Hydrology

Hydrology is the study of the properties, distribution, and circulation of water in the atmosphere, on the earth's surface, and underground. This chapter describes the surface water and groundwater resources of Dutchess County. Atmospheric water is discussed in the Climate chapter.

Water is a renewable resource that is continuously recycled through a process referred to as the hydrologic cycle, depicted in Figure 4.1. Within this cycle, water enters the atmosphere by evaporating from large water bodies, streams, and ponds, and by transpiring from plants. This water vapor condenses into clouds and eventually falls back to earth as precipitation in the form of rain, snow, sleet, or hail. In this manner, water that evaporates from the Great Lakes can be transported to New York State to fall as a warm spring rain.

The Hydrologic Cycle

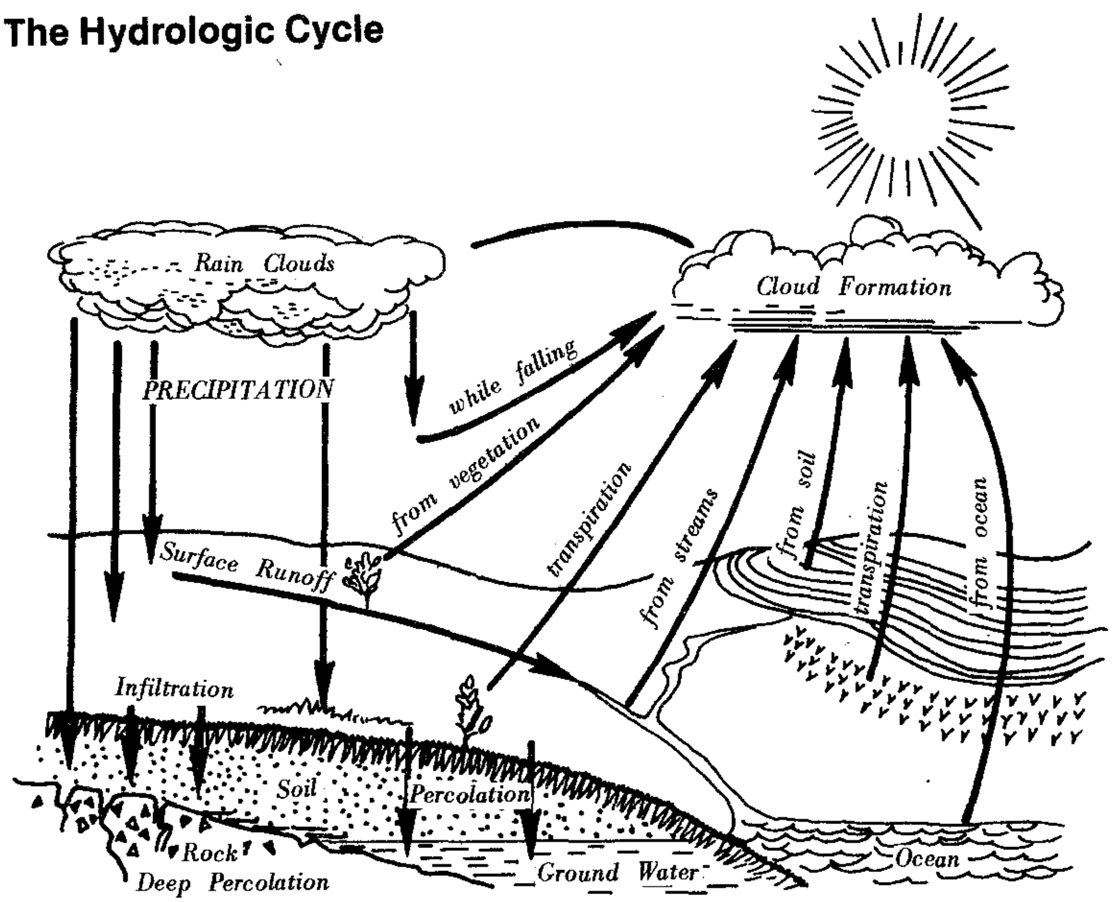


Figure 4.1

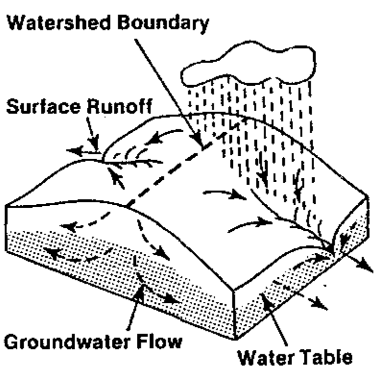
Some of this rain water may evaporate immediately. Plants will take part of it into their roots. The rest will run off into brooks, streams, and rivers or seep into underground water storage areas, called aquifers, where it can be tapped for human use. Some may find its way into deep aquifers through cracks in the underlying bedrock. It may be stored there for centuries before working its way to the surface to evaporate, thus closing the cycle. In effect, the hydrologic cycle is an enormous distillery, powered by the sun and gravity, which renews our water resources.

Human activity can have a profound impact on this natural cycle. Our water resources are increasingly threatened by pollution and misuses that can be related to the way we use our land. For example, urban development commonly results in paving over large areas of land. This increases water runoff, decreases infiltration to groundwater, and aggravates downstream flood problems. One result is an annual toll in human lives and property damage from flooding; diminishing groundwater supplies can be another. Water quality is increasingly threatened by pollution from pavement runoff, excessive use of fertilizers and pesticides, failing or inadequate septic systems and landfills, erosion from poor farming and land clearing practices, and improper disposal of hazardous wastes. Understanding the county's water resources is essential if they are to be protected from these threats.

Drainage Basins and Watercourses

Water drains from the land surface through drainage features ranging from rivulets in shopping center parking lots to large rivers like the Hudson. The entire area drained by a particular rill, creek, stream, or river is called a drainage basin or watershed. The ridge that nearly encircles a drainage basin and separates one basin from another is called the basin or watershed boundary. Figure 4.2 illustrates how this boundary affects the direction of water flow in adjacent basins.

Water Flow at the Watershed Boundary



Redrawn from Marsh, Environmental Analysis for Land Use and Site Planning 1978, page 65.

Figure 4.2

A hierarchy of drainage basins covers any land area. For example, each small tributary of the Little Wappinger Creek has its own drainage basin, and is included in the 33.4 square-mile watershed of the Little Wappinger Creek. This watershed is considered part of the 210 square-mile Wappinger Creek basin. The Wappinger watershed, in turn, is included in the lower Hudson subdivision of the Hudson River watershed, shown in Figure 4.3.

All of the water within a given watershed is part of the same hydrologic system. Watersheds, therefore, are the most appropriate geographic area for the study of water resources, the development of water resource management strategies, and the development of comprehensive waste treatment plans. Because all land uses both depend on and influence the quality and quantity of water supplies, watersheds are also the most logical physical units for natural resource management and land use planning.

Table 4.1 Major Drainage Basins in Dutchess County

Basin	Size (square miles)	Percent of County Area
Hudson River	140	17
Wappinger Creek	210	26
Fishkill Creek	194	24
Tenmile River	209	26
Croton River and Roeliff Jansen Kill	54	7
Total	807	100

Source: Ayer and Pauszek, Streams in Dutchess County, 1968.

Hudson and Housatonic Drainage Basins

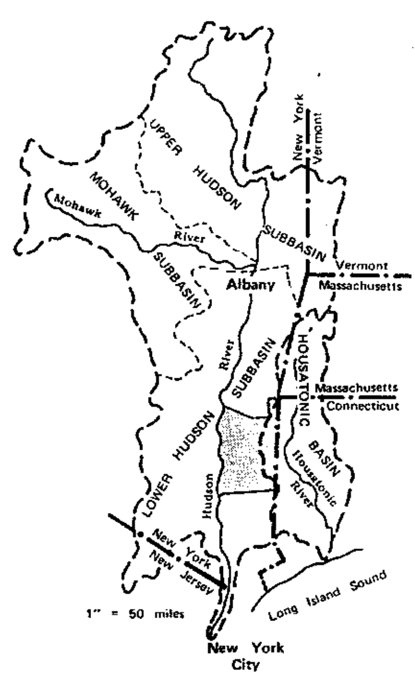
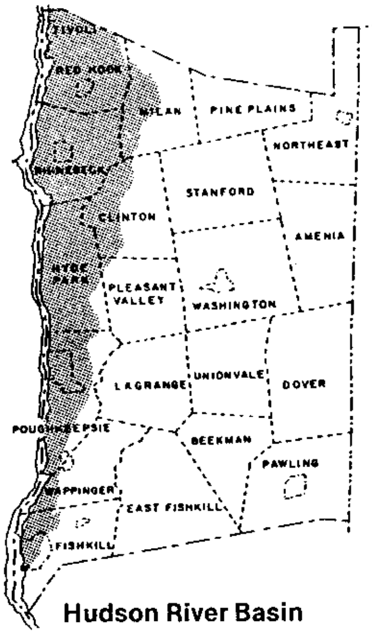


Figure 4.3

Most of Dutchess County is within the Hudson River drainage basin. As shown in Figure 4.3, a portion of the Harlem Valley drains into the Housatonic River in Connecticut. Within these two major basins, as indicated on the Drainage Basin Map, there are four primary watersheds in the county: the Wappinger, the Fishkill, the Hudson, and the Tenmile. Wappinger Creek, the Fishkill Creek, and numerous smaller streams that feed directly into the Hudson drain approximately 67 percent of the county's 807 square miles. The Tenmile River basin, which is part of the Housatonic basin, covers nearly 210 square miles or 26 percent of the county, including all of Dover and Amenia and most of Northeast and Pawling. The remaining 7 percent of the county is divided between two other watersheds. A small area in the southeastern corner drains into the Hudson River via the Croton River, through Putnam and Westchester counties. Part of the northeastern section of the county drains into the Hudson River via the Roeliff Jansen Kill and its tributaries. The appendix contains a detailed list of the lengths, drainage areas, and elevations of most of the streams in Dutchess County.



Hudson River Basin

Hudson River Basin

The Hudson River basin covers a relatively small area and discharges a low volume of water compared to other major river basins in North America. The river is tidal from its mouth in New York City to the locks at Troy. Fresh water meets salt water in a transition zone generally found below Chelsea, in the town of Wappinger.

