2.2 Regional Setting & Physical Geography

Regional Setting

The upper Rondout Watershed is located in the southern portion of the Catskill Mountain region of southeast New York State. The name "Rondout" comes from a fort which once resided at the mouth of the creek. The upper Rondout flows from its headwaters near Shandaken, running approximately 13 miles before entering the Rondout Reservoir in Neversink. The 48-square-mile watershed falls primarily in the towns of Denning in Ulster County, and Neversink in Sullivan County. Despite advancement in streamside development, a large portion of the upper Rondout remains densely forested, mainly due to its status as New York State-owned preserve land.

The Catskill Forest Preserve was established in 1885 by the New York State Assembly, and is designated as forever wild forest lands by an 1894 amendment to the New York State Constitution (now Article 14). This amendment states that the land within the preserve "shall not be leased, sold or exchanged, or be taken by any corporation, public or private, nor shall the timber thereon be sold, removed or destroyed."

In 1904, a boundary or "blue line" was established around the Forest Preserve and private land as well, designating the Catskill Park. As a result of expansion over the years, the park now encompasses nearly 700,000 acres, approximately half of which is public Forest Preserve. The Catskill Park is unique due to its makeup of both public and private land, illustrating how wilderness and the practices of modern civilization can coexist.

The upper Rondout Watershed is also located within the New York City Water Supply Watershed. At 2,000 square miles, the NYC Watershed is the largest unfiltered water supply in the United States, providing 1.4 billion gallons of clean drinking water daily to over nine million residents in New York City and some nearby municipalities (nearly half the population of New York State). The upper Rondout makes a significant contribution to this water supply, highlighting the importance of conservation measures in this region.

The Rondout Reservoir is one of New York City's most important components of the water supply system. It is the terminal reservoir of the Delaware System and so accepts waters from the Cannonsville, Pepacton, and Neversink Reservoirs. These "upstream" reservoirs are connected to the Rondout Reservoir by tunnels to three Tunnel Outlet facilities each of which houses a hydroelectric plant.

Rondout Reservoir has a water surface area of 2,100 acres and has a storage capacity of 50 billion gallons. The Reservoir is 7.2 miles long and about one mile wide and is created by the Merriman Dam – an earthen dam with a concrete core wall. The water from the Reservoir is diverted to the Delaware Aqueduct through the Rondout Effluent Chamber where water enters the building through one of 4 intake levels (to maximize water quality) and is regulated by a combination of 6 large valves. The Rondout Reservoir supplies more than 50% of the City's daily supply of water on average. The facility also makes small river releases into the lower Rondout Creek.
See the next page for a map of the system.

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The New York City Department of Environmental Protection (DEP) operates this drinking water supply under a s Filtration Avoidance Determination (FAD) issued by the Environmental Protection Agency (EPA) and the New York State Department of Health (DOH). Central to the maintenance of the FAD are a series of partnership programs between NYC and the upstate communities, as well as a set of rules and regulations administered by the DEP. Due to its location within the NYC Watershed, land use in the upper Rondout watershed is subject to the DEP rules and regulations written to protect water quality. As detailed in Section 2.10, the DEP offers a variety of watershed protection programs to encourage proper watershed management practices by landowners and municipalities.

