# An Interim Watershed Management Plan for the Lower, Non-Tidal Portion of the Rondout Creek, Ulster County, New York

**December 2010**

**Prepared by the Rondout Creek Watershed Council**

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## EXECUTIVE SUMMARY

The Rondout Creek Watershed Council (RCWC), a coalition of multiple stakeholders, was formed in 2007 to promote watershed awareness, planning and protection for the central portion of the Rondout Creek. The incubation of the RCWC, began with stream monitoring, education and outreach and subsequent watershed planning efforts that were made possible by grant funding from the NYS DEC Hudson River Estuary program. The project was initially administered by Open Space Institute/Hudson Basin River Watch and Hudson River Sloop Clearwater and later in partnership with Cornell Cooperative Extension of Greene County/Agroforestry Center.

After experiencing a series of heavy rain events and subsequent severe flooding that occurred throughout the Hudson Valley between 2004-2007, there was an enthusiastic response to the proposed coalition by local property owners, businesses, municipalities and government agencies who sought to increase the number of consensus-building watershed partnerships that would help to identify, educate and implement solutions to these and related water resource issues. In 2010, the New England Interstate Water Pollution Control Commission graciously provided additional funding for completion of this project.

The Rondout Creek is one of the largest tidal tributaries to the Hudson River. For management purposes, the watershed has been delineated into three sections: the Upper portion can also be referred to as everything above the Rondout Reservoir, extends from the headwaters flowing southerly down the slopes of Rocky Mountain in the Slide Mountain Wilderness Area of the Catskill Park into a narrow valley, receiving the Picket Brook tributary and three unnamed streams from the slopes of Peekamoose Mountain to the outlet of the Rondout Reservoir; the Lower, Non-Tidal portion which includes the area below the Rondout Reservoir to the Eddyville Dam; and the Tidal portion which extends from the Eddyville Dam to the Hudson River.[1] The New York City Department of Environmental Protection, in collaboration with local stakeholders, has developed a management plan for the upper portion of the Rondout Creek. The development of a plan for the tidal Rondout section is currently underway.

The formation of the RCWC resulted in the adoption of an intermunicipal agreement (IMA) amongst the four major municipalities in the lower non-tidal portion of the watershed -- Wawarsing, Rochester, Marbletown and Rosendale -- to produce an interim watershed management plan for this section of the watershed. The RCWC envisions that the management plans for the three sections of the Rondout will eventually be combined into one complete document addressing the needs and providing information about the entire Rondout Creek Watershed.

The purpose of this document is to provide civic leaders, policy makers, community groups and individual citizens with comprehensive information about the state of the Rondout Creek and actions that are needed to enhance water quality and quality of life within the watershed boundaries. The plan acts to identify current information that will help inform interested parties about the watershed, as well as pointing out the gaps in available information and, suggesting

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[1] http://en.wikipedia.org/wiki/Rocky_Mountain_(Ulster_County,_New_York)

what research is needed and what future actions should be taken. The basis for the information presented in the plan and the recommendations that are proposed derive from a Municipal Watershed Questionnaire, water quality and spatial data specific to the region, and pertinent information gathered from RCWC stakeholders and advisors. Based on information provided through multiple workshops and meetings, watershed protection goals and recommendations were defined in the following four categories:

1) Stormwater Management,
2) Floodplain Management,
3) Agriculture and Forestry, and
4) Outreach and Education.

Findings: Utilizing an iterative process that included frequent meetings with RCWC members, municipal officials, and a variety of key stakeholders, along with input from area experts, the following observations have been documented in the Rondout Creek Interim Watershed Management Plan (RCIWMP):

- Topography: The topography of the watershed has developed over millions of years with four main periods of bedrock deposition: 1) Late Ordovician Flysch marine trough, 2) Silurian Shawangunk Conglomerate beach, 3) Late Silurian and Early Devonian Carbonates in warm shallow seas, and 4) Devonian Catskill delta.
- Climate: Daniel Smiley's Research Center at the Mohawk Preserve reports that the annual precipitation on the preserve, in Ulster County is 44.57 inches and the average for Nov 2010 is 3.79 inches (calculated by adding up all the measures from each rain event and dividing by the number of months in a year; with an average deviation of +/- 51)[2]. Collected data also documents a shift over time to warmer temperatures and there have been fewer a number of zero degree or fewer days and more 90-degree or more days at the Mohawk Preserve. It has also been recorded that the past seven years since 2003 have been the warmest on record here.
- Impacts of Climate Change: Shoreline communities along the Rondout are very likely to see an increase in the frequency of flooding and erosion events due to climate change. This may result in:
    - The regular resuspension of waterborne pollutants that may put public health at risk
    - Inundation of critical infrastructure and facilities, especially those in flood-prone areas, leading to a loss of services
    - Further stress to already degraded stormwater and sewage systems, as well as municipal infrastructure
    - The impairment of water quality and an increase in water quantity
    - Impacts on populations of local fish and a possible increase in pest and insect epidemics.
- Biodiversity: The habitats that support biodiversity of the watershed and the species living in the diverse ecosystems provide important services such as the purification of drinking water, control of floodwaters, replenishment of aquifers, pollination of crops,

[2] http://www.mohonkpreserve.org/index.php?id=146,162,0,0,1,0

creation of fertile soil, control of insect pests, and adaptation to a changing climate. Healthy natural systems also provide opportunities for hunting and fishing, outdoor recreation, and environmental education and research. All of these services and benefits to the community cost less than the artificial or built alternatives, contribute to local economies, and are widely recognized as important assets by a variety of stakeholders.

- Riparian buffers: play a particularly important role in the watershed by:
  - Slowing the rate of runoff
  - Capturing excess nutrients carried from the land
  - Protecting stream banks and floodplains from erosion
  - Regulating water temperature changes
  - Providing food and cover to terrestrial and aquatic fauna
  - Acting as natural filtration systems.

- Water Quality: With only 9.4% average impervious cover, the lower non-tidal Rondout Creek is designated as "slightly impacted," which means that it has maintained fairly good water quality. However, numerous point and non-point sources of pollution in the watershed may threaten the health of the creek and its watershed, with some areas identified through monitoring t showing early signs of variable human impact; overall the Creek is only slightly impacted. Depending on land use patterns, however, some sections of the watershed are more impacted than others, and much of the watershed is subject to development pressure.

- Reducing Effects of Impervious Surface: Impervious surfaces can greatly alter the hydrology of a watershed and have major impacts on the amount and quality of the water entering streams and other waterbodies and aquifers. Because Green Infrastructure practices, such as rain gardens, bioswales, pervious paving, and green roofs, are viable solutions to mitigating the problems caused by impervious surfaces and assuring groundwater recharge, strengthened local regulation and goals to reduce impervious surface for particular areas should be developed

- Stormwater Regulations: The towns of Marbletown and Rosendale have been designated as Municipal Separate Stormwater Sewer System (MS4) communities in the lower non-tidal portion of the watershed and are successfully implementing various stormwater management practices. Although Wawarsing and Rochester are not yet required to implement MS4 programs, MS4 practices are valuable for protecting water quality within the watershed whether the municipality is designated as MS4 community or not.

- Economic Development: Economic initiatives, if designed with conservation and environmental considerations, can potentially enhance watershed protection, minimize negative impacts, and create green jobs.

**Recommendations**

This plan suggests recommendations for each of the four watershed protection categories identified. However, as the plan was being developed it became apparent that there were recommendations that would serve to address multiple issues. These recommendations are summarized below:

1. Continue to facilitate the functioning of the RCWC and form an ongoing intermunicipal council to oversee and coordinate the work that is already being done by the committee.
2. Promote ordinances designed to protect the natural resources of the watershed.
3. MS4 communities should continue to work toward meeting all MS4 requirements. Where feasible, towns that are currently not MS4 communities (Wawarsing and Rochester) should voluntarily adopt practices and ordinances that parallel the MS4 program. Specifically, this means implementing Best Management Practices that satisfy the six minimum control measures: 1) Public education and outreach, 2) Public Participation and Involvement, 3) Illicit discharge detection and elimination, 4) Construction Site Runoff Control, 5) Post-Construction Runoff Control, 6) Pollution prevention (see Section 4).
4. Create a comprehensive Rondout Creek Watershed Atlas with standardized maps that not only inventory the natural resources in the watershed but also identify areas at risk due to climate change and development, identify access points to the creek and other existing recreational opportunities, and f delineates local watershed management units.
5. Use zoning and planning tools to manage for open spaces, biodiversity, forestry, agriculture, and the protection of riparian and other sensitive areas. Promote education and outreach specifically to town Planning Boards and other municipal departments, advisory groups and agencies.
6. Adopt Better Site Design principles (also known as Low Impact Development or Green Infrastructure practices) to manage stormwater runoff and reduce impervious surfaces in the watershed.
7. Increase the focus on riparian zones and coordinate efforts to protect these areas throughout the watershed. This includes: mapping and identifying potential sites for restoration, creating zoning that will stop development in the floodplain, reducing impervious surfaces in these areas, increasing education about the importance of these areas.
8. Assure local food security and the rural character that graces much of the landscape in this portion of the watershed by promoting local agriculture and preserving farmland, as well as forestry and other open space, that serve to protect water quality.
9. Promote public education and outreach programs by collaborating with organizations that currently exist to raise awareness and garner support for watershed issues and best management practices. Issues to focus on include: invasive species, non-point source pollution, biodiversity, climate change
10. Intermunicipal collaborations should be explored to identify funding and cost-sharing opportunities that can further this Plan's objectives throughout all four municipalities.

## SECTION 1 - INTRODUCTION

### 1.1 Watersheds and Their Importance

A watershed is an area of land that drains water into a specific pond, stream or river for which it is named. For example the Hudson River watershed encompasses 13,000 square miles, where all the water flows downhill through a network of connected streams, ponds, wetlands and underground waters into the Hudson River. Watersheds have boundaries, called divides, located at relatively high elevations or ridges. Whenever you leave one watershed, you immediately enter another. A healthy watershed performs many functions. It serves to capture, store and recharge groundwater, filter out water pollutants, and safely release precipitation or rainwater as to avoid flood events during severe rainfall. (www.coquillewatershed.org, 2009).

These watersheds and the waterways they feed into were the focus of the Clean Water Act of 1977 amendment to the Federal Water Pollution Control Act of 1972, which set the basic structure for regulating discharges of pollutants to waters of the United States. In attempts to restore impaired waters regulations were implemented to reduce pollution from a variety of industries. Critics of the regulatory approach assert that these strategies offered few economic incentives to comply with mandated watershed protection and required the government to specify which technologies and methods should be used in every situation rather than provide situation-specific alternatives (Rosenbaum, 1998).

In response, since the 1980s, watershed organizations or partnerships as well as federal and state agencies have focused more intently on managing the quality of water resources through an approach that more strongly incorporates community engagement and empowers stakeholders rather than relying solely on government officials (Steelman and Carmin, 2002; Koontz and Korfmacher, 2000; Luxenberg, 2007). The 1987 amendments to the Clean Water Act (CWA) established Section 319: Nonpoint Source Management Program. Under Section 319, states, territories and tribes receive grant money that supports a wide variety of activities including technical assistance, financial assistance, education, training, technology transfer, demonstration projects and monitoring to assess the success of specific nonpoint source implementation projects (www.epa.gov, 2010). Watershed organizations and partnerships have become increasingly important as venues for this type of interaction and have been rapidly increasing in number since the 1990's (Low and Randhir, 2005). Water resource experts strongly recommend that towns develop watershed management plans, so that management practices on individual sites can be coordinated as to location, size and function.

A comprehensive approach to watershed management and best land use management practices has been embraced as a leading strategy to address threats to the natural environment and to improve the conditions within a watershed (Wholey, 1999). The Handbook for Developing Watershed Plans published by the EPA in 2008 defines this watershed approach as a "flexible framework for managing water resource quality and quantity within specified drainage areas, or watersheds. This approach includes collaborative stakeholder involvement and comprehensive management actions supported by sound science and technology" (EPA, 2008). The watershed planning process works within this framework by using a series of cooperative, iterative steps to characterize existing conditions, identify and prioritize problems, define management objectives, develop protection or remediation strategies, and adapt and implement selected actions as necessary (EPA, 2008).

Researchers suggest that using knowledge from multiple segments of society helps to generate policies, projects and plans that are technically sound and can more accurately address local concerns. They also assert that increased participation in these collaborative processes can increase awareness of issues and/or enhance the skills and knowledge of stakeholders. Increasing skills and knowledge can further contribute to increased adoption of best management practices (Curtis and Lockwood, 2000). Collaborative and comprehensive processes are an important component in the development of any watershed management plan.

## 1.2 History of the Rondout Creek Watershed Council:

Between 2004-07, a series of heavy rain events occurred in the Hudson River Valley region and caused severe flooding and public water supply contamination in multiple counties. By the end of that three-year period, a total of 20 counties were declared disaster areas. Major damages occurred on the Esopus and Rondout Creeks in Ulster and Greene County. The damage to private property owners and local businesses was worth millions of dollars; many homes were lost and residents forced to evacuate. The Federal Emergency Management Agency stated that an average of 3,400 New Yorkers registered for federal aid, making the disaster recovery assistance $35 million (Suro and Firda, 2007). With concerns and questions about the condition of watershed management in the Hudson Valley at a high, state and local government and agencies began more actively meeting with local residents and stakeholders to provide watershed education and identify the needs of their communities. These inquiries and meetings lead to the increased consensus-seeking watershed partnerships by the Hudson Valley property owners and residents who were affected by the flooding. Stakeholder partnerships consist of representatives from private interest groups, local public agencies, and state and federal agencies, which convene as a group, periodically and indefinitely, to discuss and or negotiate public policy within a broadly defined issue area (Leach, 2002). They strive to reach agreement and may pursue intermediate goals such as trust building, outreach, education and research.

As a direct result of these events, the Rondout Creek Watershed Council (RCWC), a coalition of multiple stakeholders, was formed in 2007 to promote watershed awareness, planning and protection. Grant funding from the NYS DEC Hudson River Estuary program was administered by the Open Space Institute (OSI) /Hudson Basin River Watch (HBRW) and enabled Hudson River Sloop Clearwater to incubate the RCWC while providing administrative support. Since the formation of the RCWC, information and education has increased significantly throughout the watershed through the development of outreach materials and events. These include: a detailed delineation of the lower, non-tidal or central portion of the Rondout Creek Watershed from the Rondout reservoir to the Eddyville dam, the completion of a municipal questionnaire that was used to draft a State of the Rondout Report, and multiple public education events. The RCWC also facilitated the adoption of an Intermunicipal Agreement among the four major municipalities, the Towns of Wawarsing, Rochester, Marbletown and Rosendale, for the development of a Rondout Creek Watershed Management Plan. A second grant from HREP supported Clearwater and HBRW to incubate parallel efforts in the Catskill and Kinderhook/Stockport Creek watersheds in partnership with Cornell Cooperative Extension of

Greene County/Agroforestry Center. In 2010, the New England Interstate Water Pollution Control Commission provided additional funding for completion of the project.

## 1.3 Rondout Creek Interim Watershed Management Plan (RCIWMP)

The purpose of this document, created by the RCWC for the lower, non-tidal portion of the Rondout Creek, is to provide civic leaders, policy makers, community groups and individual citizens with comprehensive information about the state of the Rondout Creek and actions that are needed to enhance water quality and quality of life within the watershed boundaries. The plan acts to identify current information that will help inform interested parties about what is known about the watershed, as well as pointing out the unknowns, thus suggesting what research is needed and what future actions should be taken. The plan is based upon the results garnered from a Municipal Watershed Questionnaire (MWQ) (*Appendix A*), water quality data gathered by Hudson River Basin Watch *(cross reference Section 4),* and pertinent information gathered from RCWC stakeholders.

Since this plan covers only a portion of the Rondout Creek, it is serving as an interim plan. The New York City Department of Environmental Protection has developed a management plan for the upper portion of the Rondout Creek. A plan for the tidal portion is currently underway. The RCWC envisions that the management plans for these three sections of the Rondout will be combined into one complete document addressing the needs and providing information about the entire Rondout Creek Watershed.

## 1.4 RCWC Watershed Assessment Process

### Municipal Watershed Questionnaire Summary

In 2007 the Rondout Creek Watershed Council designed and implemented a MWQ to evaluate the perspectives held by local municipalities about the condition of the watershed. This was then updated in the fall of 2009. The MWQ was distributed to the four municipalities which occupy the most land in the lower non-tidal portion of the Rondout Creek watershed area, with four distinct goals:

1. To assist municipalities in assessing what is known about the current health of the Rondout Creek watershed within their jurisdictions.
2. To create a convenient inventory of all relevant watershed management information to be used by decision makers and local agencies that are working toward watershed management.
3. To identify areas in which additional research is required.
4. To target the major areas of concern for each municipality and use them as focal topics for watershed management planning.

A total of eight representatives from each municipality's local Environmental Conservation Commissions (ECC) in the towns of Wawarsing, Rochester, Marbletown, and Rosendale completed the questionnaire(s) *(Appendix B).*

**Assets Identified in the MWQ**

Participants of the survey identified significant assets of the watershed. These included the use of the watershed as a source of drinking water, its historic and scenic values, and tourism and recreational activities such as fishing, boating, swimming and bird watching. Even though it was apparent that public use of the creek was important in all of the municipalities, official public access points to the creek are limited and have not been officially identified. The questionnaire also asked participants to identify characteristics of the watershed in need of protection. Responses included aquifers, wetlands, floodplains, forested areas, and agricultural lands. In addition, special viewsheds such as the Shawangunk Ridge and Catskill Park and the karst regions in the watershed add to the historical and scenic value of the region. The fact that the Rondout Creek has been designated as a waterway of historical importance, as well as the fact that it provides habitat for rare and endangered species, reaffirms the necessity of protecting these unique areas.

Significant work is in progress or has been completed and adopted to ensure protection of the watershed and natural resources in all four municipalities. The plans and reports selected as strong representations of watershed protection initiatives are Comprehensive Plans, Natural Resource Inventories, Open Space Plans, Biodiversity Assessments, Water Resource Inventories, well-log data and watershed ordinances. Table 1.1 presents the consolidated responses for all work that is in progress or has been completed in each municipality.

| Document | Wawarsing | Rochester | Marbletown | Rosendale |
|---|---|---|---|---|
| Comprehensive Plan | C | C | C | C |
| Natural Resource Inventory (NRI) | | C | C | C |
| Open Space Plan | | IP | C | |
| Biodiversity Assessment | | | C | C |
| Water Resource Inventory | IP | C | C | C |
| Well-Log Data | | IP | C | C |
| Watershed Ordinance | | | | |

**Table 1.4.1** Consolidated watershed resource management and protection documents that are in progress (indicated by "IP") or that have been completed (indicated by "C").

Rosendale and Warwarsing are currently in discussion about cooperating on the development of their respective Open Space Plans.

**Challenges Identified in the MWQ**

Thirteen categorical options were provided to survey participants to identify the existing challenges to watershed conservation. Their replies indicate that there are 12 perceived potential and existing threats to the health of the Rondout Creek Watershed: flooding, facilities requiring State Pollution Discharge Elimination System (SPDES) permits *(Appendix C)*, historic discharges, filling of wetlands, streams with fish advisories, improper drainage, brownfields, dried up streams, Toxic Release Inventory (TRI) *(Appendix D)* listing, inadequate wetland protection, non-point source pollution and invasive species. Common threats identified by all four municipalities were: areas that have existing SPDES permitting, filled in wetlands, and occurrences of flooding events. Recommendations derived from this questionnaire have been incorporated in the recommendations outlined in this management plan.

## 1.5 RCWC Vision and Goals of the RCIWMP

The RCWC is committed to protecting water resources, increasing community awareness through education and improving conservation efforts throughout the Rondout Creek Watershed. To further this purpose RCWC has developed the following Interim Watershed Management Plan focused on the four municipalities of the Lower, Non-Tidal portion of the Rondout Creek. The Plan will focus on the following key watershed protection goals for the lower non-tidal portion of the watershed and specified by local stakeholders.

1. Stormwater Management: Identify stormwater regulations and best practices that are currently in use in the watershed; it addresses the impacts of impervious surfaces, as well as options that maximize groundwater recharge and reduce or minimize incidents of flooding in the watershed, such as better site design and green stormwater infrastructure.

2. Floodplain Management: Address the sustainable management of riparian buffers, climate change issues, the need to use revised floodplain maps in planning, and promote access to the creek and its tributaries, where appropriate.

3. Agriculture and Forestry: Identify best management programs and practices for agriculture and forestry, which address water quality and quantity issues, open space preservation, biodiversity and wetlands protection in the watershed.

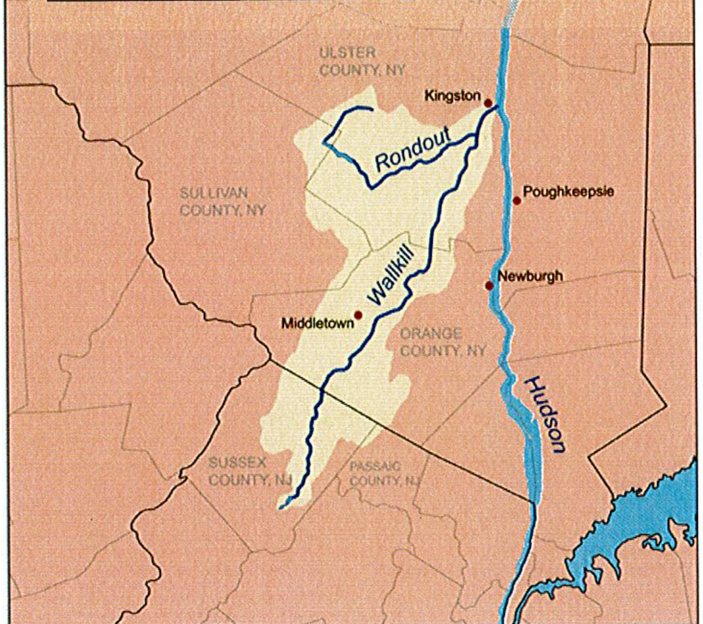
4. Outreach and Education: Identify existing programs and potential partnerships that foster stewardship and education throughout the watershed

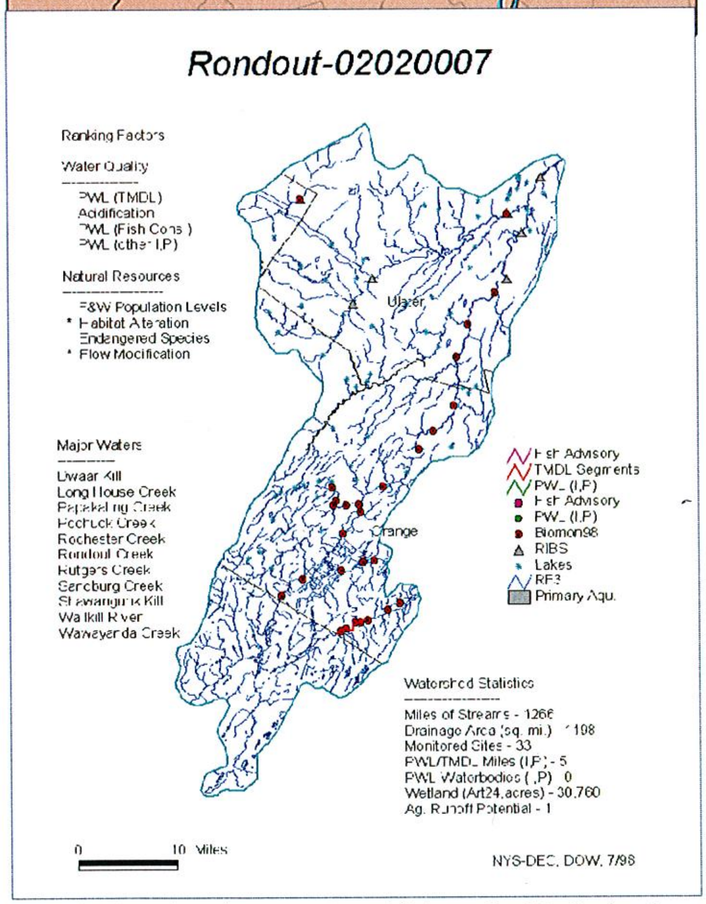
## SECTION 2 - RONDOUT CREEK AND ADJACENT WATERSHEDS

### 2.1 The Rondout-Wallkill Watershed:

The Rondout Creek is among the largest tidal tributaries to the Hudson River. The headwaters of the Rondout Creek begin in the Town of Shandaken at an elevation of 3,837 feet (DEP, 2008). The creek flows southwesterly through the Peekamoose area in the Town of Denning and into the Rondout Reservoir. The Creek is impounded by the Merriman Dam in the Town of Wawarsing to form the Rondout Reservoir, which stretches, into Sullivan County. The Rondout Creek picks up again below the dam with a State-mandated release of 10-15 million gallons per day from the reservoir, then travels southeast through Napanoch, where it bends northeast through the agricultural floodplains of Wawarsing, Rochester, and Marbletown where it plunges over the falls in High Falls. Beyond the hamlet of Rosendale, the Rondout Creek is joined by the Wallkill River beyond the Central Hudson-owned hydroelectric plant at Sturgeon Pool in Rifton.

Map 2.1.1: Rondout – Wallkill Combined Watershed

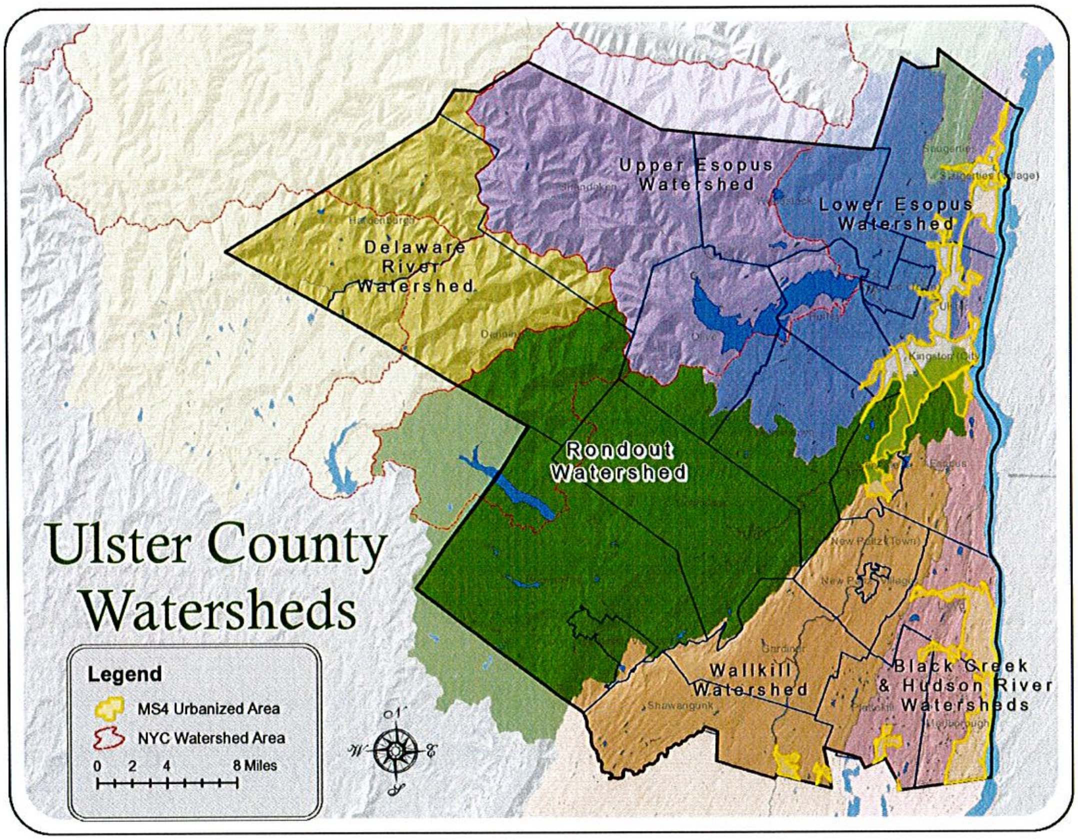



The Wallkill River system and Rondout Creek system form the approximately 3,082-km$^2$ (1,190 sq. mi.) Rondout-Wallkill watershed, the largest tributary basin entering the Hudson River south of the head of tide at Troy. The Rondout then continues to flow north over the Eddyville dam, where it is tidal for a 4-mile stretch until it empties into the Hudson River in downtown Kingston at an elevation of 190 feet. The Rondout enters the Hudson River Estuary at River Mile 91 (148 km), far enough north of the limit of saltwater intrusion so that the Rondout is characterized as a tidal freshwater system.

**Delineation:** Delineating the Rondout Creek watershed was challenging because it overlaps with the Catskill Park and the New York City Water Supply System for the Catskill and Delaware. In addition, the Hydrologic

Unit Code (HUC # 02020007 – Map 2.1.2) is called Rondout, but includes the Wallkill Creek, which flows north from New Jersey through Orange County. A *Wallkill River Watershed Conservation and Management Plan* has already been created for the Wallkill watershed. The Rondout Creek Interim Watershed Management Plan for the lower, non-tidal section has been designed to interface easily with this and other watershed planning and protection efforts in the adjacent watersheds -- the Upper Rondout, under the guidance of NYC DEP, and the Upper and Lower Esopus, with the leadership of the Lower Esopus Watershed Partnership (LEWP).



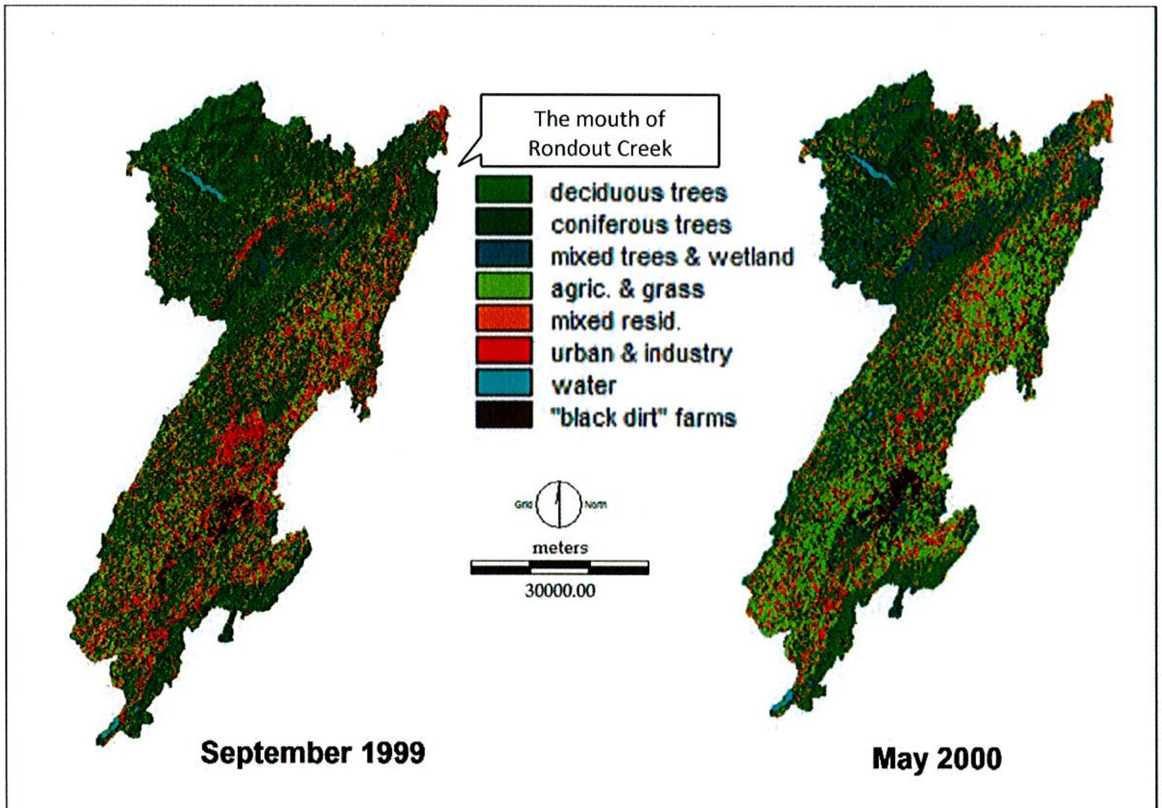

Map 2.1.3: The full Rondout Creek Watershed covers most of the southwest portion of Ulster County with the Delaware Watershed in Delaware and Sullivan Counties to the west, the Upper and Lower Esopus to the north and the Wallkill and Black Creek to the east.

**Impervious Surface in the Rondout-Wallkill Watershed**: This section has been adapted from *Using a Shoreline Inventory for Conservation and Planning: the Rondout Creek Case Study,* original research by Chris Bowser (*Appendix E*).

Because it contains a high diversity of shoreline type in a relatively short stretch, it was used extensively and historically used as an early site for sampling, inventory and collection classification for many studies. Finally, the Rondout Creek contains, within a relatively small area, many of the same issues and challenges found along the greater mainstem estuary, including competing needs of economy and ecology as well as management across municipal borders. The design and implementation of a Watershed Management Plan that takes into consideration the Rondout Watershed's ecological assets and cultural highlights will establish the context of conservation needs and could best be applied to the larger whole (connectivity of all the watersheds) in the future.

**Land Cover of the Rondout Watershed and Creek** (Winter 1999, Spring 2000): Percentage of impervious land cover within a watershed can be used as a general indicator of watershed health and non-point source pollutant loading. Impervious cover refers to roads, roofs, and parking lots that do not allow rainwater to penetrate soils, thus increasing the likelihood of erosion and non-point source pollutants to rapidly enter local waterways. Urban areas typically have a high percentage of impervious cover, agricultural areas less so, and forested areas have the least (For more information about impervious surfaces see Section 4.2).