Surface water from the Hudson River shore towns of Poughkeepsie, Hyde Park, Rhinebeck, and Red Hook drains directly into the Hudson River via streams that serve small secondary watersheds. These secondary basins within the Hudson basin include Stony Kill, Saw Kill, Landsman Kill, Crum Elbow, Fallkill, and Casper Creeks.

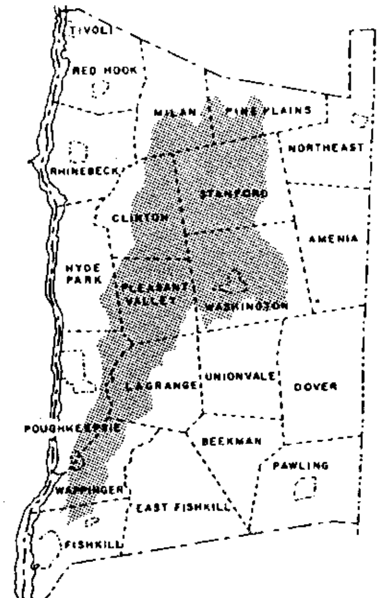
The sizes of the secondary watersheds within the Hudson River drainage basin range from one-half square mile to 30 square miles, averaging 20 square miles. Many of these watersheds include areas in more than one town. In times of heavy precipitation the relatively small size of these basins results in fairly uniform distributions of stormwater runoff. Flooding in these small watersheds is localized, therefore, and less severe than that which can occur along major waterways, such as the Tenmile River. However, poorly planned development in the urban and suburban portions of the basins could cause drainage and flooding problems in the future.

As previously described, the Wappinger and Fishkill Creeks are within the Hudson River basin. However, because of their size and significance in the county's hydrologic system, these two creeks are discussed separately below.

Wappinger Creek Basin

The Wappinger Creek and its tributaries drain approximately 210 square miles, roughly one-fourth of Dutchess County. The drainage area is 30 miles long, extending southwest from the town of Pine Plains toward New Hamburg at the southern tip of the town of Poughkeepsie. The width of the basin ranges from ten miles in the north to four miles in the south. Three primary branches--the Little Wappinger, the Main Branch, and the East Branch--drain the northern area before converging near Salt Point in the town of Pleasant Valley. The Wappinger drainage basin includes large parts of the towns of Pleasant Valley, Washington, Pine Plains, Milan, Stanford, and Clinton, as well as portions of the towns of Wappinger, Poughkeepsie, and LaGrange. In the lower basin the creek receives runoff from the county's most intensely developed areas.

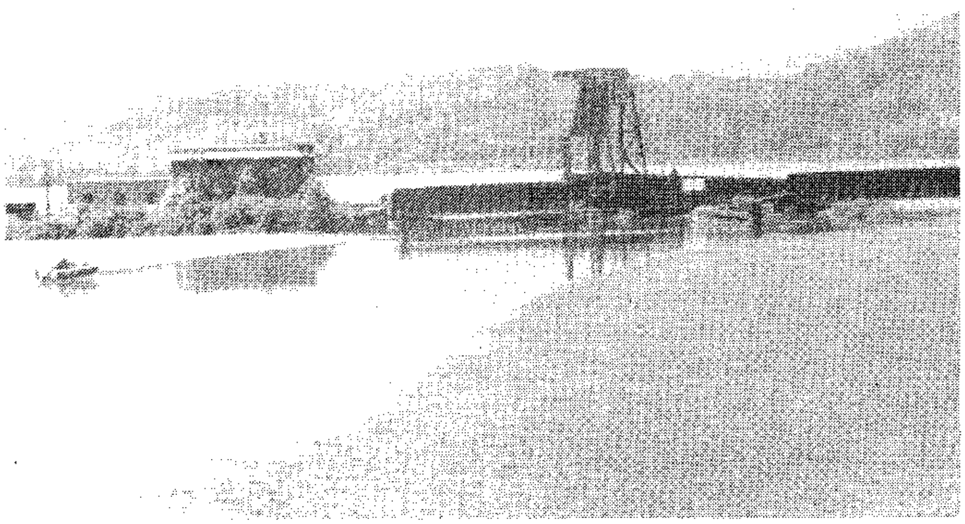
The topography of the Wappinger Creek drainage basin is varied, ranging from nearly flat meadows along the creek to the rocky slopes of Stissing Mountain, the highest point in the watershed at 1,403 feet above sea level. Most of the principal tributaries are permanent streams with elevations of 400 to 600 feet and average gradients of 10 to 15 feet per mile. The water rarely descends, however, at the average rate. Instead, it falls fastest along the steep upstream portion of the creek, especially where hard rock ridges in the stream bed have resisted erosion and created waterfalls.



Wappinger Creek Basin

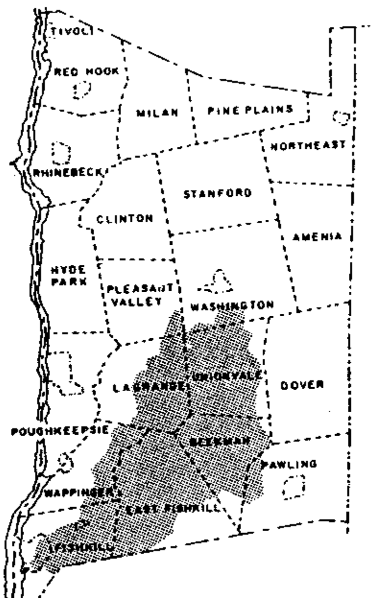
Much of the land along Wappinger Creek and its major tributaries is subject to flooding. The section downstream of the confluence of the Little Wappinger and the East Branch, at Salt Point, is especially floodprone. The entire flow from the expansive upper basin, which is three times as large as the lower portion of the watershed, funnels through this section of the creek.

The lower portion of the Wappinger basin is more urban than the upper basin, and contains large expanses of land sealed by pavement or buildings. This urbanization aggravates flood hazards by increasing the volume and speed of storm runoff; this increase, in turn, often overloads the storm drainage capacity of lowlands along the creek. Several settlements in these floodplain lowlands, including the hamlet of Pleasant Valley, the Overlook section of the town of LaGrange, and the Shady Brook Trailer Park in the town of Poughkeepsie have suffered severe flood damage in the past.



Fishkill Creek Basin

The Fishkill Creek basin covers approximately 194 square miles. Like the Wappinger basin to its north, it is long and narrow. Stream gradients are also similar. Fishkill Creek, the basin's primary stream, begins in the



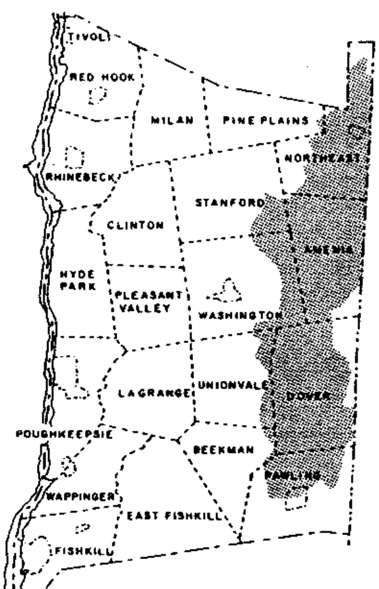
Fishkill Creek Basin

center of the county in Unionvale. From there it flows southwest, entering the Hudson River at Beacon. It drains a large part of Unionvale, Beekman, East Fishkill, and Fishkill. Sprout Creek, Fishkill Creek's primary tributary, drains major sections of LaGrange and Unionvale and small portions of Wappinger and East Fishkill.

The creeks in the Fishkill basin drain comparatively flat farm land and wetlands. In the upper reaches of the basin the stream drops slightly more than 200 feet in 10 miles. In the lower portion, where Fishkill Creek falls over slate and limestone ledges, the gradient is 200 feet in 5 miles. Most of the Fishkill Creek is 1 to 2 feet deep and less than 50 feet wide during periods of moderate flow. Tributaries funnel runoff from the upstream portion of the Fishkill Creek basin into the main stem at Lomala, along the Fishkill-East Fishkill boundary. As in the Wappinger Creek basin, this funneling effect increases the burden on downstream lowland areas during periods of heavy runoff, and can lead to flooding. The problem of inappropriate land uses in floodprone areas is not as evident in the Fishkill basin as in the Wappinger.

Tenmile River Basin

The Tenmile River drains 210 square miles in the eastern section of Dutchess County, from the Columbia County line south to the town of Pawling. The basin ranges from 5 to 8 miles wide, is 33 miles long, and is served by four principal watercourses: the main stream, Swamp River, Webatuck Creek, and Wassaic Creek. The Tenmile River falls an average of 16 feet per mile as it travels its narrow path southward from the town of Northeast, through the Harlem Valley lowlands in Amenia and Dover, to enter Connecticut near Dogtail Corners. The Swamp River, which flows north from the heart of Pawling, joins the Tenmile River south of Dover Plains.



Tenmile River Basin

The Tenmile River and its tributaries wind through extensive floodplains and wetlands. During periods of increased runoff these areas retain flood waters, helping to minimize downstream flooding. Because the Tenmile River basin is not as developed as other drainage basins in the county, there are still many opportunities to preserve the functional and wildlife values of these wetlands and floodplains while accommodating agricultural activity and growth. Homesites have, however, been developed within the Tenmile River floodplain along Lime Kiln Road, south of Dover Plains. The results of such development have been property damage to residents of flood prone areas and increased public costs for flood relief and flood management efforts.

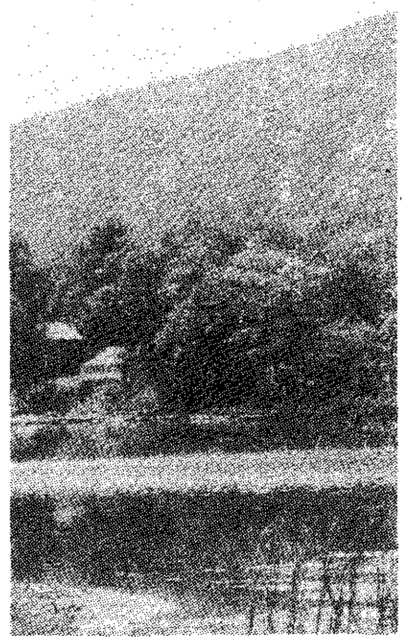
Surface Water Quantity

Dutchess County is fortunate to have abundant surface water resources. More than 600 miles of named streams traverse the county, as listed in the appendix. Unnamed streams and tributaries bring the total to more than 800 miles.

