figs. 1 and 4), the aquifer consists only of the medium-to-coarse sand of the Cohansey Formation and is 168 feet thick. At this location the underlying Kirkwood Formation is primarily silt and clay and acts as a confining layer below the aquifer. In such a geologic setting the aquifer is in good hydrologic connection to surface water, because it lacks hydraulically restrictive silty clay layers that would isolate the water-bearing sands from the surface.

At the U.S. Geological Survey Oswego Lake observation well 1 (figs. 1 and 5), the aquifer is over 360 feet thick. At this site, the aquifer is composed of sands from both the Cohansey and Kirkwood Formations. In addition, the Kirkwood contains silty clay layers between water-bearing sands that act as leaky confining layers. In this setting, ground water in the Kirkwood interacts indirectly with surface water, because the fine-grained silt and clay layers isolate the water-bearing sands from the land surface to some extent. The very coarse sand at the base of the aquifer is correlative with the Atlantic City 800-foot sand down dip to the east.

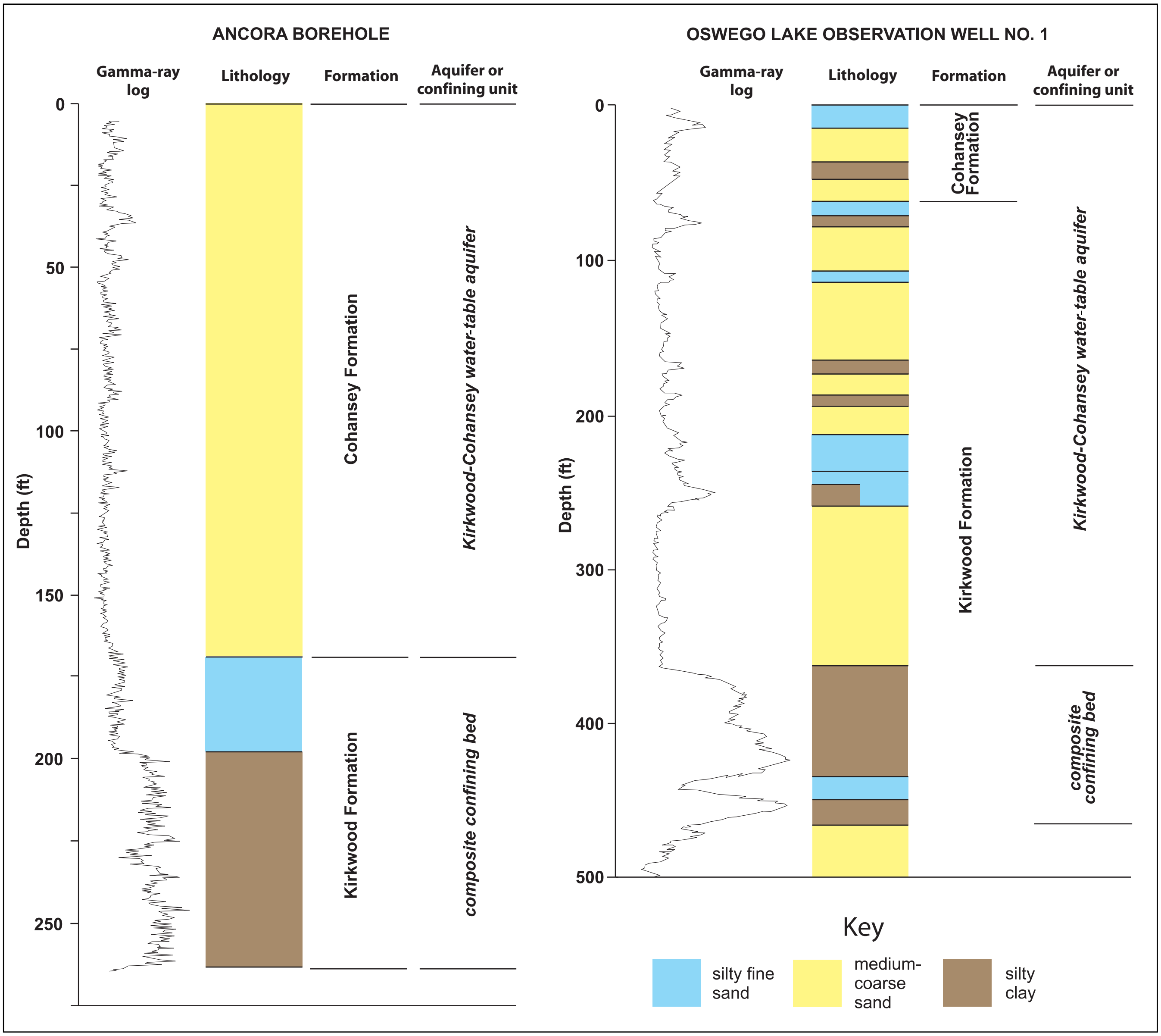

Figure 4 (left). **Figure 5** (right). Gamma-ray log and lithologic composition of the Kirkwood-Cohansey water-table aquifer at Ancora, Camden County (left) showing the absence of clay layers in the water-bearing sands of the Cohansey and Kirkwood Formations, and at Oswego Lake, Burlington County (right) showing the presence of clay layers in both the Cohansey and Kirkwood Formations. In each figure, the borehole geophysical logs to the left of the lithology log show a record of naturally occurring gamma radiation given off by geologic units in the subsurface. A deflection line to the left indicates lower radiation, which usually correlates with sand deposits. A deflection to the right indicates higher levels of radiation, which usually correlates with silt and clay. Well locations shown on figure 1.

Hydrologic Properties