Thirty-meter resolution Landsat imagery (bands 4, 3, and 2) of the Wallkill-Rondout watershed from both September 1999 (a month when deciduous trees are in full leaf) and May 2000 (a time before deciduous leaves have fully formed) were classified for land use cover using the IDRISI software package. Two seasons were used to examine the effect of multi-seasonal differences, such as deciduous leaf cover, on classification.

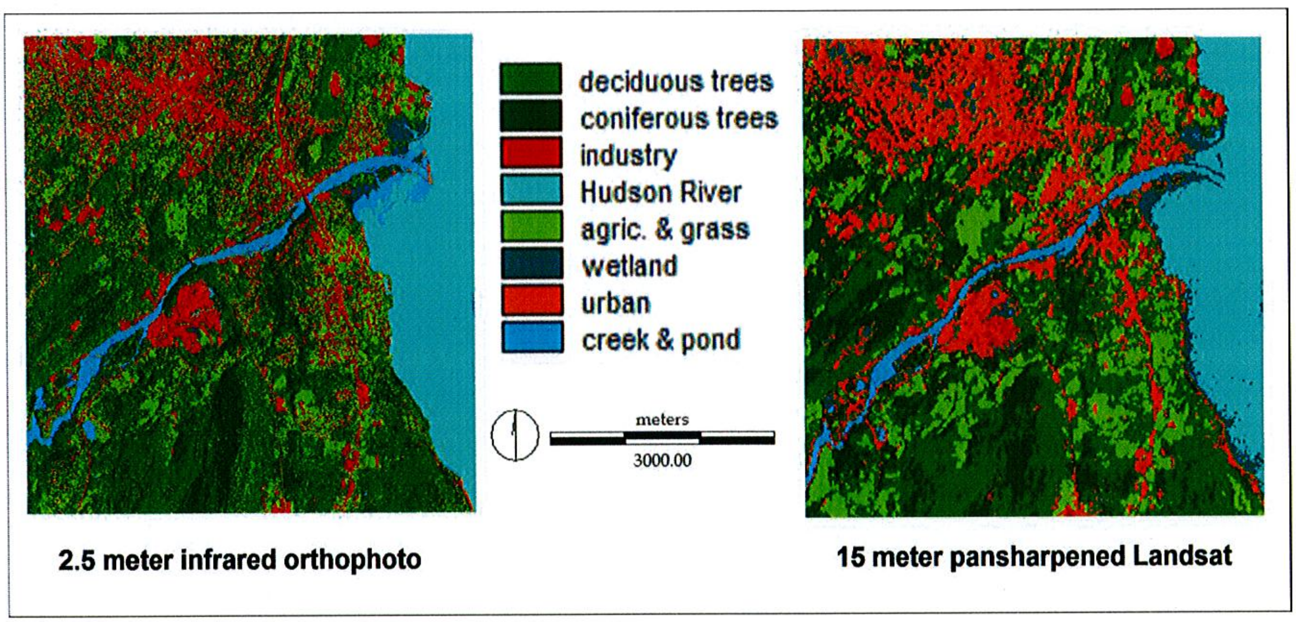



**Map 2.1.4:** Land use in the Rondout-Wallkill watershed *(Source of Landsat image: University of Maryland website: glcfapp.umiacs.umd.edu).* Note: This HUC map includes both Rondout and Wallkill watersheds.

For the September and May images, impervious surface was calculated at 9.2% and 9.6%, respectively. The presence of leaves on the trees did not greatly affect the impervious cover calculations in this analysis. According to the Center for Watershed Protection, watershed imperviousness of 10% to 25% indicates an impacted stream or estuary tributary likely to exhibit a decline in water quality, loss of biodiversity, greater storm flows and altered stream geometry. Imperviousness beyond 25% indicates severe degradation, no longer able to support a diverse stream biota and likely having poor water quality. Similar thresholds have been linked to other indicators. Wang et al., (1997) found habitat quality and biotic integrity, based on an array of fish and invertebrate community metrics, with an impact range of 10% to 20% similar to that of Zielinski's land use thresholds of 10% to 25%.

The 1999-2000 average calculation of 9.4% impervious cover for the Wallkill- Rondout Watershed indicates a watershed that is on the borderline of experiencing negative water quality impacts from runoff and non-point sources associated with impervious cover.

A similar analysis of the area around the tidal Rondout Creek, located in the northeast corner of the watershed, reveals a smaller region of greater imperviousness. An impervious cover of 14.7% to 18.5% is higher than the overall imperviousness of the entire watershed (9.4%), and indicates the tidal Rondout Creek may be an impacted estuary tributary that is experiencing negative water quality impacts from runoff and non-point sources associated with urbanization at the local scale of land use immediately adjacent to the tidal Rondout Creek.




Map 2.1.5. Land use along the tidal Rondout Creek. (L) Derived from 2.5 meter orthophotos, April 2001. (R) Derived from 15-meter pan-sharpened Landsat, May 2000. *(Source: Ulster County Information Services, Kingston, NY).*

The Rondout-Wallkill watershed, specifically the area around the tidal Rondout Creek, exhibits a percentage of impervious cover (14.7% to 18.5%) that may lead to negative water impacts. In the case of the Rondout Creek, the effects of watershed-scale water quality is especially relevant since the lower portion of the creek is the "bottleneck" of the drainage basin before entering the Hudson estuary. The Creek's tidal nature at this point also means it has a more variable flushing rate and considerable re-suspension of sediments. Shoreline hardening and the reduction of riparian vegetation can lead to reduced filtration and greater inputs of pollutants and sediment into streams. Furthermore, urban waterfronts are usually associated with impervious parking lots and rooftops as well as hardened shorelines. It is typical that imperviousness will increase as development pressures in the watershed continue.

## Section 2.2 Lower Non-Tidal (LNT) Rondout Creek Watershed

**Watershed General Description:** The Rondout Creek is a tributary of the Hudson River in Ulster and Sullivan counties of New York State. It arises on Rocky Mountain in the eastern Catskills, flows south into New York City's Rondout Reservoir, then into the valley between the Catskills and the Shawangunk Ridge, where it goes over the spectacular High Falls and finally empties out into the Hudson at Kingston, receiving the Wallkill River along the way.

The lower, non-tidal portion of the Rondout, which is the focus of this management plan, begins below the Rondout Reservoir and includes the confluence with the Wallkill River in Creek Locks upstream of the Eddyville Dam. The mainstem of the LNT Rondout Creek is part of a 383 sq. mi. drainage basin. This includes major portions of the towns of Wawarsing, Rochester, Marbletown, and Rosendale. Thirty-eight tributaries flow into the lower non-tidal portions of the creek *(Appendix F: Table 3.1 Tributaries to Rondout Creek).*

The name of the Rondout Creek comes from the fort, or redoubt, that was erected near its mouth. The Dutch equivalent of the English word redoubt (meaning a fort or stronghold), is reduyt. In the Dutch records of Wildwyck, however, the spelling used to designate this same fort is invariably Ronduyt during the earliest period, with the present form Rondout appearing as early as November 22, 1666.

The Rondout Creek became economically important in the 19th century when the Delaware and Hudson Canal followed closely alongside it from Napanoch to the village of Rondout, now part of the City of Kingston, which grew rapidly as the canal's northern port. Today it is important not only for the Rondout Reservoir, which provides drinking water to nine million people in the greater New York City metropolitan area, but also for its scenic beauty, agricultural resources and the fishing and other recreational opportunities it provides.

Including the contribution from the Wallkill, the Rondout drains a vast area stretching over 1,100 square miles (2,850 $km^2$) from Sussex County, New Jersey to its mouth in Kingston. The high mountains around its upper course and the reservoir, which collects water from three others, also add to its flow.

The Rondout goes through several different stages due to the changes in surrounding geography and past development, such as the canal and reservoir that has drawn on its waters. Its headwaters, above the reservoir, are typical of a mountain stream. Below the reservoir, the streambed remains fairly rocky but widens into the floor of a narrow valley. At Napanoch, where it turns northeast and receives its first significant tributary, the Ver Nooy Kill, it becomes wider, as does the valley it drains, and deeper.

North of the Shawangunks, where the Wallkill trickles down from Sturgeon Pool, it is wide enough to be referred to as the Rondout River. At Creek Locks, the former northern outlet of the Delaware-Hudson Canal, it becomes wide and deep enough to be navigable, and several marinas line the banks of the tidal Rondout, now more than a hundred feet (30 m) wide, at Kingston just before its mouth.

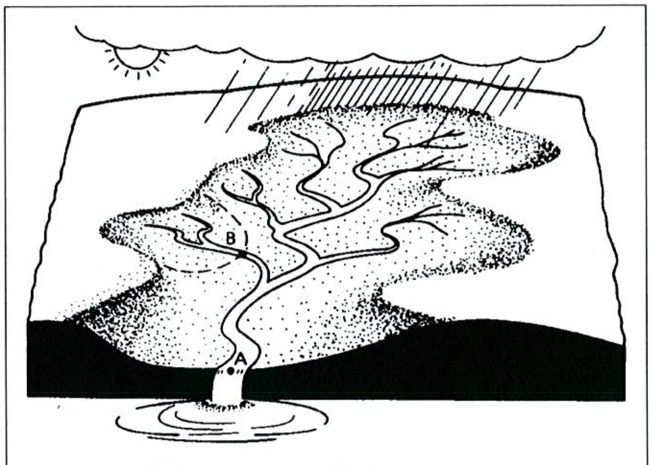
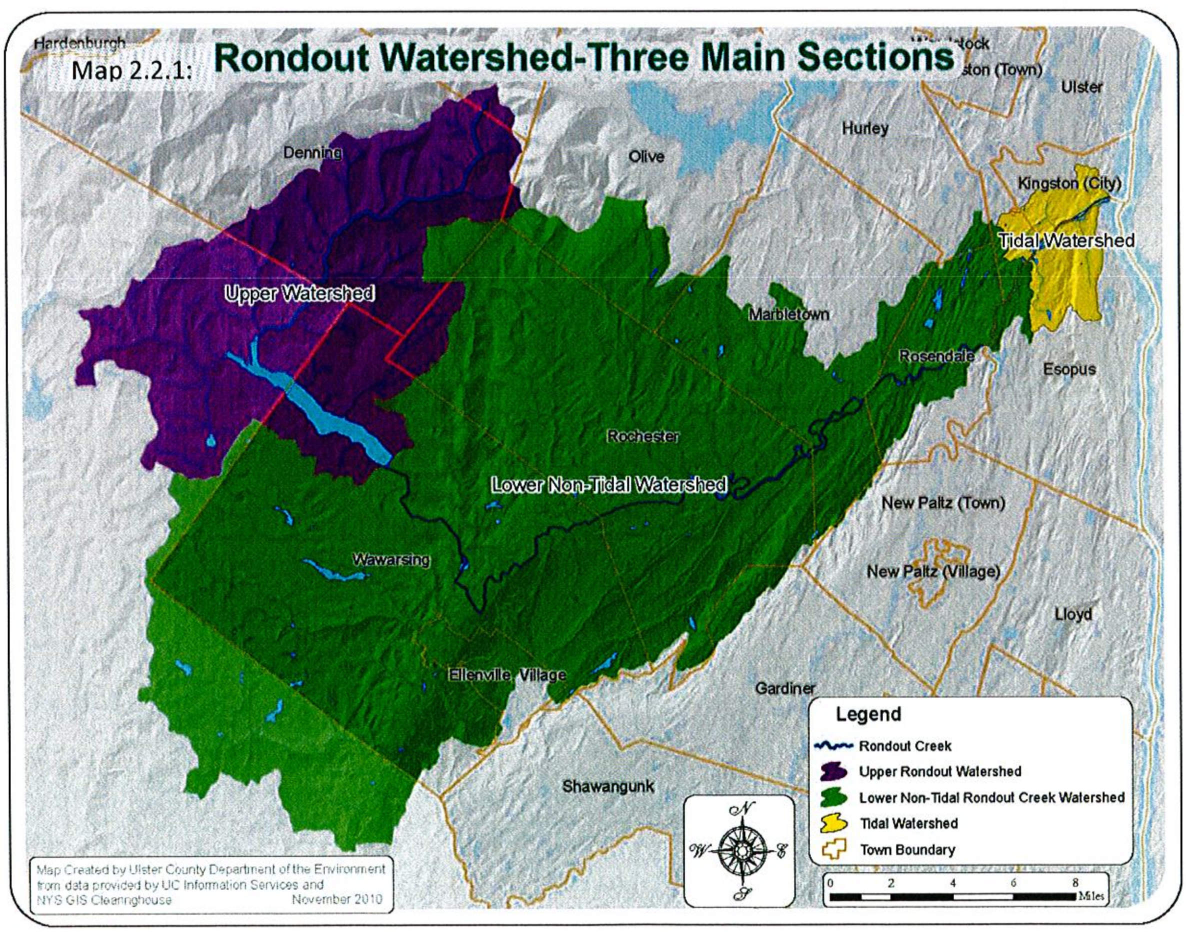


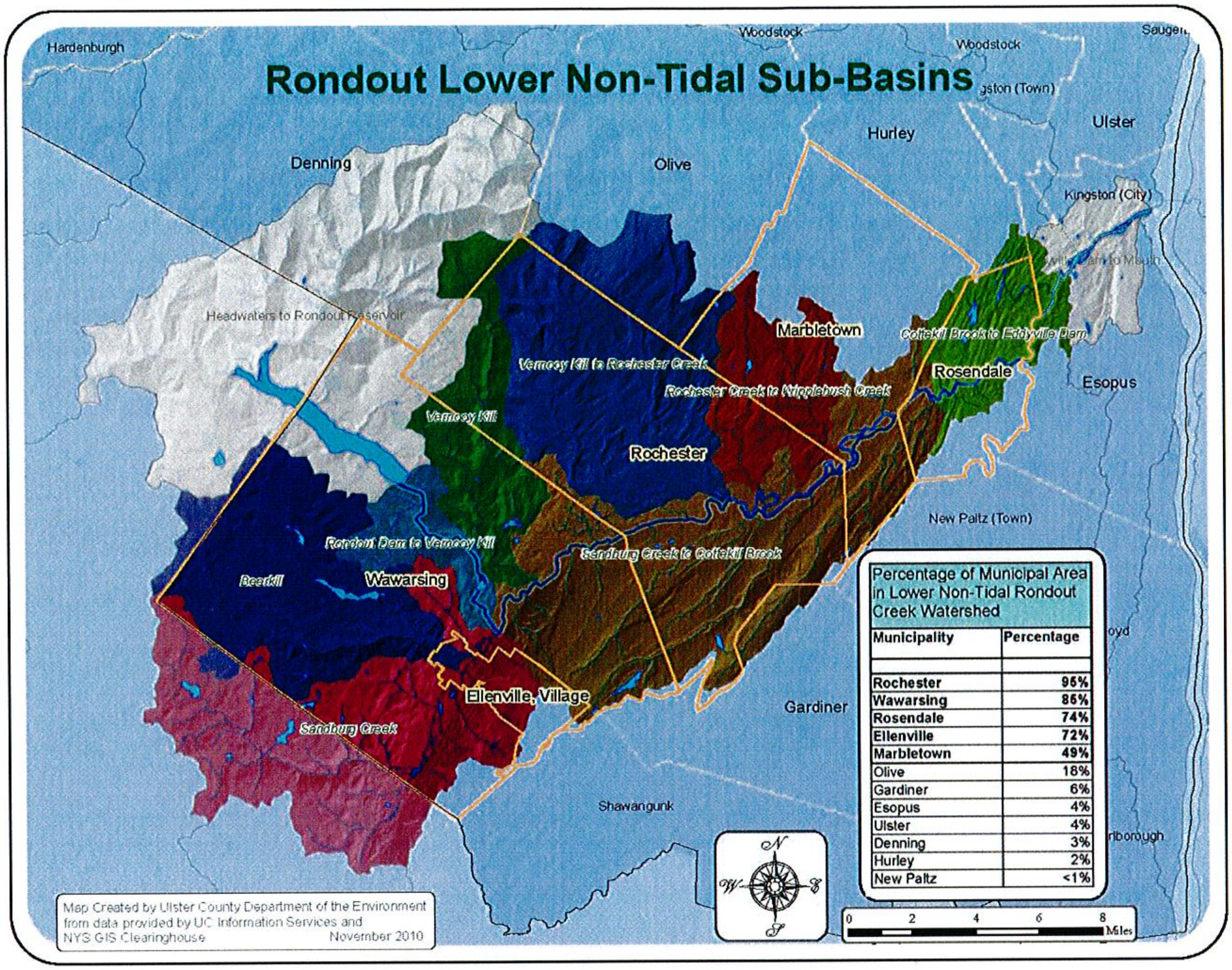

**Figure 2.2.1:** Delineation of a watershed boundary.

### Delineation of the LNT Rondout Creek

The concept of a watershed is basic to all hydrologic designs. Since large watersheds are made up of many smaller watersheds, it is necessary to define the watershed in terms of a point, which is referred to as the watershed "outlet". With respect to the outlet, the watershed consists of all land area that "sheds" water to the outlet during a rainstorm. Using the concept that "water runs downhill," a watershed is defined by all points enclosed within an area from which rain falling on these points will contribute water to the outlet.

The Lower Non-Tidal Rondout, which is the focus of this document, is located between the Upper Rondout, for which a management plan has been developed by New York City Department of Environmental Protection *(Appendix G – Upper Rondout Watershed Management Plan Summary)*, and the Tidal portion which includes about half of the City of Kingston and portions of the Town of Esopus and the Town of Ulster.



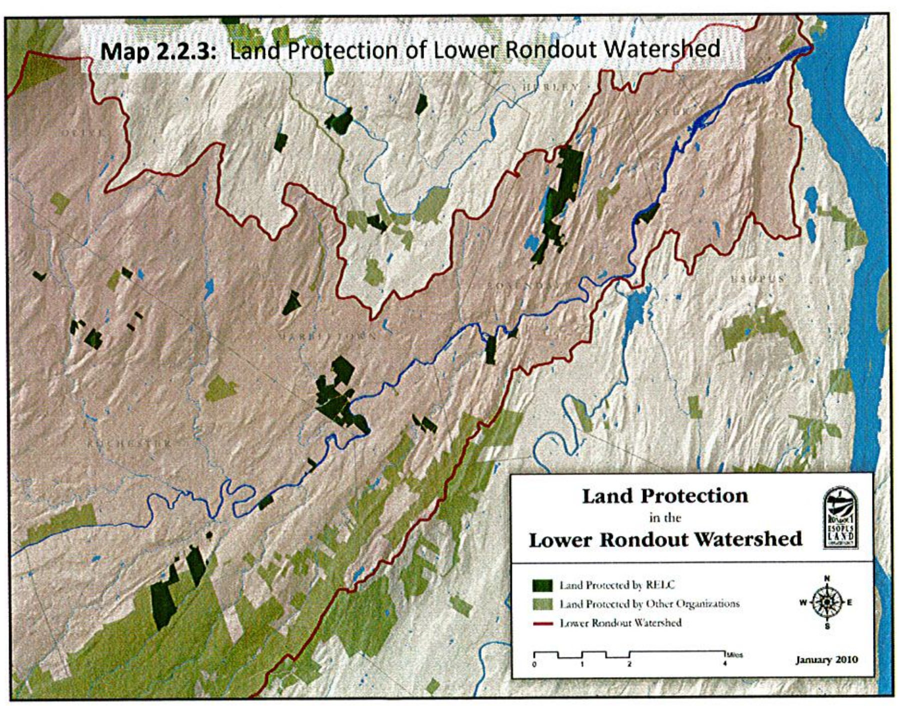



| Municipality | Percentage |
|---|---|
| Rochester | 95% |
| Wawarsing | 85% |
| Rosendale | 74% |
| Ellenville | 72% |
| Marbletown | 49% |
| Olive | 18% |
| Gardiner | 6% |
| Esopus | 4% |
| Ulster | 4% |
| Denning | 3% |
| Hurley | 2% |
| New Paltz | <1% |

**Map 2.2.2:** Smaller Sub-Basins of Lower Non-Tidal Rondout Creek Watershed

Approximately 95% of the Town of Rochester is in the LNT Rondout Creek Watershed, 85% of Wawarsing (including 72% of Ellenville), 74% of Rosendale and 49% of Marbletown; in addition to smaller parts of Olive (18%), Gardiner (8%), Esopus (4%), Denning (3%), Hurley (2%) and <1% of New Paltz. In addition, the LNT section of the Rondout includes parts of Fallsburg and Mamakating in Sullivan County.

**Map 2.2.3:** Land Protection of Lower Rondout Watershed




## Land Use in the LNT Rondout Creek

Open space preservation is often the first line of defense and the most effective strategy for protecting water resources. The responsibility for protecting large or significant portions of the watershed is often assumed by or designated to area land trusts, of which the Rondout Esopus Land Trust (RELT) is an important organization in this watershed. Map 2.3.3 shows the lands protected by RELT (in dark green), and those protected by other organizations (in lighter green), extending all the way out to the Hudson River and includes the tidal portion of the Rondout Creek Watershed. Note the large amount of protected lands along the Shawangunk Ridge, much of which is protected by Mohonk Preserve and the Nature Conservancy.

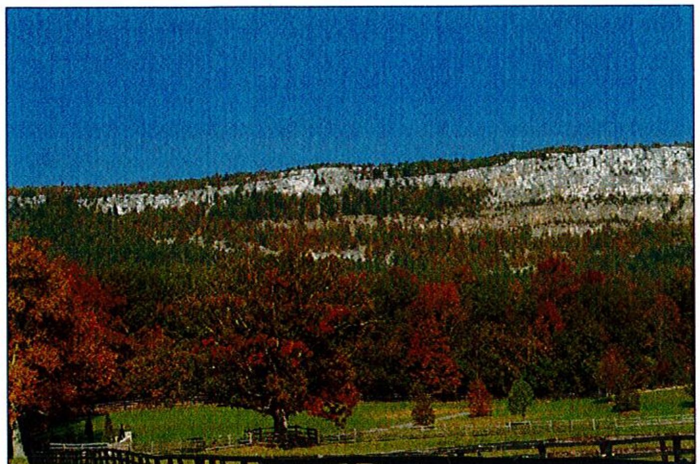


**Photo 2.2.2:** Scenic view of Shawangunk Ridge from the Wallkill Valley.

This area, along with the farms in and along the Route 209 corridor, creates a very scenic byway. Area land trusts and related organizations have partnered with local municipalities to form the Shawangunk Mountains Scenic Byway Regional Partnership (www.mtnscenicbyway.org) to help preserve the region's beauty and resources.

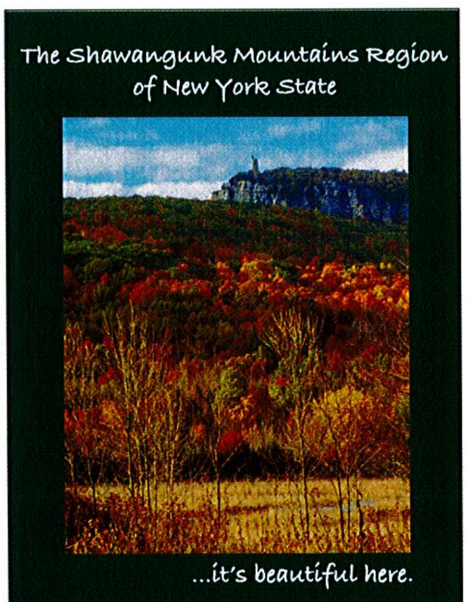



**Photo 2.2.3:** Shawangunk Mountains Scenic Byway

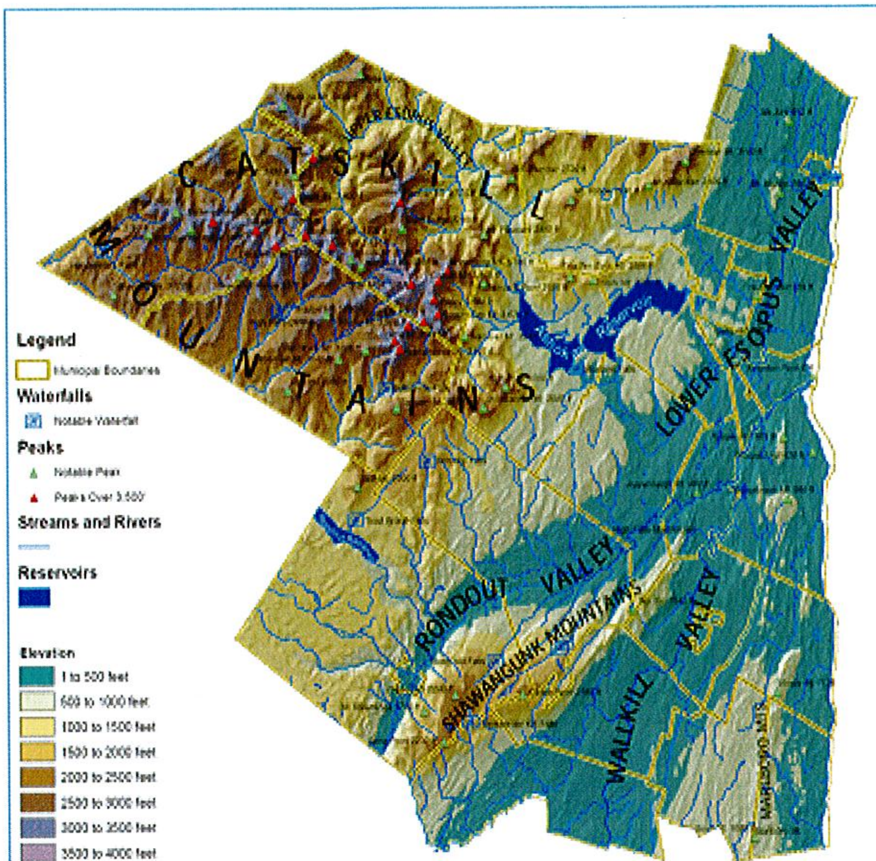
During the six years of planning the byway, nine towns and two villages came to realize that they have a lot in common and to appreciate the synergy that can be achieved by working together so they formed an intermunicipal partnership to implement a corridor management plan, to help improve transportation systems, and to advance their mutual goals of advancing economic growth through tourism, while helping to preserve the important resources of this region. The Shawangunk Mountains Regional Partnership includes the towns of Crawford, Gardiner, Marbletown, Montgomery, New Paltz, Rochester, Rosendale, Shawangunk, Wawarsing and the villages of Ellenville and New Paltz and is the management organization for the Shawangunk Mountain Scenic Byway with Al Wegener as its Executive Director.

By joining this partnership the towns participated in an intermunicipal agreement (IMA), forerunner to the one signed by the four central Rondout municipalities for watershed protection.

## SECTION 2.3 ADJACENT WATERSHEDS

The Rondout Creek watershed in the Rondout Valley roughly parallels the Lower Esopus Valley, which is to the northeast, as they both flow northward towards the Hudson River, passing through many of the same towns.

The Rondout Creek flows along the eastern and southern portions of Marbletown, through of Rosendale), and the Town of Ulster, and the City of Kingston.




Map 2.3.1: Source: Ulster County Planning Dept.

The Esopus Creek flows to the west and north of the elevated limestone ridge that shaped the Esopus Valley and gave many of the early settlements a high place to grow and expand. (A full description of both the Upper and Lower Esopus watersheds and the Ashokan Reservoir, which separates them -- as the Rondout Reservoir does the Upper and Lower Rondout -- is attached as *Appendix H*.) The Wallkill Valley and its watershed are to the southeast of the Rondout and flow into it at Creek Locks. Glacial activity in these adjoining watersheds repeatedly covered and melted, scraped and deposited the land forms and soils and outwash that defined the valley forms and their composition.

**New York City Water Supply System:**

Another major adjacent watershed is the Catskill/Delaware Watershed, which is New York City's West-of-Hudson water supply. A smaller source in Westchester and Putnam counties is the East-of-Hudson Croton Watershed. The Catskill system was completed in 1927 while the Delaware portion of the system was completed in 1967, and the Croton system in 1842. East of the Hudson River, the "Cat-Del" system as it has come to be called is comprised of a series of reservoirs. The Ashokan Reservoir is the terminal reservoir of the Catskill system. The Delaware system, consisting of the Cannonsville, Pepacton and Neversink reservoirs, is connected to the Rondout Reservoir in the Hudson watershed by aqueducts, which represent a major inter-basin transfer of water across watershed boundaries. This transfer is under the jurisdiction of the Delaware River Basin Commission. The Cat-Del system has 580 billion gallon storage capacity. Both the

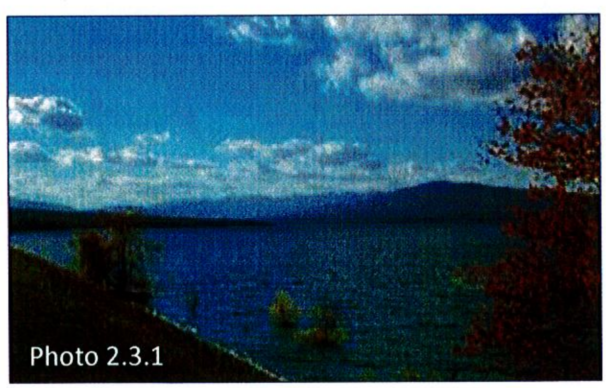


Photo 2.3.1

Catskill/Delaware and the Croton systems are connected by aqueducts to the greater New York City metropolitan area. Together theses systems deliver approximately 1.4 billion gallons of high-quality water each day to nearly nine million people in New York City and Westchester, Orange, Putnam and Ulster counties.

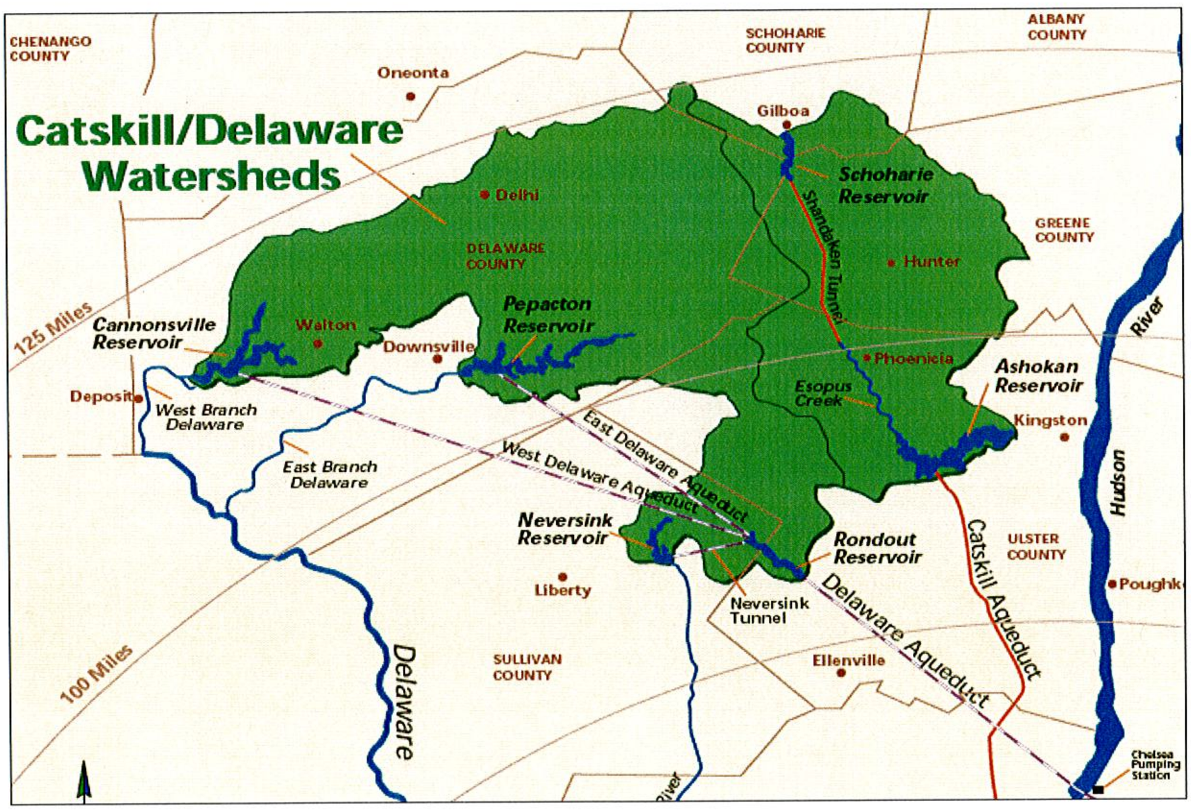

In addition to assuring water quality these areas provide important fish and wildlife habitat, open space preservation, and recreational opportunities, the New York City Department of Environmental Protection has carefully protected these major drinking water supplies by promulgating strict regulations and entering into related Memoranda of Understanding (MOUs) with municipalities which are located in these drainage basin and those through which the aqueducts run. To assure watershed protection in agricultural areas of these watersheds, the NYC DEP has worked with the Watershed Agricultural Council to implement Whole Farm Planning projects in which farmers participate in the design, installation and management of a variety of systems on their own farms that protect water resources, especially these critical reservoirs. Technical assistance and funding is provided by New York City, NY State and related agencies.