Table 4.2 Lakes and Ponds
Dutchess County, New York
(25 Acres or Larger)

Name	Location	Approximate Size in Acres
Abel's Lake	Unionvale	39
Black Pond	East Fishkill	176
Bontecou Lake	Washington	113
Lake Carvel	Pine Plains	38
Cobalt Lake	Poughkeepsie	29
Crane Pond	Dover	38
DeFlora Bros. Lake	Hyde Park	43
Dieterich Pond	Millbrook	32
Lake Dutchess	Pawling	51
Ellis Pond	Dover	61
Green Mountain Lake	Pawling	35
Halcyon Lake	Pine Plains	26
Hillside Lake	East Fishkill	26
Hunns Lake	Stanford	68
Indian Lake	Northeast	194
Little Whaley Lake	Pawling	52
Long Pond	Clinton	66
Nuclear Lake	Pawling	55
Quaker Lake	Pawling	64
Round Pond	Amenia	49
Round Pond	Milan	40
Rudd Pond	Northeast	76
Sepasco Lake	Rhinebeck	26
Sharpe Reservation Pond	Fishkill	26
Shaw Pond	Washington	26
Silver Lake	Clinton	113
Spring Lake	Milan	26
Stissing Lake	Pine Plains	78
Swift Pond	Amenia	61
Sylvan Lake	Beekman	116
Thompson Pond	Pine Plains	68
Twin Island Lake	Pine Plains	62
Tyrrel Lake	Pleasant Valley	45
Upton Lake	Stanford	43
Lake Walton	East Fishkill	42
Wappingers Lake	Wappingers Falls	122
Lake Weil	Dover	34
Whaley Lake	Pawling	287

Source: Dutchess County Department of Planning.



Unlike Putnam County to the south, Dutchess County is not well-endowed with large lakes and reservoirs. There are, however, 93 named lakes and ponds in Dutchess and dozens that are unnamed. Many were artificially created. Lakes larger than 25 acres are listed in Table 4.2. The largest lake in the county is Whaley Lake in the town of Pawling.

The Hudson River is by far the county's largest supplier of drinking water, providing more than 11.7 million gallons per day (mgd) to the city and town of Poughkeepsie and the village of Rhinebeck. With an average outflow of nearly 19,700 cubic feet per second (cfs), the Hudson remains the largest and last undeveloped surface freshwater source in southeastern New York. It has the capacity to supply drinking water to all of the county's urban and suburban areas.

The 1980 census indicates that 60 percent of the county's total population of 245,055 is served by community surface or groundwater systems; the remaining 40 percent relies on private domestic wells. Approximately 70,000 people in the county use Hudson River water; another 24,000 draw at least part of their water from surface supplies. In addition to the 11.7 mgd from the Hudson, community surface and groundwater systems provide 10.4 mgd to county residents.

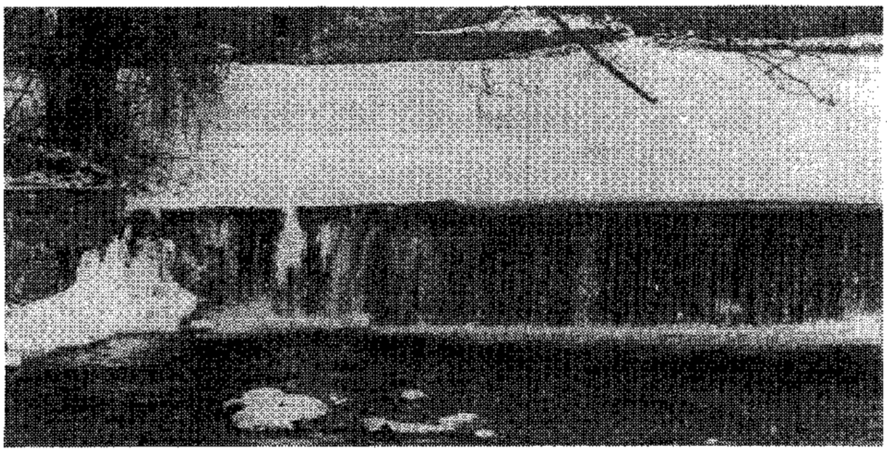
New York City has established a Hudson River tap and pumping station at Chelsea in the town of Wappinger as a precaution against water shortages in its upstate system. Although the Chelsea tap has not been used for many years, it could draw significant quantities of freshwater from the river if the need arose.

The salt front of the Hudson River shifts regularly and predictably along the southwestern border of the county. It moves with the balance between the upstream inflow of freshwater and the downstream forces of the ocean tides. Increased use of the upper Hudson River for water supplies and power plant cooling water could increase the likelihood of the salt front advancing north of Chelsea. Under such conditions the suitability of Hudson River water as a source of drinking water for Dutchess County and as an emergency source for New York City could deteriorate.

If precipitation remains constant and water quality improves, the three major streams in the county could accommodate substantial increases in demands for drinking water. However, precipitation is not constant; variations produce stream flow fluctuations which, in turn, affect both the quantity and quality of water available. Wide stream flow fluctuations have occurred in the past.

From 1928 to 1965, the flow of the Wappinger Creek near the village of Wappingers Falls ranged from 0.9 to 18,600 cfs, with an average of 236. The flow of the Tenmile River near Gaylordsville, Connecticut ranged from 7 to 17,400 cfs during the same period, with an average of 287 cfs. From 1944 to 1965, the flow of the Fishkill Creek at Beacon ranged from 0.4 to 8,800 cfs, with an average of 279 cfs. Even under severe drought conditions the three major streams sustained some flow.

The combined average flow of the Tenmile River, Fishkill Creek, and Wappinger Creek today is 840 cfs, or 543 million gallons per day. The flow may be below average 70 percent of the time. Excessive stream flow and flooding occur after severe storms, such as the hurricanes that struck the county in 1938 and 1955, and during spring runoff periods.



Little information has been collected about recent flow rates of the county's streams and rivers. At one time, the U.S. Geological Survey monitored water flow rates at 13 stream locations in the county, and once participated in a study of flow rates at 24 stream sites. Today, the USGS operates only two gaging stations: one on the Tenmile River near the Connecticut line, and another on the Wappinger Creek near Wappingers Falls. The scarcity of up-to-date information about surface water flow rates makes it difficult to assess the hydrological impacts of recent land use changes on the county's watersheds.

Many public wellfields tap aquifers adjacent to the county's major interior waterways. At present no public water supplies are drawn directly from these larger streams and rivers. Several smaller streams or reservoirs, however, do provide water for community systems in Beacon, Hyde Park, and the village of Pawling as well as for large institutions in Dover, Beekman, and Red Hook.

Table 4.3 Runoff Coefficients for Uniform Level Surfaces

Surface Type	Approx. Fraction of Rainfall that Runs Off Surface[1]
Asphalt or concrete paving, roofing, other waterproof surfaces	.90
Bituminous macadam	.85
Compacted earth and gravel without vegetation	.70
Impervious soil with vegetation	.50
Gravel	.30
Gardens and lawns	.20
Farmland and meadows	.15
Woodlands	.10

Source: Kelly, H., Planning Guidelines for Dutchess County Drainage, 1968, and

Lynch, K., Site Planning, 1971.

[1]Coefficients should be adjusted to reflect land use of entire tributary area, site slopes, soil characteristics, and other variable factors.

Land use has a dramatic effect on the amount of water that finds its way into the county's streams and rivers. The conversion of forest and agricultural land to urban and suburban uses increases the number of water users while decreasing the amount of open land available to absorb, store, and filter surface and groundwater supplies. The fraction of total rainfall that runs off a site increases rapidly as the permeability of the site surface decreases. This relationship is indicated by the runoff coefficients listed in tables 4.3 and 4.4. Woodlands, for example, usually absorb 90 percent of the rainfall they receive; the percentage may be lower on steep wooded hillsides, and considerably higher in nearly level, dense woods with highly porous soils. When woodlands are cleared and developed for commercial uses, the portion of rainfall absorbed can drop to 1 to 10 percent, leaving 90 to 99 percent to run off the site.

A normal amount of runoff is necessary to sustain the county's lakes, ponds, wetlands, and streams, and the

Table 4.4 Runoff Coefficients for Composite Land Uses

Land Use Type	Approx. Fraction of Rainfall that Runs Off Surface[1]
Residential lots	
2 acres and larger	.15
1/2 - 2 acres	.25
15,000 ft.^{2}, (.34 acre) to 1/2 acre	.30
7,000 ft.^{2}, (.16 acre)	.40
40 dwelling units per acre (1,089 ft.^{2}, each)	.50-.70
Industrial uses	.60
Commercial uses	.75
Dense urban commercial use	.70-.90

Source: Kelly H., Planning Guidelines for Dutchess County Drainage, 1968, and

Lynch, K., Site Planning, 1971.

[1]Coefficients should be adjusted to reflect land use of entire tributary area, site slopes, soil characteristics, and other variable factors.

uses and natural communities they support. The large volumes of runoff shed by developed sites, however, can adversely affect drainage systems, surface water volume and quality, flood patterns, soil erosion rates, and groundwater supplies. Careful land use practices play an essential role in minimizing these impacts and ensuring that adequate supplies of clean water will be available in the future.

Surface Water Quality

Both natural processes and human activities affect water quality. The types of rocks and soils that water passes through, the length of time it remains in contact with them, and the amount of soil that water carries in suspension are all natural factors that influence water quality. Erosion is one form of natural "pollution" that can be greatly increased by poor land use management practices. Other human activities may adversely affect water quality by discharging physical, chemical, or thermal pollutants into water bodies.

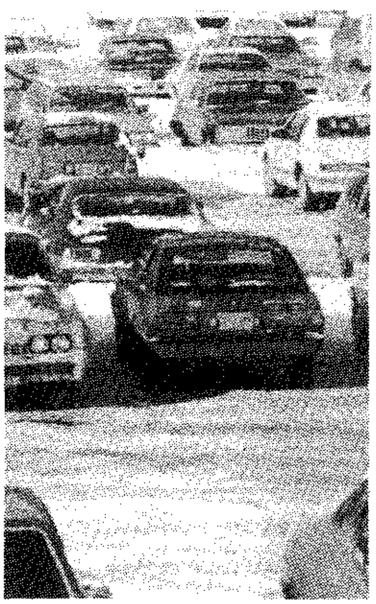
Natural Factors

The type and quantity of minerals in solution determine water hardness. For example, large concentrations of magnesium and calcium make water hard. Hardness is often recognized by its soap-consuming character and by the tendency of the minerals to form solid deposits, called precipitates, in the water. Many streams in Dutchess County have hard water. Some of the minerals in such water have beneficial effects. Fluoride concentrations of one milligram per liter (mgl), for example, are known to reduce the incidence of dental cavities. Water in Dutchess County was found to have significant natural fluoride content during a sampling period from 1970 to 1975.