The Kirkwood-Cohansey water-table aquifer is highly permeable due to the dominance of well-sorted, medium- to coarse-grained sand. The hydrologic properties of the aquifer have been determined through aquifer pumping tests and other hydrologic test methods. Time-drawdown data from pumping tests typically exhibit unconfined-aquifer characteristics where clay layers are few or absent (fig. 4) and leaky-aquifer characteristics where silt and clay layers are more abundant (fig. 5). Table 1 summarizes the range of conductive properties obtained from aquifer test analysis. Additional hydrologic properties such as storativity, specific yield, and leakance values at aquifer test locations can be obtained online from the NJGS website (see table 1 caption).

Well Yields

Aquifers are geologic units that are capable of supplying useful quantities of water to wells and springs. The productivity of an aquifer is measured by the volume of water it can supply instantaneously, or its "yield," and its ability to sustain yield. Wells sited and tested for maximum yield, including major water supply, irrigation, and industrial-supply wells, are often referred to as "high-capacity wells." High-capacity wells test the maximum yield of aquifers. The data from 938 high-capacity wells completed in the Kirkwood-Cohansey aquifer on file with the New Jersey Department of Environmental Protection (NJDEP) show that this aquifer is prolific, with yields measured up to 4500 gallons per minute (gpm) and a mean yield of 400 gpm.

Median	Range	Source of information
Horizontal Hydraulic Conductivity (feet per day)		
141	36-420	NJGS database – 33 tests
130	53-250	USGS (Martin, 1990) – 13 tests
Vertical Hydraulic Conductivity (feet per day)		
2.6	.0078125-12.4	NJGS database – 22 tests
Transmissivity (feet squared per day)		
11,765	3102-38,475	NJGS database – 37 tests
7900	3600-20,000	USGS published – 14 tests

Table 1. Hydrologic properties of Kirkwood-Cohansey water-table aquifer. NJGS database can be found at www.njgeology.org/geodata/dgs02-1.htm