**Ecosystems Protection Pays Off**

In the 1990's as development pressures increased in the area, the Catskill-Delaware System was threatened with increasing pollution due to construction, agricultural runoff and other activities. The City was faced with an important decision: whether to build an artificial filtering system at a cost of approximately $6-$8 billion or to invest $1 billion in sustainable development practices which would restore the Catskills' natural filtering purification capacity. Choosing to protect ecosystems and the services they provide, they convened a multi-stakeholder process to encourage Whole Farm Planning, upgraded sewage treatment plants to tertiary treatment and implemented other watershed protection measures. In 1997, EPA issued a five-year Filtration Avoidance Determination, which ultimately saved City taxpayers $5 to $7 billion in construction costs and actually increased property values in these rural areas. (Penn State College of Ag Sciences, Coop Extension & Center for Biodiversity Research, Environmental Resources Research Inst., *Biodiversity: Our Living World: Your Life Depends On It!*, Penn State U: University Park, PA 2001, p. 7.) Under the Surface Water

Treatment Rule, New York City is required to filter water from the Croton system, which provides 10 to 15 percent of the City's water; however, many of the protections developed for the Cat-Del system also apply in the Croton watershed *(EPA)*.

**Role of the Rondout Reservoir:** The Rondout Reservoir (see Photo 2.3.2) is the terminal reservoir in New York City's Delaware System, which was the subject of a 1931 Supreme Court decision (amended in 1954) that apportioned water rights between New York, Pennsylvania, and New Jersey. The Delaware System comprises the Neversink, Pepacton, and Cannonsville reservoirs, which all deliver water to the Rondout Reservoir in Ulster County via separate tunnels. At each of these outlets are hydroelectric facilities. The Rondout Reservoir impounds the Rondout Creek with the Merriman Dam, an earthen-covered concrete cut-off wall structure with a masonry spillway. The reservoir has a storage capacity of 50 billion gallons of water and sends water to the Rondout-West Branch Tunnel (a section of the Delaware Aqueduct) at a maximum of 825 million gallons per day (MGD). The Rondout Reservoir also releases water into the lower Rondout Creek at a rate of 10-15 MGD as per DEC regulations.




Map 2.3.3: The Delaware System: Cannonsville, Pepacton, Neversink, and Rondout reservoirs

The importance of the Rondout Reservoir to the city's water supply system cannot be understated. It provides, on average, 50% or more of the city's supply. The operational objectives for this reservoir are as follows:

- Avoid spilling water into the downstream Rondout Creek.

- Keep the elevation of the reservoir high enough to maximize delivery through the Rondout-West Branch Tunnel.

- Manage diversions into the reservoir from Neversink, Pepacton, and Cannonsville reservoirs to achieve operational objectives.

- Meet the needs of hydroelectric energy generation agreements.

- Comply with all federal, state, and consent decree requirements.

The operating objectives of the Rondout Reservoir and upstream contributing reservoirs also reflect an arrangement with the Delaware River Basin Commission and downstream consent decree parties through the Flexible Flow Management Program (FFMP). The FFMP release levels from Cannonsville, Pepacton and Neversink reservoirs are based on reservoir storage levels. Storage levels will indicate which FFMP zone the reservoir is in, which in turn correlates to a determined release level. The higher the storage, the higher the downstream release rate.

While Rondout Reservoir is not subject to the FFMP, it is affected by the operation of the upstream reservoirs under this program. Fifty percent of snow water equivalent of the snowpack, which is measured biweekly, may require manipulation of the current and long-term reservoir level outside of normal operations, depending upon the analysis of short and long term meteorological and hydrological conditions. Targeting an appropriate elevation to account for the potential runoff as a result of snowpack within the watershed may be accomplished within a reasonable period, but is also dependent upon the conditions within the East-of-Hudson system and the Delaware System reservoirs.

DEP manages the Rondout Reservoir in a way that has a significant impact on flood prevention in the Rondout Valley. The reservoir is managed with a primary goal of not spilling and the operators take into account snowpack, meteorological forecasting and modeling, careful management of inflows (upstream reservoirs and local runoff), and to allow for ample water to be released to the lower Delaware River and Rondout Creek. While the reservoir is not operated for flood control (nor was it designed for this purpose), the operating objectives of DEP

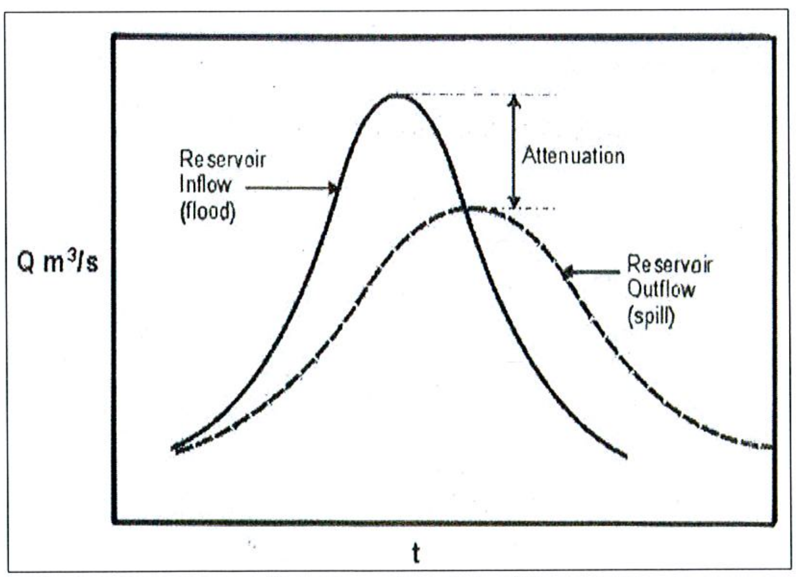



Figure 2.3.1: Source: "A *Review of the Role of Dams in Flood Mitigation*", a paper submitted to the World Commission on Dams (www.dams.org) in March 2000 by Peter Hawker

provide benefits for flood mitigation and reduction. Reservoirs provide flood attenuation even when full.

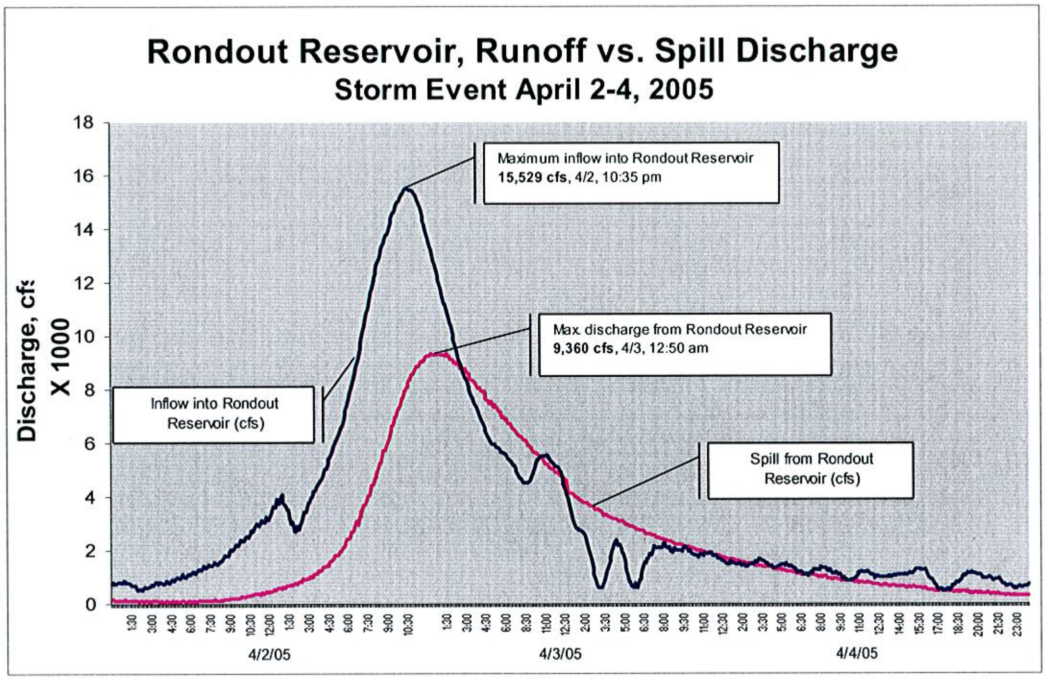



Fig. 2.3.2: Attenuating floodwaters means slowing down and/or reducing flow to the reservoir compared to outflow from the reservoir. *(Source NYC DEP)*

Even when the Rondout Reservoir spills, attenuation can occur. For example, during a storm on April 2-4, 2005, the maximum inflow to the reservoir was 15,529 cubic feet per second (cfs) on April 2 at 10:35 pm. The maximum outflow was 9,360 cfs on April 3 at 12:50 pm. In this case, the reservoir, even when full, attenuated 40% of the water that entered it. This has a benefit downstream by holding back floodwaters and delaying downstream flows.

## 3.1 SOILS AND GEOLOGY

Close scrutiny of the Rondout Creek Watershed reveals a complex story of the inter-relationships of bedroll control of drainage from millions of years of sedimentary rock deposition, episodic processes of tectonic uplift and deformation by folding and faulting, eons of erosion of ancient mountains, and more recent glacial action and soil development.

**3.1.1 Historical Geology:** The topography of the watershed has developed over millions of years. Four main periods of bedrock deposition are recorded in the rock record:

- Late Ordovician Flysch (Austin Glen, Normanskill) marine trough
- Silurian Shawangunk Conglomerate beach
- Late Silurian and Early Devonian Carbonates in warm shallow seas
- Devonian Catskill Delta

Late Ordovician Flysch (Austin Glen, Normanskill) marine trough: The oldest sedimentary bedrock units in the basin are the Late Middle Ordovician gray fine-grain thin-bedded siltstone, shale and sandstone deposits named Austin Glen and Normanskill Formations. Approximately 8000 feet of sediments were deposited in a sinking north-south trough as the backbone of the Appalachian Mountain chain. In Ulster County the sediments were derived by erosion of bedrock within the older precursors to the Taconic Mountains of eastern New York. The rock particles were transported westward and downslope and deposited in the marine trench. Many of the sedimentary layers were "turbidites" formed on the sloping sea floor disturbed by local earthquakes causing the sediment to shake, become suspended in the water, flow down slope, and come to rest with a gradation in grain size. A "turbidite" bed is a deposition from one slide event with sediment sorted from coarse grain (gravel or sand) on the bottom to fine grain (silt or mud) on top. After deposition of these fine-grain gray marine sediments were consolidated into rock by heat and pressure. Later, at least two tectonic events of mountain building such as upheaval and deformation occurred resulting in folded and faulted bedrock rising above sea level and subjected to periods of erosion.

Silurian Shawangunk Conglomerate beach: The Shawangunk Mountains are a ridge composed of huge slabs of quartzite conglomerate interleaved with thrust slabs of Ordovician Martinsburg (Hudson River Beds of Austin Glen and Normanskill Formations). The Shawangunk Conglomerate was deposited at the beginning of the Upper Silurian Period (423 to 421 million years ago) in geologic time. The conglomerate consists of beds of sandstone and quartz pebbles, which were deposited on a beach. The beach developed on an eroded surface of the Ordovician Martinsburg bedrock, which had already been folded and faulted. The deposition of nearly horizontal beds of sediments on a beach overlying the folded and faulted beds below is called an angular unconformity. The contact zone represents a period of time when deposition was not occurring while sediments were lithified into rock, the rock was deformed by earth's compressional forces, and the older Martinsburg marine rocks were brought to rest at a beach level with upland to the east and a salt-water sea to the west.

The beach zone was oriented north to south and a marine sea was located to the west. Transport of the sand and pebbles came from erosion of crystalline rocks in the vicinity of the present day

Taconic Mountains on the border of New York with Massachusetts and Connecticut. The coarse-grained sand and gravel size pieces of quartz were rounded and polished as they were carried westward by streams and floods to a littoral or beach zone in the area of eastern Ulster and Orange Counties. Smaller size sediments (fine sand, silt, clay) were transported across the beach and into the sea. The Shawangunk conglomerate correlates with sandstones to the west such as the Herkimer sandstone of central New York. The littoral zone slowly sank or sea level rose maintaining the beach in approximately in the same geographic location for approximately 1800 feet of sediment to accumulate. Interbedded red shale and coatings of red iron oxide on grains indicate that the sediments were in a subaerial environment in contrast to other deposits under water. The sediments were lithified by heat and pressure and eventually the beach zone was uplifted by earth forces and the brittle rock was fractured along lines running north 30 degrees east. The broken slabs of the Shawangunk Conglomerate were thrust to the northwest and deformed into a heap of slabs forming the Shawangunk Ridge. The edges of the slabs are the cliff faces. Made of Silurian Shawangunk conglomerate, a white, quartz-pebble, well-indurated rock with an inward dip of the bedding, the escarpment is ideal for rock climbing and attracts and challenges climbers from around the globe. (Van Diver 1985: 92)

Late Silurian and Early Devonian Carbonates in warm shallow seas: The folded carbonate belt of Eastern New York includes the Upper Silurian Rondout Formation and the overlying Lower Devonian Helderberg Group. Carbonate rocks are those made up of limestone and dolostone. The chief mineral of limestone is calcite (calcium carbonate) and of dolostone is dolomite (magnesium-calcium carbonate). Carbonate sediments are is deposited in warm tropical marine waters. The particles of calcium carbonate are formed in green algae and corals in oxidizing conditions. Various species of green and blue-green algae extract the calcium from seawater and form a carbonate skeleton under a green chlorophyll skin. Other marine creatures have carbonate spines, shells, exo- and endo-skeletons, and multi-dwelling units or colonies such as corals. Carbonate rocks are classified by function and shape of floral and faunal debris, which is discarded on the sea flow and the matrix holding the particles together. The grains may be biological pieces and parts, excreted pellets, oolites (pearl-like spheres), and broken pieces of limestone. The two types of matrix cementing the particles together include lime mud known as micrite and crystalline calcite known as spar. The classification name is composed of the particle name and matrix name. Hence, in a bed of Thallassia algae growing in lime mud in the Florida Keys, the modern day marine processes are making a carbonate rock known as a "bio-micrite." "Bio" is for the origin of the algae parts and "micrite" is for the fine grain mud matrix.

One can go to the Florida Keys and Florida Bay and witness the deposition of modern day carbonate sediments in the shallow warm marine coastal waters. One can also travel to Florida and witness accidents related to collapse of karst features which houses, cars, and all manner of things that have fallen into expanding sinkholes. Karst features are described below.

Between Rosendale and Kingston and from Kingston north to Coeymans, the Helderberg Group is folded and faulted into a complicated three-dimensional puzzle of duplex structures. Also the mining of some strata for cement has removed significant volumes of bedrock both in surface and underground mines. Since the majority of these units are composed of limestone and dolostone, they are somewhat soluble in water, and more soluble in acid rain water. The solution of such carbonate bedrock leads to development of streams, which disappear into the ground and emerge as springs some distance away. Caves, sinkholes, conduits, and a myriad of various shapes and sizes of solution cavities form karst landscape. The unique characteristic of karst areas versus regular competent bedrock areas is that large volumes of groundwater can flow very rapidly from the surface into and through underground karst conduits.

**KARST AQUIFER REGION**: For that reason, the 2009 NYS Open Space Conservation Plan defines the as follows and has designated this area as a regional priority for conservation (p. 71):

> "The Karst Aquifers are situated in a narrow band of carbonate rocks that extend throughout Ulster County, generally parallel with the Hudson River and tending south-southwest through portions of Saugerties, Kingston, Esopus, Marbletown, Rosendale, Rochester, and Ellenville continuously outcropping just northwest and along the flank of the Shawangunk Mountain Ridge. This region is characterized by such features as caves, sinkholes, mines, springs, lakes and sinking streams. The area is rich in biological, geological and historical resources, provides diverse outdoor recreational opportunities and critical water reserves."

In addition to recreational and water supply uses, the very same karst features can transport spilled or released contaminants into groundwater supplies very rapidly with no filtration by soils or other natural mitigation. Such potentially hazardous conditions require special protection for the groundwater within these carbonate units.

Because the Rondout flows over these bedrock units and also is hydraulically connected with the groundwater within these carbonate rock, protection of the groundwater resources is a natural topic for inclusion in a discussion of management of the Rondout Creek.

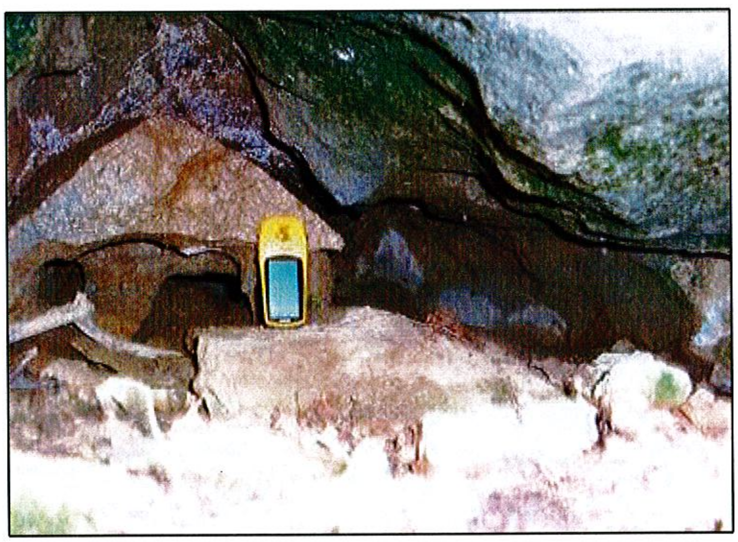
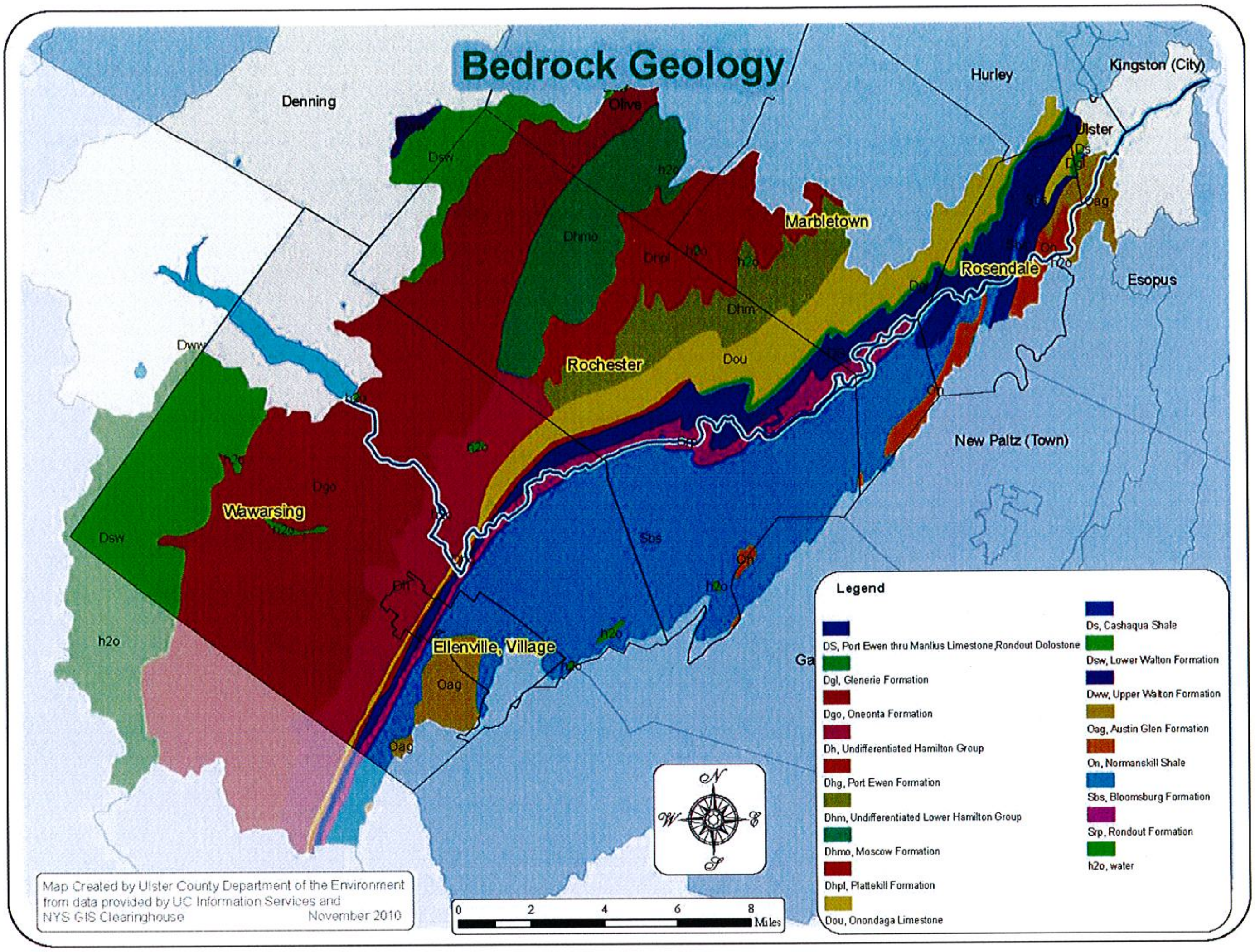


**Photo 3.1.1 Karst dissolution:** Note the fissures and opening created by rainwater and snowmelt. Small hand-held GPS unit indicates scale of the erosion. With features like this, development should either be avoided or done very careful to protect underlying aquifers and to ensure structural stability.

3.1.1.4 Devonian Catskill Delta: Estimates indicate that the 7000 to 9000 feet of sediment were deposited as the Catskill Delta on the edge of a sinking shallow sea. The sediments were eroded from the ancient Taconic Mountains and transported westward to the shallow marine environment. The youngest bedrock was deposition as a coarse grain layer of the Slide Mountain Formation on top of the Catskill Delta 550 million years ago.




**Map 3.1.1 Bedrock Geology.** Courtesy of Ulster County Department of the Environment, November 2010.

**3.1.2 Course of the Rondout Creek from Reservoir to Eddyville Dam:** The lower non-tidal Rondout Creek is a major drainageway capturing water flowing down the southeast front of the Catskill Plateau and from the northwestern side of the Shawangunk Ridge. These two drainage areas converge in the southwest-northeast trending Silurian-Devonian carbonate belt and the stream flows northeast from Ellenville toward High Falls, Rosendale, and Eddyville.

The lower Rondout Creek flows southeast from the NYC Rondout Reservoir down the slopes of the near horizontal sedimentary deltaic deposits of the Catskill Plateau. At Napanoch the Rondout Creek is joined by Sandburg Creek flowing northeast from Ellenville. At that point the Rondout makes a right angle turn and flow s northeast within the Silurian-Devonian carbonate belt. The solubility and softness of calcite and dolomite minerals allow the bedrock to be easily eroded and the carbonate belt forms the natural lowland to conduct the stream flow to the northeast.

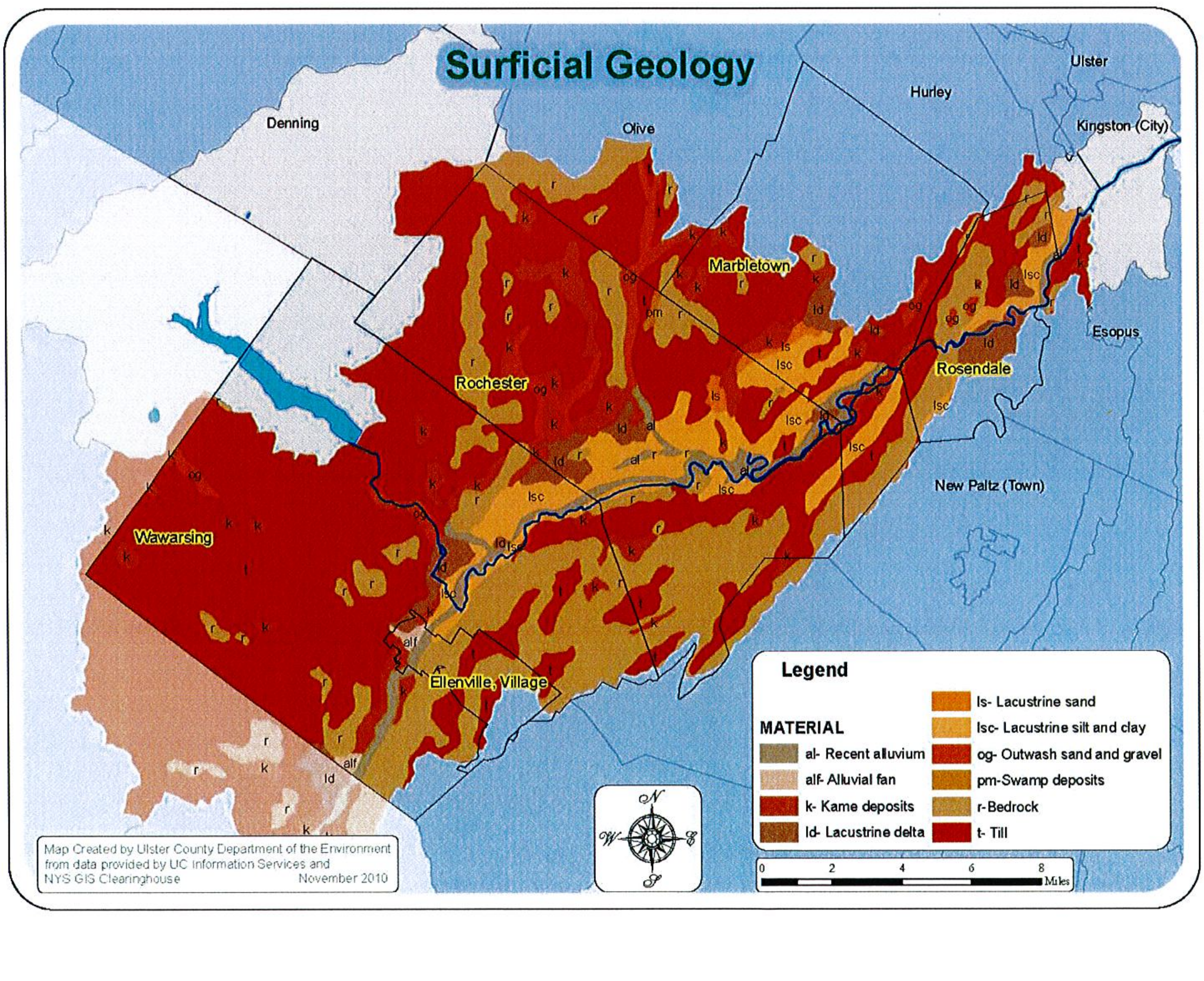
From Napanoch to Kerhonkson the Rondout Creek follows a meandering pathway on a floodplain (about 2000 feet wide). From Kerhonkson to within one mile of Accord, the stream flows in a wide nearly straight arc changing direction from northeast to nearly east always hugging the southeast limit of the floodplain.

With respect to stream flow, a constricting point is located directly south of Mill Hook and about 1500 feet north of the intersection of Berme Road and Granite Road. Immediately after the constriction, the Rondout Creek resumes a meander pattern from Accord to High Falls. At High Falls, a dam confines the stream flow and periodically the water is diverted through a sluice and tunnel system to drive electric generating turbines. Before the dam, the last 2000 feet of stream bed is confined by Berme Road on the southeast and Lucas Avenue on the northwest up to the bridge where Route 213 crosses the stream on the west side of High Falls.

After the power plant, the Rondout follows a relatively straight course from Bruceville to Lawrenceville because the stream is confined on both sides by a v-shaped bedrock valley. At Lawrenceville the stream follows a course of incised meanders through Rosendale to LeFevre Falls. About 2,000 feet below the Falls, the Wallkill River spillway from Sturgeon Pool enters the Rondout from the south. At the confluence the Rondout changes course and flows north-northeast in a v-shape valley with very gentle arcs (in contrast to curly meanders) to Eddyville.

### 3.1.4 Surficial Geology

**Map 3.1.2 Surficial Geology.** Courtesy of Ulster County Department of the Environment, 2010.



**Rondout Surficial Geology:** Overburden is the general term for unconsolidated sediments deposited above bedrock and consists of surficial geologic sediments with developing soil on top. Surficial geology includes the study of sediments placed on the bedrock surface as a result of geologic processes of erosion, transport, and deposition by glaciers, wind, streams, and glacial meltwaters above, within, under and away from the ice. Other processes include lacustrine environments such as ponds and lakes as well as delta formation where streams transport sediments into such still bodies of water and drop the sediments upon entrance. The surficial geologic units mapped by the New York Geological Survey on the Lower Hudson sheet (map scale 1:250,000) include the following:

Till (map symbol "t") consists of sediments deposited directly by a glacier without reworking by melt water and is comprised of a mixture of clay, silt, sand, gravel, and boulders. Such materials originate from the pressure and grinding of glacial ice eroding underlying sediments and bedrock. There were four ice ages and detailed mapping has shown that much of the New York State shows evidence of advance and retreat of more than one glacial episode.

Stratified drift may be glaciofluvial, glaciolacustrine, or glacialmarine in nature depending on the water body interacting with the glacier such as streams, lakes or salt water. In moving water such as a stream flow or tidal oscillation, the sediments tend to be sorted and beds are formed by size related to intensity of action. Greater velocity or amplitude can move larger size particles and when the energy is dissipated strata of like size are deposited. In still water such as ponds and lakes or wetlands, sediments can be deposited by settling from suspension. Often the source of water is glacial melting on top, within, under or on the sides of glaciers. Stratified drift deposits are a broad category of many distinct types such as lacustrine, kame, outwash deposits, and swamps.

Glaciofluvial deposits include kame and outwash deposits.

Kame (map symbol "k") deposits are mounds, knobs, or short irregular ridges, composed of stratified sand and gravel deposited by a subglacial stream as a fan or delta at the margin of a melting glacier or by a superglacial stream in a low place or hole on the surface of a glacier or as a deposit on the surface of or at the margin of stagnant ice.

Outwash deposits (map symbol "og") consists of sand and gravel strata left by melt water streams in front of an end moraine of the margin of an active glacier.

Lacustrine deposits include deltas, silt, and silt and clay deposits.

Lacustrine deltas (map symbol "ld") are formed where glacial or other flowing water enters a lake or pond. The sediment is dropped because energy of stream movement or momentum diminishes upon reaching the base level or surface elevation of the lake or pond. The sediment grain size in the delta is the largest grain sizes transported by the moving water. The smaller sediments such as clay and silt can be carried by suspension farther out into the body of still water.

Lacustrine silt (map symbol "ls") is material, which may be at the toe of the delta or lake bottom sediments depending on stream carrying capacity when entering a still body of water. Other silt deposits, formed by wind blowing over the glacier and exposed sediments, are known as "loess".

Such wind-blown silt deposits are lumped in with lake silt deposits on the surficial maps included in this report.

Lacustrine silt and clay deposits (map symbol "lsc") are lake bottom deposits from fine grain silt and clay material dropping from suspension in still waters. Such deposits are often seasonal with alternating fine light and dark strata.

Swamp sediments (map symbol "pm") consist of organic and fine grain sediments deposited under saturated reducing conditions in slow moving wetland waters.

Alluvial deposits (map symbol "al") are composed of alluvium that is deposited by streams or running water as a stream channel. In contrast to fluvial deposits associated with actual streams, alluvial features are related to episodic heavy rains associated with erosion, transport, and deposition of material, which is normally dry on sloped landscapes.

Alluvial fans (map symbol "af") are outspreading, gently sloping sediment masses deposited by an intermittent stream on generally dry lands as a result of episodes of heavy rains. Viewed from above, the shape of deposits is in the shape of an open fan with the apex at the upgradient point of dispersal, similar to the dispersion of a delta where a stream enters still waters.

Once the surficial deposits are in place, the slow process of development of a soil profile takes places over thousands of years driven by mechanical and chemical reactions driven by periods of rainfall, leaching, drying out, and natural mixing such as worm borrowing. Each soil is characterized of the type surficial deposit upon which it develops as well as topography and nearby agents of change.

In some areas, surficial deposits have never formed or have been eroded away leaving bare bedrock exposed (map symbol = "r").

Distribution of Surficial Deposits and Bedrock Knobs and Planes: On the northwestern side of the Rondout Creek drainage basin, till is widely distributed by the action of glaciers at elevations above those listed for each sub-basin.

| | |
|---|---|
| 580 feet | Sandburg Creek |
| 490 feet | Beerkill Creek |
| 611 feet | Direct Discharge below Rondout Reservoir |
| 895 feet | Vernooy Kill |

Within the till area, several hill tops are shown as rock areas as well as medial drainage divide areas between Vernooy Kill sub-basin and Sagebush--Mombaccus drainage and on the west side of the Beaverdam and Rochester Creek drainage. A large bedrock exposure area is shown near the intersection of the boundaries of the Towns of Rochester, Marbletown and Olive in the headwaters of Vly Creek. Also another bedrock area is mapped on the northern edge of the Rondout Basin around the peaks of Little Rocky, Mombaccus, and High Point in southeastern Olive. These bedrock high points often show glacial striations indicating that while a glacier was moving over the bare bedrock, rock chips in the muddy frozen base of the glacier have scratched grooves. Sometimes two directions of striations are superimposed showing movement of two glaciers or ice lobes moving in different directions.

The Sandburg Creek to Wallkill River Sub-Basin shows is the area on the western side of the Shawangunk Ridge where drainage flows westward down to the Rondout Creek. On the surficial geology map distinct linear patterns of till and bedrock exposure are shown. Obviously the bedrock areas are the open steep spans of the Shawangunk Conglomerate slabs dipping west toward the Rondout. The till is found in depressions and valleys in areas which may have been former ice caves formed by erosion and mass wasting of open linear fractures between large slabs of the conglomerate bedrock. The path of the Rondout Creek was described as a nearly straight arc from Kerhonkson to within one mile of Accord. From inspection of the surficial geology map (Map 3.1.4), it is evident that resistant bedrock on the east side of the creek controls the direction of flow.

