

INTRODUCTION

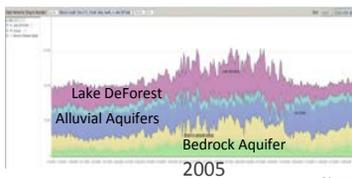


• **Concerns** over the viability of the fractured bedrock aquifer that provides about 1/3 of Rockland County’s water supply prompted a 5-year study by the U.S. Geological Survey (USGS) to (1) define the hydrogeologic framework of the aquifer, (2) assess conditions within it, and (3) identify other potential sources of water for the County. The study was done in cooperation with Rockland County and the New York State Department of Environmental Conservation.

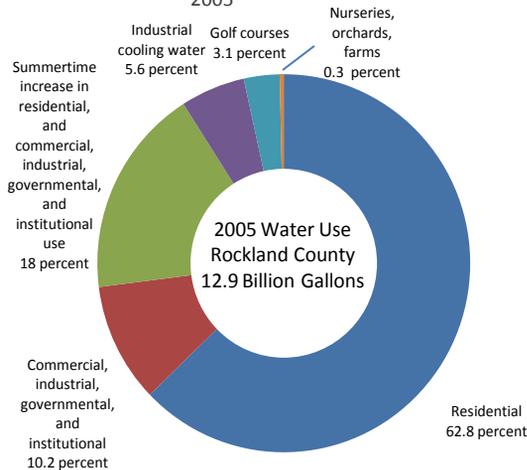
• **Population growth** in Rockland County to nearly 300,000 people has been paralleled by significant hydrologic changes over the past 50 years – water demand and impervious surface area have increased, and sanitary sewers now serve most areas and discharge wastewater to the Hudson and Ramapo Rivers. Total water use in 2005 was estimated at 12.9 billion gallons. Peak water demand during the Summer exceeds other times of year by as much as 50 percent.

• **Public Water Supply** in 2005 was provided by three sources in nearly equal parts:

- (1) The fractured sedimentary bedrock aquifer that underlies most of the developed areas of the County
- (2) Alluvial (sand and gravel) aquifers in the Ramapo and Mahwah River valleys
- (3) Surface-water impoundment of the Hackensack River at Lake DeForest



Water withdrawals at both Lake DeForest and in the Ramapo Valley wellfield are limited by requirements for streamflow maintenance downstream into New Jersey.



• **Water Use** in Rockland County was about 12.9 billion gallons in 2005, with residential use the largest category. The increase in summertime use is the next largest category (much of it lawn watering and other outside uses that do not go to the sanitary sewer system). Average domestic water use from private wells was estimated at about 1.4 million gallons per day (4 percent of total water use).



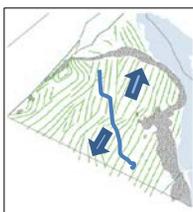
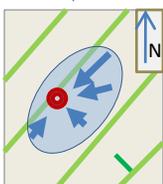
HYDROGEOLOGIC FRAMEWORK

• **The sedimentary bedrock** aquifer underlies the lowland part of the county and consists, from east to west, of mudstone, sandstone, and conglomerate strata that have been tilted about 10 degrees toward the northwest. Fractures parallel to the bedding planes of the sedimentary bedrock are the major water-bearing zones in the aquifer.

• **The tilt or dip of the water-bearing fractures** with the bedding produces regional groundwater flow “with the grain” (along the strike) of the bedrock, either to the northeast or the southwest. Groundwater flow “against the grain” is localized and generally shallow. Therefore, pumping wells affect groundwater levels in bedrock aquifer areas to the northeast and southwest of each well, and updip to the southeast. Pumping from major wellfields has caused groundwater levels to decline as far as 1 mile away.

• **The Regional groundwater flow system** was defined by overlaying the aquifer framework over a groundwater-level map and then identifying groundwater divides. Groundwater flows from divide areas toward lower elevation discharge areas – rivers, streams, lakes, and wetlands. The dominant regional flow directions are to the northeast and southwest, and the major groundwater divide parallels the Palisades Parkway.