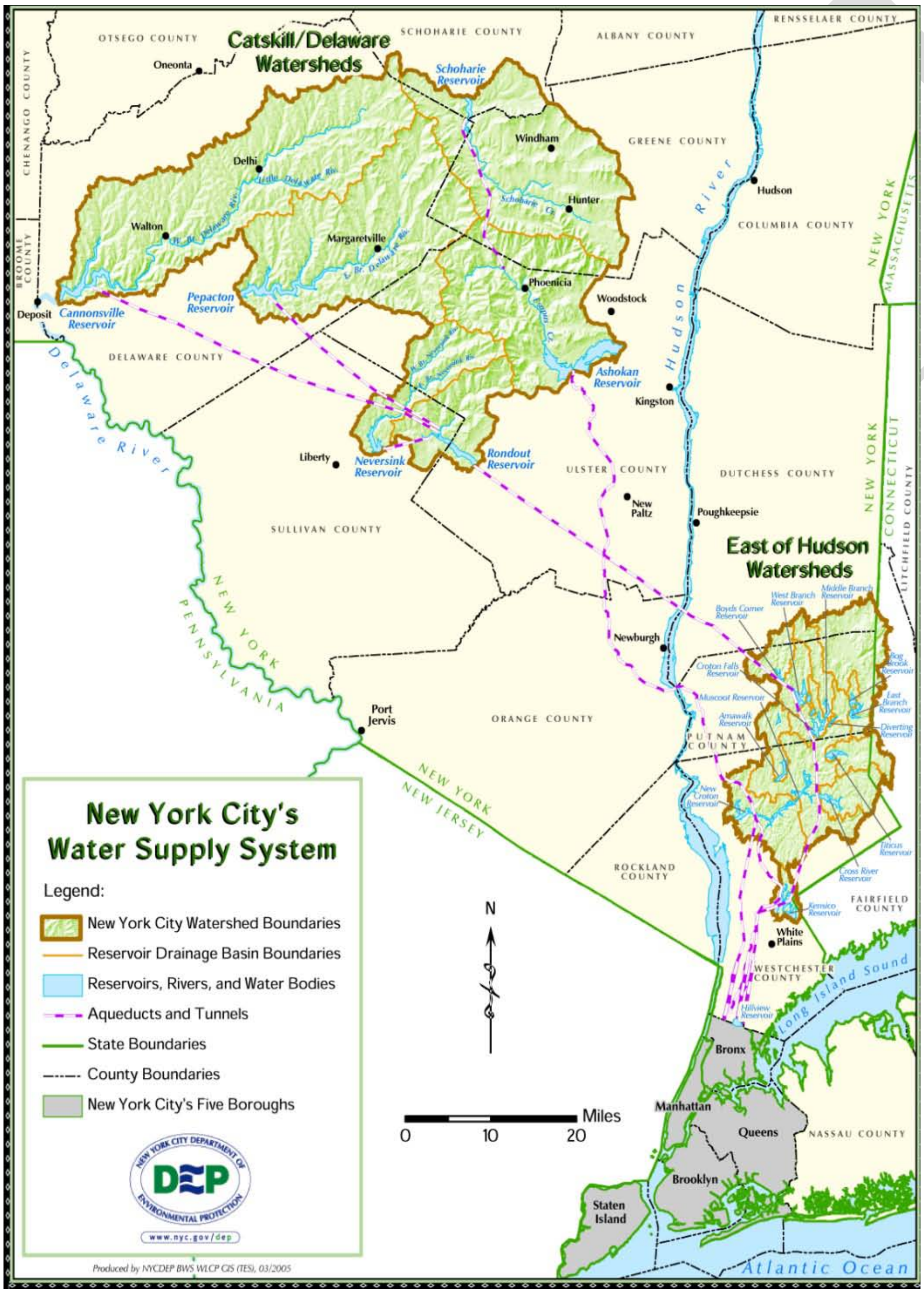

Figure 1 Map of the New York City Water Supply System.

Physical Geography

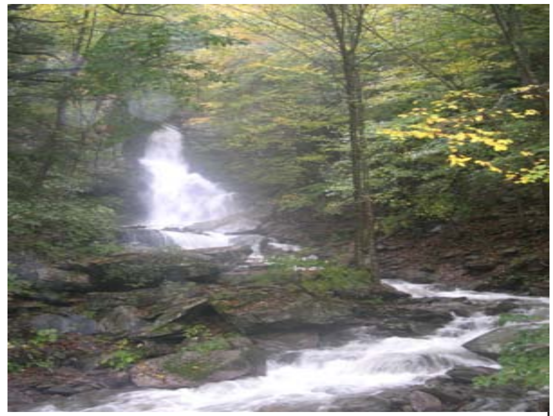

Figure 2 Dynamic physical geography

Physical geography encompasses the physical elements and processes that comprise the earth's surface features and associated processes. These processes include: energy, air, water, weather, climate, landforms, soils, animals, plants, and the Earth itself. The study of physical geography attempts to explain the geographic patterns of climate, vegetation, soils, hydrology, and landforms, and the physical environments that result from their interactions.