Several kame areas are shown in the Beaverdam and Rochester Creek drainage basin indicating significant meltwater activity as glaciers were waning. Comparing the stream flow patterns and the kame deposits in that area, disrupted drainage patterns are caused by kames acting as dams to flow. Many streams flow south and are diverted to the east by kame deposits and bedrock outcrops.

The lowland drainage-way from Spring Glen to Rosendale within the Silurian-Devonian carbonate belt has many types of surficial units, such as lacustrine, fluvial and alluvial deposits. Because the carbonate belt encompasses convergence of stream waters on lowlands, there are more sites for lakes and ponds to occur after glacial retreat. Outwash and subsequent freshwater erosion, transport and deposition are the dominant post-glacial geologic processes forming the modern landscape.

From Napanoch to High Falls, broad linear bands of lacustrine silt and clay are shown covering the valley floor on the northwest side of the Rondout Creek, while the southeast side is confined by bedrock and till deposits. From the confluence with the Wallkill flow east of the New York Thruway to the dam at Eddyville, a similar, somewhat thinner band of lacustrine silt and clay lies on the northwestern side of the Rondout and bedrock on the southeastern side. Although the surficial map shows areas of till in the segment from High Falls to the Wallkill confluence, the till is a thin veneer and the Rondout stream flows over and between bedrock walls.

**3.1.5 Soils:** A soil profile is made up of different horizons defined by the physical, chemical and hydraulic characteristics as the soil changes from the surface downward toward bedrock. The soil profile develops in the surficial sediments from the time they are exposed to the atmosphere and weather. In the Rondout Valley most soil profiles have been developing foe about 10,000 years after the end of the lat ice age until now. Each soil type is a product of a surficial deposit consisting of a grain-size distribution from clay-size particles though boulder-size. Rainfall and snowmelt play a significant role in the vertical change in the profile due to the interaction of water infiltrating through the loose sediments interacting with some sediments, which are soluble in water and even more soluble in acid rain. Some minerals are dissolved and transported downward in the water. Other minerals undergo chemical alteration depending on conditions of temperature, pH, and oxidation-reduction potential. The annual freeze-thaw cycle and mixing of sediments and formation of worm-castings also alter the sediments as the soil develops.

As mentioned previously, soils develop on surficial deposits. There are more soil classifications than types of surficial deposits because soil types are classified by more factors including parent material, climate, plant and animal life, topographic relief (elevation and slope), time, and hydrologic conditions.

Ulster County Department of the Environment is preparing a simplified version from the Soil Survey of Ulster County, NY (published by USDA, June 1979). Many soils have the same locality name and are further subdivided by slope and association with other soil types and bedrock and boulders. For instance the following four soils are grouped together because they all developed in reddish glacial till above sandstone, siltstone, and shale bedrock.

| | |
|---|---|
| OgB | Oquaga Channery silt loam, 3 to 8 percent slopes |
| OIC | Oquaga & Lordstown Channery silt loams, 8-15 percent slopes |
| ORC | Oquaga-Arnot-Rock Outcrop Complex, sloping |
| ORD | Oquaga-Arnot-Rock Outcrop Complex, moderately steep |

All of these soils are related in that they formed on reddish till derived from red sandstone bedrock by scraping and gouging by the base a moving glacier. A similar consolidation of soils into groups is presented in Table 18 in the Soil Survey of Ulster County, NY (pages 271 and 272) based on the parent material, depth and grain-size (texture) of the soil as well as degree of soil drainage and saturation (excessively drained to very poorly drained).

***Sandburg Creek to Wallkill River Sub-Basin (Shawangunk Mountain).*** Although much of the Shawangunk ridge consists of barren conglomerate slabs with no soil development, soils can be found derived from till, lacustrine, and swamp deposits. Well-drained Lordstown and Arnot soils are found in the low areas where the Ordovician shale, siltstone, and sandstone are exposed in windows between the conglomerate slabs. Where water was confined in depressions, lacustrine environments provided the parent material for the poorly drained Madelin soils. Palms muck soil developed in a few isolated swamps.

***Sandburg Creek, Beerkill, Rondout Reservoir direct drainage, and Vernooy Sub-Basins.*** The upland till areas identified above in the surficial till discussion extend across these four sub-basins. The soils developed on till encompass the full range of drainage capacities from Menlo, Morris, Wellsboro, Lackawanna, Lordstown, Oquaga, and Arnot soils. The soils formed on glacial outwash deposits include Walpole and Lamson soils on the "poor" end of the drainage scale. Wayland and Palms muck soils are also on the "poor" end of the scale. The Wayland soil develops along flat stream segments where the valley is wide enough to accommodate a floodplain and the Palms muck forms in swamps confined isolated depressions. The Vernooy drainage area has more Arnot soils and associated rock outcrop than the other sub-basins.

***Vernooy Kill to Rochester Creek to Cobbeskill Brook Sub-Basins.*** These areas have similar soils and till to the sub-basins to the southwest, except for a broader range of till parent materials. All of the till soils are on the well drained half of the drainage scale. Those soils include Bath, Mardin, Wellsboro, Valois, Lordstown, Oquaga, Arnot, and Nassau. The Arnot-Lordsville soils have the greatest distribution. The Hoosick soil is found in former stream terrace, outwash terrace, and outwash fan locations, providing many good sources of stratified sand and gravel for building materials.

***From Rondout Reservoir to Honk Lake,*** the Rondout Creek traverses a sloped course with the Swartswood and Lackawanna well drained soils representing the only soils developing on tills of that area. The dominant soils are developed as stream terraces. The Raynham, Red Hook, and Scio soil types are mid-range on the drainage scale. Hoosic soils are extremely well drained sand and gravel deposits, which are valuable mining resources.

***From Honk Lake to the stream valley*** in the Route 209 corridor, the well drained Lordstown and Arnot soils are developed on till deposits. The extremely well-drained Plainfield and Suncock soils develop on deltaic and floodplains associated with the stream and its valley.

***Along the Sandburg Creek*** flowing from Sullivan County to the point of confluence with the Rondout northeast of Ellenville, the floodplain soils represent the full range of drainage from very poorly drained to excessively drained including Wayland, Middlebury, Tioga, and Suncock. Stream terrace deposits of Unadilla and Raynham are found along this segment. The Unadilla, a well-drained soil is probably the most common soil along the full length of the Rondout Valley along the Route 209 corridor. Stratified Haven alluvium and the Plainfield delta sands are also common along the Sandburg Creek segment.

***From the Sandburg and Rondout Confluence to Kerhonkson*** the same suit of soils are found along the lowlands within the floodplain.

***From Kerhonkson to St. Josen,*** two stream terrace groups of soils are found, the silty Unadilla, Scio, and Raynham soils differing by drainage capacity and the stratified sand and gravel Haven, Pompton, and Walpole soils also differing by drainage capacity. Poorly drained Wayland soils are found on the floodplain.

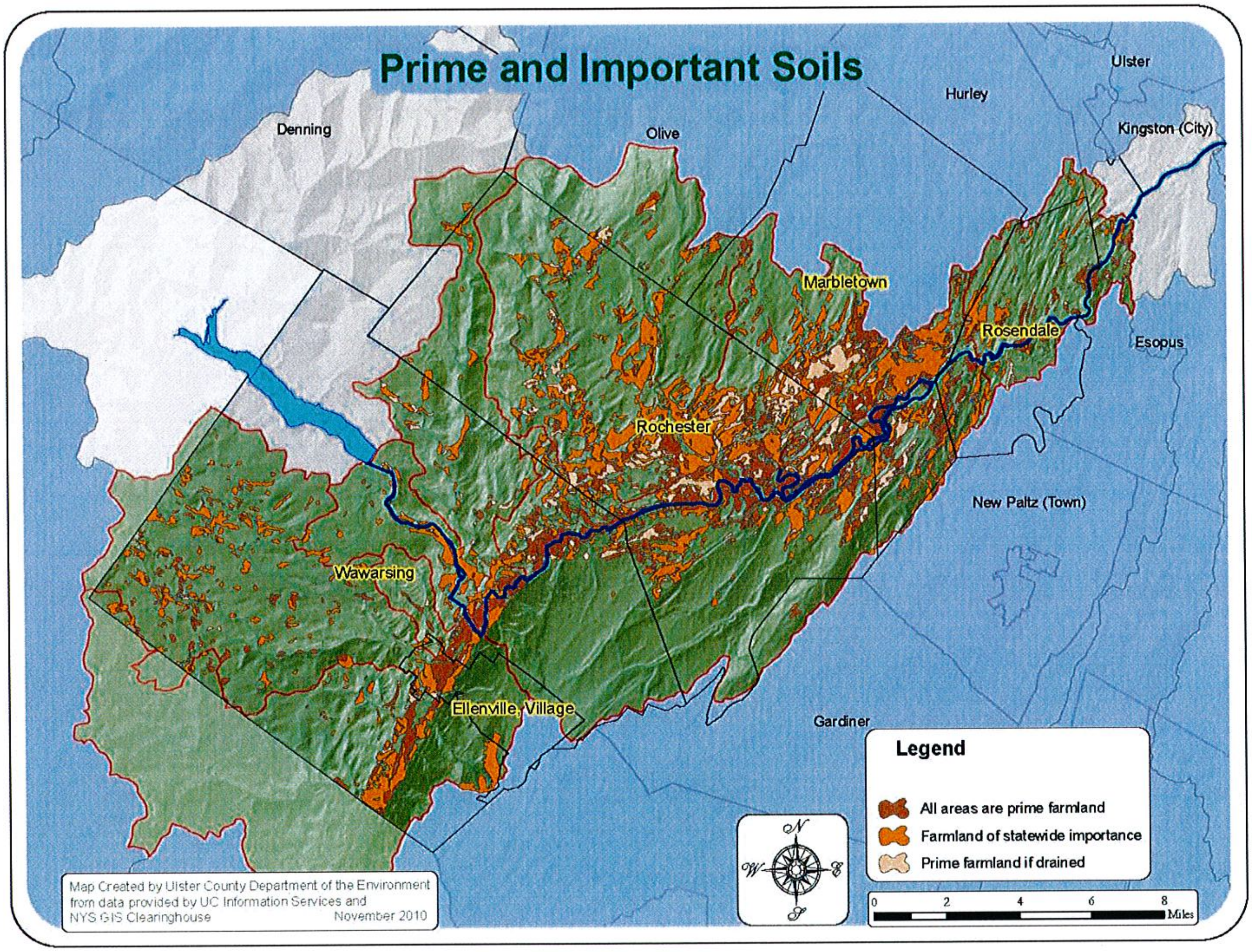
***From St. Josen to Alligerville,*** the soils are different from those upstream and downstream. Till-derived soils such as the well drained Bath and Mardin developed in an area where a moraine was probably left behind with the retreat of glacier ice. The Rondout breeched the moraine and has probably been eroding it ever since. In this segment other soils associated with outwash terraces and lake plains include Hudson-Schoharie, Odessa, Raynham, Red Hook, and Hoosic.

***From Alligerville to High Falls Cemetery,*** these soils are predominantly stream terrace soils such as Unadilla, Scio, Canandaigua, Haven, and Walpole. Tioga floodplain soils are also included. Unadilla is the dominant soil type.

***From High Falls Cemetery to the High Falls Dam,*** the soil have greater diversity of grain size, drainage capability, and origin since soils are found to develop on tills, terraces, and floodplains. The till-derived soils include Stockbridge and Farmington, both of which indicate the presence of limestone bedrock. Stream terrace soil types include Hudson, Schoharie, Scio, Hoosic, Riverhead, Plainfield, and Lamson. Floodplains are represented by Suncock soil.

***From High Falls Dam to Rosendale;*** till, stream terrace, and floodplain soils are found along the stream although the stream has steep bedrock valley walls and thin floodplain areas. The till soils include Lordstown, Arnot, and Farmington, all associated with rock outcrops. Farmington is specifically associated with limestone bedrock. The limited stream terrace development is represented by stratified Red Hook and Hoosic soil types and coarse textured Plainfield soil. The floodplain soil is Wayland, poorly drained compared to all of the other soils in this area.

***Rosendale to Bloomington*** has a large array of soil types. Soils derived from thin tills include the Menlo, Stockbridge, and Farmington. The soils associated with lakes and stream terraces include Hudson, Schoharie, Unadilla, Riverhead, and Plainfield. The Middlebury, Hamlin, and Wayland soils developed on floodplains.




**<u>Map 3.1.3</u> Prime and Important Soils.** Courtesy of Ulster County Department of the Environment, 2010.

## SECTION 3.2 CLIMATE AND PRECIPITATION

**Ulster County Climate Data**

A preliminary analysis of the Preserve's weather data shows that the average temperature has risen about two degrees over the past 114 years.
Composed of more than 40,000 days of weather observations, these records comprise the collection of the Preserve's Mohonk Lake Cooperative Weather Station, established in 1896 by the U.S. Weather Bureau (now the National Weather Service).

Weather readings at Mohonk began in the mid-1880s, taken by the Smiley family, founders of the neighboring Mohonk Mountain House, and are now continued by Preserve research staff. Beginning in the late 1970s, data collection expanded to include regular monitoring the pH of precipitation, lakes, and streams.

The Daniel Smiley's Research Center /weather station offers 100-plus years of invaluable information on changes in weather patterns, temperature shifts, seasons beginning sooner and ending later, and how it all affects the 180 species that live and thrive in this little corner of Ulster County.

This data is important to identifying the extent of global climate change; researchers need access to reliable data covering the longest period possible. The Preserve's weather data is dependable because the station has been in the same, comparatively stable location for over a century and the same protocol has been followed by the relatively few people involved in collecting the data

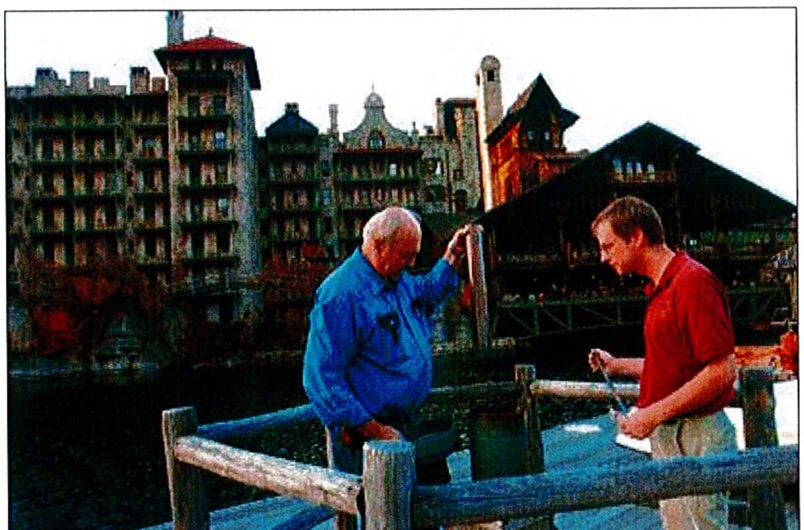


**Photo 3.2.1** Paul Huth, left, director of research at Daniel Smiley Research Center of the Mohonk Preserve, and John Thompson, natural resource specialist, check the rain gauge near the Mohonk Mountain House. (Freeman photo by Tania Barricklo)

(http://www.mohonkpreserve.org/index.php?weatherdata).That information is carefully recorded, by hand, in a daily logbook, which is exactly what Smiley used in his observations, spanning more than 50 years. The weather observers provide the information each month on a digital database for the National Weather Service .

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[1] www.nws.noaa.gov

The data documents a shift over time to warmer temperatures and there has been fewer a number of zero degree or fewer days and more 90-degree or more days at the Mohawk Preserve. It has also been recorded that the past seven years since 2003 have been the warmest on record here.

Changes on the ground have also been recorded: How many days in winter is the ground bare; how many days did rain fall instead of snow; noting that the bare ground will affect the food supply for the animal species in the Preserve come spring seasons.

In reference to Ulster County's dynamic biodiversity and ecological systems, the data has shown a trend over time verifying that the mountain laurel blooms five to seven days earlier now than in the past and the first birds arrive from the south about a week earlier than before. It's noted that the robin has been removed from the migratory list because winters have been warm enough for them to overwinter. Even though they prefer worms, they can change to seeds during the winter to sustain them.

Results of this precise procedure have illuminated climate researchers about the following: A warming trend driven largely by trends in maximum temperatures, especially during summer; increasing daily temperature range during summer and a reduction in the number of freeze-days per year with little change in the length of the freeze-free season. (Nov 15, 2010 – Daily Freeman)

Daniel Smiley's Research Center reports that the annual precipitation on the preserve is 44.57 inches and the average for Nov 2010 is 3.79 inches (calculated by adding up all the measures from each rain event and dividing by the number of months in a year; with an average deviation of +/- 51).

**Municipal Climate Data**

The average temperatures for Wawarsing, Rosendale, Marbletown and Rochester are all similar to each other and the US average. None of the towns have average temperatures above $80^0$F or below $10^0$F. Based on comparison of Figures 3.2.1 –3.2.4 from city-data.com, the precipitation within each town is greater than the US average, with no town receiving more than 5 inches of precipitation. Rosendale has the least variation in precipitation with Marbletown, Wawarsing and Rochester having periods of lows of 3 inches followed by highs of 4 to 5 inches (*Based on data reported by over 4,000 weather station and processed through city-data.com)*[2].

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[2] http://www.city-data.com

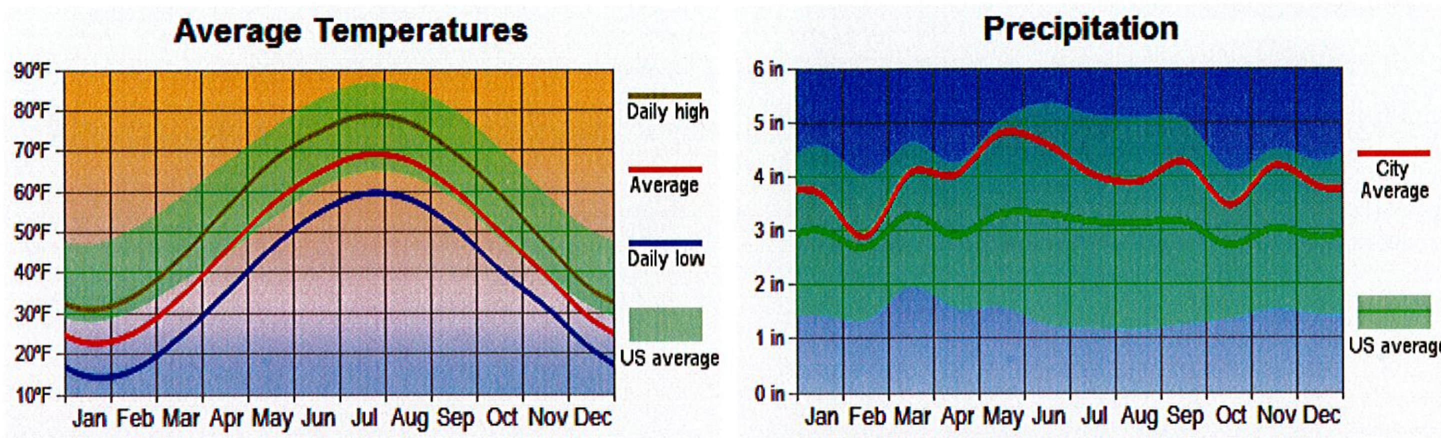


**Figure 3.2.1**: **Average climate in Wawarsing, NY.** Data for this graphs is based on reports from over 4,000 weather stations *(www.city-data.com)*

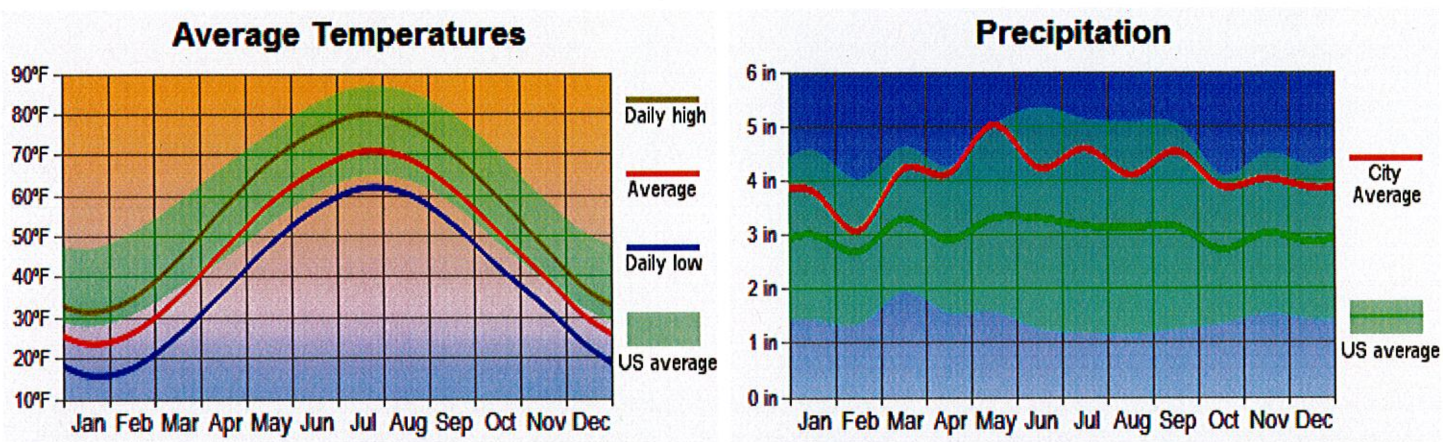


**Figure. 3.2.2: Average climate in Accord NY** – one of Rochester's largest hamlets.

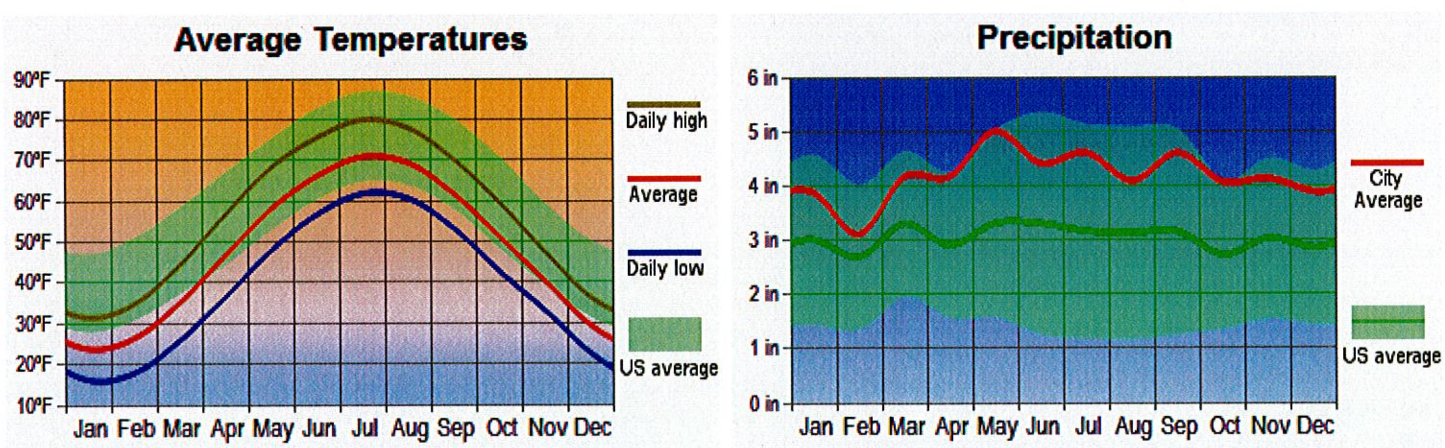


**Figure. 3.2.3: Average climate in Marbletown, NY.**

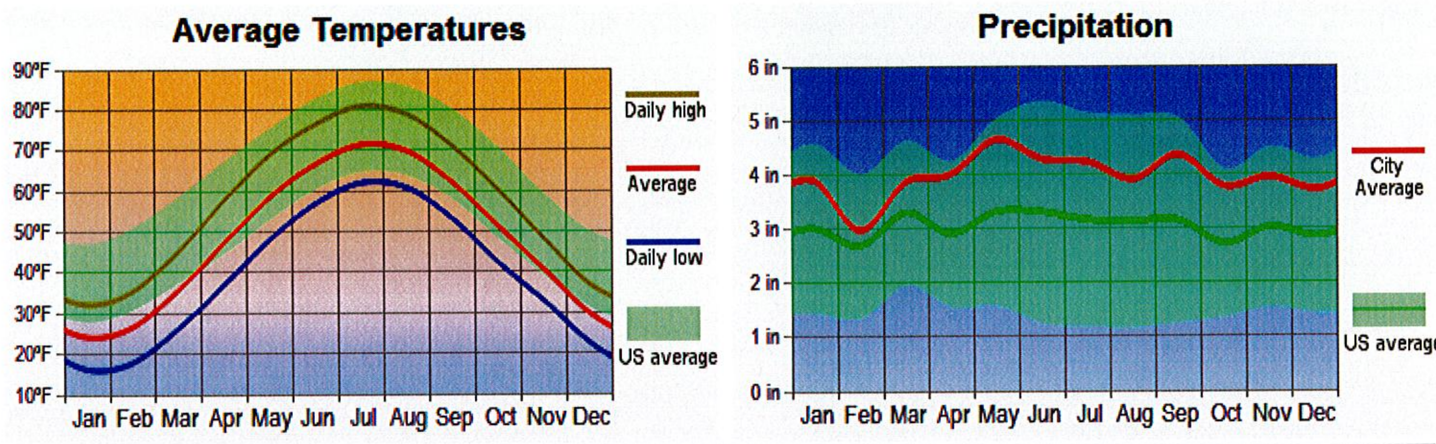


**Figure. 3.2.4: Average climate in Rosendale, NY.**

## Climate Change and Sea Level Rise

Our climate is changing. Since 1970 the global annual average temperature has increased nearly 1 degree and annual average temperatures in the United States have increased by 1.8 degrees. More specifically, annual average temperatures in New York State and the Hudson Valley have increased 2 degrees and winters in New York State are almost 5 degrees warmer than they were in the 1970's[3].

More recently, 2010 from January to August is tied with 1998 as the warmest year on record. Temperature records dates back to 1880. Furthermore the summer of 2010 was the hottest on record in New York City as well as 10 other states. In comparison to other decades, the 2000's were the hottest for the entire globe surpassing the previous record set in the 1990's.

On a local level, warmer winters, hotter summers and more extreme heat have been observed and these trends are predicted to continue. Scientists also project that the most intense rainfall events will become even more intense. With warmer air temperatures we are likely to see more winter precipitation come as rain rather than snow. The snow that does fall is likely to be wetter and heavier than average. Snow pack is also melting earlier in the year. When combined with changes in precipitation patterns this will lead to seasonally early and more intense high river flows.

The effects of global warming have been and will continue to contribute significantly to sea level rise. Sea level has risen fifteen inches over the last 150 years in New York Harbor and 4-6 inches since 1960[4]. Effects of sea level rise are compounded by potential increases in extreme precipitation and storms associated with climate change.

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[3] *(http://www.epa.gov/climatechange/science/recenttc.html).*

[4] *(http://www.epa.gov/climatechange/science/recenttc.html)*

Shoreline communities along the Rondout are very likely to see an increase in the frequency of flooding and erosion events. For example, the City of Kingston is in the tidal portion of the Rondout Creek watershed and is vulnerable to a variety of impacts from sea level rise and storm surge. Shoreline communities with brownfields or contaminated sites in areas at high risk of flooding could see the regular resuspension of waterborne pollutants that may put public health at risk. Critical infrastructure and facilities may be inundated leading to a loss of services at great cost to the community. Degraded stormwater and sewage systems will be further stressed by more intense large rainfall events and the vulnerability of bridges, culverts and road failures will increase. Rising temperatures or flood events reducing water quality may affect drinking water. Short term drought may affect water quantity and quality both for drinking water and for aquatic life in the creek. Warmer air and water temperatures will affect recreational fish species of the region and may lead to an increase in pests and insect epidemics.

ClimAID[5] is a state-funded integrated assessment program for effective climate change adaptation strategies in New York State with the goals of providing the state with cutting-edge information on its vulnerability to climate change and to facilitate the development of adaptation policies informed by both local experience and state-of-the-art scientific knowledge. Through this effort the state has developed sea level rise projections. See Figure 3.3.5.

**Draft ClimAID Sea Level Rise Projections:**

| **Lower Hudson Valley & Long Island** | **2020s** | **2050s** | **2080s** |
|---|---|---|---|
| Sea Level Rise[1] | + 2 to 5 in | + 7 to 12 in | + 12 to 23 in |
| Sea Level Rise[2] Rapid Ice Melt | ~ 5 to 10 in | ~ 19 to 29 in | ~ 41 to 55 in |
| **Mid-Hudson Valley & Capitol Region** | **2020s** | **2050s** | **2080s** |
| Sea Level Rise[1] | + 1 to 4 in | + 5 to 9 in | + 8 to 18 in |
| Seal Level Rise[2] Rapid Ice Melt | ~4 to 9 in | ~ 17 to 26 in | ~ 37 to 50 in |

**Figure. 3.2.5**: 1. Shown is the central range (middle 67%) of values from model-based probabilities (16 models x 3 scenarios) rounded to the nearest inch. 2. The rapid ice melt scenario is based on acceleration of recent rates of ice melt in the Greenland and West Antarctic Ice sheets and paleclimate studies. Note: Baseline is average sea level from 1971-2000.

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[5]http://www.nyserda.org/programs/Environment/EMEP/conference_2009/presentations/Solecki_DeGaetano_Horton_Climate%20Change%20in%20New%20York%20State.pdf

**Climate Change Recommendations:**

The communities of the Lower Non-Tidal Rondout Creek watershed have to be prepared. The warming of the globe will continue even if all greenhouse gas emissions are halted. The following are recommendations to be considered by the communities that border the Rondout Creek.

1. Based on the ClimAID Sea Level Rise Projections, the municipalities of the lower non-tidal Rondout Creek watershed should revise land use and zoning ordinances to require a buffer between mean high water and any proposed structures.

2. All communities bordering the Rondout should adopt the Climate Smart Communities Pledge (Appendix H)

3. Join and be an active member of the Hudson Valley Climate Change Network of the DEC Hudson River Estuary Program

4. Get involved in the 10% Challenge. This can best been managed through the local CAC and advised through the Rondout Creek Watershed Council in partnership with Sustainable Hudson Valley (SHV). SHV is leading the way in the Hudson Valley for implementation of the 10% Challenge.

5. Pass a local law to insure that predevelopment runoff is equal to post development runoff for all proposed projects in your community.

6. Require that all proposed development designs include tree plantings to prevent the expansion of impervious surfaces.

7. Map vulnerable stream bank areas that need to be revegetated and collaborate with state partners to rehabilitate them over a set period of time.

8. Pass a local law to increase the protection of wetlands in your community.

9. Engage CACs in reviewing development proposals and providing guidance to the planning board on ways to reduce the impact of development on natural systems.

10. Limit development in the 100-year floodplain and/or require developers to show how they will be addressing the projections of sea level rise in their proposal.

11. Direct new development away from high risk areas and develop programs to fund elevation and/or relocation of structures or systems in high risk areas.

12. Work on seeking funding through joint projects or proposals with neighboring municipalities.

13. Make use of mapping tools to identify at risk areas. Define areas of both greatest <u>current</u> and <u>future</u> vulnerability to flooding with the intent of reducing vulnerability in high-risk areas and transition to long-term cost-effective measures that emphasize natural flood protection systems.

14. Adopt NYS Sea Level Rise (SLR) projections as guideline measures from which to base strategies for addressing climate change and the affects of flooding on land use. Incorporate climate change and increased vulnerability to flooding into local emergency management planning.

## SECTION 3.3  BIODIVERSITY

**Significance of Biodiversity to Watershed Planning:** Watershed planning provides an ideal opportunity to consider conservation of biological resources. The plants, animals, and habitats — or *biodiversity* — of the Rondout watershed are a significant part of the region's character, natural infrastructure, and economy, and contribute directly to the quality and quantity of drinking water available to residents living in the region.

The term "biodiversity" is used to describe all the components of nature that are needed to sustain life. While people often associate the term biodiversity with threatened and endangered species, it actually encompasses much more. Biodiversity refers to all living things, both rare *and* common, the complex relationships between them, as well as their relationship to the environment. Biodiversity includes genetic variety, species diversity, and variability in natural communities, ecosystems, and landscapes. All of these parts and processes comprise the web of life that contributes to healthy ecosystems. For example, soil organisms convert leaves, twigs, and other organic litter into humus, and affect the infiltration and distribution of water in the soil.

Why is biodiversity important to the people living in the Lower Non-tidal Rondout Creek watershed? For starters, the watershed has a diverse and rich natural heritage, with species and ecological communities of regional, statewide, and global significance. These natural systems are the scenery and living fabric that provides the Rondout Creek watershed with a regional identity, and creates a sense of place for its residents. And healthy, natural systems are in essence a "green infrastructure," supplying services that support life as we know it, through purification of drinking water, control of floodwaters, replenishment of aquifers, pollination of crops, creation of fertile soil, control of insect pests, and adaptation to a changing climate. They also provide opportunities for hunting and fishing, outdoor recreation, and environmental education and research. All of these services and benefits to the community cost less than the artificial or built alternatives, contribute to local economies, and are widely recognized as important assets by a variety of stakeholders.