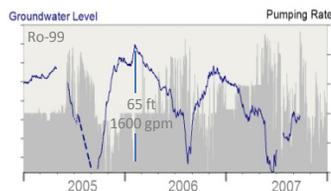
Pumping Well (red)
 Capture Zone (blue)
 Bedrock Strike (lt green)
 Dip direction (dark green)



Bedrock structure and generalized groundwater flow directions

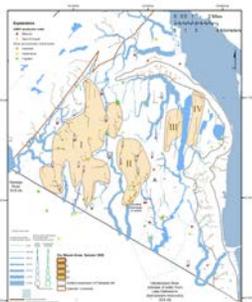
BEDROCK AQUIFER CONDITIONS

•There has not been a continuous downward trend in groundwater levels across the bedrock aquifer, based on review of pumpage and water-level data as far back as 1989. Groundwater levels have locally declined in response to new stresses from production wells, especially when they have been used continuously.



Summertime groundwater declines 2005-07

•The greatest concern regarding sustainability of groundwater resources is the aquifer response to the annual increase in pumpage from May through October (a 25-percent average increase in 2005). Summertime groundwater-level decline rates at public supply wells were used to extrapolate groundwater declines under constant pumping at each well from initial May water levels through October. Results indicate that water levels at one-third of supply wells would approach the depth of the well pump before October. As a result, pumping rates would have to be reduced at these wells to prevent further water-level declines. Large water-level declines could also increase the likelihood of air entrainment in pumping wells, which is another constraint on pumping rate.



Brown Areas= Dry Streams September 2005

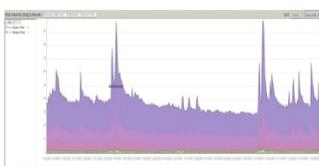
•Streams are also affected by seasonal groundwater pumping. Nearly all but the largest streams in the productive west-central area of the aquifer ceased to flow during dry conditions in late summer of 2005. Seasonal groundwater-level fluctuations in the aquifer were also largest within that same area.

•Annual recharge estimates from historic streamflow data range from 15 to 25 inches across the county; this variation arises from differences in precipitation, overburden thickness, and percent of impervious cover.

Comparisons of groundwater withdrawals in 2006 with recharge estimates derived from three gaged stream basins indicate that pumpage is equivalent to between 12 and 24 percent of recharge in these watersheds.



•Impervious surfaces (1) prevent recharge of the aquifer, (2) prevent uptake of moisture by vegetation, and (3) rapidly route stormwater runoff to streams, which increases peak stormflows. A 17 percent impervious surface area in the Pascack Brook watershed results in about a 5 percent loss of recharge per year (nearly 400 million gallons of water).



Sanitary Sewer Flows - 2005

•Sanitary Sewering transported about 14.7 billion gallons of water from Rockland County to the Hudson and Ramapo Rivers in 2005. This amount exceeds the water use estimate for that year. The pattern of flows to the treatment plants is different (more like streamflow) than the seasonal water-use pattern. The reason for this discrepancy is that during and after storms, sanitary sewers receive inflow of storm runoff, groundwater infiltration, and perhaps sump pump discharges from homes.

POTENTIAL ADDITIONAL WATER SOURCES —From a purely hydrologic perspective (each of these sources have their own set of caveats and concerns other than hydrology)

1. **Increased Pumpage from the Bedrock Aquifer** is possible in areas of the aquifer that are not currently tapped for public supply. Individual well yields would likely be lower than those of most current supply wells.
2. **Ambrey Pond Reservoir** has been proposed in the northern part of the County. It would draw surface water from Highlands area drainages, including Lake Tiorati.
3. **Stormwater retention / reuse.** Retention, treatment, and transfer of stormwater from key drainages in the County is a potential means of retaining water lost to impervious surfaces.
4. **Increase Flow Augmentation to the Ramapo River through releases from the Stony Brook watershed.** This would help maintain pumping capacity of the Ramapo Valley Wellfield. Storage of excess streamflow in an impoundment could be released to the Ramapo River during dry periods.
5. **Desalination of Water from the Hudson River.** The Hudson River represents a continuous source of brackish water that could be treated to provide a source of freshwater.
6. **Indirect Use of Recycled Water** — 14.7 billion gallons of treated wastewater was available to Rockland County in 2005 — more than the total water use that year. Diversion of at least part of that water, highly treated with further natural treatment in wetlands or surface waters prior to joining drinking water supplies, offers a continuous source of freshwater for local and regional water needs.