The Catskill Mountain chain is an example of a physiographic region – the Appalachian Plateau – in which most parts are similar in geologic structure and have had a relatively unified geomorphic history. The pattern of relief features and landforms differ significantly from that of adjacent regions. This region provides a geomorphic history shaped nearly 12,000 years ago by the movement of the Wisconsin Glaciers which once covered most of Canada and the northern United States (Titus 1996).

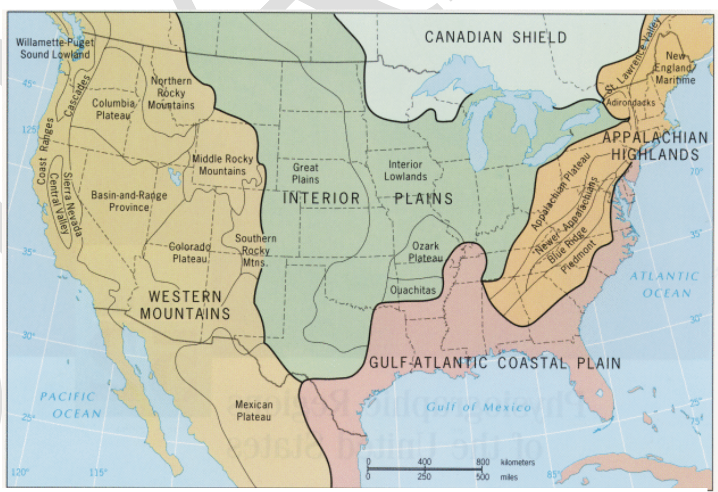

Figure 3 Physiographic Regions of the United States, including the Appalachian Plateau (NASA Earth Observing System)

The upper Rondout Creek was largely formed by the movement of the Hudson Valley glacier. As a portion of this glacier advanced up the Esopus Creek, it formed an ice dam which impounded water behind it. The ice dam caused water to be diverted away from the Esopus and into the Rondout Creek, resulting in the heavy erosion of what is now called Peekamoose Gorge. The Rondout continued to serve as a spillway for the Esopus basin, resulting in further erosion of the stream valley. As the glaciers fully retreated, flows in the Rondout lessened and left the Rondout valley much larger than such a small stream would normally need.

The upper Rondout is nestled between the Neversink and Esopus basins in the southern portion of the Catskill Park. It is located primarily in the towns of Neversink in Sullivan County, and Denning in Ulster County. The Rondout begins as a small stream near Peekamoose, flowing just

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over 13 miles before entering the Rondout Reservoir in Neversink. Through its course the stream drops approximately 610 ft. in elevation from Peekamoose Lake at nearly 1,450 ft., until it flows into the Rondout Reservoir at 840 ft. in elevation. The watershed is decorated with several peaks of the Catskill Mountain chain, such as Rocky, Peekamoose, Samson, Van Wyck, and Sugarloaf Mountains. The total watershed drainage area is approximately 48-square-mile, with an average stream valley slope of 1.2 %.

Large tributaries which deliver flows to the upper Rondout Creek include: in order from upstream to downstream, Buttermilk Falls Brook, Bear Hole Brook, Stone Cabin Brook, Sundown Creek, and Sugarloaf Brook. Figure 2 depicts these tributaries and their sub-basins. The upper Rondout watershed also has numerous smaller unnamed tributaries which drain the smaller sub-basins. Most of the watershed is oriented northeast to southwest. The hydrology of the upper Rondout watershed is discussed in greater detail in Section 2.3, and its geology Section 2.4.