**Threats to Biodiversity and Associated Impacts to Watershed Health:** Two of the greatest threats to biodiversity are habitat loss and invasion of non-native species (Wilcove et al. 1998). In particular, land use changes that degrade and destroy natural habitats pose the most significant threats to native biodiversity. Suburban sprawl, for instance, fragments the landscape into smaller and smaller patches of habitat, and surrounds these fragments with development, often having lethal effects on wildlife species that require large, connected natural areas. Furthermore, the resulting patchwork of land uses and human activity creates ideal conditions for invasive species to take hold. For example, the recent discovery of the invasive emerald ash borer in the Catskill Forest Preserve may have serious impacts on North American ash tree species, which comprise nearly 7% of all trees in the state. (NYSDEC 2010) Increasingly, global climate change presents a new array of conservation challenges and variables, such as shifts in habitat availability and timing of natural events.


Photo 3.3.1 Emerald ash borer.

Land-use decisions made at the municipal and regional level will have lasting impacts on the function of natural systems in the Lower non-tidal Rondout Creek watershed, and their ability to support its human communities. For example, loss of habitat can lead to a corresponding loss in basic watershed functions, such as water infiltration and purification by forests and grasslands, erosion control along stream banks, and flood attenuation in wetlands. Habitat loss and fragmentation also creates unsuitable conditions for many native plants and animals, and leads to increased populations of more common, nuisance species such as white-tailed deer, Canada geese, mosquitoes, and black-legged tick, which carries Lyme disease. The effects of widespread deer browse, for instance, are a major cause of regeneration failure and change in forest composition in the region.

Additional threats to biodiversity include impacts associated with human development, many of which can be prevented or managed to reduce harmful effects, such as from light pollution, failing septic systems, waste from household pets, and pollution of natural areas from contaminants such as road salt, pesticides, fertilizers, and household chemicals and pharmaceuticals.

**Biodiversity of the Lower Non-Tidal Rondout Creek Watershed:** The rich biodiversity of the Lower Non-tidal Rondout Creek watershed is a result of the variable landscape included within its boundaries.

To the north are the forested Catskill Mountain foothills, where several headwater streams, like Sapbush Creek in Rochester, originate in the Catskill Forest Preserve. To the south are the steep rocky slopes of the Shawangunk Ridge, supporting another large forested area that is the source of several headwater streams like the Stony Kill in Wawarsing. The higher-elevation tributaries flow to the more level terrain of the Upper Rondout and Rondout Creek valley, where farmland and fields are more common, such as where Kripplebush Creek meets the Rondout in southern Marbletown. To the east, before the non-tidal Lower Rondout becomes tidal, the watershed holds the limestone caves and Binnewater Lakes of Rosendale.

The biological resources of the Lower non-tidal Rondout Creek watershed have been recognized on many levels as having high conservation value:

- The *New York State Open Space Conservation Plan* (2009) recognizes the Lower Hudson Valley for its extremely diverse natural landscape, and identifies several "Regional Priority Conservation Areas" in the Rondout watershed. These conservation priorities include the:
    - "Great Rondout Wetlands," which includes the Great Pacama Vly and Cedar Swamp;
    - "Karst Aquifer Region" which is characterized by caves, sinkholes, mines, springs, lakes, and sinking streams;
    - "Catskills Unfragmented Forest;" and
    - "Shawangunk Mountain Region."

  The Plan also prioritizes the protection of natural linkages between the Shawangunk Ridge and other significant biodiversity areas in close proximity. In the Rondout watershed, such linkages include a Catskills/Shawangunk connection in Wawarsing

(NYS Department of Correctional Services – Wawarsing farmlands) and a Shawangunk/Karst Aquifer connection surrounding the Wallkill Valley Rail Trail in Rosendale.

- The Rondout watershed includes portions of three Significant Biodiversity Areas (SBA) described in the NYSDEC's *Hudson River Estuary Wildlife and Habitat Conservation Framework* (Penhollow et al. 2006). Much of the Shawangunk Ridge SBA is within the watershed, and all of the Rosendale Cave Complex SBA falls within its boundaries. The southern end of the Catskill Mountain SBA is within the northern limits of the watershed.

- The Shawangunk Mountains Scenic Byway region is a 134,000-acre area that is largely defined by the 88-mile state scenic byway that encircles the northern Shawangunks and lands in the Rondout and Wallkill Valleys. The northern half of the Byway region lies within the Rondout watershed. The *Shawangunk Mountains Regional Open Space Plan* (December 2008) outlines strategies to preserve valuable resources, including the waterways, wetlands, forests, grasslands, and landscape connections that support the region's rich biodiversity and maintain clean air and water.

- The Nature Conservancy's report, *Identifying Conservation Priorities in the Hudson River Estuary Watershed* (Shirer and Tear 2005), identifies ecoregional aquatic conservation targets (priority watersheds) within the Hudson River Estuary watershed, and the Rondout Creek Watershed is listed as one of these priorities.

- The Nature Conservancy recognizes that the Shawangunk Ridge's scenic cliffs, plateaus and talus fields make it one of Earth's "Last Great Places." Since the first gift of land in 1969, the Conservancy has helped preserve more than 12,000 of the 40,000 protected acres on the ridge. Popularly called the "Gunks" by locals, they support more than 35 natural communities, including one of only two ridgetop dwarf pine barrens in the world, chestnut oak forests, hemlock forests, pitch pine forests, lakes, rivers and wetlands. Twenty-seven rare plant and animal species have been documented here (www.nature.org/wherewework/northamerica/states/newyork/preserves/art12373.html). TNC hold and/or helps manage land in or near Minnewaska State Park Preserve in Rosendale and Sam's Point Dwarf Pine Preserve in Wawarsing, which is home not only of rare dwarf pines and birches, but it harbors one of the least known lakes of the chain of lakes in the area: Martanza Lake (www.nature.org/wherewework/northamerica/states/newyork/preserves/art12373.html).

- The Catskills Mountains, protected in large measure by the NYC DEP, are part of a vast unfragmented forest that provides important habitat to many species, including timber rattlesnake, a threatened species in New York.

**Priority Habitats of the Watershed:** The underlying geology, soils, topography, surface and groundwater, and land use history of the Rondout Creek watershed all weave together to shape a diversity of habitats that support an equally diverse array of plant and animal communities. The biodiversity of the creek mouth and lower, tidal portion of the Rondout will be described in the tidal Rondout Creek watershed plan underway by the City of Kingston – and the *Upper Rondout*

*Creek Stream Management Plan* (2010) describes the biodiversity of the upper Rondout Creek watershed from the Peekamoose Gorge to the Rondout Reservoir.

The priority habitats of the lower non-tidal Rondout watershed, discussed in this plan, include streams and riparian corridors; forests; a variety of wetlands; grasslands, shrublands, and farms; and cliffs and caves. Lists of breeding birds, amphibians, reptiles, rare species, and ecological communities have been documented in the Towns of Marbletown, Rochester, Rosendale, and Warwarsing.

While the entire watershed has not been studied to locate and map all biological resources, there is a growing body of information on where important habitats are, and what plants and animals they support, as a result of local and regional initiatives:

- The Shawangunk Ridge Biodiversity Partnership's *Green Assets* project developed a series of maps that show important ecological community types or "conservation targets" on the Ridge, along with elevation/slope, protected areas, and tax parcels. The maps were designed to help land use decision-makers identify and protect ecologically important habitat, unfragmented forest, and connections between natural areas. Parts of the four municipalities in the Lower Non-tidal Rondout watershed are included on these maps. (2006)

- The Town of Marbletown has detailed habitat maps for approximately 6,000 acres in the Catskill foothills and along the Rondout Creek (Hudsonia 2007), and an additional 7,500 acres of habitat mapped in an adjacent area by a volunteer community group in 2006. Both maps are described in companion reports, which also include habitat profiles and specific conservation recommendations. Further discussion of the Town's forests, streams, and wildlife habitats are contained in the Marbletown Natural Heritage Plan. (2008)

- The Town of Rochester completed a Draft Natural Resource Inventory in 2006 that has maps and information on resources and features such as geology, wetlands and streams, and slope. Biological data are largely limited to information from the *Green Assets* program and New York Natural Heritage Program for the portion of the town south of the Rondout Creek.

- The Town of Rosendale completed a Natural Resource Inventory in 2010 that incorporates maps and information about the town's geology, groundwater, surface water, and biological communities, including a detailed habitat map of 4,300 acres in the Binnewater Lakes region completed by a volunteer training group in 2004. Maps of ecological communities are included for other parts of the town. Habitat mapping for the remaining one-third of the town is underway and will complete a larger town-wide biodiversity assessment, "The Natural Wealth of Rosendale."

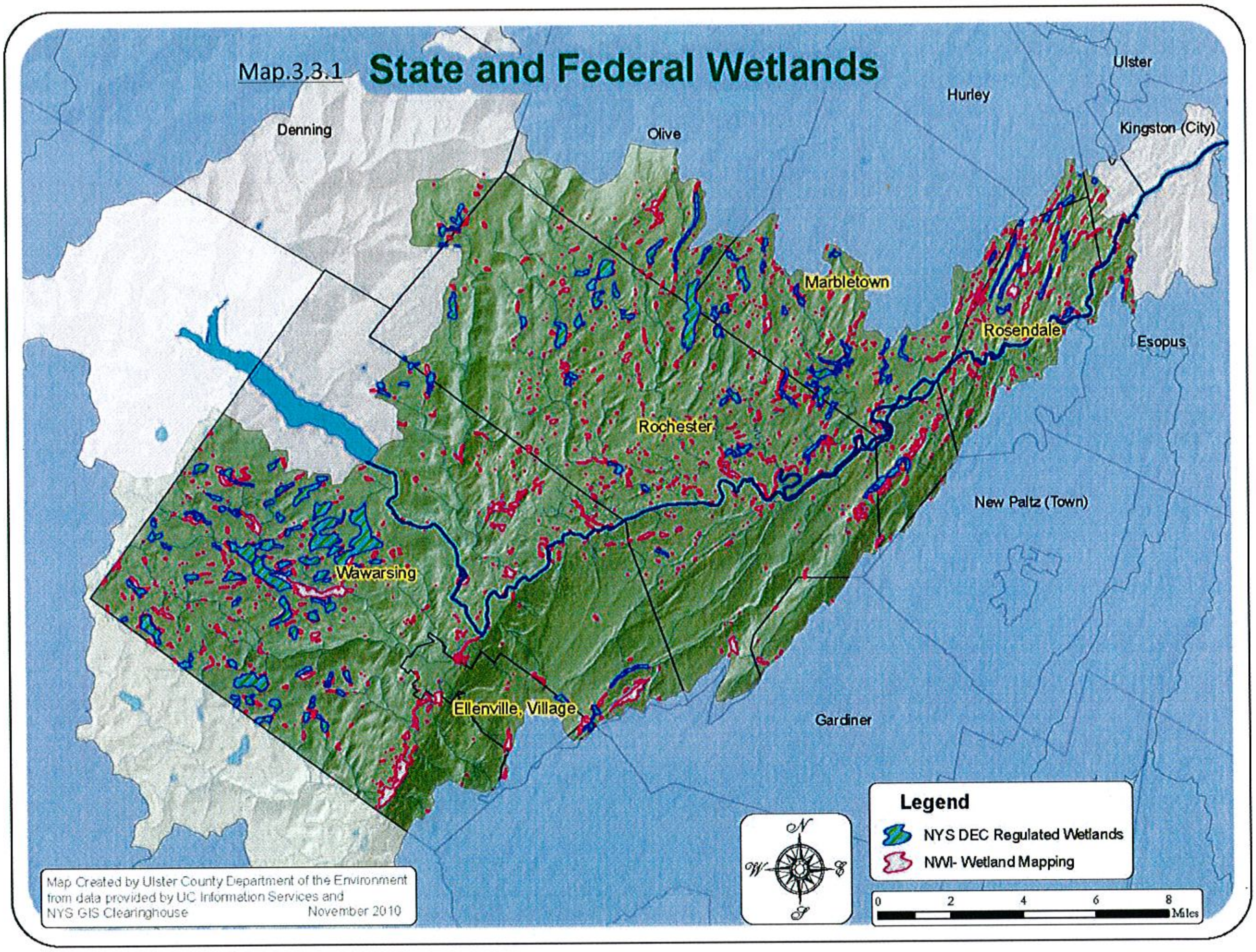
**How to Use This Information:** Knowing what habitats and species occur in the Rondout watershed can be useful not only for watershed planning, but for taking conservation action at the municipal level, as well. It is likely that many of the habitats that have been identified and mapped in the watershed occur elsewhere where underlying conditions are similar. Future assessments can take into consideration what is known about important habitat occurrences in the watershed, to predict and assess their distribution in other unstudied areas, and to proactively plan for the associated rare species. Such information can provide a starting place for habitat maps, natural resource inventories, open space plans, and other conservation and smart growth plans. This approach will also contribute to keeping common species in the watershed common, and maintaining overall ecosystem function. Finally, many of the planning and conservation recommendations discussed in this plan for the watershed also apply to land-use decision making at the local level.

**Stream Corridors and Wetlands:** Streams in a watershed start at high elevations, called headwaters; sometimes these begin as merely rivulets or small waterfalls. When a first order stream is joined by another, it becomes a second order stream, and the order increases each time another confluence occurs. Because they tend to be located in more pristine areas headwater wetlands, often a mosaic of riparian habitat, ponds, emergent marshes and fens, are especially important habitats to support biodiversity. Extensive wetland complexes also occur in lower terrain, but may support different species. A wetland complex is any group of adjacent and nearby swamps, marshes, wet meadows or other wetland types and associated streams or ponds. Wetland complexes with especially high habitat value include extensive complexes, those with a wide variety of wetland types, and those that have intact upland habitat between the wetlands. There are many wetland complexes of special conservation interest in the watershed. These should be noted because of the connections they provide for native species to move through the various stages and seasons of their life cycle. Section 3.4 discusses in depth the importance of protecting streams with a buffer of riparian vegetation.

Of special importance are isolated wetlands are wetlands that are not connected. These wetlands can be easy to overlook: they are usually too small to appear on maps, they may be dry in late summer or fall, and their extent varies from year to year. Even if found on National Wetlands Inventory (NWI) maps, they are no longer protected by the Army Corps of Engineers, and are usually too small to be listed on NYS DEC wetland maps. (Wetlands should always be field delineated in any case). Isolated wetlands can also be part of a larger wetland complexes can consist of scattered water bodies that appear isolated from above but are hydrologically connected below ground. Modification of part of such a complex can lead to unforeseen effects on other parts of the complex. These can include seasonal pools such as intermittent wetlands and kettle shrub pools.

- **Intermittent Woodland Pools** are areas of shallow standing water that form in depressions in upland forest habitats that hold water in winter and spring but dry up by mid-late summer; also called "vernal pools" as they are active in the spring. They usually lack surface water inlets and outlets. Because of the seasonal drawdown and the absence of surface water connection to other water bodies, fish are unable to survive. The fishless environmental is a critical habitat feature, protecting the eggs for a group of amphibians that cannot reproduce successfully in the presence of fish.

Photo 3.3.2 Marbled Salamander depends on Intermittent Woodland Pools to reproduce. *(Photo Tim Kerin)*




- **Intermittent Streams** flow only part of the year or after rain or snowmelt. They support invertebrates, stream salamanders, and other organisms. The stream channel is typically small--only one to several meters wide -- and often flows into a perennial stream, pond, or wetland. Flows range from scouring, during heavy rains or snow melt, to dry in late summer. Even when the stream has stopped flowing it may contain small pools that hold water and support aquatic invertebrates and small fish. They are especially vulnerable to human disturbance, alteration, or pollution, which then affects the watercourse and wetlands into which they flow. To protect stream banks and channel prevent alteration by unfortified vehicle crossings, siltation or channelization, or polluted discharges.

- **Perennial Streams** provide essential water sources for wildlife throughout the year, and are critical habitat for many plant, vertebrate, and invertebrate species. (See Section 3.4 for more information on riparian buffers needed to protect streams and other waterbodies.

Photo 3.3.3 Second Binnewater Lake. *(Photo by Michael Montella)*

**Lakes, Ponds and Open Water:** The LNT Rondout Creek watershed also has many lakes, including the clear Sky Lakes of the Shawangunk Ridge and the chain of Binnewater Lakes in Rosendale. In addition to naturally occurring ponds, man-made ponds are used for watering animals, crop irrigation, and as retention basins to hold stormwater.

**Forests:** The value of forests to the ecology and economy of the LNT Rondout watershed is detailed in Section 3.5, along with specific recommendations for sustainable management. Listed here are the major forest types found in the region in both upland and wetland areas:

**Upland Habitats**

- **Upland Deciduous Forests** are found adjacent to and punctuated by hardwood swamps, rock outcrops, streams, intermittent woodland pools, springs and seeps, and areas of coniferous and mixed forest. They have more than 75% deciduous cover, including maple, oak, beech, ash and tulip.
- **Upland Conifer Forests** have more than 75% coniferous cover, such as pine, hemlock, and spruce.
- **Upland Mixed Forests** have between 25-75% deciduous or coniferous cover.
- **Young woods** are a subset of the upland deciduous forest category, characterized by wooded areas in which all or most trees are small in size, less than 12 inches diameter at breast height. They can develop quickly from abandoned mowed fields, and generally show less variety in tree species than do the mature forests.

Photo 3.3.4 Hardwood swamp. *(Photo by Tim Kerin)*

**Wetland Forests**

- **Hardwood swamps** are characterized by a damp to submerged muck floor with raised hummocks of trees, shrubs, and ferns. The dominant vegetation types are deciduous trees and shrubs.
- **Hemlock-Hardwood swamps** have an overall firmer swamp floor, and more elongated, distinct, and somewhat drier hummocks with many exposed tree roots. They are dominated by white pines and eastern hemlocks.

In general, forested areas with the highest conservation value include large forests, mature and relatively undisturbed forests, and those with a lower proportion of edge to interior habitat. Smaller forests that provide connections between other forests, such as linear corridors or patches that could be used as "stepping stones," are also valuable in the landscape context. Keeping the larger landscape perspective is critical. Forest patches, meadows and other pieces of habitat that may well extend beyond municipal boundaries may have great value by providing connectivity corridors for wildlife moving between larger, more obvious core areas and should not be disregarded (http://hudsonia.org/wp-content/files/Habitat%20map%20reports/Washington_Cons_Zones.pdf).

Photo 3.3.5 Barred owl living in Hardwood Swamp.

**Grasslands, Shrublands, and Farms:** Valuable habitat and open space is provided by grasslands, meadows and farms. Many species like to alternate between the edge of forests, which can provide shelter from weather and predators, and open fields, however fragmentation of habitat leading to increased edges (edge effect) can also be detrimental. Here are a few habitats found in meadows and fields:

- **Upland meadows** are characterized by croplands, pastures, and mowed grasslands. Dominant vegetation includes pasture grasses, clovers, goldenrods, asters, spotted knapweed, and other forbs. Animal species include bluebirds, prairie warblers, red-tailed hawks, many types of butterflies, woodchucks, and deer.
- **Wet Meadows** are open, shallow wetlands dominated by herbaceous vegetation that have little or no standing water for much of the growing season. They are primarily home to grasses, sedges, and forbs, and are especially important for rare plants and butterflies. If standing water is present, the area is referred to as a marsh.
- **Shrubby oldfields** are a successional stage in the transition that occurs when cropland, pasture, or mowed fields have been abandoned. As grasses, forbs, shrubs, and saplings, as usually less than 6 feet high, move in, these areas provide habitat for diverse plants and wildlife. Eventually, as trees become larger and more prevalent, these oldfields become young forests. Sometimes found under power line rights of way or in areas that have been cleared for logging or other purposes, shrubby oldfields are a great resource for bird watchers, and unfortunately also for ATV enthusiasts, who may not understand their habitat value. Plants include goldenrods, berries, multiflora rose, sumac, eastern red cedar, red maple, black locust, oaks, quaking aspen, and white pine, dogwood and birches. In addition to a variety of songbirds, this habitat supports many butterflies.

Photo 3.3.6 Shrubby Oldfield. *(Photo by Tim Kerin)*

**Cliffs and Caves:** Two specialized habitats found in the watershed are crest, ledge and talus that prevalent features of the Shawangunk cliffs and the limestone cave complex that extends from the northern edge of the Shawangunks in Rosendale to Kingston.

- **Crest, Ledge and Talus** habitats typically have sparse vegetation, shallow soils, and large areas of bare rock. Talus is the accumulation of rock fragments and boulders on or at the base of steep ledges or cliffs. They can differ with respect to their bedrock chemistry and may support rare plants, amphibians, reptiles, birds, and mammals despite their harsh conditions. Talus at the base of the Shawangunk cliffs is likely to be composed of Shawangunk conglomerate, but will be more calcareous (calcium-containing) in the Karst region.

Photo 3.3.7 Entrance to "The Cave" – which is actually a mine – at Williams Lake. *(Photo by Laura Heady)*

- **Caves and Mines:** Scattered through the LNT Rondout Creek watershed are caves and abandoned mines, containing limestone formations that store huge quantities of underground water and provide roosting and hibernating habitat for bats, including the small brown bat and the endangered Indiana Bat. From 1826 to 1915 cement mining was a major industry in Rosendale, with the last mine closing in 1970. Now, one of the abandoned mines, the Widow Jane Mine on the former Snyder Estate now owned by the Century House Historic Society, also doubles as a performance space.

Natural caves may also be home to algae, bacteria, and crustaceans adapted to the dark environment. There are two natural caves (considered by cavers large enough for a human to enter): one is Pompey's Cave in Kripplebush off Lucas Avenue; another small dry cave in Rosendale is located between the Snyder Estate and Turco Brothers' Water Service, which takes water from the karst aquifer adjacent to Route 213 to fill pools. There are also two caves near the Bashakill: Surprise Cave and Rhoades Cave (Neversink watershed) and Salamander Cave in Kingston (Tidal Rondout watershed). The Northeast Cave Conservancy is a good resource for information on caves (www.necaveconservancy.org).

Photo 3.3.8 Indiana bat hibernaculum in Karst Aquifer Region. *(Photo: Tim Kerin)*

The NYS DEC Open Space Plan of 2009 has designated a narrow band of carbonate rocks that extend throughout Ulster County, generally parallel with the Hudson River and trending south-southwest, through portions of Saugerties, Kingston, Esopus, Marbletown, Rosendale, Rochester and Ellenville, continuously outcropping just northwest and along the flank of the Shawangunk Mountain Ridge as the Karst Aquifer Region. The region is characterized by such features as caves, sinkholes, mines, springs, lakes and sinking streams. The area is rich in biological, geological and historical resources, provides diverse outdoor recreational opportunities and critical water reserves (p. 71).

**Conclusions and Recommendations:** Among the major threats to preserving biodiversity and the ecological services intact and connected habitats in the LNY Rondout Creek Watershed provide are:

Photo 3.3.9 Endangered Indian Bat *(Photo: Tim Kerin)*

- Development of open space and farmland causing loss of habitat, with resulting increase in

fragmentation of existing habitat, pollution and impervious surface.
- Invasive species, climate change and acid rain threaten areas of special significance such as Sam's Point and the Karst Aquifer Region.

While the threats to the watershed's rich biodiversity may be challenging to address, the economic benefits of conservation-oriented planning are many. An excellent example is the NYC DEP far-sighted decision to use watershed protection practices to preserve water quality and avoid the major cost of filtration, cited earlier. Increased property values and quality of life benefits accompanied these avoided costs. Sustainable development means integrating ecological preservation with economic prosperity, wisely and equitably.

Whatever the scale, from making decisions at a site-plan review, to developing a town open space plan, or setting watershed protection goals, the key steps to conserving biodiversity resources are as follows:

1) identify resources
2) prioritize resources
3) plan, protect, and manage resources.

Photo 3.3.10 Endangered cricket frog. *(Photo by Tim Kerin)*

The Lower Non-Tidal Rondout Creek Watershed Plan is a tool that residents, municipalities, conservation groups, county agencies, and other stakeholders can use to learn about the rich diversity of plants, animals, and habitats in the watershed, and set priorities so that implementation efforts are effective and efficient, and reflect community values. It also can be used to identify gaps in information and set goals for future study and research. Finally, it can provide a planning framework to protect the biodiversity of the Rondout watershed, so that future generations will be able to live in healthy, quality communities and enjoy their natural heritage for a long time to come.

Many of the recommendations outlined here reflect general conservation principles for protecting biodiversity. They include (adapted from Kiviat and Stevens 2001):

- Consider habitat and biodiversity concerns early in the planning process.
- Direct human uses toward the least sensitive areas, and minimize alteration of natural features, including vegetation, soils, bedrock, and waterways.
- Protect large, contiguous, and unaltered tracts of habitats wherever possible.
- Protect contiguous habitat areas in large, circular or broadly-shaped configurations within the larger landscape.
- Preserve links between habitats on adjacent properties via broad connections, not narrow corridors.
- Create, restore, and maintain broad buffer zones of natural vegetation along streams, along shores of other water bodies and wetlands, and at the perimeter of other sensitive habitats.

- Maintain buffer zones between development and land intended for habitat.
- Prioritize higher-quality habitats for protection, as degraded habitats decrease the biological value of the larger ecological landscape.
- Preserve natural processes such as forest fires, floodplain flooding, and beaver flooding to maintain the diversity of habitats and species dependent on such processes.
- Preserve farmland potential.
- Protect habitats associated with resources of special economic, public health, or aesthetic importance to the community. These include aquifers or other sources of drinking water, active farms, and scenic views.
- In general, encourage development of altered land instead of unaltered land.
- Concentrate development along existing roads; discourage construction of new roads in undeveloped areas.
- Promote clustered and pedestrian-centered development wherever possible, to maximize extent of unaltered land and minimize expanded vehicle use.
- Minimize extent of impervious surfaces (roofs, roads, parking lots, etc.), and maximize onsite groundwater infiltration. Minimize areas of disturbance.

Municipalities in the watershed might consider including similar principles in their comprehensive plans or in future intermunicipal agreements. If followed by communities in the Rondout watershed, these general guiding principles may contribute to the realization of the watershed plan's goals for smart growth, water resource protection, and biodiversity conservation.

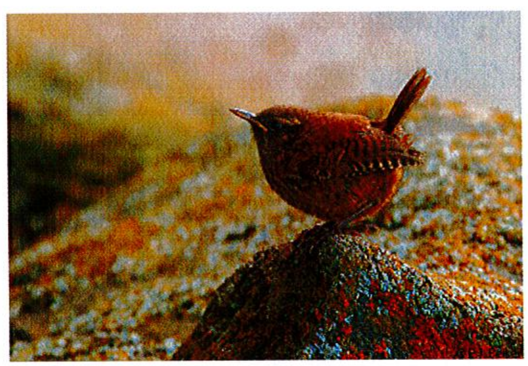


Photo 3.3.11 Winter wren. *(Photo by Tim Kerin).*

## 3.4 Riparian Vegetation Ecology and Management

### Role of vegetation in maintaining a healthy stream

Although people value trees and other plants along a stream for their contribution to the beauty of the streamside landscape, the vegetation in a watershed, especially in the *riparian* area, plays a critical role in providing for a healthy stream system. The riparian, or streamside, plant community maintains the riverine landscape and moderates conditions within the aquatic ecosystem.

As rainfall runs off the landscape, riparian vegetation:

- Slows the rate of runoff;
- Captures excess nutrients carried from the land;
- Protects stream banks and floodplains from the erosive force of water;
- Regulates water temperature changes.

It also:

- Provides food and cover to terrestrial and aquatic fauna;
- Conserves soil moisture, ground water and atmospheric humidity.

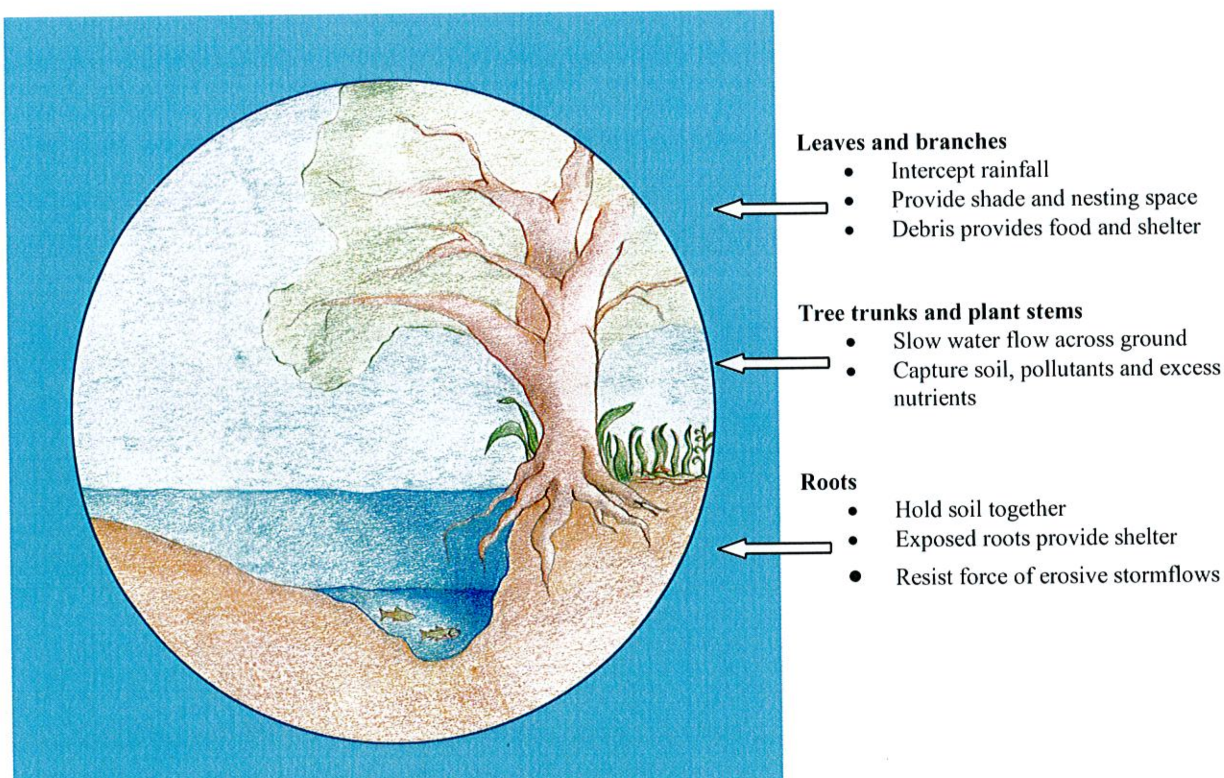



**Figure 3.4.1** Illustrates ecological functions of various plant parts. (Patty Hanson, LaDue Design)

### Erosion and pollution prevention capabilities

Riparian vegetation serves as a buffer for the stream against activities on upland areas. Most human activities whether agriculture, development, or even recreation, can result in a disturbance or discharge, which can negatively impact the unprotected stream. Riparian vegetation captures, stores and filters pollutants in overland flow from upland sources, such as salt from roadways and excess fertilizers from lawns and cropland. The width, density, and structure of the riparian vegetation community are important characteristics of the buffer that also impact the level of its functionality.

On bare soils, high stream flows can result in bank erosion and overbank flow can cause soil erosion and scour on the floodplain. The roots of vegetation along the bank hold the soil and shield against erosive flows. On the floodplain, vegetation slows flood flows, reducing the energy of water. This reduction in energy will decrease the ability of water to cause erosion and scour. Furthermore, as vegetation slows the water, the soil suspended in the water is deposited on the floodplain (rather than carried to the stream).

**Photo 3.4.1**. Riparian understory along Rondout Creek.

## Hydrologic influences

Vegetation intercepts rainfall and slows runoff. This delay increases the amount of precipitation that infiltrates the soil, recharges groundwater supplies and reduces overland runoff. This reduction and delay in runoff decreases the occurrence of destructive flash floods, lowers the height of flood waters, and extends the duration of the runoff event. These benefits are evident in forested watersheds such as the lower Rondout when compared to watersheds of similar size which have high levels of urban development (Figure3.4.2). The reduction in flood stage and duration also results in fewer disturbances to stream banks and floodplains.