Groundwater usually has a higher dissolved mineral content than surface water because of its increased contact with rocks and soil. Because most streams are fed by ground sources, they often show some of the hard-water characteristics of groundwater. This phenomenon is most pronounced during dry periods; after a heavy rainfall, or during snowmelts, the concentration of dissolved minerals in these streams is diluted.

Human Influences

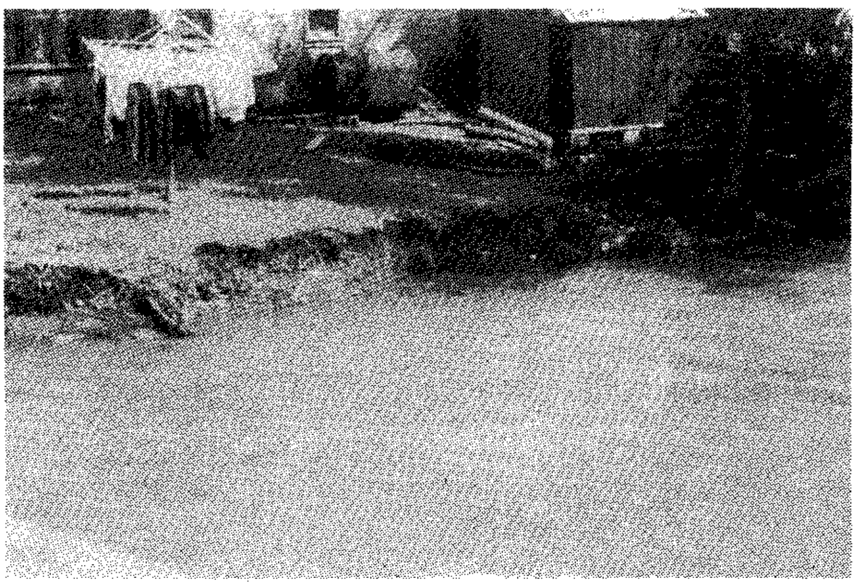
Water pollution caused by human actitivies may appear in the form of dissolved and particulate solids, biodegradable and non-biodegradable organic materials, infectious agents, nutrients, toxic substances, or unnatural changes in heat, taste, odor, and color in ground and surface waters. Selected sources of these pollutants, their effects on water, and ways to prevent and abate such pollution are listed in the appendix.



Information about Dutchess County's surface water quality is spotty and inconsistent. A 1981 report by the New York State Department of Environmental Conservation (DEC) examined 19 county streams, lakes, and ponds considered to be under stress from various pollutants. The major suspected pollution sources named in the report were landfills, petrochemical-laden runoff from parking lots and streets, and failing septic tanks. Industrial waste discharges, sediment, agricultural chemicals, and sewage treatment plant discharges have also been identified as sources of water pollution. The DEC report was based on past tests or observations by government officials. No large-scale program for systematically monitoring the quality of the county's surface waters is currently in place.

The flow rate is a major factor in determining a stream's ability to absorb wastes. With increased flow this assimilation capacity increases if other factors affecting purification, such as waste type and quantity and water temperature, are held constant. Low flow periods, therefore, are critical times for maintaining water quality.

Upstream erosion and pollution are gradually choking many of the county's lakes and ponds. Materials carried downstream fill the lakes with silt and accelerate the natural eutrophication process through which lakes evolve into dry land. Eutrophic lakes are of limited use for recreation or water supply. Controlling erosion and pollution discharges is an essential step in prolonging the useful life of these water resources.



Acid rain is gaining recognition as a serious pollution problem. As a result of the combustion of tremendous quantities of fossil fuels, such as coal and oil, the United States annually discharges approximately 50 million metric tons of sulfur and nitrogen oxides into the atmosphere. Through a series of complex chemical reactions some of these pollutants are converted into acids, which return to earth in rain or snow. As discussed in more detail in the Climate chapter, investigators have concluded that acid rain and the chemical changes it seems to induce in soil and runoff water are responsible for the destruction of plant and animal life in hundreds of Adirondack lakes. Studies report that acid rain has damaged buildings, significantly increased the acidity of surface waters, and affected forests throughout the midwestern and northeastern United States and Canada, but the true magnitude of the problem is still under debate. Studies of the impact of acid rain on the Hudson Valley are underway.

Hudson River water is known to contain at least 26 toxic chemicals, including federal priority pollutants such as PCBs, DDT, arsenic, cadmium, mercury, and cyanide. Recent studies indicate that 225 facilities in four states, including 208 permited facilities in New York, discharge toxic chemicals into the river. The most commonly discharged pollutants are oil and grease, which contain carcinogenic benzene and lead.

The Hudson is considerably cleaner than it was in the 1960s and early 1970s, before major water pollution control laws were passed. The presence of toxic chemicals in discharges and in river-bottom sediments, however, fuels a continuing debate about the river's suitability as a drinking water source, and raises questions about the need for more extensive water and waste treatment systems.

Water Quality Standards

The federal and New York State governments have developed water quality and purity standards. The Federal Water Pollution Control Act of 1972, as amended, imposes strict standards on water quality and pollutant levels. Part 701 of the 1974 New York Environmental Conservation Laws outlines the water quality and priority classifications and standards for New York State.

Under New York State law, fresh surface waters are classified according to their present quality and the "best" or most pollution-sensitive uses for water of that quality. The New York State Department of Environmental Conservation (DEC) applies standards that correspond to these classifications when reviewing stream disturbance or pollutant discharge permit applications. This is to prevent the existing water quality from deteriorating. The major classifications are listed in Table 4.5.

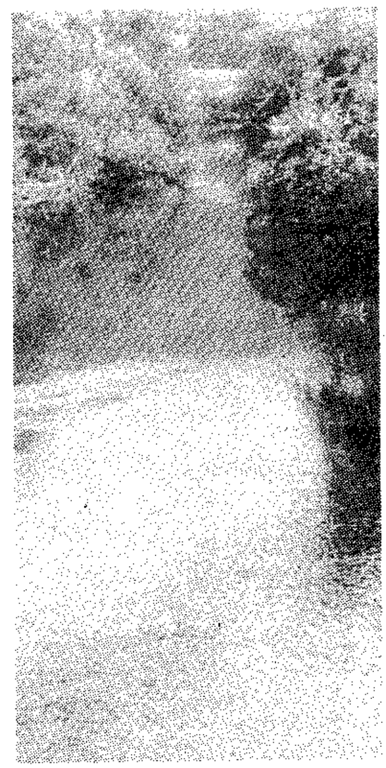
Table 4.5 Stream Classifications

Class	Best Use
AA	Drinking (after chlorination)
A	Drinking (after chlorination and filtration)
B	Bathing
C (t)	Fishing (trout)
C	Fishing
D	Secondary contact recreation

Source: NYS Department of Environmental Conservation.

Most of the streams, rivers, lakes, and ponds within Dutchess County are Class B, C, or D. Some of the more significant AA and A streams and lakes are listed below:

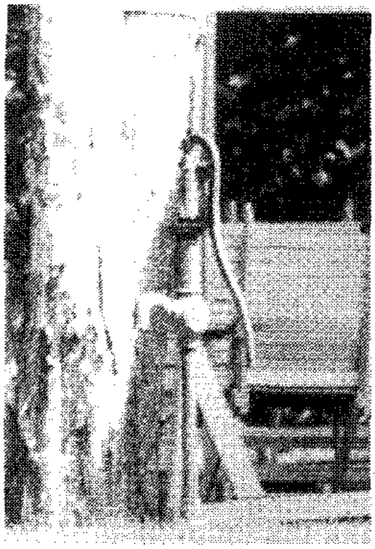
- Clove Creek - at Fishkill water supply
- Crum Elbow Creek and tributaries - upstream of Hyde Park Fire and Water District intake
- Ellis Pond
- Fishkill Creek - at Beacon water supply
- Gardiner Hollow Brook - at Green Haven State Prison water supply
- Green Mountain Lake
- Hiller Brook and tributaries - at Pawling Village water supply.
- Indian Kill - at Staatsburg water supply
- Long Pond
- Pawling Reservoir
- Silver Lake
- Swamp River - at Harlem Valley Hospital water supply
- Tenmile River, wells, stream, and tributaries - at at Dover Plains auxiliary water supply
- Tributaries of Cargill Reservoir



These classifications affect, but do not unduly restrict, land uses along waterways. If wastes are treated to satisfy the appropriate standards, they can be discharged under permit. The standards protect the rights and property values of landowners along water courses by protecting them from water pollution. Stream classifications are periodically revised by the New York State Department of Environmental Conservation. Public hearings are an integral part of the reclassification process.

Groundwater Resources

Groundwater is the supply of water beneath the earth's surface. After precipitation is absorbed by soil, it travels beneath the surface and is stored in a water-saturated underground layer of earth, unconsolidated deposits, or porous stone. Aquifers are natural groundwater reservoirs that recharge surface streams, support plant life, and provide water for drinking, home, and industrial use.



The importance of the county's groundwater is often underestimated because aquifers are out of sight and difficult to measure. Yet, at least 60 percent of the county's population relies on community or individual wells. Wells serve as back-up or auxiliary supplies for another 15 to 25 percent of county residents. Many of these wells draw on groundwater supplies that lie outside sand and gravel or limestone aquifers, and they often give yields that are low compared to the volumes of water that the major aquifers can provide.

The largest and most productive aquifers occur along the county's major stream and river valleys, where thick glacial deposits of sand and gravel overlie limestone. As shown on the following Groundwater Occurrences Map, these aquifers are found in the Harlem Valley along the Tenmile and Swamp Rivers, along the Wappinger Creek, and along the Fishkill Creek. Extensive sand and gravel deposits also exist along the Sprout Creek in East Fishkill and LaGrange, the east branch of the Wappinger Creek in Washington, and the Sawkill Creek in Red Hook. Relatively little is known about the boundaries and interrelationships of these aquifers, their capacity, their quality, or their sensitivity to development pressures.

