New Jersey Geological and Water Survey Information Circular

Englishtown Aquifer System

Introduction

The Englishtown **aquifer system**[1] is a valuable ground-water resource in the New Jersey Coastal Plain, especially in Monmouth and northern Ocean Counties (Nichols, 1977). New Jersey towns such as Atlantic Highlands, Belmar, Brielle, Freehold, Jackson, Lakewood, Mount Holly, and New Egypt, rely on it to supply water for public use. The aquifer is in the Englishtown Formation, a late Cretaceous, 75-million-year-old deposit of fine- to coarse-grained sand, locally interbedded with thin to thick beds of dark clay that contain abundant carbonaceous (woody) material. The formation crops out in a thin, northeast to southwest band (fig. 1) that is thickest in the northeast (~150 ft.) near Raritan Bay and thinnest to the southwest (~50 ft.) near the Delaware River in Salem County (Owens and others, 1998). Where it is thickest, it consists of sand with clay interbeds (figs. 1, 2a and 2b); where it is thinnest, the Englishtown is silty fine sand (Owens and Sohl, 1969).

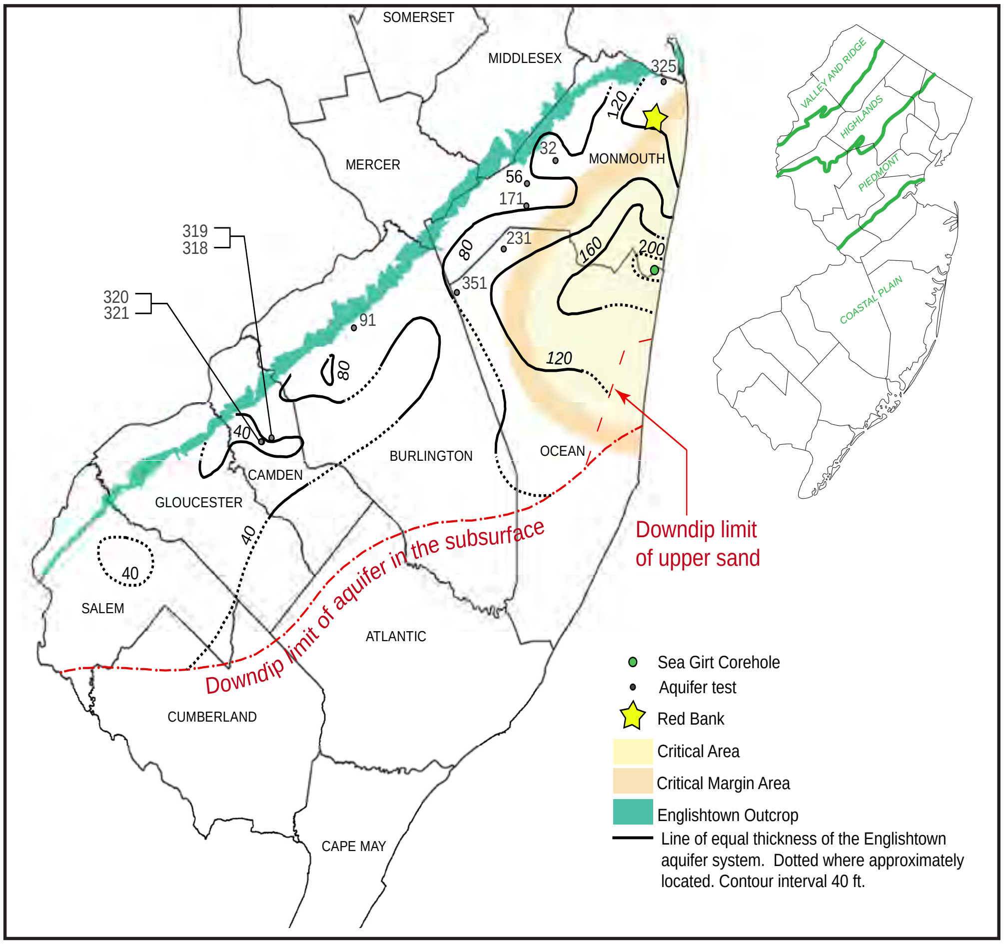

Figure 1. Outcrop belt and subsurface thickness of the Englishtown Formation in the New Jersey Coastal Plain. Also shown is the downdip limit of the aquifer (modified from Zapecza, 1989). The aquifer test sites are listed in table 2.