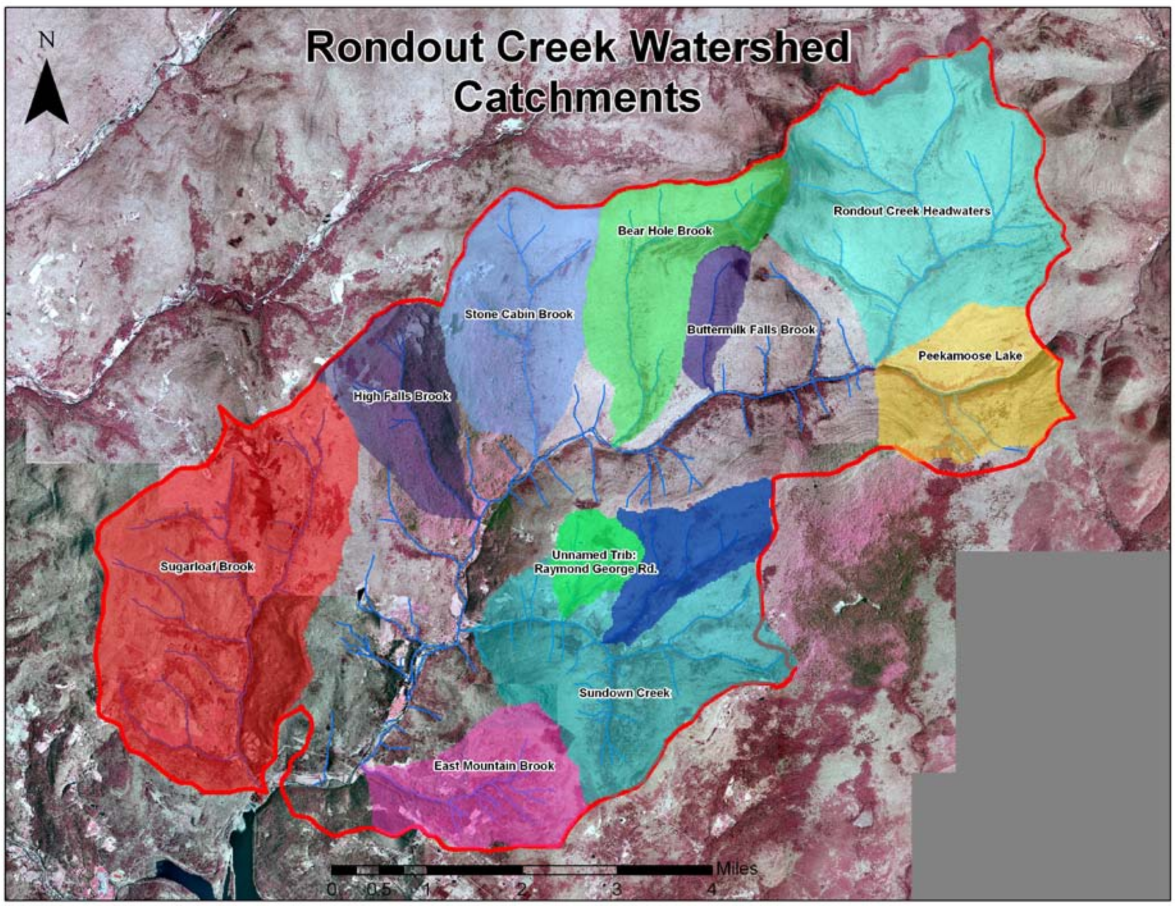

Figure 4 Map of Rondout Creek and tributary sub-basins above the Rondout Reservoir

Climate

The climate of the Rondout basin is primarily driven by the humid continental type, which dominates the northeastern United States. The average annual temperature for the area is 44.8˚ F and the area typically receives approximately 41 inches of rain/year. Due to up-sloping and down-sloping, the character of the mountaintop topography can affect the climate of the basin. Up-sloping occurs when air is lifted up over the mountains, the air expands, cooling and condensing into moisture, which takes the form of clouds and precipitation (Thaler, 1996). Down-sloping occurs when air sinking within a dome of high pressure or air that is forced downslope of a mountain range, warms up and loses moisture, as is shown by a drop in relative humidity (Thaler, 1996). These weather phenomena can cause differences in cloud cover and precipitation within the Catskills, and explains the drastic variations in rainfall between Catskill basins (Figure 4).