As explained in the Geology chapter, the water-bearing characteristics of unconsolidated deposits vary widely because of differences in porosity and permeability. Permeability is a measure of the ability of a material to transmit water. In unconsolidated deposits, permeability depends on the size of the pores between the particles of sand, gravel, silt, or clay. In bedrock, permeability depends on the degree of fracturing and how well the rock fractures, crevices, and cavities interconnect. The higher the permeability of a material, the greater its potential yield as a water supply.

Porosity is a measure of how much pore space a given volume of material contains; this amount determines how much water the material can hold. The more pores there are and the larger they are, the more water can be held in storage.

Sand and gravel are especially valuable aquifer materials because they are highly porous and permeable. The pores in sand and gravel deposits are large enough to hold considerable volumes of water, while allowing water to flow easily toward wells, springs, and other discharge points. Known yields from sand and gravel aquifers in Dutchess County range from 2 to 1,400 gallons per minute (gpm). Clay, on the other hand, is an extremely dense, impermeable material whose microscopic pores and particles inhibit groundwater flow. Glacial till falls between clay and sand in porosity, permeability, and water yield. Till contains an assortment of particle types and sizes. Reported yields from wells tapping glacial till range from 1 to 180 gpm. The water storage characteristics of the county's unconsolidated deposits are discussed in more detail in Chapter Two. Reported well yields are summarized Table 4.6.

The consolidated deposits of limestone and dolostone, called the Wappinger Group, are the most productive bedrock formations in the county, with an average yield of 22 gpm from drilled wells. This productivity is due to the fact that limestone dissolves easily, allowing water to flow into the numerous channels, caverns, and fissures that characteristically develop in the rock. Water from these sources is hard, with a median mineral content of 229 parts per million (ppm), and relatively high in dissolved solids, at 316 ppm.

Table 4.6 Reported Well Yields
Dutchess County
(gallons per minute)

Formation	Range	Median	Mean
Unconsolidated Deposits			
Glacial Till	1 to 180	10	22
Clay and Silt	not available	not available	not available
Sand and gravel	2 to 1400	20	136
Bedrock			
Pelitic Rock	0 to 135	9 to 15	16
Poughquag Quartzite	2 to 30	8	10
Wappinger Group	1 to 220	13	22
Austin Glen Graywacke	0 to 135	10 to 15	16
Hudson Highlands and Housatonic Gneiss	1 to 45	8	11

Source: Unconsolidated deposit yield figures and bedrock median yields:
Gerber, Water Resources Study for Dutchess County, 1982.

Bedrock range and mean yields:
Simmons, et al., Groundwater Resources of Dutchess County, 1961.

As described in Chapter Two, much of Dutchess County's bedrock is composed of pelites, primarily shales and slates. All of the pelitic units in the county have low porosity and low permeability. The bedding planes and fissures in these rocks serve as channels for the storage and movement of groundwater. Studies by the United States Geological Survey show that yields from drilled wells in pelitic rock units and in Austin Glen Graywacke average 16 gpm, with hilltop wells yielding 14 gpm and valley wells yielding 17 gpm. The water from pelitic rock wells is relatively soft, with a median of 138 ppm, while the median content of dissolved solids is comparatively high at 234 ppm. Hydrogen sulfide affects some of the water drawn from this bedrock, resulting in a "rotten egg" odor. Water in the Austin Glen formation is moderately hard.

The more mountainous parts of Dutchess County are underlain by crystalline types of bedrock such as Hudson Highlands Gneiss and Poughquag Quartzite. Because these are denser than pelitic bedrock, there are fewer openings for water infiltration. Well yields are relatively low, averaging 11 gpm for the gneiss and 10 gpm for the quartzite. Like the pelitic rock, water from these formations is relatively soft at 138 ppm, and the median content of dissolved solids is 234 ppm.

Although Dutchess County has made considerable progress in mapping and gathering information about its aquifers, little is known about the detailed characteristics of these groundwater supplies. What is known is that improper land use practices can deplete and pollute aquifers, leaving them unfit or inaccessible for human use. The processes through which such damage can occur are described below.

Depletion

Groundwater supplies are replenished by precipitation that gradually percolates through the soil, into deposits of sand, gravel, clay, till, or bedrock formations. This process of replenishment is called groundwater recharge. Groundwater travels through subsurface deposits and into wells, streams, lakes, springs, and other discharge points.

Aquifers exist in a state of equilibrium when the rate of recharge matches the rate of water withdrawal. As water is drawn off into surface water supplies, it is replaced through groundwater recharge so that the volume of water in the aquifers remains stable. This equilibrium can persist as long as water use does not over-tax the ability of the groundwater reservoir to replenish itself.

Wherever development densities become great enough to disrupt the groundwater recharge process, groundwater supplies diminish. Water tables subside and, eventually, wells go dry. If such groundwater "mining" is allowed to continue, water supplies can permanently disappear over large areas.

Three interrelated land use practices contribute to aquifer depletion. The first is overcrowding. If the homes, businesses, industries, and institutions using wells in any area demand more water than the area's groundwater receives from rainfall and other sources, the amount of groundwater available will decrease. Often it takes many years before such steady depletion is noticed. The effect of residential overcrowding on groundwater supplies is depicted in Figure 4.4.

Effects of Overcrowding on Groundwater Supplies

1) Low Density: Plenty of water

2) Higher Density: Lower water table, but still adequate water supplies.

3) Overcrowding: Water table dropping and wells going dry.

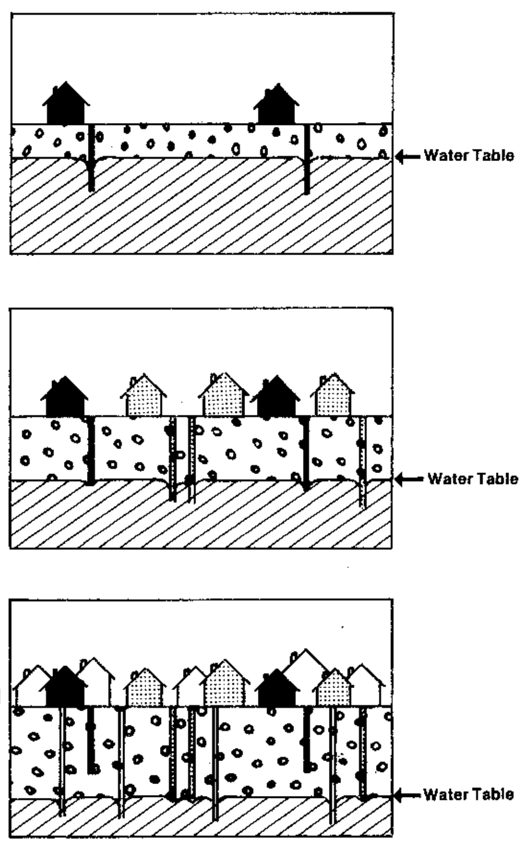


Figure 4.4

A second cause of groundwater depletion is the common practice of converting groundwater into surface water. This happens in communities and industries that depend on wells for their water supplies, and discharge their waste water into surface streams or rivers. These waterways carry the treated waste water downstream, away from the source aquifers, and prevent it from recharging the underground supplies. Individual septic systems are designed to return well water to the ground, but community sewers and industries usually discharge wastes into surface waters.

The third contributor to aquifer depletion is reduction of the aquifer recharge area. The recharge area absorbs rainfall, floodwaters, and snowmelt and allows them to filter down into the aquifer to replenish groundwater supplies. Covering the recharge area with buildings, parking lots, roads, and other impervious materials reduces the soil acreage available for recharge; rain that previously would have soaked into the soil runs off into streams and rivers instead.

The ability of groundwater supplies to sustain different land uses depends on the recharge rate of the subsurface materials as well as the land uses themselves. Thick sand and gravel deposits have an estimated natural recharge rate of 0.93 gallons per minute per acre, compared to a rate of 0.12 gpm per acre for clay and silt. These rates reflect differences in porosity and permeability that enable sand and gravel to absorb and transmit water more quickly than clay can. Recharge rates also depend on the slope of the land, the surface vegetation, and the intensity and amount of precipitation.

Table 4.7 Recharge Rates and Recommended Maximum Densities
(For Homes on Septic Systems)

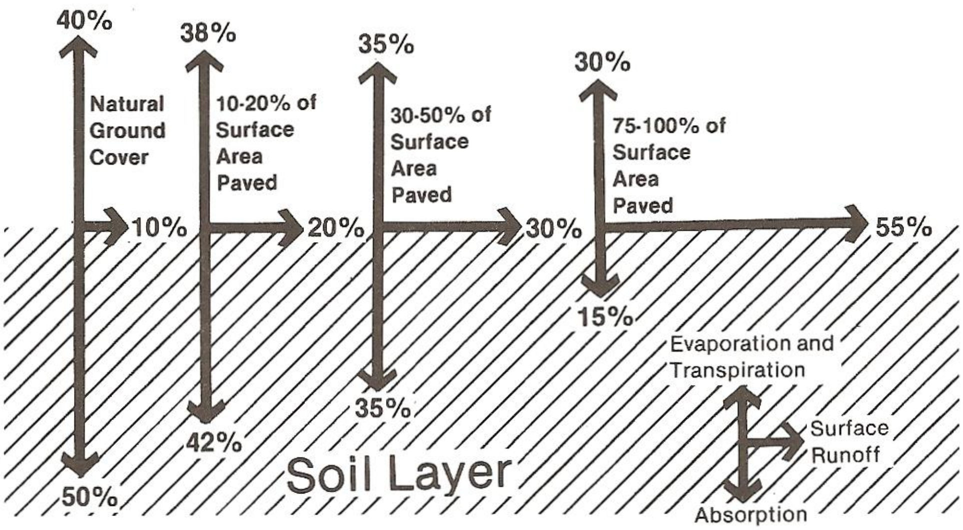
Surficial Deposit	Natural Recharge Rate (gpm/acre)	Maximum Dwellings per Acre[1]	Minimum Acres per Dwelling[1]
Thin sand and gravel	0.74	1.45	0.70
Thick sand and gravel	0.93	1.80	0.55
Thin soil over bedrock	0.35	0.70	1.40
Thick silty till	0.17	0.30	3.30
Clay-silt	0.12	0.24	4.20

Source: Hauser, E., for Dutchess County Department of Planning. Adapted from Gerber, R.G., Water Resources Study For Dutchess County, 1982.