Description of the Aquifer System

At outcrop, and in the shallow subsurface, the Englishtown sand functions as a single aquifer (Zapecza, 1989). This aquifer is sufficiently thick and coarse grained in Monmouth, Ocean, and parts of Burlington Counties to be an important source of water. In the deeper subsurface of Monmouth and Ocean Counties, the Englishtown contains two, and rarely three, aquifer sands separated by clay-and-silt **confining beds**, and hence, is termed an aquifer system (Nichols, 1977). At the Sea Girt corehole (Miller and others, 2006), the Englishtown aquifer system contains an upper sand that is less than 70 feet thick, and a lower sand less than 15 feet thick; the two sands are separated by 80 feet of a clay-and-silt confining unit (fig. 3). In northern Monmouth County, it is a maximum of 140 feet thick near Red Bank (figs. 1 and 3). In southeastern Monmouth and northeastern Ocean Counties, the system reaches a maximum thickness of approximately 200 feet (including the middle confining bed) (Zapecza, 1989; fig. 1). In this area, most wells are screened in the upper sand.

[1]Terms in bold type are defined in Glossary on page 5.

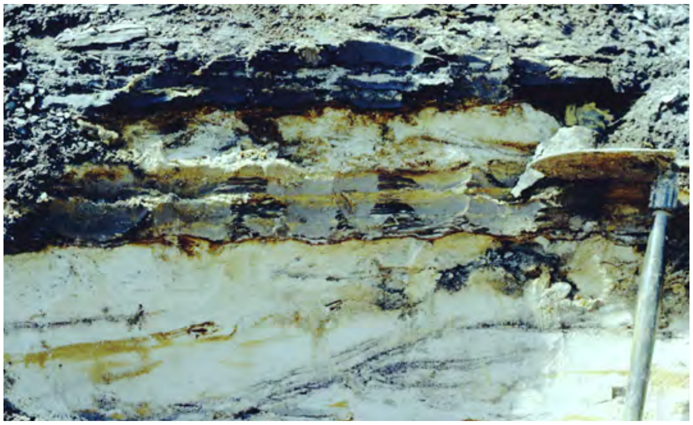

Figure 2a. Interbedded delta front sand and clay, Englishtown Formation, Monmouth County.

Figure 2b. Cross-bedded shallow marine sand, Englishtown Formation, Monmouth County.