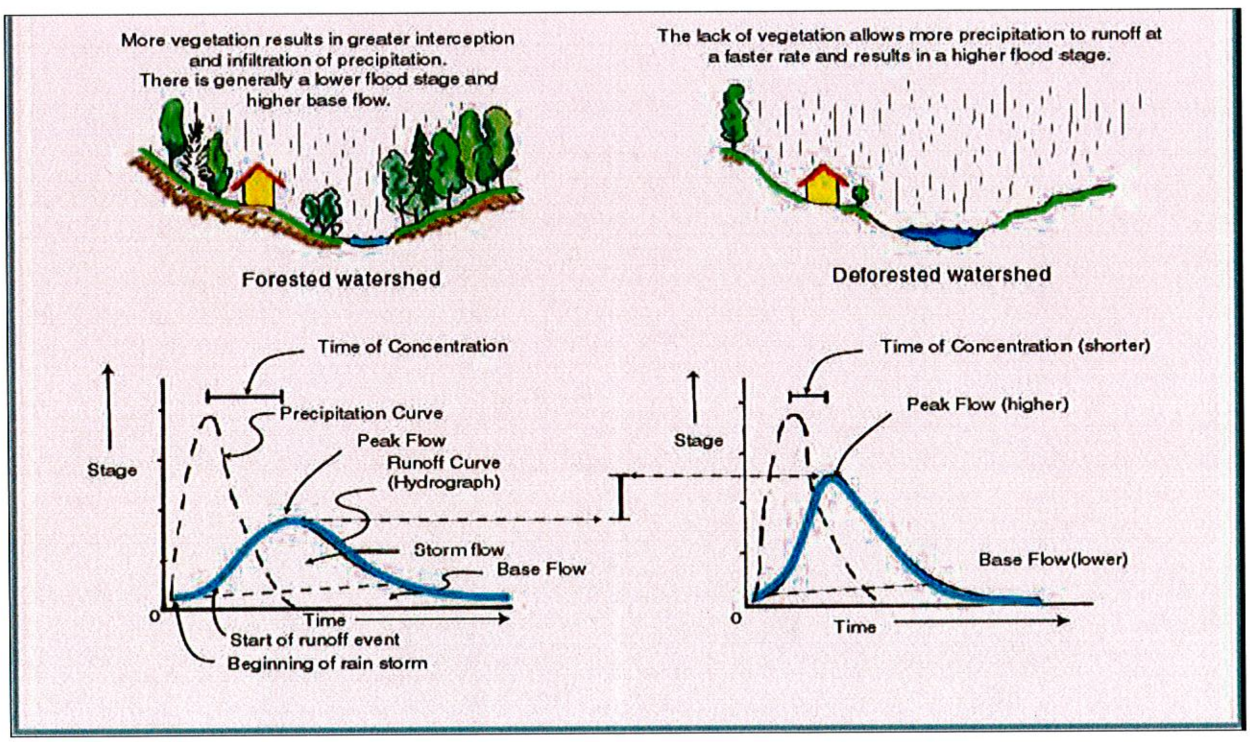



Figure 3.4.2 Comparison of Runoff on a Forested Watershed Versus a Deforested Watershed. Illustration by P. Eskeli 2002, from Watershed Hydrology, P.E. Black,1991, Prentice Hall, page 202, 214.

## Ecological importance of vegetation in the riparian zone

Streamside vegetation also functions to provide climate, habitat, and nutrients necessary for aquatic and terrestrial wildlife. Trees shading a stream help maintain cool water temperatures needed by native fish populations. Low-hanging branches and roots on undercut banks create cover for fish from predators such as birds and raccoons. Natural additions of organic leaf and woody material provide a food resource needed by terrestrial insects and aquatic macorinvertebrates (stoneflies, mayflies, etc.) – the primary source of food for fish. Large woody material also provides valuable in-stream habitat for both fish and aquatic wildlife. Terrestrial wildlife depends upon vegetation for cover as they move from the upland community to the water's edge. A diverse plant community, one similar to the native vegetation of the lower Rondout, provides a wide range of conditions and materials needed to support a diverse community of wildlife. If vegetation is continuous within the riparian zone along the length of a stream, a corridor is available for wildlife migration. Connectivity between the riparian and upland plant communities enhances the ability of upland and riparian plant and animal communities to thrive despite natural or human induced stress on either community. These intact corridors will become even more critical if temperatures begin to increase with climate change as wildlife potentially shifts from southern to northern ranges and lower to higher elevations.

## Characteristics of a healthy riparian plant community

A healthy riparian community should be diverse. It should have a wide variety of plants, including trees, shrubs, grasses, and herbs (Figure 3.4.3). The age of plant species should be varied with sufficient regeneration of new plants to ensure the future of the community. An important difference between an upland plant community and a riparian community is that the riparian community must be adapted to frequent disturbance from flooding. Consequently, many riparian plants including willow, alder, and poplar, can re-grow from stump sprouts or can reestablish their root system if up-ended. Furthermore, the seeds from these species are adapted to thrive in depositional areas, such as gravel bars and lower flood benches.

**Diverse Plant Types**
(trees, shrubs, grasses, herbs)

+

**Diverse Plant Ages**
(young and old)

+

**Disturbance-adapted,**
**Moisture-loving Plants**
(accustomed to flooding & ice flows)

=

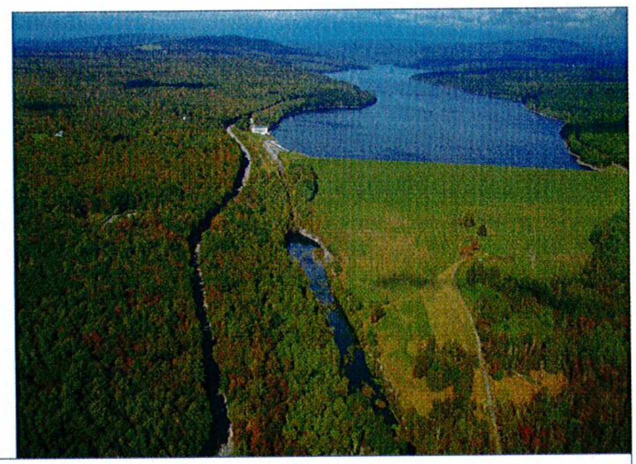
**Healthy Riparian Buffers**

Figure 3.4.3 and Photo 3.4.2 A healthy riparian community is densely vegetated, has a diverse age structure and is composed of plants that can resist disturbance.

## Riparian Vegetation in the lower Non-Tidal Rondout Watershed

Forest history and composition in the lower Rondout Watershed

Catskill Mountain and Hudson Valley forests have evolved since the ice age reflecting the changes in climate, competition and human land use. The first of these changes was the result of the climatic warming that occurred after the ice age which enabled warm climate adapted plant communities to replace the cooler climate communities. Following the retreat of the glaciers, the forest of the Rondout watershed gradually re-established and evolved from the boreal spruce/fir dominated forests, (examples of which can presently be found in Canada) to the maple-beech-birch northern hardwood forests (typical of the Adirondacks and northern New England) with the final transition of the lower elevations of the watershed to a southern hardwood forest dominated by oaks, hickory and ash (typical of the northern Appalachians). Dr. Michael Kudish provides an excellent documentation of evolution and site requirements of the region's forests in his book, The Catskill Forest: A History (Kudish, 2000).



**Photos 3.4.3 & 3.4.4** Primarily forested upper Rondout watershed and lower Rondout Creek as it flows out of the NYC DEP Reservoir.

More recently, human activities have affected the forest either through manipulation of forests through development or for maintenance of desirable species (high-grade wood) for wood products. Native Americans used prescribed burning as a means of allowing nut bearing oaks and hickories to establish dominance in the forests. European settlers in the 18th and 19th centuries contributed to a rising industrial economy by clearing vast areas of land for agriculture, harvest of construction materials, and hemlock bark harvesting for the extraction of tannin. The land cover in the lower Rondout began to revert to forest with the local collapse of these economies in the 20th century and the acquisition of land by the State for the Catskill Forest Preserve, known as Sundown Wild Forest (Kudish, 2000).

Previous land uses have had a significant role in determining the type of vegetation found along the stream. The most intensive development activities were confined to the valley floor along the stream. Pastures and fields were created from cleared, forested floodplains. Abandoned, old fields have experienced a consistent pattern of recovery, with primary-colonizer species dominating the initial regrowth including sumac, dogwoods, aspens, hawthorns, and white pine. These species are succeeded by other light loving hardwood tree species such as ash, basswood and elm or in lower parts of the watershed, hickories, butternut, and oak. Hemlocks are largely confined to steeper stream banks and slopes where cultivation or harvesting of hemlocks for bark was impossible. More recent housing construction has re-intensified activity along the stream and been accompanied by the introduction of non-native vegetation typical of household lawns and gardens. While today the lower Rondout watershed is largely forested, agriculture and development activities are still concentrated along the valley floor, leaving the riparian area predominantly herbaceous.

The valley floor, which predominately follows the Route 209 corridor, is consistently dotted with municipalities and agriculture. This mosaic of impervious cover and farm fields within the valley floor has left riparian buffers somewhat fragmented unlike the upper reaches of the lower Roundout, which flow out of more heavily forested areas like the Catskills to the north & west and the Shawangunks to the south & east.

Closer examining the lower Rondout's Catskill watersheds through land cover data, the Beerkill, Sandburg Creek, Vernooy Kill and Rochester Creek all appear to have fairly healthy riparian buffers until they approach the Route 209 corridor. This also holds true when looking at the streams coming out of the Shawangunks like the Stony Kill, Saunders Kill, Peters Kill and Coxing Kill. These streams garner even greater protection than the Catskill tributaries due to the multitude of land preservation organizations located in the Shawangunks including Sam's Point Preserve, Minnewaska State Park, Mohonk Preserve and The Mohonk Mountain House.

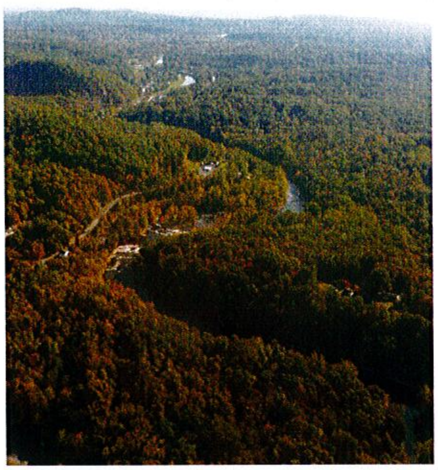


**Photo 3.4.5** Healthy riparian buffer of lower Rondout Creek as it flows adjacent to Route 213 through the Town of Rosendale.

Two points of concern regarding riparian buffers are again confined to the Route209 corridor; first being the channelized portion of the Beerkill as it flows through Ellenville, and secondly the Rondout itself as it begins to be flanked by agriculture. As an Army Corps of Engineers flood control project, the Beerkill was essentially channelized and had its bed hardened as it passes through Ellenville. Although this has reduced flooding in Ellenville, it has no doubt increased downstream flows, sedimentation, increased water temperature and reduced both terrestrial and wildlife populations.

Secondly, as the lower Rondout begins its meandering journey through the agricultural valley floor, it becomes more entrenched and with little vegetative buffer between the Rondout and its adjacent agriculture fields. Vegetation is typically limited to the steep stream banks with little (ie. a single line of trees) if no buffer on the floodplain. Some of these banks are more than 20 ft. in vertical height and vegetation serves as the only real stabilizing protection for the Rondout. One of the reasons the lower Rondout has become more entrenched is the berm building that has taken place with increased sediment loads from agriculture and development runoff.

**Photo 3.4.6** Lower Rondout Creek meandering through the farms of Accord.

In many instances, farmers have added fill and debris to berms to increase their height, further cutting off the Rondout from its floodplain. The streambanks of the lower Rondout, especially on outside bends, are subject to greater stresses and with minimal vegetative stabilization above them, are subject to potential loss of vegetation and loss of property. Ideally buffers could be restored in the floodplain sections adjacent to these banks to help improve their stability and reduce sediment input into the stream, while at the same time improving water quality and wildlife & fish habitat.

The Riparian Forest

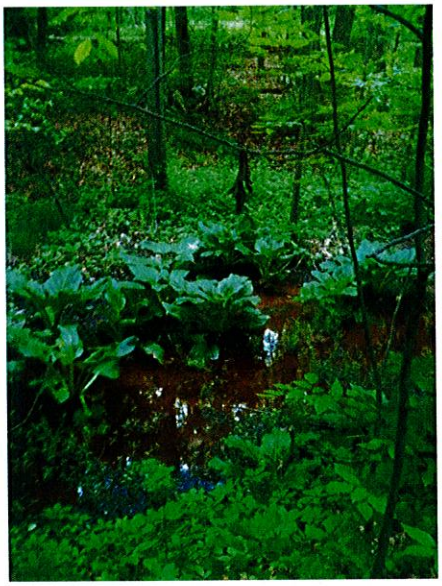


**Photo 3.4.7** A wetland indicator, skunk cabbage, thrives in the riparian areas along the lower Rondout Creek amongst a variety of other understory vegetation.

Typically, riparian forest communities consist of species that thrive in wet locations and have the ability to resist or recover from flood disturbances. Extensive riparian communities typically exist in floodplain or wetland areas where a gentle slope exists. Many of the species present in these plant communities are exclusive to riparian areas. In areas where a steep valley slope exists, the riparian community may occupy only a narrow corridor along the stream and then quickly transition to an upland forest community. Soils, ground water and solar aspect may create conditions that allow the riparian forest species to occupy steeper slopes along the stream, as in the case where hemlock in habits the steep, northfacing slopes along the watercourse.

Natural disturbance and its effects on the riparian vegetation

Due to the proximity of riparian areas to water, they are subject to disturbances associated with extreme forces of nature and human development. Natural disturbances include floods, ice floes, and to a lesser extent, high winds, pest and disease epidemics, drought, and fire. Large deer herds can also significantly alter the composition and structure of vegetation through browsing, leaving stands of mature trees with no understory.

The flood of 1996 on the lower Rondout created and reopened numerous high flow channels, reworked point bars, scoured floodplains and eroded formerly vegetated stream banks. Immediately following the flood, the channel and floodplains were scattered with woody debris and downed live trees. In the years since this event, much of the vegetation has recovered. Trees and shrubs, flattened by the force of floodwaters, have re-established their form. Gravel bars and sites disturbed in previous flood events became the seedbed for herbs and grasses. This type of natural regeneration is possible where the stream is stable and major flood events occur with sufficient interval to allow establishment. The effect of flood disturbance on vegetation along stable stream reaches is short term and the recovery/disturbance regime can be cyclical. If the disturbance of floods and ice are too frequent, large trees will not have the opportunity to establish. Typically, the limit that trees can encroach upon the channel is defined by the area disturbed by the runoff event that achieves bankfull flow (expected to occur on average every 1.3 years).

Local geology and stream geomorphology may complicate the recovery process. A number of sites were found along Rondout Creek where vegetation has not been able to reestablish itself on bank failures created during recent flood events. On these sites it will be necessary to understand the cause of the failure before deciding whether or not to attempt planting vegetation to aid in site recovery. In these instances, the hydraulics of flowing water, the morphological evaluation of the stream channel, the geology of the stream bank, and the requirements and capabilities of vegetation must be considered before attempting restoration. Since the geologic setting on these sites is partially responsible for the disturbance, the period required for natural recovery of the site would be expected to be significantly longer unless facilitated by large-scale restoration efforts.

Damage caused by ice break up in the spring can result in increased mortality for young trees and shrubs located along the stream banks. These ice flows can also cause channel blockages, resulting in erosion and scour associated with high flow channels and overbank flows. Typically this type of disturbance has a short recovery period.

<u>Threats to Riparian Forests</u>

*1) Pests and Disease*

**Photo 3.4.8** Hemlock woolly adelgid on the underside of a Hemlock branch

Pests and diseases that attack vegetation can also affect changes in the ecology of the riparian area and could be considered a disturbance. The hemlock woolly adelgid (*Adelges tsugae*) is an insect, which feeds on the sap of hemlocks (*Tsuga spp.*) at the base of the needles causing them to desiccate and the tree to take on a grayish color (Figure 3.4.8). Stress caused by this feeding can kill the tree in as little as 4 years or take up to 10 years where conditions enable the tree to tolerate the attack (McClure, 2001). This native insect of Japan was first found in the U.S. in Virginia in 1951 and has spread northward into the Hudson Valley and Catskills (Adams, 2002).

With respect to stream management, the loss of hemlocks along the banks of the Rondout Creek and its many tributaries poses a threat to bank stability and the aquatic habitat of the stream. Wildlife, such as deer and birds, find the dense hemlock cover to be an excellent shelter from weather extremes while cool water species such as trout benefit greatly from the shading these hemlock stands create along streams. Finally, dark green hemlock groves along the stream are quiet, peaceful places that are greatly valued by the people who live along the Rondout Creek. Nearby the Olive Natural Heritage Society, Inc. is monitoring the advance of the hemlock woolly adelgid in the Catskills and is working in cooperation with NYS DEC on testing releases of *Pseudosymnus tsugae.*

Without a major intervention (as yet unplanned), it is likely that the process of gradual infestation and demise of local hemlock stands by woolly adelgid will follow the patterns observed in areas already affected to the south. Reports from Southern Connecticut describe the re-colonization of hemlock sites by black birch, red maple and oak (Orwig, 2001). This transition from a dark, cool, sheltered coniferous stand to open hardwood cover is likely to raise soil temperatures and reduce soil moisture for sites where hemlocks currently dominate vegetative cover. Likewise, in the streams, water temperatures are likely to increase and the presence of thermal refuge for cool water loving fish such as trout are likely to diminish.

Other forest pests are on the brink of infesting the Rondout Valley that pose even greater risks than the woolly adelgid. Emerald Ash Borer (*Agrilus planipennis*; EAB) and Asian Long-horned Beetle (*Anonplophora glabripennis*; ALB ) are two particular insects that have ravaged forests elsewhere in the United States. EAB has recently been indentified at a campground in Saugerties, which is in the neighboring Esopus Creek watershed. Likewise ALB threatens to invade from the south (New York City) or east (Worchester, MA). The high level of tourism and second home ownership in and throughout the Rondout Valley makes this area particularly vulnerable to the transport of these species. Together, these two pests could seriously impact the forests that comprise the livelihood of so many creatures and humans. Statewide concerns about EAB and ALB have led to a recent ban on the movement of firewood within a 50-mile radius of where it was cut.

*2) Human disturbance and its effects on the riparian vegetation*

Although natural events disrupt development and succession of riparian vegetation growth, human activities frequently transform the environment and, as a result, can have long lasting impacts on the capability of vegetation to survive and function. Presently, the most significant sources of human disturbance on riparian vegetation in the upper Rondout include the construction and maintenance of roadway infrastructure, the maintenance of utility lines, and the development of homes and gardens near the stream and its floodplain.

The alignment Route 209 and Route 213 closely follows the stream alignment of the lower Rondout Creek. Use and maintenance of these roads has a significant impact on the riparian vegetation. The narrow buffer of land between the creek and the road receives runoff containing salt, gravel, and chemicals from the road that stunt vegetation growth and increase mortality. Road maintenance activities also regularly disturb the soil along the shoulder and on the road cut banks. This disturbance fosters the establishment of undesirable, invasive plants, which establish more quickly than native vegetation in these areas. The linear gap in the canopy created by the roadway separates the riparian vegetation from the upland plant communities. This opening also allows light into the vegetative understory, which may preclude the establishment of native, shade-loving plants such as black cherry and hemlock.

Utility lines parallel the roadway and cross the stream at various points requiring the utility company to cut swaths through the riparian vegetation at each crossing, further fragmenting essential beltways for animal movement from streamside to upland areas. Although the road right-of-way and utility line sometimes overlap, at several locations along the stream, the right-of-way crosses through the riparian area separate from the road. This further reduces the vigor of riparian vegetation and prevents the vegetation from achieving the later stages of natural succession, typified by climax species such as sugar maple, beech and hemlock.

Residential land use and development of new homes can have a great impact on the watershed and the ecology of the riparian area. Houses require access roads and utility lines that frequently have to cross the stream. Homeowners who love the stream and want to be close to it may clear trees and shrubs to provide access and views of the stream. Following this clearing, the stream bank begins to erode, the channel over-widens and shallows. The wide, shallow condition results in greater bedload deposition and increases stress on the unprotected bank. Eventually stream alignment may change and begin to cause erosion on the property of downstream landowners. Hudson valley stream banks require a mix of vegetation such as grasses and herbs that have a shallower rooting depth, shrubs with a medium root depth, and trees with deep roots. Grasses

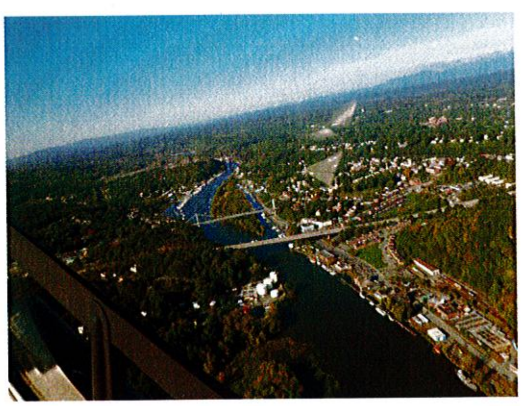


**Photo 3.4.9** Lower Rondout Creek entering Kingston flanked by roads and development on both sides of the stream.

alone are insufficient to maintain bank stability in steeply sloping streams such as the Rondout Creek.

Invasive Plants and Riparian Vegetation

Sometimes the attempt to beautify a home with new and different plants introduces a plant that spreads out of control and "invades" the native plant community. Invasive plants present a threat when they alter the ecology of the native plant community. This impact may extend to an alteration of the landscape should the invasive plant destabilize the geomorphology of the watershed (Melanson, 2002).

The spread of Japanese Knotweed (*Fallopia japonica*), an exotic, invasive plant gaining a foothold in many streams in the Hudson Valley, is an example of a plant causing such a disruption. As its common name implies, Japanese knotweed's origins are in Asia. It shades out existing vegetation and forms dense stands along the bank (Figure 3.4.10 a-c). Although the impact of a Japanese knotweed invasion on the ecology of the riparian area is not fully understood, the traits of Japanese knotweed pose several concerns. Some of these concerns include:

- Knotweed appears to be less effective at stabilizing streambanks than deeper-rooted shrubs and trees, possibly resulting in more rapid bank erosion.
- The shade of its broad leaves and the cover by its dead litter limit the growth of native plants that provide food and shelter for associated native animals.
- Knotweed branches do not lean out over stream channels, providing little cooling from shade.
- Dead knotweed leaves (*detritus*) may alter food webs and impact the food supply for terrestrial and aquatic life.
- Large stands of knotweed impede access to waterways for fishing and streamside hiking.
- The presence of knotweed could reduce property value.
- Knotweed may alter the chemical make-up of the soil, altering soil microfauna and soil properties.

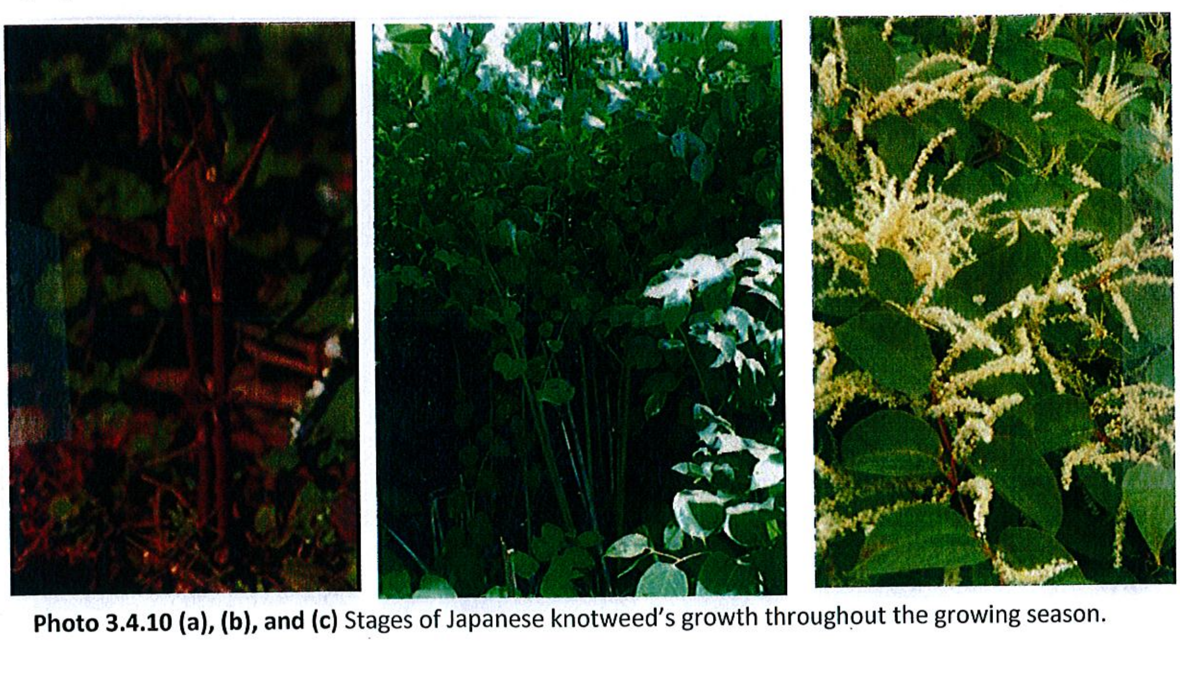


**Photo 3.4.10 (a), (b), and (c)** Stages of Japanese knotweed's growth throughout the growing season.

**Recommendations for healthy Riparian Buffers**

*Hemlock Woolly Adelgid*

- Potential link between the presence of Hemlock woolly adelgid on a site and the degree to which people use or access the site
- Chemical pest control options would most likely provide little more than temporary, localized control due to the widespread nature of the infestation
- the use of pesticides to the control the infestation is not recommended in the riparian area due to impacts on water quality and aquatic life
- Planting adelgid resistant conifers such as white pine is recommended to maintain coniferous cover on former hemlock dominated sites (Ward, 2001).

Extensive information about the Hemlock Woolly adelgid is available at the US Forest Service's Northeastern Area "forest health protection" webpage: www.na.fs.fed.us.

*Asian Long horned Beetle and Emerald Ash Borer*

For more information about the Asian Long-horned Beetle and the Emerald Ash Borer:

APHIS fact sheets for general information about invasive forest pests:
www.aphis.usda.gov/publications/plant_health/content/printable_version/fs_invspec_forest_health.pdf

For ALB:
www.aphis.usda.gov/publications/plant_health/content/printable_version/faq_alb_mass_regarea.pdf

For EAB:
www.aphis.usda.gov/publications/plant_health/content/printable_version/EAB-GreenMenace-reprint-June09.pdf

*Human Disturbance*

- Routes to the stream from individual residences should be carefully selected. Access points should be located where the force of the water on the bank under high flow is lower and disturbance to riparian vegetation can be minimized.
- Foot traffic and disturbance in the flood prone are should be restricted
- Dense natural buffers should be promoted and encouraged.

Additional information on streamside gardening and riparian buffers can be found at: www.catskillstreams.org/stewardship_streamside_rb.html.

*Japanese knotweed*

- The broad use of herbicides is not recommended in riparian areas due to threats to water quality and aquatic life
- Mechanical control, by cutting or pulling requires regular attention to remove any regrowth; rhizomes can extend up to 12 ft. deep and 25 ft. wide.
- Any fill material introduced into a riparian area should be free of Japanese knotweed fragments.
- Any Japanese knotweed roots pulled or dug up should be disposed of in a manner that will prevent it from spreading or re-establishing itself.
- Bare streambanks should be planted with native vegetation so that Japanese knotweed does not become established.

An excellent source for native plants and expert advice can be found at Catskill Native Nursery on Samsonville in the Town of Rochester. For more information: www.catskillnativenursery.com. [1]

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[1] Submitted by Jennifer Grieser, Catskill Stream Buffer Initiative Coordinator, NYC Department of Environmental Protection

For more information about invasive species in general: www.dec.ny.gov/animals/265.html

**Implementation Strategies for Riparian Buffers**

1. Use GIS technology to map land use in riparian areas
2. Identify and prioritize potential riparian planting sites using a combination of mapping techniques and field surveys.
3. Develop a network of volunteers that can be trained to assist in assessing sites, planting trees along riparian buffers, eradicating invasive species, and monitoring for forest pests such as the Asian longhorned beetle. Establish a subcommittee that focuses on coordinating plantings for target areas, and eradicating invasive species.
4. Develop education programs focused on farmers as well as smaller landowners that raise awareness about best management practices in the riparian areas.
5. Coordinate a Visual Stream Assessment. The Lower Hudson Coalition of Conservation Districts offers a Streamwalk program www.lhccd.org/streamwalk2004.html that a stream assessment can be modeled after. This will assist in determining location of invasive species as well as potential planting sites in the riparian corridor.

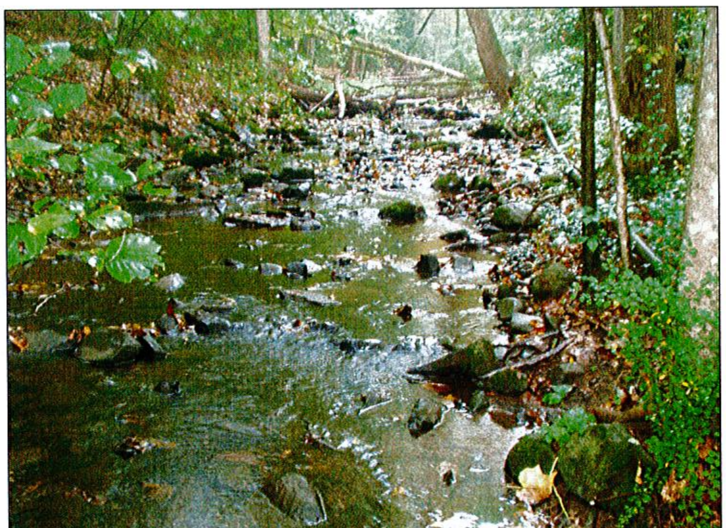


**Photo 3.4.11** Looking upstream from sampling siteTan House Brook, Snyder Estate, Rosendale *(Photo Martha Cheo)*

## SECTION 3.5 AGRICULTURE AND FORESTRY

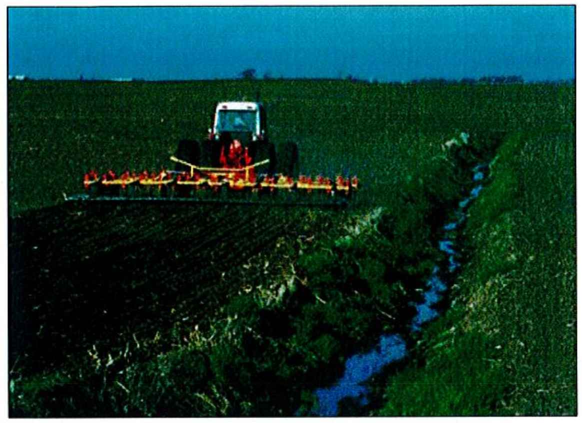


**Photo 3.5.1** Close relationship of agriculture to creek and streams.

**Agriculture in the Watershed:** According to the United States Department of Agriculture (USDA), National Agriculture Statistic Services (NASS) 2007 census within the southeast reg ion of New York State there are 24 very large family farms, 20 large family farm and 42 non-family operations in Ulster County's agricultural district #90. There are 14 small family farms that yield high sales and 104 small family farms that have low sales on a local level. There are limited resources available to 60 of those farms. The management expense of non-irrigated cropland is $23.50 per acres and $10.00 per acre for pasturelands in Ulster County (according to NASS).

**LNT Rondout Agriculture:** According to the United States Department of Agriculture (USDA), National Agriculture Statistic Services (NASS) 2007 census and sorted by zip codes, the number of agricultural land areas, farmsteads, designated buildings, animal facilities, ponds, roads and/or wastelands are as follows:

- Town of Wawarsing and the Village of Ellenville (12428) – 9 operations
- Town of Rochester (12404) – 30 operations
- Town of Marbletown (12484) – 10 operations
- Town of Rosendale (12472) – no operations listed

**Photo 3.5.2** "World's Largest Garden Gnome" at Kelder's Farm in Kerhonkson.

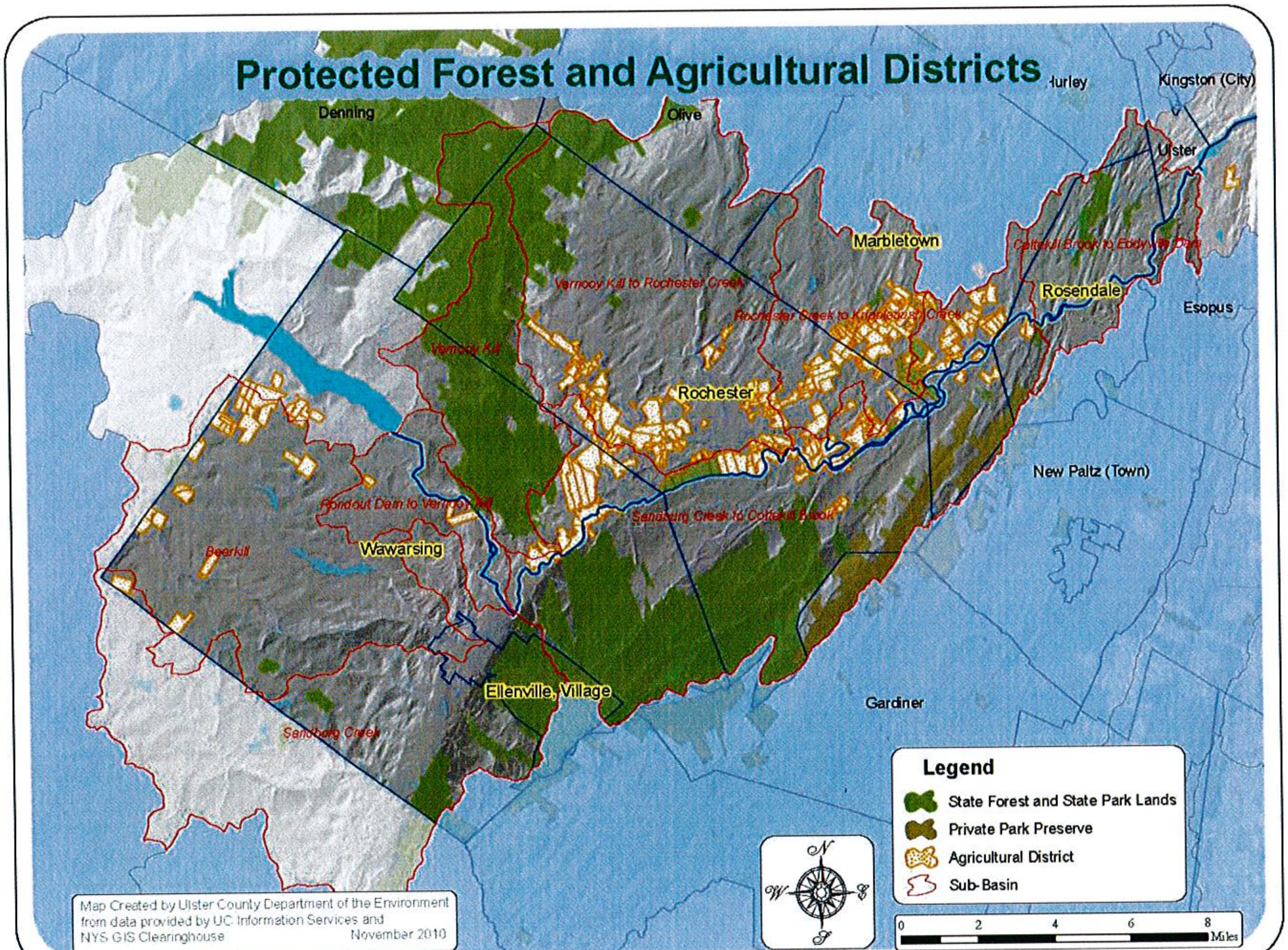
The Town of Rosendale may have small family farms but if they aren't registered or designated as farmland the agricultural the census will not reflect the existence of they operation. This also means that for the other three municipalities there may be a number of un-represented smaller farming operations that need to be surveyed.