The recharge rate decreases below the "natural rate" shown in Table 4.7 as the impervious area increases. If the total impervious area over an aquifer becomes too large in proportion to the aquifer's size and volume, or if the impervious area is located on top of the best natural recharge area, the aquifer cannot sustain itself. In residential areas, recharge rates decline sharply when densities exceed two dwelling units per acre. Densities of two or more acres per dwelling unit usually cause no appreciable reduction in recharge rates.

Figure 4.5 illustrates the relationship between the percentage of land surface that is paved and the amount of precipitation that can filter down into the groundwater. This relationship is also shown in Tables 4.3 and 4.4, discussed in the previous section. The variability of natural recharge rates underscores the importance of assessing the effects of impervious surfaces on groundwater supplies as land use decisions are made.

Effect of Paving on Rainfall Absorption, Runoff and Evaporation.



Source: Tourbier and Westmacott, Water Resources Protection Technology, 1981.

Figure 4.5

Pollution

Dutchess County's aquifers are vulnerable to contamination as well as depletion. Road deicing salts, overcrowded septic systems, landfills, and leaky petroleum or chemical storage tanks contribute to the risk of aquifer contamination. The innumerable household, commercial, and agricultural chemicals that find their way into

groundwater via septic fields, dumpsites, or direct application to the land also pose significant threats to groundwater quality.

The same characteristics that enable the county's best aquifers to absorb, store, and yield large amounts of groundwater allow them to absorb, store, and transmit pollutants. The fissures, channels, and caverns that develop in limestone bedrock, for example, make limestone highly susceptible to contamination and enable contaminants to travel great distances through the bedrock deposits. The crevices in shale and the pores in sand and gravel also permit pollutants to migrate rapidly.

Many cases of groundwater pollution have appeared in recent years. The most common pollutants fall into one of six categories:

- road deicing salts, e.g., sodium chloride, from roads and stockpiles;
- organic solvents, e.g., trichloroethylene, carbon tetrachloride, from dump sites, industrial sites, household products;
- fertilizers;
- pesticides;
- petroleum products, e.g., gasoline and heating fuel, from spills, leaking tanks, and pavement runoff; and,
- septic wastes.

In residential areas the most common groundwater contaminant is the nitrate-nitrogen discharged into leach fields. The Federal Safe Drinking Water Limit for nitrate-nitrogen in drinking water is 10 milligrams per liter. Concentrations in septic tanks usually range from 30 to 70 milligrams per liter. In soils capable of treating septic wastes, one-half of this amount is eliminated before the wastes reach the water table. The remainder enters the groundwater supply without being treated, and must be diluted to bring its concentration down to safe levels. As illustrated in Figure 4.6, overcrowding that prevents this dilution can cause serious health problems by contaminating groundwater supplies.

Maximum tolerable residential densities have been estimated for Dutchess County, based on groundwater quality considerations and geological characteristics. These densities are shown in Table 4.7. For areas that depend on septic systems and wells, recommended maximum densities range from 4.2 acres per dwelling over clays and silts, to 0.55 acres per dwelling over thick sand and gravel. These numbers are general guidelines, however, and vary with annual rainfall, slope, existing land use, surrounding topography, and other factors.

Effects of Overcrowding on Groundwater Quality

Low Density: Adequate room to filter septic wastes without contaminating wells.

Overcrowding: Septic wastes contaminating nearby wells and groundwater supply.

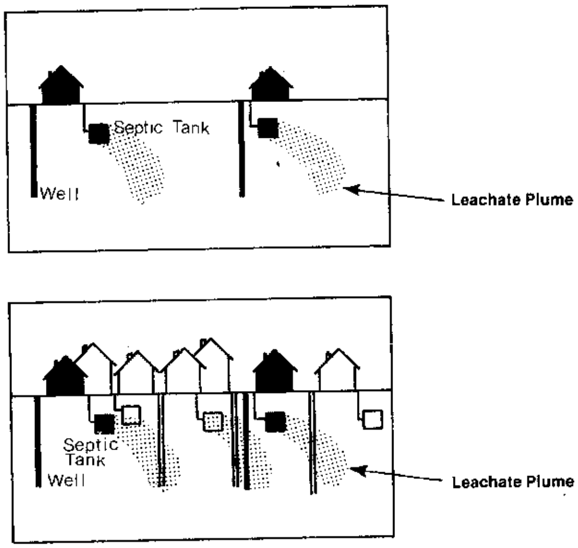
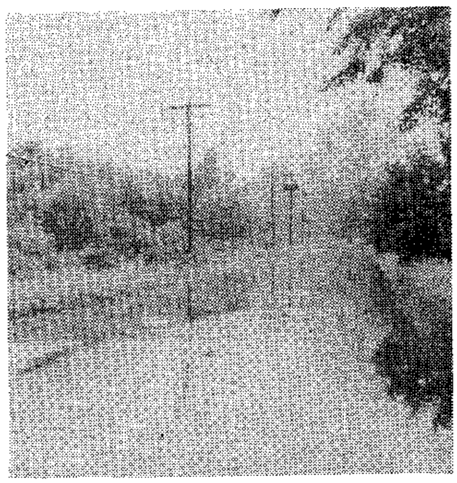


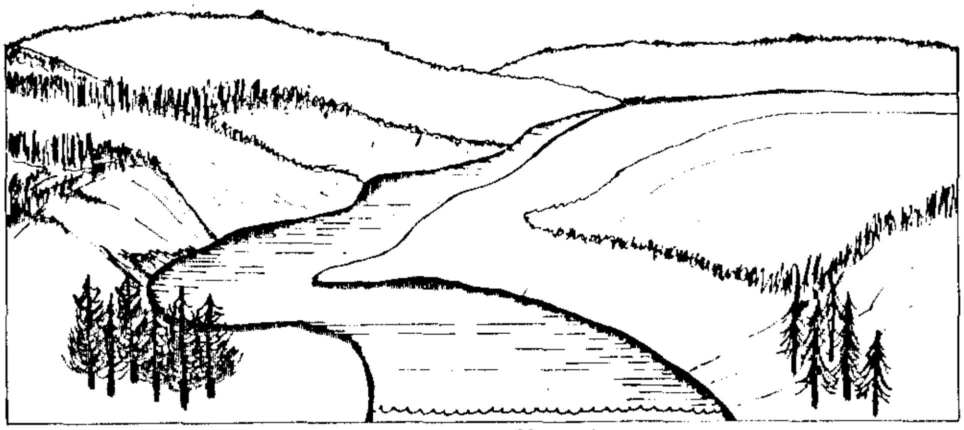
Figure 4.6

Floodplains

Floodplains are low-lying areas, normally adjacent to streams, which are inundated in times of heavy rains or severe snow melts. As shown in Figure 4.7, they act as shock absorbers in a drainage system by providing space for excess runoff. Left undisturbed, floodplains can also serve as recharge areas for groundwater supplies.



The 100-year Floodplain



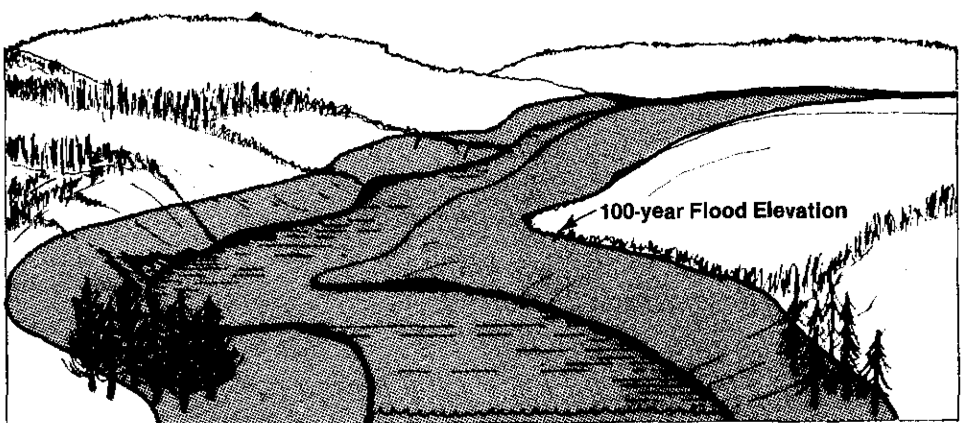


Figure 4.7

Floodplains that have a one percent chance of being completely inundated in a given year are called 100-year floodplains. Such floodplains line the river, stream, and major tributary valleys of Dutchess County. Most of them appear on the following Floodplains Map; more detailed maps of the 100-year floodplains in communities outside the county's southwestern core area are being developed. In reviewing floodplain maps, however, it is important to note that the locations of floodplain boundaries are not static. Floodplain filling, changes in the amount of developed land area, and other activities that alter the drainage characteristics of a watershed can affect the shape and size of floodplains within that watershed.