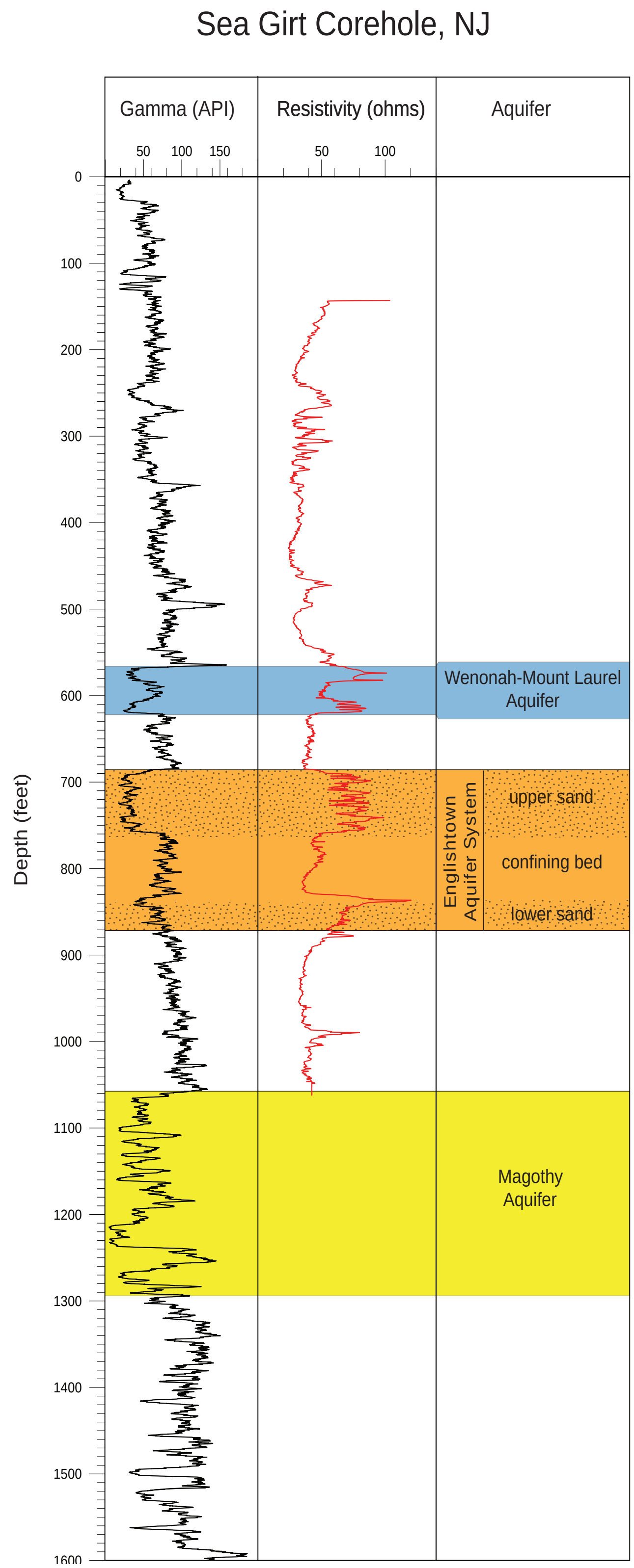

Figure 3. Major confined aquifers at the 174AX Sea Girt site.

Water Quality

The water is typically fresh, moderately hard and alkaline (pH > 7.0). Calcium-bicarbonate-type water dominates. Salinity, or sodium and potassium levels, are higher downdip or southeast with greater depth. Calcium and magnesium levels generally are lower to the southeast. Iron and manganese levels are higher locally, near outcrop, but are lower downdip, to the southeast (Seaber, 1965).

Well Yields and Aquifer Properties

Aquifers are contained in underground geologic formations or groups of formations that are capable of supplying useful volumes of water to wells and springs. In the Englishtown aquifer, water is transmitted through the sands' **intergranular pores**. The productivity of an aquifer is measured by the volume of water it can supply to a well or its "yield," and its ability to sustain yield. Wells tested for maximum yield, which include major water-supply wells, irrigation wells, and industrial-supply wells, are often referred as high-capacity wells. High-capacity wells test the maximum yield of aquifers. Table 1 is a statistical summary of the reported yield of 63 selected high-capacity wells completed in the Englishtown aquifer with records filed with the New Jersey Department of Environmental Protection (NJDEP). The data show that the aquifer system may yield as much as 660 gallons per minute (gpm) to a single well with an average yield of 369 gallons per minute.

Figure 1 shows the locations of eleven wells that were tested for several days to evaluate the Englishtown aquifer properties for transmissivity,

Summary of Yields of 63 High-Capacity Wells Completed in the Englishtown Aquifer System	
Average yield	369 gpm
Minimum yield	35 gpm
Maximum yield	660 gpm

Table 1. Yield of high-capacity wells (in gpm) completed in Englishtown aquifer system.

storativity and leakance. The tests, listed in table 2, reveal a **transmissivity** ranging from a low of 430 ft^2/day to a high of 3,800 ft^2/day and a median of 840 ft^2/day. A 10^{-3} to 10^{-5} range in **storativity** values is indicative of confined conditions for the Englishtown aquifer at the test locations shown in figure 1. Leakage into the Englishtown aquifer is evident in most of the tests with **leakance** values in the range of 10^{-3} to 10^{-6} day^{-1}. The source of the leakage is the overlying Wenonah-Mount Laurel aquifer, which is shown in figure 3.