The Town of Wawarsing has 5 field crop operations that have an annual yield of less than $50,000 and 5 other operations that have a not specified annual yield. The Town of Rochester has 1 operation that yields $250,000 per year, 2 operations that yield between $50,000-250,000 and 15 that yield less than $50,000. The Town of Marbletown has 4 field crop operations that yield between $50,000-250,000 and 6 that yield less than $50,000.

With nearly 60 active farm members, the Rondout Valley Grower's Association was organized to invigorate the farm businesses by undertaking a strong effort to better market the Rondout

Valley Farms products; to do so they have established a brand name reputation for RVGA products.

The Rondout Valley Grower's Association is just one of the many agricultural center organizations that are working to improve the state of farm business and enhance overall economic development. For more detailed examples of economic development programs and agencies refer to Section 5 (Economic Development in the Watershed).




Map 3.5.1 Protected forest and agricultural districts in the lower non-tidal portion of the Rondout Creek.

**Recommendations for Agriculture:** The following recommendations are summarized from existing programs provided by the United States Department of Agriculture's (USDA) Forestry Services Association (FSA)[1] and Natural Resources Conservation Services (NRCS)[2]:

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[1] http://www.fsa.usda.gov/FSA/webapp?area=home&subject=fmlp&topic=landing

[2] http://www.nrcs.usda.gov/programs/

1. Agricultural Management Assistance (AMA) provides cost share assistance to agricultural producers to voluntarily address issues such as water management, water quality, and erosion control by incorporating conservation into their farming operations. Producers may construct or improve water management structures or irrigation structures; plant trees for windbreaks or to improve water quality; and mitigate risk through production diversification or resource conservation practices, including soil erosion control, integrated pest management, or transition to organic farming.

2. The Cooperative Conservation Partnership Initiative (CCPI) is a voluntary conservation initiative that enables the use of certain conservation programs along with resource of eligible partners to provide financial and technical assistance to owners and operators of agricultural and non-industrial private forest lands.

3. The Environmental Quality Incentives Program (EQIP) was approved in 1996 by amending the Food Security Act of 1985 (Farm Bill), reauthorized in the Farm Security and Rural Investment Act of 2002 and again reauthorized in the Food, Conservation and Energy Act of 2008. EQIP provides a voluntary conservation program for farmers, ranchers and owners of private, non-industrial forest land that promotes agricultural production, forest management and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible producers install or implement conservation practices on eligible agricultural land.

    a. The five EQIP national priorities are:
        i. Reductions of nonpoint source pollution, such as nutrients, sediment, pesticides, or excess salinity in impaired watersheds consistent with Total Daily Maximum Loads (TMDLs), where available; the reduction of surface and groundwater contamination; and reduction of contamination from agricultural point sources, such as concentrated animal feeding operations (CAFOs);
        ii. Conservation of ground and surface water resources
        iii. Reduction of emissions, such as particulate matter, nitrogen oxides (NOX), volatile organic compounds, and ozone precursors and depleters that contribute to air quality impairment violations of National Ambient Air Quality Standards
        iv. Reduction in soil erosion and sedimentation from unacceptable levels on agricultural land and
        v. Promotion of at-risk species habitat conservation.

4. The Wildlife Habitat Incentive Program (WHIP) is a voluntary program for conservation-minded landowners who want to develop and improve wildlife habitat on agricultural land, nonindustrial private forest land, and Indian land.

5. The purpose of the Emergency Watershed Protection (EWP) program is to undertake emergency measures, including the purchase of flood plain easements, for runoff retardation and soil erosion prevention to safeguard lives and property from floods, drought, and the products of erosion on any watershed whenever fire, flood or any other

natural occurrence is causing or has caused a sudden impairment of the watershed.

6. FSA makes direct and guaranteed farm ownership (FO) and operating loans (OL) to family-size farmers and ranchers who cannot obtain commercial credit from a bank, Farm Credit System institution, or other lender. FSA loans can be used to purchase land, livestock, equipment, feed, seed, and supplies. Our loans can also be used to construct buildings or make farm improvements.

**Forestry in the Watershed:** Promoting and maintaining a sustainable and viable forestry industry should be a goal for the Lower Non-Tidal Rondout Watershed. For details on upland and wetland forest habitats see Section 3.3 (Biodiversity). To accomplish this there is currently a number of government, not-for-profit and industry programs in place to assist municipalities in achieving this goal. In addition to actively using the resources that are available, municipalities in the watershed need a current comprehensive plan that is supported by up-to-date zoning and land use regulations -- all of which should support the stewardship of forestlands and provide incentives for landowners to maintain large forested tracts of land.

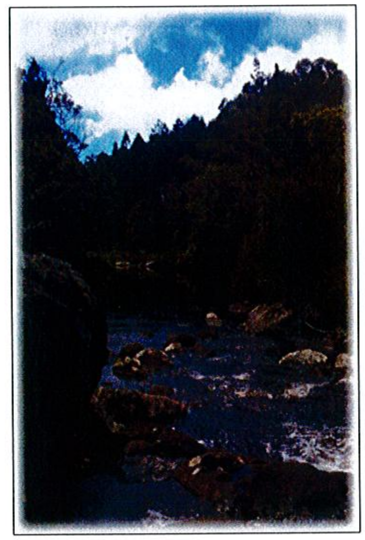

**Photo 3.5.3** Shows the massive amounts of forestry still preserved in some watersheds.

The following section reviews:

- Existing laws that exist to protect water quality
- Programs that provide training, technical assistance and funding to promote sustainable forestry management
- Ways to increase awareness of sustainable forestry among citizens andtown officials
- Opportunities for coordination and partnerships in planning for forest uses
- The benefit of updating a municipalities comprehensive plan to better promote forestry practices
- The importance of updating land use regulations to "facilitate the practice of forestry"
- Land use regulations that are currently in use and other that can be used to support forestry and forest uses
- The use of Timber Harvest Plans, including Best Management Practices.
- Review standards for the practice of land clearing of trees

The following discussion on Forestry is summarized from the publication "A Municipal Official's Guide to Forestry in New York State[1]. Please visit http://www.dec.ny.gov/docs/lands_forests_pdf/guidetoforestry.pdf for a complete copy of this publication.

[1] *A Municipal Official's Guide to Forestry in New York State*, NY Planning Federations, DEC and Empire State Forest Products Association: (pg 10-21) February 2005

**Existing Laws and Programs** (for a complete description of the following law and programs please see Appendix J)

Forestry-related requirements: New York State and the Federal government regulate forest activities, particularly timber harvesting, and their impact on water quality through the following government offices: The US Army Corps of Engineers, the New York State Department of Environmental Conservation and the NY State Department of Transportation. In addition State and Federal laws govern the use and disposal of hazardous materials such as petroleum products, fuels, and pesticides.

Voluntary programs: Several State, Federal, university and not-for-profit programs provide training, technical assistance and funding to private forest landowners, forest managers and loggers to promote sustainable forestry management. These include:

- The NY State Forestry Best Management Practices Field Guide
- the NY Forest Tax Program
- NY Logger Training
- NYS DECs Cooperative Forest Management Program
- NYS DEC's Cooperating Forester Program
- Cornell's Forestry Extension Program
- Cornell University's Master Forest Owner Program
- The Watershed Agricultural Council's Watershed Forest Program
- Various Forest Certification Programs

**Forest Regulations Currently in Use:** There are several ways in which forest management activities and timber harvesting are currently reviewed in New York municipalities. They may be a permitted use – with or without notification or review – or may be allowed through a special use permit or site plan review process. Some towns require town board review, while others require planning or zoning board review and still others allow enforcement officers to make the decision. A few communities involve a consulting professional forester to conduct or assist in the review.

**Photo 3.5.4** A representation of preserved forestry.

It is useful to review the purpose of permitted uses, special use permits, site plan review and use variances in local zoning. All of these approaches have been used in reviewing proposals for timber harvests, yet some are more appropriate than others. Permitted uses are those that the municipality feels should be allowed in a particular zone under all circumstances, though they may be made subject to specific conditions that would be reviewed as part of a ministerial decision by the community's enforcement officer. Some towns that do not list timber harvesting as a permitted use nevertheless allow it through a temporary permit that may be obtained from the enforcement officer.

Special use permits are for those uses that are felt to be generally appropriate for a particular zone, though perhaps not in all circumstances or as proposed, and are subject to either general or specific conditions to assure compatibility with and/or minimal impacts on nearby uses. Special use permits are normally issued by the planning board or zoning board of appeals as part of a discretionary review process involving a public hearing.

While the special use permit process may allow timber harvests, this is often a burdensome and unpredictable process for landowners because review standards can be vague or unreasonable and the timeline is often drawn-out. The special use permit process is, in fact, designed to review development proposals, and the expertise of reviewing bodies is, accordingly, chiefly in the development area, not in the various facets of forest management.

Site plan review is a process that is used to assure that whatever use is permitted is sited so as to minimize adverse impacts on- and off-site. Occasionally, this process is used to review proposed timber harvests and impose standards that really only apply to development proposals.

Use variances can permit uses that are not listed as allowed in a particular zone. These are issued by the zoning board of appeals as part of a quasi-judicial review process involving a public hearing.

The problem with the use variance process in reviewing proposed timber harvests is that this process exists to handle the unanticipated exception to the rule. The burden of proof of the appropriateness of the use rests on the landowner. Yet timber harvesting is a normal and common forest activity in many rural areas. It should not be more difficult to manage land for forest use than it is to develop. It is far better to allow the use in appropriate zones, and, if there are concerns about the way in which timber harvests are carried out, address these with specific conditions.

**Opportunities for Local Leadership:** While the various programs exist to provide technical and other assistance to forest landowners in managing their forests for sustainability, it is at the local level where decisions are made as to whether, where and under what circumstances forest uses and harvesting are actually allowed. This puts local officials in the driver's seat and requires a carefully-considered approach to these issues. The following is a summary of recommendations that will promote and enhance healthy forestry practices within local Municipalities.

**Photo 3.5.5** Volunteers planting trees in their local watershed.

**Recommendations for Forestry:**

**1. Public participation and education:** Often, just raising the level of awareness of forests and sustainable forestry among citizens and town officials can bring a great deal of understanding to a community about the multiple values of forests as working landscapes, including the benefits they provide and threats to forestry. Efforts to convey generally-accepted forest practices and cycles to the public and to compare these with farm operations can also be helpful. Speakers, including educators, professional foresters and others can be invited to participate in informational workshops or forums. Not-for-profit land trusts, conservation organizations, Conservation Advisory Councils, county Soil and Water Conservation Districts (SWCDs) and county Environmental Management Councils also play an important role. Local newspapers or town newsletters can run a series of guest columns addressing various aspects of forestry and forest uses. Following an educational effort, the public should be invited to be an active participant in any adoption or updating of a community's comprehensive plan and/or land use regulations that address forest uses. Involving citizens early in the process is important as this translates into long-term support and efforts that are more likely to be implemented.

**2. Coordination and partnerships:** There are many opportunities for coordination and partnerships in planning for forest uses. Towns can promote a variety of cooperative resources that are available to help private forest landowners be the best possible stewards of their forest land, including the several voluntary programs described above. Soil and Water Conservation Districts, Resource Conservation and Development Councils (RC&D), Regional Forest Practice Boards and county and regional planning agencies have knowledge of regional forest issues and resources and may be able to provide useful technical assistance or bring neighboring towns together to talk. Working with neighboring towns using a regional approach can provide advantages in protecting a critical mass of forest lands as a long-term working landscape. It can also help assure consistency across municipal boundaries in safeguarding important environmental features and systems that provide regional benefits. Intermunicipal agreements are a tool allowed by State law that can help towns manage shared resources in a mutually-beneficial way. Regional planning approaches often receive preferential consideration for grant assistance from public agencies that recognize the advantages of this approach.

**3. Updating the comprehensive plan:** Towns that are currently without a comprehensive plan and land use regulations should consider developing and adopting these. All New York communities that use zoning must base that zoning on an adopted comprehensive plan. A comprehensive plan is intended to guide future growth and development as well as identify important natural and cultural resources that should be protected and sustainably managed. A comprehensive plan should have three parts:

1) *Inventory* and analysis - The inventory is the primary building block of the plan because it identifies unique land capabilities and constraints that can be used to guide development, management and protection efforts. A comprehensive plan should inventory and map the town's forest lands, as well as other land uses. An analysis should use a future population projection for the town, together with information about natural resource capabilities and constraints, existing land uses and infrastructure to make observations about the needs of forestry and forest land values

verses development pressures and the needs of the community as a whole.

2) Goals and objectives - Goals and objectives set forth the broad values and specific intentions of the community. They are often drawn from public input as part of a citizen participation process, from community surveys and from the input of the local planning advisory group. Forest goals and objectives should meld public opinion with the factual information derived from the inventory and analysis to guide the plan's final recommendations for action.

3) An action strategy - This identifies the comprehensive plan's specific recommendations related to forest land and uses. This should include a Future Land Use Map that identifies a "critical mass" of land to include the key, contiguous forest land holdings considered by the community to have the greatest value for single or multiple forest purposes. This map should provide a basis for reexamining zoning and making any needed changes for consistency with the plan map.

**4. Evaluating Existing Land Use Regulations**

Land use regulations, including the zoning and subdivision ordinances, are often updated in a parallel process to or right after the adoption of the comprehensive plan. Regulations must be "in accordance" with a comprehensive plan and are required, among other things, to "facilitate the practice of forestry," according to the State's 2003 Right to Practice Forestry law (Town Law Section 263). This means that towns should specifically identify forest uses as allowed and desirable in the town. Frequently, town zones omit any mention of forest uses or harvesting as allowed uses. Towns should also review existing regulations to identify any "forestry unfriendly" language. This may include language that creates obstacles to generally accepted forest management. It is important for towns to clearly distinguish between forestry uses or sustainable forestry practices, and development activities that change the underlying land use as well as permanently remove trees and forest cover. Often attempts to regulate development or land clearing end up restricting sustainable forestry.

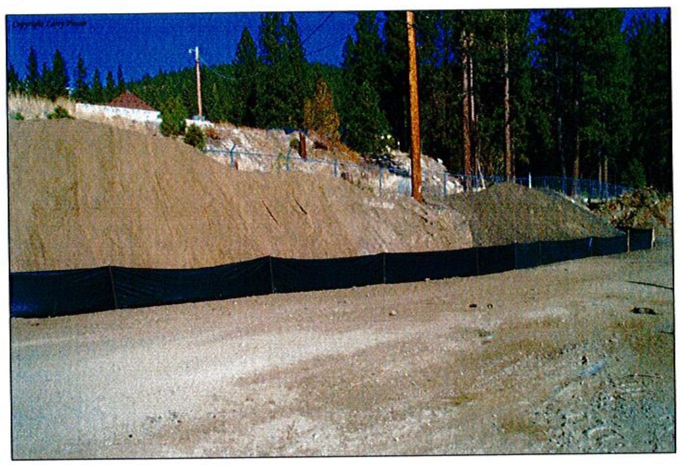

**Photo 3.5.6** Shows the lack of land use regulations.

**5. Updating Land Use Regulations**

Land use regulations can be updated in ways that will support forestry and forest uses and provide for the fair yet meaningful review of timber harvests by incorporating the following standards:

- A definition of forest use – identifying the many was that forest land can be used
- Appropriate zoning – adopting a forest of farm.forest zone is one way to readly manage land for multiple forest uses while discouraging potentially conflicting uses such as residential subdivisions.
- A reasonable review process – developing a process that informs the town of any planned harvest, and gives the town the opportunity to assure that all the environmental and safety objectives of the town are met.

### 6.Timber Harvest Plans

The DEC and other professionals recommend that timber harvesting be preceded by a well-thought-out timber harvest plan that protects soil and water resources and fish and wildlife habitat. Towns can require that such a plan be submitted as part of the local review process. A consulting forester can help the town design a form that identifies the elements local officials want to see included in a timber harvest plan. Landowners should be encouraged to contact a forestry professional for assistance in developing the timber harvest plan and conducting an on-the-ground evaluation of the site. A typical timber harvesting plan that is designed to meet landowner objectives as well as a town's review requirements will likely cost the landowner between $1,000 and $2,000; for the small landowner, this could be a significant percent of the value of the harvest. Towns should be mindful that their regulations should not impose undue hardship on working forest landowners and operations.

**Photo 3.5.7** The slow deterioration of the surrounding foresty in a watershed.

### 7. Land Clearing of Trees

Some towns may wish to adopt review standards for the land clearing of trees for development (frequently mistakenly called "clearcutting" – a silvicultural practice). Because the objective of such a review differs from that of sustainable forestry management, any standards should be separate from a planned timber harvesting review process. In fact, suburban towns are well advised to adopt land clearing standards to help them demonstrate compliance with the Phase II Stormwater requirements (Section 402) of the Clean Water Act.

**Photo 3.5.8** Example extreme deforestation near a watershed.

This Act requires permits for stormwater discharges from land clearing that disturbs one or more acres.

# SECTION 4 - WATER QUALITY

## Section 4.1 WATER QUALITY ASSESSMENTS:

All waters in New York State are assigned a letter classification that denotes their "best uses." In brief, the classifications are as follows:

| | |
|---|---|
| Class A | Drinking water (and all other uses below). |
| Class B | Swimming and boating (and all other uses below). |
| Class C | Fishing and fish propagation. Possibly swimming and boating, but may be limited. |
| Class D | Fishing, but not fish propagation. Possibly swimming and boating, but may be limited. |

An additional designation of T indicates that the river supports trout survival. If a river also supports trout propagation, TS is added.

There are specific numeric and narrative standards that apply to the different classifications. For example, the pH of A, B, and C waters must be between 6.5 and 8.5. The dissolved oxygen concentration for A, B and C trout spawning waters (TS) cannot be less than 7.0 mg/L from other than natural conditions. Except for Class A waters, nutrients (nitrogen and phosphorus) are regulated only by a narrative standard: "None in amounts that will result in growths of algae, weeds and slimes that will impair the waters for their best usages."

For more information on stream classifications and standards, see: *NY State Codes, Rules and Regulations Title 6, Chapter X: Part 701: Classifications-Surface Waters and Groundwaters*[1] and *Part 703: Surface Water & Groundwater Quality Standard*[2]:

The classification of the Lower Non-tidal Rondout Creek is as follows:

| | |
|---|---|
| From the Eddyville Dam to Kerhonkson | Class B |
| From Kerhonkson to the mouth of the Vernooy Kill | Class B(T) |
| From Vernooy Kill to Sandburg Creek | Class C(T) |
| From Sandburg Creek to Honk Lake | Class C |
| From Honk Lake to the Rondout Reservoir dam | Class C(TS) |

Many of the tributaries to the Lower Non-Tidal Rondout are designated trout and/or trout spawning waters, and a few are Class A drinking water streams (in addition to tributaries to the Rondout Reservoir).

For more information on classifications in the Rondout Creek Watershed, see: *NY State Codes, Rules and Regulations Title 6, Chapter X, Part 855: Rondout River, Rondout Creek and Wallkill River Drainage Basin*[3]

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[1] http://www.dec.ny.gov/regs/4592.html#15992

[2] http://www.dec.ny.gov/regs/4590.html#16133

[3] http://www.dec.ny.gov/regs/4559.html#16947

## WATER QUALITY ASSESSMENTS – BACKGROUND AND METHODS

Background: The NYSDEC Division of Water, Bureau of Water Assessment and Management, is responsible for monitoring New York State waters to determine overall quality of waters, trends in water quality, and to identify water quality problems and issues. This monitoring effort is coordinated through the Rotating Integrated Basin Studies (RIBS) Program. RIBS monitoring produces 2 years of data on the each of the state's 17 major drainage basins in a 5-year cycle. In year one of the sampling effort, screening sampling is conducted on a large number of waterbodies; in year two, a smaller number of locations are intensively sampled. In the screening year, only habitat assessments and macroinvertebrate sampling are conducted; in the intensive year, water chemistry, bottom sediment and invertebrate tissue chemistry, toxicity testing, macroinvertebrate assessments, and habitat assessment are done.

In 2002, the NYSDEC completed an extensive Biological Assessment of the Rondout Creek Watershed. In the next (most recent) 5-year cycle for the Rondout (2007-2008), the NYSDEC was only able to assess a few sites in the Rondout Creek Watershed because of the large area that the state must cover each year. In 2007, they sampled one site on the Rondout Creek and one site on each of two major tributaries, Sandburg Creek in the Village of Ellenville and Mill Brook in the Town of Rochester. No intensive sites were located on the Rondout in 2008, but one location in Kerhonkson at State Route 44/55 was sampled as part of a special study on nutrients.

**Photo 4.1.1 Looking upstream from sampling site Tan House Brook, Snyder Estate, Rosendale.**

Recognizing the need for more water quality data on a smaller scale, the NYSDEC Hudson River Estuary Program (HREP) provided funding to Hudson Basin River Watch (HBRW) in 2007 to assess 15 sites in the Rondout Creek Watershed. HBRW selected sites based on input from the Rondout Creek Watershed Council (RCWC), the New York State Department of Environmental Conservation (NYSDEC), and the New York City Department of Environmental Protection (NYCDEP). Sites that were selected included those sites that had never been studied by the NYSDEC or NYCDEP, sites on some of the smaller tributaries, and those that had been identified as potential areas of concern in the 2002 assessment completed by the NYSDEC. Two of the 15 sites were located above the Rondout Reservoir; their results are not discussed in this watershed management plan, as they likely do not significantly impact the water quality of the Lower Rondout Creek.

In 2009 and 2010, the Rondout Creek Watershed Council contracted with HBRW to assess two additional sites each year on the Sandburg Creek to try to determine the location of impacts on this major tributary to the Rondout.

Methods: The assessments mentioned above were "Biological Assessments" using NYSDEC Stream Biomonitoring Unit methods (used both by NYSDEC and HBRW). The primary indicators of water quality in these assessments are freshwater benthic macroinvertebrates

(BMIs). BMIs are larger-than-microscopic invertebrate animals that live in and on stream bottoms, including aquatic insects, worms, clams, snails, and crustaceans. BMIs are useful water quality indicators because different species have different sensitivities to environmental impacts. They are less mobile than fish, and thus cannot avoid discharges or other pollution. Unlike chemical indicators, BMIs provide a picture of overall, integrated water quality, including synergistic effects; substances lower than detectable limits, and non-chemical impacts to the habitat, such as siltation or thermal changes.

Live BMI samples are collected in riffle habitats using a kick net, then preserved and identified in a laboratory under a microscope. The results are used to calculate four different "metrics" that are then averaged to find an overall water quality score for each site. Calculation of the metrics is based on the types and number of organisms present and known tolerances of different organisms to various amounts and types of pollutants. The overall water quality score is called a "Biological Assessment Profile" (BAP) and is ranked on a scale from 0 to 10, with 10 indicating the best water quality. The BAP can fall into one of four categories of pollution impact, with each category corresponding to a specific quarter of the scale: "severely impacted" = 0-2.5, "moderately impacted" = 2.5-5.0, "slightly impacted" = 5.0-7.5, and "non-impacted" = 7.5-10.

The results are also used to generate an "Impact Source Determination" (ISD) for each site. The NYSDEC Stream Biomonitoring Unit uses a method called "Impact Source Determination" (ISD) to identify types of impacts that may negatively affect water quality. The BMI community at a site is compared to existing models of known communities indicative of certain types of

Table 1. Descriptions of Impact Source Determination (ISD) classes used by New York State Department of Environmental Conservation for stream biomonitoring.

| ISD Class | Description |
|---|---|
| Natural | Minimal human impacts. Includes pristine stream segments and those receiving discharges that minimally affect the biota. |
| Nonpoint nutrients | Mostly nonpoint agricultural and sources with similar impacts. Includes row crop runoff, golf course runoff, well-treated sewage effluent, and urban runoff. May include pesticide effects. |
| Toxic | Industrial, municipal, or urban runoff. May include municipal waste-water treatment plant discharges that include industrial wastes, and (or) are characterized by high ammonia or chlorine levels. |
| Organic | Sewage effluent and (or) animal wastes. Includes conventional waste-water treatment plant discharges, livestock waste inputs, and failing septic systems. |
| Complex | Municipal and (or) industrial. Includes industrial point sources and municipal waste-water treatment plant discharges that include industrial wastes. May also include combined sewer overflows and urban runoff. |
| Siltation | Sites affected by moderate to heavy deposition of fine particles. |
| Impoundment | Includes upstream lake or reservoir releases, dammed stream segments, or stream segments with upstream areas of natural pond, wetland, or sluggish zones. |

impacts. If no model exhibits at least a 50% similarity to the sampled community, then the ISD results are inconclusive. Table 4.1.1 lists the seven ISD models ("classes") used by the NYSDEC [4].

For more information about the NYSDEC Stream Biomonitoring Unit methods, visit http://www.dec.ny.gov/chemical/23847.html

Other basic physical and chemical parameters are also assessed at each site. Physical parameters include depth, width, current velocity, percent canopy cover, percent embeddedness, percent of different substrate sizes, aquatic vegetation present, and habitat quality Chemical parameters include dissolved oxygen, pH, conductivity, and temperature. These are measured with a calibrated digital "Hydrolab Quanta Water Quality Monitoring System."

## WATER QUALITY ASSESSMENTS - FINDINGS

Mainstem Rondout: The Lower Non-Tidal Rondout Creek maintains fairly good water quality, but numerous point and non-point sources of pollution in the watershed may threaten the health of the river, as many areas are showing slight signs of human impact.

Photo 4.1.2 HBRW Stream Monitoring Training on Rondout Creek in Kerhonkson. *(Photo: M. Cheo)*

The 2007 assessment by HBRW, combined with data from the NYSDEC, found the water quality to be "non-impacted" below the Rondout Reservoir at Lackawack, but "slightly impacted" at the Eastern Correctional Facility (both sites in the Town of Wawarsing). The water quality continued to be "slightly impacted" at several sites downstream in the towns of Wawarsing and Rochester (Port Ben Road in East Wawarsing, two sites in Kerhonkson, a site in Accord, and the Alligerville Bridge).

The 2007 assessment by HBRW, combined with data from the NYSDEC, found the water quality to be "non-impacted" below the Rondout Reservoir at Lackawack, but "slightly impacted" at the Eastern Correctional Facility (both sites in the Town of Wawarsing). The water quality continued to be "slightly impacted" at several sites downstream in the towns of Wawarsing and Rochester (Port Ben Road in East Wawarsing, two sites in Kerhonkson, a site in Accord, and the Alligerville Bridge). The water quality did not recover to "non-impacted" until the town of Rosendale, at the County Route 7 bridge, but then dropped back down to "slightly impacted" after the State Route 32 bridge in Rosendale, downstream of the Rosendale Wastewater Treatment Plant (WWTP). The river then became "moderately impacted" further downstream, below the confluence with the Wallkill River and the large hydroelectric dam at Sturgeon Pool.

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[4] Riva-Murray, K., et. al., 2002. Impact Source Determination with Biomonitoring Data in New York State. Northeastern Naturalist, 9(2):127-162.

The 2002 NYSDEC assessment showed trends similar to the 2007 HBRW assessment, with sites in Wawarsing found to be "slightly impacted," although the recovery to "non-impacted" occurred much earlier, in Accord (Town of Rochester). The 2002 assessment did not sample downstream of Rosendale.[5]

The most recent data on the Rondout is from 2008 when the NYSDEC sampled just one site, which showed that the Rondout was still "slightly impacted" at the 44/55 bridge in Kerhonkson (Town of Wawarsing)[6].

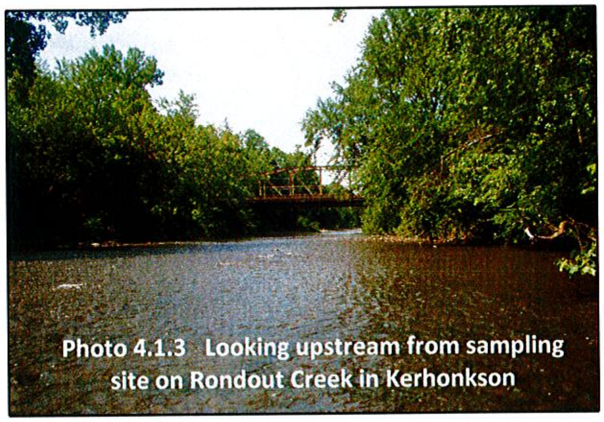

Photo 4.1.3 Looking upstream from sampling site on Rondout Creek in Kerhonkson

These water quality assessments were based on analyzing samples of the stream invertebrate community ("Biological Assessments"). Note that no surveys of the Rondout Creek were undertaken in the Town of Marbletown because this methodology cannot be used in areas close to large impoundments.

Tributaries: Most tributaries were found to be "non-impacted" in both 2002 and 2007. A few tributaries, including Peters Kill, Kripplebush Creek, and Saunders/Stony Kill were found to be "slightly impacted," but due to natural habitat or weather conditions rather than human impact. The Mill Brook was found to be "slightly impacted" in 2002 but "non-impacted" in 2007.

The main tributary that requires further investigation is Sandburg Creek, a major tributary that flows through the Village of Ellenville before entering the Rondout south of Napanoch. In both 2002 and 2007, the Rondout dropped by one water quality category (from "non-impacted" to "slightly impacted) between the sites upstream and downstream of where the Sandburg flows into the Rondout.

The Sandburg Creek flows east through rural Sullivan County to the Hamlet of Spring Glen in Wawarsing. It then turns north, flowing through the old Nevele Grande Resort site and the currently operating Honors Haven Resort. It then flows through the Village of Ellenville. On the outskirts of the village, the Sandburg receives discharge from the Ellenville WWTP. Shortly thereafter it is met by the "non-impacted" Beer Kill, and then the Rondout.

In 2002, the Sandburg Creek was "non-impacted" at Canal Street in the Village of Ellenville. In 2007, it was "slightly impacted" at Canal Street and also just downstream of the Ellenville WWTP. In 2009, HBRW assessed the creek at two sites upstream of Ellenville, in the Hamlet of Spring Glen and at the Honors Haven Resort golf course. Both sites were found to be "non-impacted." In 2010, the Sandburg was "slightly impacted" (but close to "non-impacted") at a site just downstream from the Honors Haven Resort golf course and "non-impacted" at Canal Street in the Village of Ellenville.

More information is needed to flush out the condition of the Sandburg Creek and its impact on the Rondout. In 2007, flow conditions were fairly low, so the BMI community may have been

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5 Bode, R.W., et al., 2002 Rondout Creek Biological Assessment. NYSDEC, Albany, NY

6 Alexander J. Smith, NYSDEC Stream Biomonitoring Unit, email correspondence, October 2010

more vulnerable to the various runoff and discharge influences than in 2010, when flow conditions were higher. However, without having multiple samples from each site in each year, it is difficult to determine whether the different results reflect true water quality changes or natural variation inherent in the biological community and sampling methodology.

Unfortunately there is no data for 2010 on the status of the Rondout downstream of the Sandburg. It would be interesting to know if the Rondout was still "slightly impacted" downstream of the Sandburg even though the Sandburg at Canal Street was "non-impacted" in 2010. In 2002, this was the case: the Sandburg at Canal Street was "non-impacted" and the Rondout in East Wawarsing was "slightly impacted." Impacts that year could have come from urban runoff from the Hamlet of Napanoch and/or from the Napanoch WWTP. Not enough sites were sampled to tease out these possible impacts.