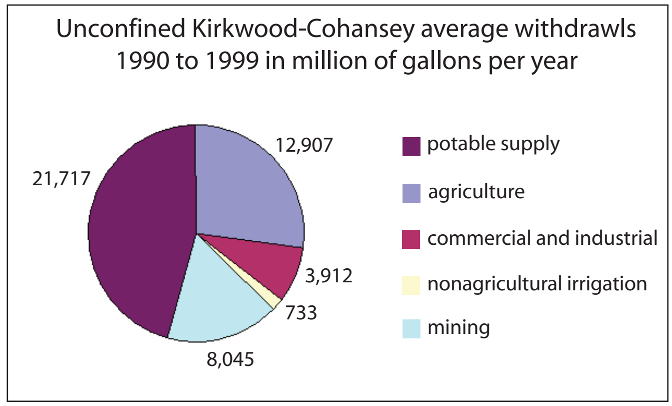

Figure 6. Daily water use by category from the Kirkwood-Cohansey aquifer. Daily withdrawals from power generation (1 million gallons) and commercial uses (67 million gallons) are too low to show on graph.

Water Use

Figure 6 shows reported withdrawals of water from the Kirkwood-Cohansey aquifer for different uses (Hoffman and Liberman, 2000). The data summarize fresh-water withdrawal activities for commercial, industrial, and agricultural users whose use averages more than 100,000 gallons per day, and who are regulated by the NJDEP Bureau of Water Allocation through the water allocation permit process. The data show that the majority of water withdrawn from the Kirkwood-Cohansey aquifer is used for potable consumption. Agricultural irrigation makes up the next largest category of the major diversions of ground water from the aquifer. The third largest category is mining, which refers primarily to dewatering of sand pits for mineral extraction. Figure 7 shows the geographic distribution of pumpage from the aquifer.

Water Quality

Ground water in this aquifer is typically fresh, acidic, highly corrosive, and low in dissolved solids. Iron and manganese levels may be elevated locally. Mercury and radium concentrations exceed primary drinking water standards in some wells. The mercury is believed to have been released into the environment by human activity and is not thought to occur naturally (Dooley, 1992; Barringer and others 1997). Radium occurs naturally in the aquifers. Research indicates that its release into ground water may be facilitated by the application of agricultural chemicals (Szabo and others 1997).

Water Resource Issues

Interaction with surface water and wetlands

One of the principal resource issues affecting the availability of water from the Kirkwood-Cohansey water-table aquifer stems from its interaction with surface water. Water-table aquifers discharge locally to streams, wetlands, and other surface water bodies (fig. 8). Pumping ground water can cause the water-table to drop below surface-water elevations, inducing surface water to leak into the aquifer. This process, known as induced leakage (fig. 9), can diminish stream flow and impair wetlands. Wells near surface water bodies in a water-table aquifer are more likely to induce leakage than those farther away, because their pumping effects extend to the water body itself.

Removal from storage

Because water-table aquifers discharge to local surface-water bodies, pumping water from these aquifers reduces the amount of water available to replenish surface water. Locating wells far from surface-water bodies decreases the immediate impact from induced leakage.