Reported Water Use

Figure 4 shows withdrawals of water from the Englishtown aquifer system for different uses (Hoffman and Liberman, 2000). The data summarize freshwater withdrawals for commercial, industrial, and agricultural uses averaging more than 100,000 gallons per day. Such large withdrawals are regulated by the NJDEP, Bureau of Water Allocation and Well Permitting (BWAWP) by the water-allocation-permit process. The data show that an average of 3.0 billion gallons of water per year was withdrawn from the aquifer between 1990 and 1995. Most (92 percent) of the water from the Englishtown aquifer system is for potable supply. Non-agricultural irrigation (4 percent) makes up the next largest use, followed by agriculture (1.5 percent) and mining (1 percent).

Water-Resource Issues

Overpumpage

The State of New Jersey declared the Englishtown aquifer system to be a Critical Aquifer in 1988 because high rates of ground-water use caused large and progressively declining water levels in the Englishtown aquifer around major pumping centers. This progressive decline in ground-water levels threatened its ability to sustain productivity at efficient rates and increased the potential of saltwater intrusion from pe-

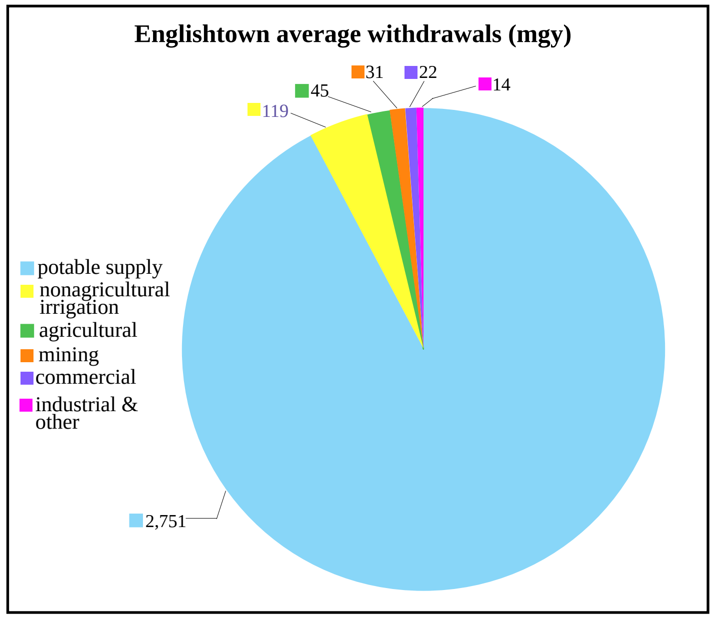

Figure 4. Withdrawals of water from the Englishtown aquifer system for diverse uses, 1990 to 1995.

Aquifer Test File Number	Site Name	Aquifer Properties				
32	Freehold Twp MUA Point Ivy Well 3	T=3300	S=7.1x10^{-4}	--	b=90	K=36
56	Manalapan Twp Water Dept Well 3	T=520	S=3.5x10^{-3}	l'=1.1x10^{-3}	b=50	K=10
91	Deerwood Country Club Well 18	T=1900	S=1.7x10^{-3}	l'=2.1x10^{-3}	b=39	K=50
171	Charleston Springs Golf Course TW1E	T=430	S=3.1x10^{-4}	l'=3.8x10^{-5}	b=56	K=8
231	Six Flags Great Adventure Well 1R	T=1000	S=6.0x10^{-5}	l'=3.0x10^{-6}	b=30	K=34
318	Gibbsboro Well 56	T=840	S=5.3x10^{-5}	l'=6.6x10^{-6}	b=20	K=42
319	Gibbsboro Well 57	T=770	S=9.0x10^{-5}	l'=5.7x10^{-5}	b=20	K=39
320	Laurel Springs Well 60	T=620	S=7.7x10^{-5}	l'=3.8x10^{-5}	b=20	K=31
321	Laurel Springs Well 61	T=640	S=7.0x10^{-5}	l'=2.2x10^{-5}	b=20	K=32
325	Atlantic Highlands Well 6	T=3800	S=2.1x10^{-4}	l'=3.0x10^{-5}	b=80	K=48
351	NJAW New Egypt System Well 1A	T=580	S=2.8x10^{-5}	l'=2.2x10^{-5}	b=95	K=6