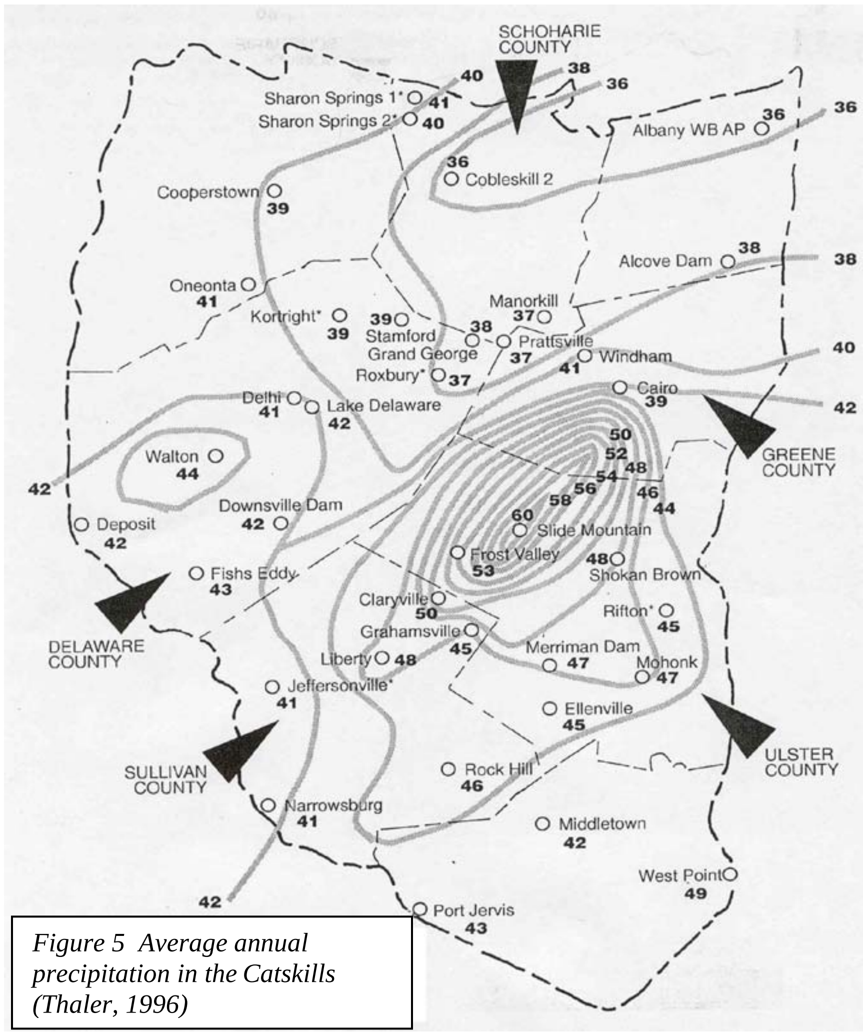

Figure 5 Average annual precipitation in the Catskills (Thaler, 1996)

Global Climate Change Effects on the Watershed

Global climate change may impact the Rondout basin in coming years. Greenhouse gases are trapping energy in our atmosphere that would normally be lost to space and causing global temperatures to rise. This warming is a natural phenomenon that provides enough heat to allow humans to thrive on earth, but the burning of fossil fuels, and the atmospheric concentration of other gases such as methane, have dramatically increased the rate of warming (Figure 5). Based on local data collected between 1952 and 2005, researchers have concluded that a broad general pattern of warming air temperatures, increased precipitation, increased stream runoff and increased potential evapotranspiration has occurred in the Catskills region (Burns et al., 2007).

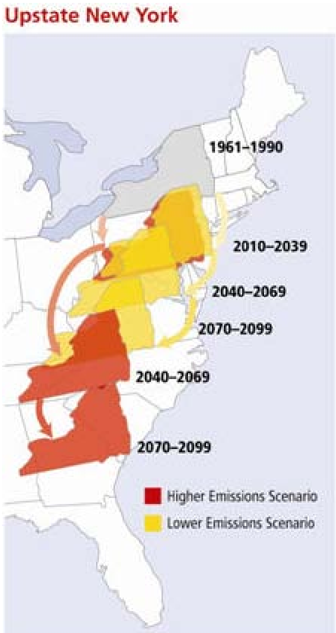

Figure 6. Projected climate "migrations" for Upstate, NY based on average summer heat index, under the lower (yellow)- and higher-emissions (rust) scenarios. Based on the average of the GFDL, HadCM3 and PCM model projections (Frumhoff et al., 2006)