Table 4.8 100-Year Floodplain Acreages

Dutchess County Municipalities

Municipality	Approximate Floodplain Acreage	Percentage of Municipality
CITIES:		
Beacon	463	14.5
Poughkeepsie	147	4.4
TOWNS:		
Amenia	981	3.5
Beekman	944	4.8
Clinton	1,227	4.9
Dover	2,549	7.1
East Fishkill	5,436	14.8
Fishkill	1,862	10.9
Hyde Park	1,440	6.1
LaGrange	4,779	19.2
Milan	345	1.5
North East	1,102	4.0
Pawling	2,086	7.6
Pine Plains	955	4.8
Pleasant Valley	3,930	18.5
Poughkeepsie	2,260	12.1
Red Hook	1,051	4.8
Rhinebeck	760	3.4
Stanford	977	3.0
Union Vale	492	2.1
Wappinger	3,563	21.0
Washington	393	1.1
VILLAGES:		
Fishkill	96	18.1
Millbrook	121	10.3
Millerton	37	10.2
Pawling	224	17.4
Red Hook	Not available	Not available
Rhinebeck	70	7.3
Tivoli	44	4.5
Wappinger Falls	110	14.1
COUNTY TOTAL	38,444	7.5

Source: Dutchess County Department of Planning, January, 1985

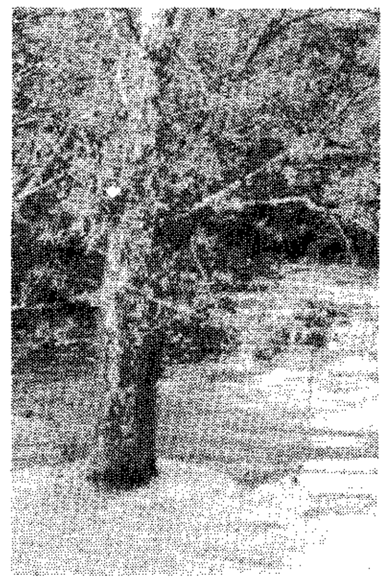
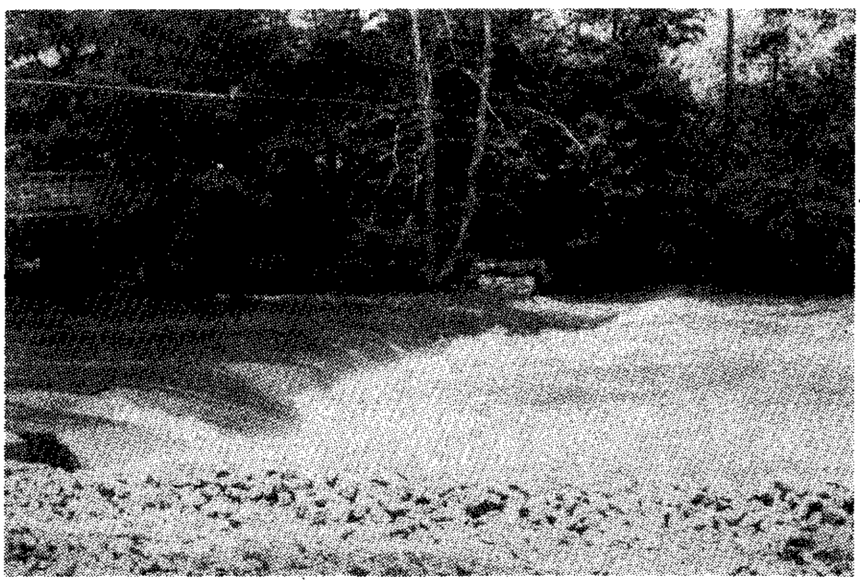


Table 4.8 indicates that 7.5 percent of Dutchess County is flood-prone, equalling approximately 38,444 acres. The floodplain acreages listed in the table, which are based on the accompanying Floodplain Map,

show that the percentage of flood-prone land ranges from zero in the village of Red Hook to approximately 21.0 in the town of Wappinger.

As previously discussed, a floodplain's ability to carry floodflows safely depends both on the types of development within the floodplain and on the land use characteristics of the watershed that the floodplain is within. The amount of runoff within a watershed increases with the amount of developed area. All of the runoff from a given watershed eventually funnels through a series of channels to the major stream or river at the watershed mouth. The floodplains along these channels become inundated more frequently and with greater volumes of water as upstream development intensifies.

Floodplain filling often increases stream velocity and level, which, in turn, endangers downstream development and erodes the stream channel. Structures such as shopping centers, industrial sites, and residential complexes that are located in floodplains often suffer water damage and, in some cases, are destroyed. Severe floods can also take lives. Proper floodplain zoning can minimize the property damage and safety hazards that inappropriate floodplain development can cause.



As described in the Climate chapter, several significant floods have occurred in Dutchess County. Flooding frequently occurs in the early spring when melting snow cannot be absorbed by the still-frozen ground. Serious floods are often the result of hurricanes or coastal storms that strike in the late summer or fall, such as those that occurred in 1938 and 1955.

Floodplain soils in the county consist of sand and silt mixtures with some gravel. The floodplains are usually fertile and flat, and often deceptively attractive development sites. The floodplains most susceptible to serious flood damage during the August and September storm season are along the lower Wappinger and Fishkill Creeks where development has already occurred. In the Harlem Valley, extensive flooding has occurred along the Webatuck Creek, the Swamp River, and the Tenmile River.

The Federal Emergency Management Administration (FEMA) has prepared detailed maps of most of the 100-year floodplains in Dutchess County. These maps are used to determine low-cost federal flood insurance rates and to develop local land use controls that comply with FEMA's requirements.

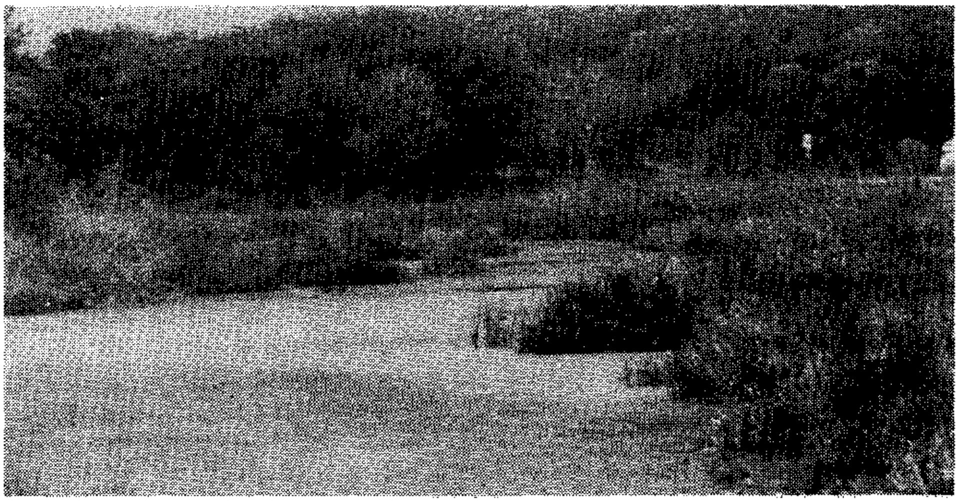
Wetlands

Wetlands are found where the water table is at or near the surface of the land for most of the year and plants suited to wet conditions have a competitive edge over dry land species. Different kinds of wetlands can exist depending upon location, topography, geology, hydrology, vegetation, and type of water (salt, fresh, or brackish). Wooded swamps, sphagnum bogs, lily ponds, cattail marshes, tidal estuaries, and wet meadows are examples of wetland types.

Freshwater wetlands cover 6.4 percent of Dutchess County, or approximately 33,000 acres. As shown in the following Wetlands Map, many of the wetlands in the county are small and scattered about the county without any discernible pattern. There are concentrations, however, along many of the major waterways, including the Swamp River in the towns of Pawling and Dover, the Tenmile River in Amenia and Northeast, and the Fishkill Creek in East Fishkill. The Great Swamp, which extends along the Tenmile and Swamp Rivers from Dover well into Putnam County, is one of the largest and most diverse wetlands in the state. Several large tidal wetlands border the Hudson River.

Historically, wetlands have been regarded as waste lands, useful only if they could be filled or drained for development or agricultural purposes. Because of this attitude at least half of New York State's wetlands have been destroyed since colonial times. Recently, however, wetlands have begun to be recognized for the many benefits they provide.

Wetlands are unique resources at the interface between water and land. Hydrogeologic studies have shown that wetlands are often important regulators and purifiers of surface water and groundwater supplies. They trap sediments, filter certain pollutants, and reduce flood hazards by acting as storage areas for extra runoff. Flooded wetlands can, in turn, recharge groundwater supplies or surface waters. Water stored in wetlands helps maintain continuous stream flows during droughts.



In addition to these valuable water management functions, wetlands provide food, cover, and breeding grounds for water fowl and other wildlife. They support unusual plant life and diverse ecological communities, and provide recreational, educational, and aesthetic benefits.

As development pressures increase, corresponding pressures to fill, drain, or build in wetlands also increase. At such times, it is particularly important to keep the limiting characteristics of wetlands in mind. Wetlands are not suitable locations for landfills, basements, septic systems, or other structures and uses that function poorly in wet soils or destroy natural wetland functions.

Concern about the destruction of wetland resources led to the passage of the New York State Freshwater Wetlands Act in 1975. This act requires permits for all non-agricultural activities that could change the quality of wetlands 12.4 acres or larger and smaller wetlands of unusual local importance. It also requires the State Department of Environmental Conservation to inventory and evaluate the wetlands of the state. The act applies to 4.4 percent of Dutchess County, and approximately 70 percent of the county's total wetland acreage. The approximate numbers of regulated and total wetland acres in each town are listed in Table 4.9. A list of large and significant wetlands is given in the appendix.

Table 4.9 Freshwater Wetlands
Dutchess County

Area	State-Regulated Wetlands Acres	State-Regulated Wetlands Percent of Area	Total Wetlands Acres	Total Wetlands Percent of Area
Amenia	1,350	4.9	1,547	5.6
Beekman	458	2.3	756	3.8
Clinton	1,016	4.1	1,516	6.1
Dover	1,835	5.1	2,363	6.6
East Fishkill	3,179	8.6	3,921	10.7
Fishkill	508	2.9	603	3.4
Hyde Park	844	3.6	2,063	8.7
LaGrange	1,684	6.8	2,242	9.0
Milan	613	2.6	1,030	4.4
Northeast	1,460	5.2	1,665	6.0
Pawling	1,360	4.7	1,550	5.4
Pine Plains	1,207	6.1	1,533	7.8
Pleas. Valley	750	3.5	1,204	5.7
Poughkeepsie	315	1.7	787	4.2
Red Hook	911	4.0	2,118	9.4
Rhinebeck	672	2.9	1,323	5.7
Stanford	1,264	3.9	1,798	5.6
Unionvale	925	3.9	1,185	5.0
Wappinger	695	4.1	1,387	8.1
Washington	1,538	4.1	2,303	6.1
C. Beacon	0	0.0	26	0.8
C. Poughkeepsie	13	0.4	54	1.6
COUNTY TOTAL	22,597	4.4	32,974	6.4

Source: Dutchess County Environmental Management Council

Note: Village figures are included in town wetland totals.

Resource Management Implications

Dutchess County's surface water and groundwater supplies support a large human population and sustain a diverse natural resource base. The abundance of water in the county has made it easy to take these resources for granted, and to treat land and water use as if they were unrelated. In recent years, however, the interdependence of land use, water quality, and water quantity has become obvious as reports of water shortages, groundwater contamination, and drainage problems have multiplied. It is now clear that allowing water supplies to be damaged by overuse and pollution can threaten the county's environmental, social, and economic well-being. Well-integrated land and water management plans are needed to restore water supplies that are showing signs of misuse, and to prevent further damage from occurring.