T=Transmissivity (ft^2/day) S=Storativity (dimensionless) l'=leakance (day^{-1}) b=aquifer thickness (ft) K=hydraulic conductivity (ft/day)

Table 2. Summary of aquifer tests on file at NJGWS. Aquifer test file number identifies a particular aquifer test in the NJGWS paper files and in the Hydro database. Site Name identifies the owner and test well. Aquifer Properties are values obtained by the analysis of time-drawdown data. Values of hydraulic conductivity (K) are calculated by dividing the transmissivity (T) by aquifer thickness (b).

ripheral parts of the aquifer, where salty water was thought to exist. The declaration of Water Supply Critical Area 1, which includes the Englishtown Aquifer (fig. 1), centered on Monmouth County. It allowed the State to limit future use of the resource in these areas and required water purveyors to seek alternate sources to replace portions of existing allocations. Following reduced pumping in the aquifer, the ground-water levels rebounded and rose 80 feet in places toward former levels.

Occurrence of Saltwater in the Englishtown Aquifer System

Saltwater intrusion is a resource-management issue for the Englishtown aquifer. Recent exploration by the New Jersey Geological and Water Survey near Sandy Hook has identified elevated levels of chloride and sodium indicative of seawater in the Englishtown aquifer at a depth of 220 to 295 feet (Mulliken, 2011). Figure 5 is the log of the Sandy Hook well and shows salt water below fresh water in the aquifer. Water quality in the aquifer off the Atlantic Coast is not known. The geologic formation becomes finer grained seaward and downdip, which reduces the potential for onshore movement of salt water. Overall, the potential for movement of saltwater landward from the ocean has not been fully assessed. Simulation of potential withdrawals from the aquifer in 2040 using a groundwater-flow model did not show movement of the fresh water/salt water interface (Pope and Gordon, 1999).