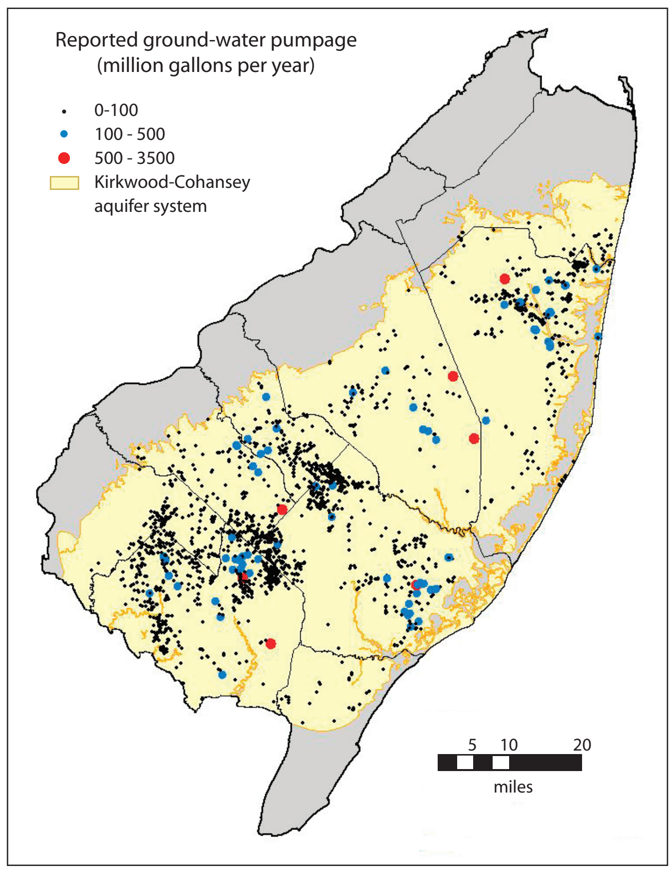

Figure 7. Distribution and rates of pumpage from the Kirkwood-Cohansey aquifer.

But impacts to surface water can still occur because pumpage from a water-table aquifer ultimately depletes storage. Removal of water from storage may take some time to impact surface water, as much as many months. The precise timing of such delayed impacts depends on the amount of storage in the aquifer and the distance between a well and surface-water body. This suggests, for instance, that high-volume pumpage during the summer season may not impact surface-water bodies until later in the year. This is a significant issue, because water use is typically highest in summer and stream flows typically are lowest in autumn when the effects of depleted storage may be greatest.

Saltwater intrusion

Given that the Kirkwood-Cohansey is an unconfined aquifer, saltwater intrusion is not a major issue over most of its extent. However, because it can interact hydrologically with the ocean, bays, tidal marshes and tidal streams, saltwater intrusion is a potential concern in coastal areas where salty tidal surface water exists.

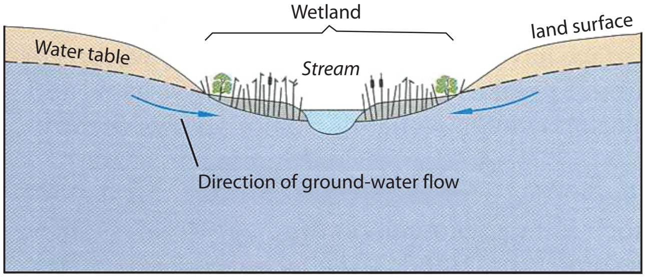

Figure 8. Relationship between water table and wetlands in stream corridor. The water-table aquifer often intersects and sustains wetlands. After Winter and others (1998, figure 17).

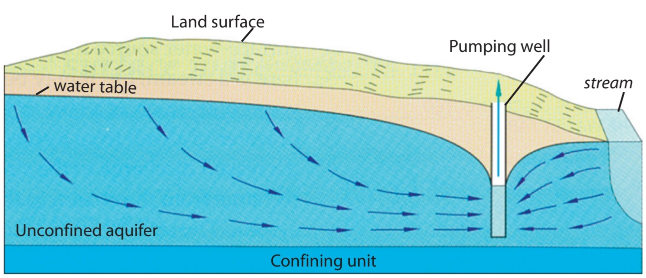

Figure 9. A representation of induced stream leakage due to ground-water pumping in a water-table aquifer near a stream. After Alley and others (1999, figure 13).

Vulnerability to contamination

Water-table aquifers lack protective confining layers that might block vertical movement of water from the surface. This means that these aquifers are especially vulnerable to contaminants introduced at the ground surface. Clay lenses within the aquifer are typically discontinuous and thus not effective in protecting the aquifer from downward movement of surface contamination. In addition, the high permeability of the aquifer means that contaminants can disseminate relatively rapidly once introduced into the subsurface.

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