Drainage Basins

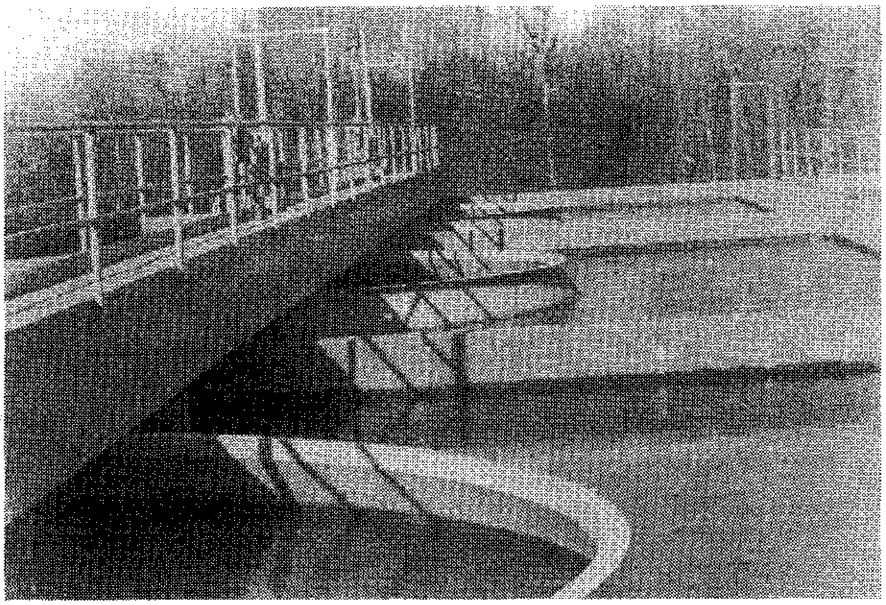
Drainage basins define the geographic limits of natural water systems. Land use changes within a basin affect water quality, flow, and use. Therefore, drainage basins should be adopted as the basic units for planning central utilities, managing groundwater resources, and protecting surface water quality. Where this requires intermunicipal and intercounty cooperation, mechanisms that foster such cooperation should be established.

The amount of runoff leaving an area increases dramatically as development intensifies. The cumulative results of such land use changes are usually more serious flooding of downstream land, greater demands on culverts, storm sewers, and other drainage system components, and more rapid erosion of stream channels and soils. To prevent these problems, new developments should be designed so that the amount of runoff from the developed site is no greater than the amount that left the site before it was developed.

Erosion and sedimentation are gradually robbing the soil of valuable nutrients and choking many of the county's surface waters. Sedimentation also clogs artificial drainage features, so that they require more frequent maintenance or replacement. Erosion and sedimentation should be minimized through strict runoff control programs on construction sites, crop fields, and other areas where soil is exposed or disturbed.

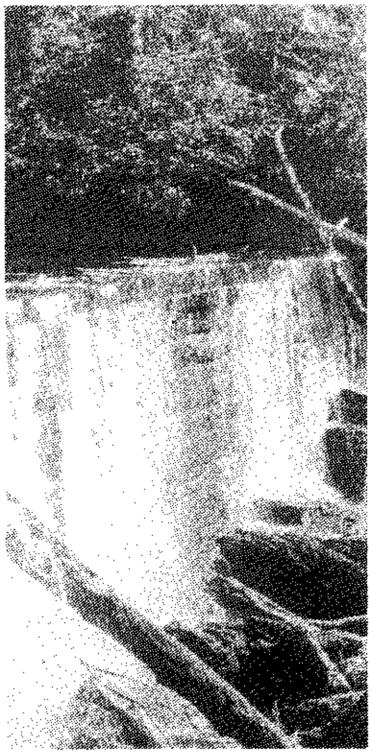
Hudson River

The importance of the Hudson River cannot be overemphasized as a source of drinking water, a drainage channel, a tidal estuary, a transportation corridor, a significant wildlife habitat, and a major element of the county's visual and historical identity. Major changes in how the Hudson River is used could significantly affect the quantity and quality of river water available to county residents. For example, withdrawing large quantities of freshwater could cause the Hudson River salt front to move northward. If it were to move far enough, the salt front could threaten Poughkeepsie's water supply.



The potential for competition among those who use the Hudson for power plant cooling, drinking water, sewage and industrial waste disposal, transportation, recreation and fish production must be acknowledged. To ensure that the Hudson River resource is equitably shared and protected, Dutchess County communities should be actively involved in discussions of all issues that affect the river. Furthermore, the county should participate in regional planning efforts that affect the Hudson basin.

Surface Water



In addition to the Hudson River, Dutchess County contains 800 miles of streams and numerous lakes and ponds. All of these resources have been mapped, but relatively little is known about their quality, rates of flow, and responses to land use change. Without such information, it is difficult to assess the effects of development activities and runoff control measures on the amount of water flowing through the county's drainage basins, or to evaluate how land use trends are affecting surface waters. An effective surface water quality and quantity monitoring system to collect this necessary information should be developed as a first step in a long-range effort to manage and protect the county's surface water resources.

Significant amounts of pollutants are finding their way into the county's surface waters through seepage and runoff. Examples of such pollutants are agricultural chemicals, oil and grease, and wastes from inadequate septic systems. Finding the sources of such materials is often difficult because they are not usually discharged from a particular point or outfall pipe. Decision makers should, therefore, support efforts to identify and control non-point source pollution, and should encourage more responsible use of potential pollutants by owners and users of the land.

Community leaders should also support local efforts to control pollution from specific discharge points, such as industrial outfall pipes and sewage treatment plants. Supporting ongoing monitoring programs and aggressive enforcement of state pollution control laws is a logical first step. Through such efforts, county residents can work to restore all of the county's waters to levels of cleanliness that can support healthy wildlife and vegetative communities and a broad range of recreational uses.

Groundwater

More than 60 percent of Dutchess County residents depend on groundwater, as do many of the county's major industries and commercial enterprises. Despite this dependency, however, land use practices have reflected little understanding of the groundwater resource and its vulnerability to pollution and depletion. This "invisible" resource has usually been taken for granted. Only recently have a growing number of groundwater contamination problems and water shortages brought enough attention to this resource to make the need for better information and protection clear.

Overcrowding, loss of recharge area, and surface disposal of water withdrawn from aquifers contribute to the depletion of groundwater supplies. In many areas, residential neighborhoods that have been overcrowded for years are beginning to experience water shortages and pollution problems. Wells have also been contaminated by fuel spills, leaking gasoline tanks, wastes fron landfill sites, and industrial discharges. Protective measures are needed to ensure that today's land use decisions will not cause additional water problems in the future.

Groundwater protection programs should include a variety of approaches to managing the quantity and quality of groundwater. Components of this program should include:

1) density controls in areas dependent on groundwater and septic systems;

2) analysis of soil and groundwater characteristics during the review of all new development proposals:

3) elimination of all subsurface discharges of untreated or inadequately treated waste chemicals;

4) requirements that new developments produce no increases in runoff above natural levels;

5) strict enforcement of laws governing above-ground and underground chemical storage and spill control;

6) public education programs concerning the effects of common household chemicals on groundwater quality;

7) better management of salt stockpiles and road salt application to prevent salt from contaminating surface and groundwater supplies;

8) improved septic system maintenance;

9) use of alternatives to land disposal of municipal wastes;

10) development of central sewer systems in areas developed at greater densities than what the soils and groundwater can tolerate;

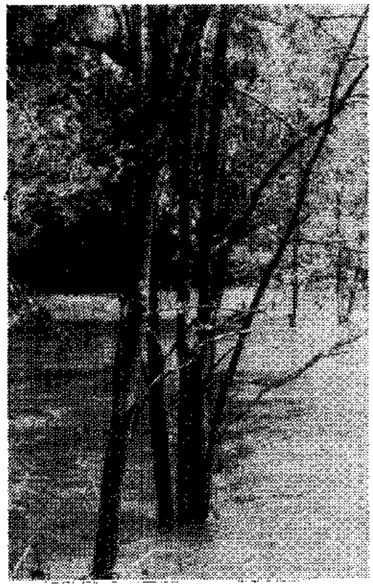
11) identification and special protection of the county's best aquifers and recharge areas; and,

12) comprehensive and effective collection of information about the county's groundwater supplies.

Groundwater management efforts should emphasize increasing everyone's awareness of the importance of the county's water resources, and their interrelationship with all resources and land use activities.

Floodplains

Floodplains exist along most of the county's major creeks, steams, and rivers. Inappropriate development decreases the ability of floodplains to carry flood waters and to absorb runoff from developed areas, and increases floodwater velocity. These phenomena, in turn, result in damage to downstream development, place floodplain occupants at risk, and can impose significant costs on affected communities. It is in the best interest of those communities to preserve the natural functions of the 100-year floodplain, permitting in them only flood-resistant accessory uses that do not interfere with floodplain functions.



Floodplains are uniquely suitable for recreational uses that do not require extensive filling because they border attractive waterways and form greenbelts through communities. They can serve as utility corridors or wildlife habitat, and their fertile soil often makes floodplains valuable cropland. Other appropriate uses might include parking lots designed to permit stormwater infiltration, bikeways, hiking trails, and required yards or residential buffers. Floodplains are not appropriate sites for extensive filling, residential buildings, mobile homes, or large, impervious surfaces often associated with commercial or industrial complexes.

Dutchess County and its municipalities must also become aware of the relationships within watersheds among land uses, runoff, and flood susceptibility. As development pressures increase throughout the county's watersheds, it becomes increasingly important to limit runoff and erosion from development sites so that flooding does not become more severe, and to leave floodplains undisturbed so they can carry floodwaters safely.

Wetlands

Wetlands cover only 6.4 percent of Dutchess County, yet they play a crucial role in regulating the quality and quantity of water supplies and in managing stormwater runoff. They are also the county's most productive wildlife habitat, and as open space they support diverse recreational uses. Although their qualities vary, wetlands are usually not appropriate development sites because of their hydrological characteristics and environmental values. Their destruction imposes significant economic costs on society. Therefore, except in cases where their values are clearly shown to be negligible, wetlands should be protected from development.