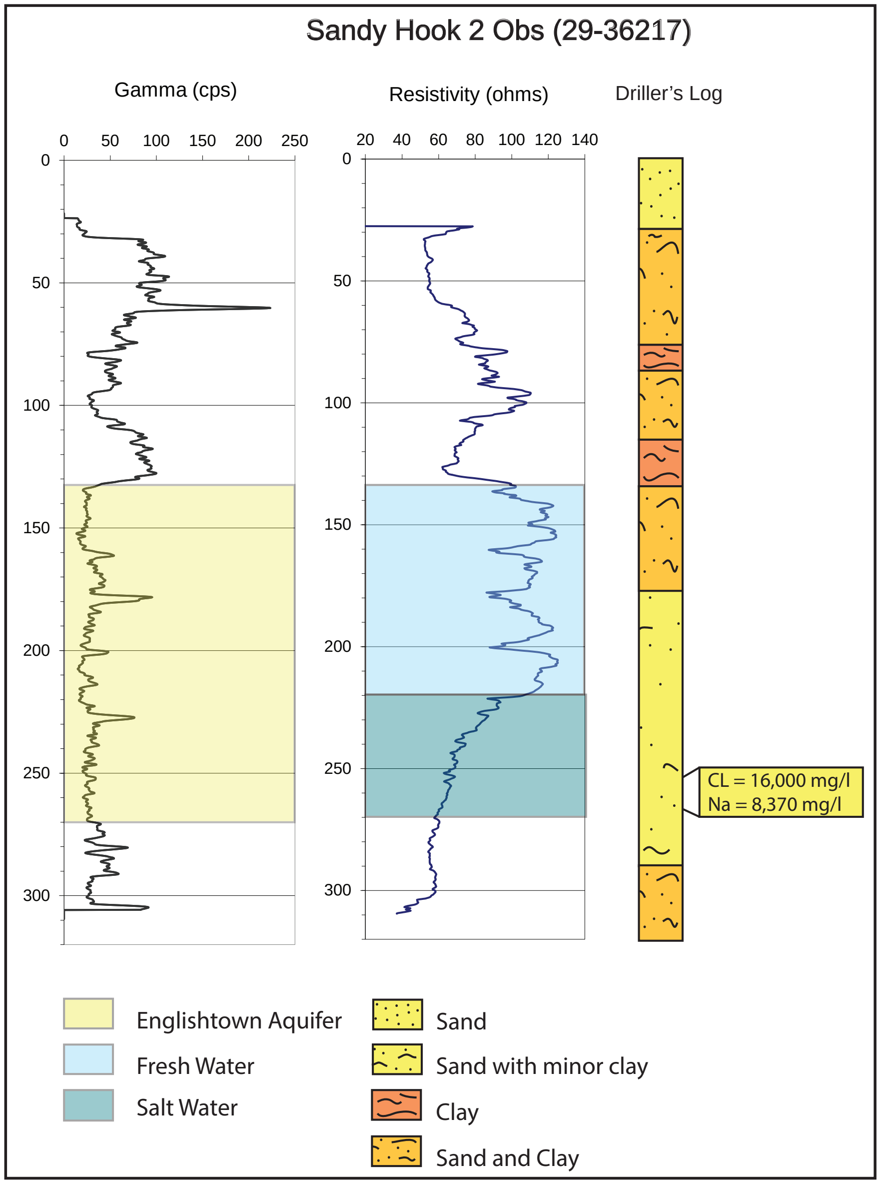

Figure 5. Salt water in Englishtown aquifer. Electric log and gamma log run in Sandy Hook observation well completed into the Englishtown aquifer. Aquifer is present between approximately 130 feet below land surface (bls) and 270 feet bls. Driller's log indicates mostly sand between 130 - 270 feet bls. Gamma log largely confirms drillers' log, with sand exhibiting low gamma reading or counts per second between 130 - 270 feet bls. Resistivity log (on right) shows high-resistivity sands from 130 to about 220 feet and low resistivity (conductive) sands from 220 - 270 feet bls. Groundwater sample collected from 250 feet revealed saltwater with chloride and sodium concentrations of 16,000 mg/l and 8,370 mg/l, respectively. At this location, there is a 50-foot thick tongue of saltwater underlying freshwater in the approximately 140-foot thick Englishtown aquifer. Extent of salt water in aquifer is undefined.

Relationship to Surface Water

The Englishtown aquifer system discharges to surface water, overlying aquifers, the Atlantic Ocean, and Delaware and Raritan Bays. Pumpage from the aquifer reduces the volume of water discharged to surface water. Martin (1990) concluded that pumpage from the Englishtown aquifer results in less discharge to local streams in the outcrop areas of both the Englishtown and Wenonah-Mount Laurel aquifers. The U.S. Geological Survey estimated that for developed conditions, discharge to **unconfined** parts of the aquifer, and therefore to streams, diminished from 5.0 mgd to 2.7 mgd, or approximately 50 percent (CH2M Hill, Metcalf and Eddy, Inc., 1992). This change is dissipated over a large geographic area and is not easily detected in any single surface-water body.

Glossary

aquifer system A body of permeable and poorly permeable material that functions regionally as a water-yielding unit; it consists of two or more permeable beds.

confining beds A hydrogeologic unit of impermeable or distinctly less permeable material bounding one or more aquifers.

intergranular pores Spaces that occur between the grains of soil, sediment, or incompletely cemented sedimentary rock.

leakance A measure of groundwater flow across a semi-confining unit and is the ratio K'/b', in which K' and b' are the vertical hydraulic conductivity and the thickness, of the confining beds (Lohman, 1972).

storativity The volume of water released from storage in a vertical column of 1.0 feet^2 when the water table declines 1.0 foot.

transmissivity The rate of flow through the vertical section of an aquifer 1.0 foot wide and extending the full saturated height.

unconfined A condition in which the upper surface of the zone of saturation is at atmospheric pressure. The zone of saturation refers to the area in an aquifer, below the water table, where all pores and fractures are filled with water.

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2014

(Revised, 2014)

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