Temperature increases will have effects on food production, plants, wildlife, invasive species, flooding, drought, snowfall and the economy. Based upon current climatic trends, our climate may migrate to the extent that by the end of the century, summers in upstate New York may feel like Virginia (Figure 5) (Frumhoff et al., 2006). This climatic migration will affect plant and animal life, allowing new warmer climate species to thrive at the expense of our traditional plants and animals. The number of snow-covered days across the Northeast is decreasing, as less precipitation falls as snow and more as rain, and as warmer temperatures melt the snow more quickly. By the end of the century, the southern and western parts of the Northeast could experience as few as 5 to 10 snow-covered days in winter, compared with 10 to 45 days historically (Frumhoff et al., 2006). Decreased snowfall and increased rainfall would have negative effects on stream flows and the economy of the Catskills.

Lack of snow fall will prevent streams and groundwater from receiving a slow sustaining release of water through the winter and spring. Replacing the slow release will be more intense storms,

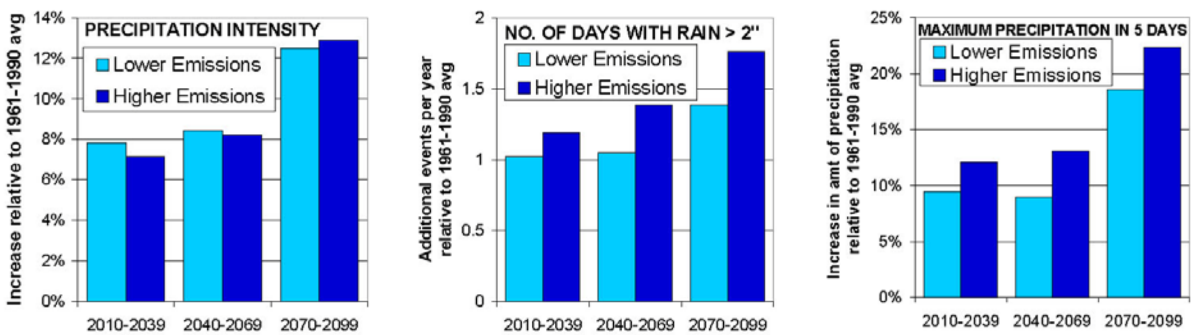

Figure 7 Projected increases in three indices of extreme precipitation: (1) precipitation intensity, (2) number of days per year with more than two inches of rain, and (3) maximum amount of precipitation to fall during a five day period each year (Frumhoff et al., 2006)

which will sporadically dump large quantities of water into the system potentially causing damaging flooding (Figure 6). However, streams will return to base flow relatively quickly once the rain stops. Modeling predictions indicate that in the next century we will see more extreme stream flows that will cause streams to flow higher in winter, likely increasing flood risk, and lower in summer, exacerbating drought (Frumhoff et al., 2006). Changing the dynamic of the hydrologic cycle would also impact the NYC water supply system, forcing potential changes in operational measures.

Because we do not have a clear understanding of all of the impacts of climate change, stream managers need to employ the "no-regrets policy" with regard to their current management actions and policies. The no-regrets policy is the recognition that lack of certainty regarding a threat or risk should not be used as an excuse for not taking action to avert that threat, that delaying action until there is compelling evidence of harm will often mean that it is then too costly or impossible to avert the threat.

Stream managers –including streamside landowners-- need a basic understanding of how streams are formed and evolve to effectively adapt to coming changes. This will likely include training to anticipate and compare the consequences of different management options, and plan accordingly, for example, over-sizing culverts and bridge spans, leaving larger buffers of undisturbed streamside vegetation, and consider limiting new development of infrastructure or personal property in areas where conditions indicate a high risk of the stream channel shifting across the floodplain [or flooding?].

References

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Thaler, J.S. 1996. Catskill Weather. Purple Mountain Press, Fleischmanns, NY.

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