Tables 4.2 and 4.3 list all sampling sites from 2002 to 2010, their locations, BAP scores, ISD classes (where available), and stream classifications. For more detailed information on the water quality assessments at each site sampled by HBRW, see Appendix J.

| Site # | Town, Village, or Hamlet | Location | Year, BAP, Assessment, ISD | Classification |
|---|---|---|---|---|
| RN03 & DEC | Lackawack | Sportsmen Rd | 2002: Non-impacted, Natural<br>2007: 7.91, Non-impacted, NPS nutrients & Natural | C(TS) |
| RN07 | Wawarsing | Eastern Correctional | 2007: 7.20, Slightly impacted, Natural | C(T) |
| RN08 & DEC | Wawarsing | Port Ben Rd | 2002: Slightly-impacted, Natural & NPS nutrients<br>2007: 6.30, Slightly impacted, NPS nutrients | C(T) |
| RN09 & DEC | Kerhonkson | Rte 44/55 | 2002: Slightly impacted, Complex<br>2007: 6.20, Slightly impacted, NPS nutrients<br>2008: 6.83, Slightly impacted, Organic and Complex | B or B(T) |
| RN09 A | Kerhonkson | DEC river access | 2007: 6.20, Slightly impacted, NPS nutrients & Complex | B |
| DEC | Accord | Upstream of Rochester Creek confluence | 2002: Non-impacted, Siltation | B |
| RN10 | Accord | 5011 Rte 209 | 2007: 6.10, Slightly impacted, NPS nutrients (Naturally poor habitat) | B |
| RN12 | Alligerville | Alligerville bridge | 2002: Non-impacted, Natural<br>2007: 7.20, Slightly impacted, NPS nutrients & Organic | B |
| DEC | Rosendale | Rte 7 | 2002: 8.6, Non-impacted, Natural<br>2007: 8.0, Non-impacted, Siltation | B |
| RN14 | Rosendale | Downstream of Rosendale WWTP | 2007: 6.20, Slightly impacted, NPS nutrients | B |
| RN15 | Rosendale/Esopus | 895 Creeklocks Rd | 2007: 4.80, Moderately impacted, Organic & Complex & NPS nutrients | B |

**Table 4.2: Biological Assessment Profile (BAP) Scores, Water Quality Assessments, and ISD Results, By Year Sampled for the Mainstem Rondout (sites listed from upstream to downstream).** Note: Site #'s are listed for HBRW sites. Site #'s are not available for DEC sites. It is noted where DEC and HBRW used the same sites. Not all information is available for all sites. Additional information from DEC sites can be obtained from the NYSDEC Bio-monitoring Unit. Additional information from other sites can be obtained from HBRW.

| Site # | Creek | Town, Village, or Hamlet | Location | Year, BAP, Assessment, ISD | Classifica-tion |
|---|---|---|---|---|---|
| DEC | West Beer Kill | Ellenville | Old Greenfield Rd & Rte 52 | 2002: Non-impacted | B(TS) |
| DEC | Beer Kill | Ellenville | Rte 209 | 2002: Non-impacted | C(T) |
| RN04 | Beer Kill | Ellenville | Cape Ave | 2007: 8.80, Non-impacted, Natural & NPS nutrients | C(T) |
| RN05A | Sandburg Creek | Spring Glen | Old Rte 209 | 2009: 8.95, Non-impacted, NPS nutrients | B(TS) |
| RN05B | Sandburg Creek | Wawarsing | Honors Haven Golf Course | 2009: 8.50, Non-impacted, NPS nutrients | B(T) |
| RN05C | Sandburg Creek | Wawarsing | Downstream of Honors Haven Golf Course | 2010: 7.36, Slightly impacted, NPS nutrients | B(T) |
| RN05D & DEC | Sandburg Creek | Ellenville | Canal St | 2002: 8.26, Non-impacted<br>2007: 6.19, Slightly impacted, NPS nutrients & Organic<br>2010: 8.37, Non-impacted, NPS nutrients | B(T) |
| RN05 | Sandburg Creek | Ellenville | Downstream of Ellenville WWTP | 2007: 6.50, Slightly impacted, NPS nutrients, Complex | B(T) |
| RN06 | Fantine Kill | Ellenville | Beckley Dr | 2007: 8.40, Non-impacted, Natural | B(T) |
| DEC | Vernooy Kill | Wawarsing | Rte 209 | 2002: Non-impacted | Part C(TS) |
| DEC | Mill Brook | Mill Hook | Roundout Valley Resort | 2002: 6.89, Slightly impacted, NPS nutrients<br>2007: 7.53, Non-impacted | A(TS) |
| DEC | Rochester Creek | Mill Hook | Mettacahonts Rd | 2002: Non-impacted | A(TS) |
| RN11 | Saunders Kill/Stony Kill | Rochester | Just downstream of confluence | 2007: 7.50, Slightly-impacted, NPS nutrients | AA(T) |
| DEC | North Peters Kill | Whitfield | Canyon Lake Rd | 2002: Non-impacted | Part A(T) |
| DEC | Peters Kill | Rochester | St. Josen | 2002: Slightly impacted (skewed due to moss & midges) | B(T) |
| DEC | Kripplebush Creek | Kripplebush | Rte 209 | 2002: Slightly impacted (naturally poor habitat) | C(TS) |
| RN13 | Cottekill Brook | Marbletown | Lucas Tpke | 2007: 8.14, Non-impacted, Natural | C(TS) |
| HBRW Training | Tan House Brook | Marbletown | Snyder Estate | 2006: 7.08, Slightly impacted | C |
| DEC | Coxing Kill | High Falls | School Hill Rd | 2002: Non-impacted | C(T) |

**TABLE 4.3: Biological Assessment Profile (BAP) Scores, Water Quality Assessments, and ISD Results, By Year Sampled for Tributaries to the Rondout Creek (listed from upstream to downstream).** Note: Site #'s are listed for HBRW sites. Site #'s are not available for DEC sites. In some cases, DEC and HBRW used the same sites. Not all information is available for all sites. Additional information from DEC sites can be obtained from the NYSDEC Bio-monitoring Unit. Additional information from other sites can be obtained from HBRW.

Water Quality Standards: None of the sites assessed by HBRW violated the pH or dissolved oxygen standards for their classification. However, when a river is "moderately" or "severely" impacted based on a biological assessment, it is likely that the river is no longer meeting its uses. The site on Creeklocks Road downstream of the confluence with the Wallkill was "moderately impacted." This section of the river is class B, which includes swimming, boating, fishing and fish propagation. A "moderately impacted" river may not be able to support these uses.

The Creeklocks Road site was the only "moderately impacted" site. But a majority of sites scored as "slightly impacted." Thus while much of the river may still be supporting its uses, it is no longer in a completely natural state, and the aquatic community is experiencing some stress from human impacts.

It is also important to note that the assessments did not include bacteriological sampling, so it is not known if the river is meeting its standard for coliform bacteria. This is an important indicator of health for a Class B (swimming) river.

## POTENTIAL SOURCES OF IMPACTS

Non-point Source Pollution: "Non-point nutrients" was by far the most common source of impact indicated by the ISD. This ISD class refers mainly to inputs of nitrogen and phosphorus, which can cause excess algal growth, depressed oxygen conditions, and negative impacts to the aquatic community. In 2007, the ISD indicated "non-point nutrients" for almost all mainstem Rondout sites except the Eastern Correctional Facility in Wawarsing. "Non-point nutrients" were also indicated for almost all the tributaries that were "slightly impacted."

Non-point nutrients can come from a variety of sources including agricultural areas, golf courses, and urban areas. In addition these nutrients can come from "well-treated sewage effluent" which refers to effluent from septic systems or WWTPs in which the organics have been broken down but nutrient concentrations remain. There is widespread agricultural activity in the Rondout Valley, but it may be more likely that the Rondout's drop to "slightly impacted" below the confluence with the Sandburg Creek is from urban runoff entering Sandburg Creek from the Village of Ellenville and contributions from various WWTP discharges.

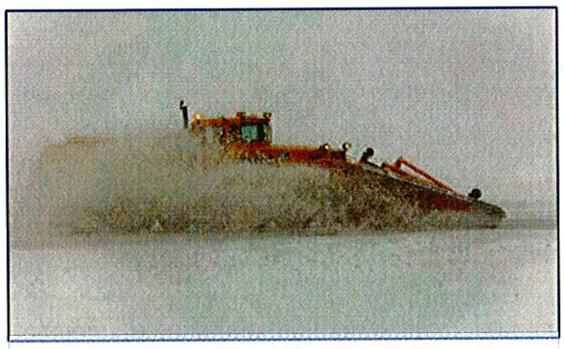


**Photo 4.1.3 Non-Point Sources: Salt loading**

Point Source Pollution: There are several SPDES discharges in the Rondout Creek Watershed in the Town of Wawarsing, none in the towns of Rochester and Marbletown, and one in the Town of Rosendale. The 2007 assessments looked at sites upstream and downstream of four wastewater treatment plants (WWTPs): Ellenville, Napanoch, Kerhonkson, and Rosendale.

The Ellenville WWTP did not cause any significant change in the BAP score of the Sandburg Creek; the site upstream of the Ellenville WWTP (Canal Street) was already "slightly impacted." Thus non-point urban runoff from the village or some other impact upstream may have caused the water quality impacts on the Sandburg Creek in 2007. However, wastewater effluent could have prolonged the creek's recovery. Similarly, the Napanoch and Kerhonkson WWTPs did not cause any significant changes in the BAP score of the Rondout Creek; the sites upstream and downstream of each WWTP were all "slightly impacted."

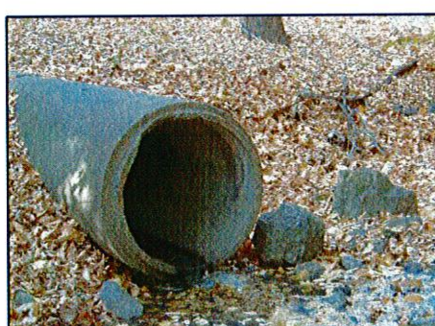


**Fig. 4.1.4 Point Sources = End of Pipe**

The discharges could have, however, been responsible for prolonging the river's recovery. The ISD classes "Organic" and "Complex" indicate that municipal WWTPs could be one source of impact, among other possible sources. In 2007, the ISD indicated "Complex" at two sites that were downstream of WWTPs: Ellenville and Kerhonkson. "Complex" also appeared at Route 44/55 in 2002 and "Complex and "Organic" appeared at that site in 2008. "Organic" also appeared at the Alligerville Bridge in 2007.

None of the three WWTPs in the area (Ellenville, Napanoch, and Kerhonkson WWTPs) had any violations of their SPDES permit standards during any of the years in which water quality assessments occurred.[7]

Further downstream in Rosendale, the river had recovered to "non-impacted," but dropped to "slightly impacted" just downstream of the Rosendale WWTP. The Rosendale WWTP does on occasion violate its standard for total suspended solids, but there were no violations in the months of August and September of 2007.[8]

It is possible this drop is partially due to habitat differences. BMI's are found in riffles, shallow areas where the water moves quickly over rocky bottoms. Downstream of the WWTP, the riffle spanned the width of the river, but was not as long as it was wide. Ideally, a riffle should be twice as long as the width of the river. Upstream of the WWTP, the riffle met those criteria.

Impoundments and Channelization: The Rondout Reservoir dam did not exert any noticeable effect on water quality. The macroinvertebrate community at Lackawack was "non-impacted" both in 2002 and 2007.

Fig. 4.1.5 Rondout Creek immediately downstream of confluence with Wallkill below Sturgeon Pool

**Site RN15, Creeklocks Road**
**September 15, 2007, 5 p.m.**

**Site RN15, Creeklocks Road**
**September 16, 2007, 9 a.m.**

[7] Leonard M. Distel, Supervisor, Town of Wawarsing, and Mike Ryman, Chief Operator, Village of Ellenville Sewer Department, personal communications, November 2010.

[8] Terry Johnson, Water and Sewer Superintendent, Town of Rosendale, personal communication, October 2010.

The most impacted site in the whole watershed (found to be "moderately impacted" in the 2007 HBRW assessment) is located downstream from the confluence with the Wallkill River and is greatly affected by large changes in flow from the Central Hudson hydroelectric dam at Sturgeon Pool. Photos in Fig. 4.1.6 were taken at that site at 5 p.m. one day (shortly after a release) and 9 a.m. the following day after the high waters had subsided. The difference in flow in that 16-hour period is significant.

The old Delaware and Hudson Canal channel connects to Sandburg Creek upstream of the Village of Ellenville and the Honors Haven Resort. It did not exert any noticeable effect on water quality. The macroinvertebrate community was "non-impacted" at the Honors Haven resort in 2009 and "slightly impacted" (but close to "non-impacted") in 2010.

## RECOMMENDATIONS

Controlling Non-point Source Nutrients: Non-point nutrients can be controlled through storm water management. The NYSDEC provides storm water management guidance to municipalities through its "Municipal Separate Storm Sewer Systems" (MS4) program[9]. MS4s are any system that conveys storm water, such as roads, pipes, catch basins, curbs, gutters, ditches, man-made channels, or storm drains. They can be owned or operated by a State, city, town, borough, county, parish, district or other public body that discharges into the waters of the United States. The municipal separate storm sewer is designed or used for collecting or conveying stormwater that is not a combined sewer or part of a Publicly Owned Treatment Works (POTW). Municipalities that are designated as "MS4 Communities" through the NYSDEC Phase II Stormwater Permit Program must develop, implement, and enforce a "Storm water Management Program" (SWMP) to reduce pollution to the "maximum extent practicable" (MEP) to protect water quality. SWMPs must include six "minimum control measures," including:

1. Public Education and Outreach;
2. Public Involvement/Participation;
3. Illicit Discharge Detection and Elimination;
4. Construction Site Runoff Control;
5. Post-Construction Runoff Control; and
6. Pollution Prevention/Good Housekeeping at municipal sites and operations.

Fig. 4.1.6 Stream monitoring day with Rosendale 3rd graders.

Public education and outreach is important because people value their waterways and implementing this measure will help them to understand what they can do to protect and restore the health of their waterbodies. This will also provide the basis for public support for other control measures and projects related to the waterways. The public education and outreach program should include information about the impacts of stormwater discharges

[9] Overview of the Municipal Separate Stormwater Sewer System (MS4) Phase II Stormwater Permit Program. A Summary of MS4 Phase II Permit Requirements. Revised August 2003 http://www.dec.ny.gov/docs/water_pdf/ms4_overview.pdf

on waterbodies, pollutants and their sources, and preventative measures that can be taken to reduce their occurrence. A possible program for this might include speakers to community groups and schools, utility bill insets, displays at events or malls, and news articles or radio spots.

Public involvement and participation will help MS4s cultivate stronger programs and higher compliance levels if they involve people in the SWMP from the beginning. The public involvement must also comply with public participation and involvement provisions of the Clean Water act, as applicable. The public involvement/participation program will identify key individuals and groups who are interested in or affected by the SWMP. It will also describe the activities the MS4s will perform to provide program access and gather needed input. To ensure the public has the ability to become and remain involved the name contact person for the SWMP must be published. Also the draft annual report must be presented before submitting the annual report, at a meeting that is open to the public with time for public input. The summary of the input and comments should be included in the annual report, and the final report should be made available for public inspection. The program might include activities such as forming an advisory committee that will work in corroboration with other municipalities, and encouraging citizen volunteer programs for beach cleanups, litter removal and stream monitoring.

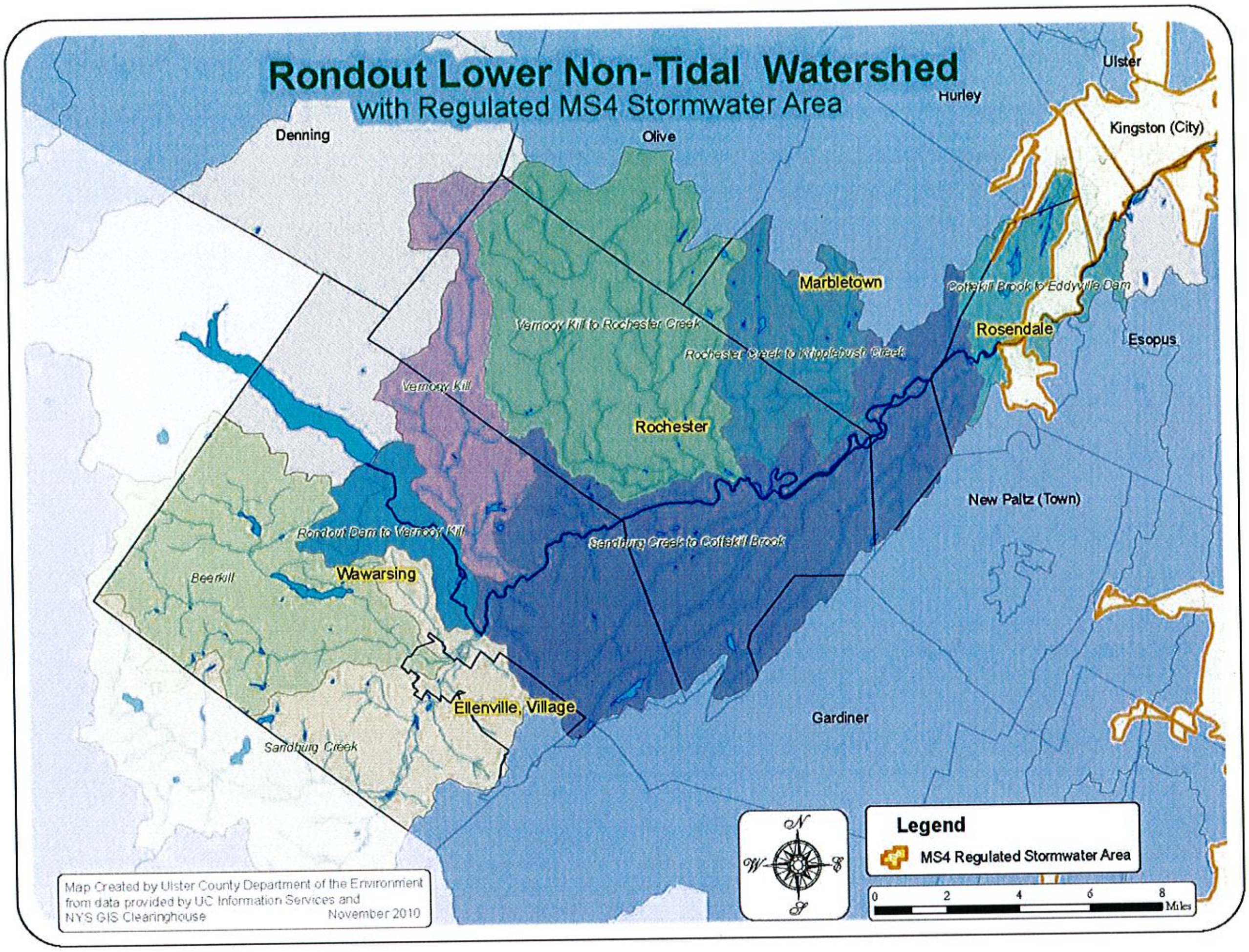
Illicit discharge detection and elimination will reduce the amount of discharges that enter the system through direct or indirect connections. This results in inadequately treated discharges that contribute high levels of pollutants, including toxics, heavy metals, oils and grease, viruses and bacteria that enter waterbodies. The municipalities must develop, implement, and enforce a program to detect and eliminate illicit discharges into the MS4.Another requirement is the creation of a map showing the location of any points where an MS4 discharges to either the waters of the U.S. or to another MS4, and the names and location of all waters of the U.S. The formation of an ordinance or other regulatory mechanism, that will prohibit illicit discharges into the storm sewer system and implement appropriate enforcement procedures and actions is a major regulatory aspect to detect illicit discharges. Additionally municipalities should develop and implement a program to detect and address non-stormwater discharges to the system. Public employees, businesses and the general public of hazards associated with illegal discharges will increase public awareness and involvement, will simultaneously strengthening the previous requirements. Measurable goals and appropriate management practices should be implemented to ensure the reduction of all pollutants of concern from illicit discharges to the stormwater system to the MEP. Possible programs for this measure might include conducting shoreline surveys, inspecting storm sewers, and establishing citizen watch groups.

Construction site runoff control requires measurable goals and appropriate management practices to ensure the reduction of all pollutants of concern from illicit discharges to the stormwater system to the MEP. A program to reduce pollutants in stormwater runoff to the MS4 from construction activities that disturb land of one acre or more must be developed and implemented. However, if construction is on land less than one acre, is part of a larger common plan of development or sale, it must be included in the program. The program should at a minimum provide the development and implementation of an ordinance or other regulatory mechanism to control erosion and sediment control management practices, and the implementation of sanctions to ensure compliance, if needed. Site plan review procedures that will incorporate consideration of potential water quality impacts, with pre-construction site plans to ensure consistency with local sediment and erosion control requirements must also be included. Finally procedures for site inspections and enforcement of control measures, and education and training for construction site operators about the requirements is necessary to ensure the successfulness of construction site runoff control. MS4s need to become familiar with the SPDES General Permit for Stormwater Discharges from Construction Activity because their program must, at a minimum, provide equivalent protection to this permit.

Fig. 4.1.7: Severe erosion.

Post construction site runoff control is important because as runoff flows over land altered by development, it picks up pollutants that are then transferred into the waterways. Prior planning and design for minimization of pollutants in post construction areas is a cost effective approach to stormwater quality management. MS4s must develop and implement a program that reduce the discharge of pollutants to the MEP, through the use of ordinances or other regulatory mechanism to address post construction runoff from development and redevelopment. As with construction site runoff control, post construction site runoff requires that there are measurable goals, management practices, and controls in place to ensure the reduction of all pollutants to the MEP. Inspection of development and redevelopment sites must be carried out to insure compliance and penalize violators. In addition to inspecting sites the use of zoning ordinances and other regulatory mechanisms must be used to successfully reduce construction runoff.

Pollution prevention and good housekeeping measures for municipal operations will reduce or prevent pollution from the operation and maintenance activities, which can become sources of pollutants that need to be minimized through the SWMP. Good housekeeping measures for municipal operations will reduce or prevent pollution form entering nearby waterbodies with stormwater runoff. MS4s must develop and implement an operation and maintenance program that will reduce and prevent the discharge of pollutants to the MEP from activities such as park and open space maintenance, roadway maintenance, adjustments to local geography to affect the continuous movement of water on, above and below the landscape. As a guideline the management practices identified in the NYS Management Practices Catalogue for Nonpoint Source Pollution Prevention should be utilized as needed. Possible program activities are the development of maintenance schedules and inspection procedures for structural and non-structural controls, and coordinate with flood control managers to identify and address environmental impacts from flood management projects.




The towns of Marbletown and Rosendale are the only MS4 communities in the Lower Non-Tidal Rondout Creek Watershed. They have implemented successful SWMPs. Table 4.1 outlines specific practices used by these communities. Current efforts to manage and educate about stormwater have been successful. Rosendale has found that flooding has decreased due to increased inspection and maintenance of post construction best management practices. Marbletown found that stormwater trainings for contractors resulted in improved erosion and sediment control at construction sites. When economically feasible, Marbletown plans to incorporate runoff reduction techniques and green infrastructure in the routine upgrade of existing stormwater conveyance systems and municipal operations.[10]

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[10] Stormwater Management Program Annual Report, 2009, Town of Marbletown. Stormwater Management Program Annual Report, 2009, Town of Rosendale.

Table 4.1: Practices Implemented in MS4 communities in LNT Rondout Creek Watershed

| Practice Implemented | Marbletown | Rosendale |
|---|---|---|
| Developed educational materials on stormwater management and related issues. | x | x |
| Encouraged public involvement in stream clean ups. | x | x |
| Encouraged public involvement in community meetings to review SWMPs. | x | x |
| Mapped 100% of stormwater outfalls and screened for dry weather discharges. | x | x |
| Hosted public presentations on Better Site Design and Low Impact Development | x | |
| Provided stormwater training sessions for town employees | x | |
| Marked stormdrains | | x |
| Corrected illicit discharges (failing septic systems) | | x |
| Implemented and enforced regulatory mechanisms to control illicit discharges and manage stormwater runoff from construction sites and new developments, post-construction. | x | x |

Other municipalities in the watershed can follow the examples set by Marbletown and Rosendale to educate and involve the public in stormwater issues and implement practices that eliminate illicit discharges and reduce stormwater runoff and resulting non-point source pollution from construction sites, new developments, and municipal operations.

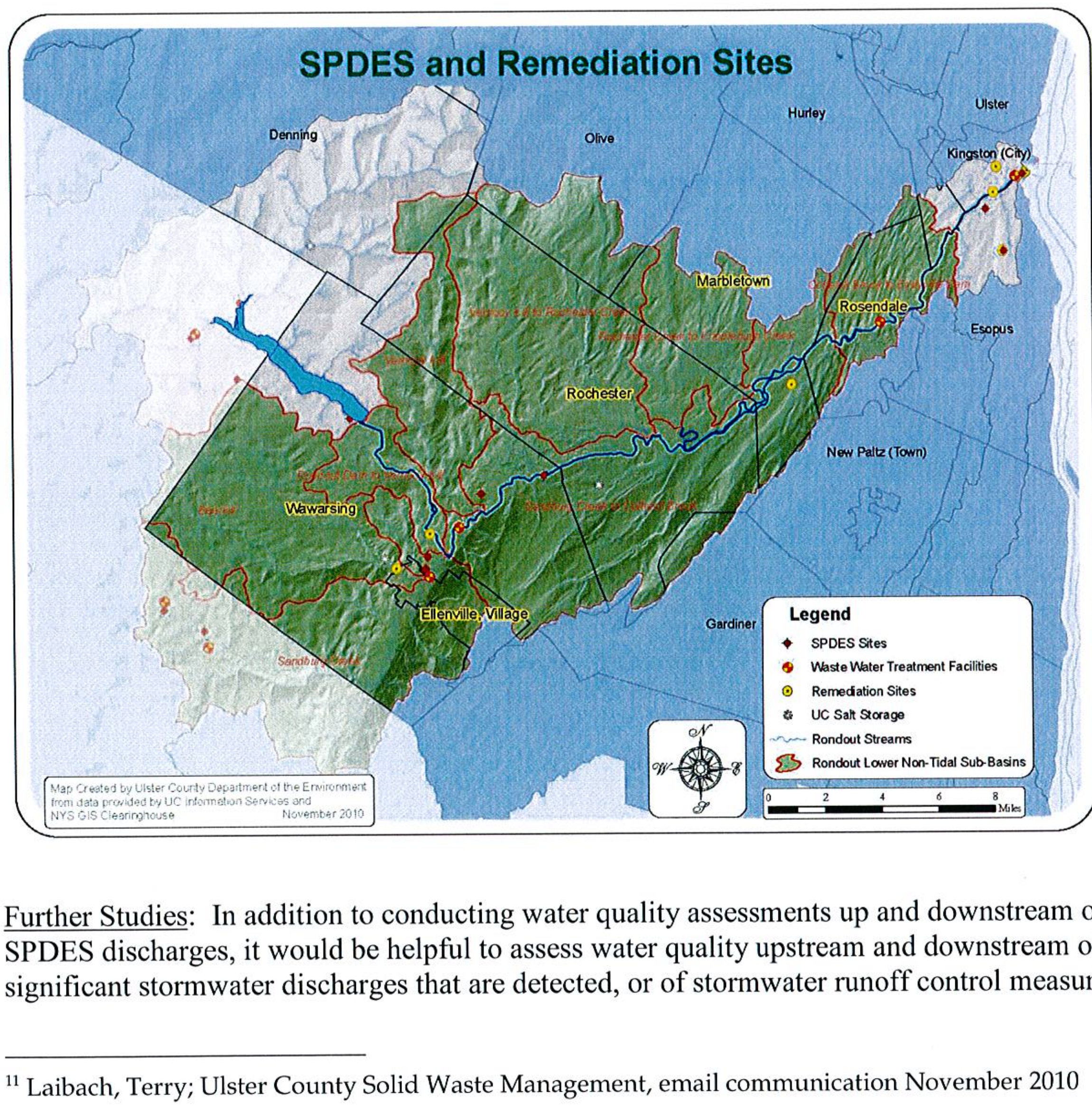
An illicit discharge is a discharge that enters a MS4 system directly or indirectly, but it is not a discharge that MS4 systems are designed to process. They could include: sanitary wastewater, septic tank effluent, car wash wastewaters, improper oil disposal, radiator flushing disposal, laundry wastewaters, spills from roadway accidents, and improper disposal of auto and household toxics. Other non-stormwater discharge flows that may not be considered "illicit discharges" but can cause non-point source pollution include water line flushing, irrigation water, foundation and footing drains, residential car washing, swimming pool discharges, street wash water, and fire fighting activities. In addition to mapping and inspecting MS4 outfalls, mapping potential sites of illicit discharges could be a helpful strategy in controlling stormwater pollution. For example, if septic systems along a river corridor were mapped, this could help identify potential hot spots of pollution and help to target future sites for stream monitoring efforts.

Point Source Pollution: While none of the WWTPs in Wawarsing appeared to have a significantly negative influence on the Rondout Creek based on the 2007 study, they may be prolonging the river's recovery. It would be important to monitor the operations of these SPDES discharges for violations and continue to conduct water quality assessments upstream and downstream of their locations. Regarding the Rosendale WWTP, it would be helpful to consult with NYSDEC Biomonitoring Unit about the habitat quality in the site to help judge if it may have influenced the "slightly-impacted" water quality result.

When active all the landfills in the lower in the lower non-tidal Rondout were unlined. However, they have all been closed and replaced with transfer station, where recyclables and nonrecyclable waste are stored prior being transported to the Ulster County Resource Recovery Agency to be processed and marketed or sent to out of county landfills. Although there are currently no active landfills, the leachate or emissions from the closed landfills in each of the towns and could act as a potential source of point source pollution.[11]

Table 4.2: Landfill Closures in LNT Rondout Creek Watershed Municipalities

| Town | Active dates | Closure dates |
|---|---|---|
| Wawarsing | 1975-1993 | 1997 |
| Marbletown | 1977-1982 | NA |
| Rochester | 1973-1993 | 1996 |
| Rosendale | 1978-1993 | 1998 |




Further Studies: In addition to conducting water quality assessments up and downstream of SPDES discharges, it would be helpful to assess water quality upstream and downstream of any significant stormwater discharges that are detected, or of stormwater runoff control measures that

[11] Laibach, Terry; Ulster County Solid Waste Management, email communication November 2010

are implemented. This will help determine whether water quality impacts are coming from point sources or non-point sources of pollution.

The ISD indicated nutrients as the most common source of impact in the watershed. Nutrients are likely coming from many non-point sources in the watershed, so reducing stormwater runoff could reduce this source of pollution. In addition, "Well-treated sewage effluent" is another possible source of excess nutrients. WWTPs are usually required to remove organic and toxic materials from their effluent, but often not required to remove nutrients such as phosphorus. More research on this potential source of nutrients from WWTPs would be helpful.

Excess nutrient loading into a river can lead to eutrophication – a situation that can cause oxygen levels to drop below what is needed to sustain a healthy aquatic community. "Cultural" (human caused) eutrophication of surface waters has become a major source of water quality impairment throughout the US. In response, the United States Environmental Protection Agency (USEPA) has devised a national strategy for the development of regional nutrient criteria. New York State has an effort underway to revise its narrative nutrient standard.

The NYSDEC has recently developed a method of measuring stream nutrient enrichment using BMIs called the "Nutrient Biotic Index" (NBI).[12] The level of eutrophication in a stream can be calculated based on the tolerance of the various BMI taxa to phosphorus and nitrogen. For further exploration on the impact of nutrients in the Rondout Creek Watershed, the data discussed in this section could be analyzed using this methodology.

It would also be important to conduct an assessment of coliform bacteria on the Rondout. Each community along the river could provide input on what areas are used for swimming, and a study could be designed accordingly, using NYS Department of Health standards for coliform bacteria at bathing beaches. This assessment would be especially useful in the High Falls area, where swimming is popular and no water quality assessment has ever been conducted.

Another recommended area of further study is the Sandburg Creek and the Rondout in Wawarsing. A study that included assessments of the Lackawack, Honors Haven, Canal Street, Ellenville WWTP, Eastern Correctional, and Port Ben Road sites, plus an additional site on the Rondout upstream of Sandburg Creek but downstream of the Hamlet of Napanoch, would help determine the following:

- The level of impact in the Sandburg Creek
- Where the impact may be coming from (Honors Haven golf course, Village of Ellenville urban runoff, or Ellenville WWTP).
- The level of impact in the Rondout Creek in Napanoch and East Wawarsing.
- Where the impact may be coming from (Sandburg Creek, Napanoch area urban runoff, or the Napanoch WWTP).

There are numerous factors that affect the health of a river. With continued water quality assessment, and reduction of the human impacts found, the relatively good health of the Rondout can be protected, and even improved.

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[12] Smith, A.J., et. al., 2009. Standard Operating Procedure: Biological Monitoring of Surface Waters in New York State, p. 53. NYSDEC, Albany, NY.

## SECTION 4. 2 MANAGING WATER RESOURCES: STORMWATER AND WASTEWATER

Management of water in communities and on the landscape is an age-old issue. Drainage practices for rainwater and melting snow have evolved for thousands of years. In earlier times, before most communities had sewer systems for wastewater, water draining from streets in cities and other communities would also carry human waste, animal manure and garbage. Over time, sewer systems were developed to carry water away from populated centers, and early systems did not provide any treatment so raw sewage was discharged to water bodies. Treatment standards for wastewater (water carrying human waste and other concentrated waste sources from industry) have gradually become tighter over time as impacts on waterways increase and become more apparent. Meanwhile, the water quality impacts of rain and melting snow flowing into local waterways, which is now called stormwater runoff, did not get as much attention for many years. After the Federal Clean Water Act was enacted in 1972, large amounts of Federal funding were allocated for building and upgrading wastewater treatment plants and collection sewers. But it was not until 1990 that Phase 1 of the Federal regulations was enacted to address stormwater discharges from larger communities. Regulations addressing discharges from smaller communities and from construction sites were first enacted by NY State in 2003 (Phase 2). Since then, stormwater programs have evolved, and newer ideas about using green infrastructure for both stormwater and wastewater management have begun receiving more attention. This section provides background information on these programs and trends and discusses some important next steps for advancing these strategies in the Rondout watershed and surrounding region.

The NYS DEC stormwater programs require all construction sites that meet certain thresholds to obtain a stormwater permit. For smaller sites, this permit requires an erosion and sediment control plan implemented during construction, with site practices that are temporary until the construction is completed. For larger sites, permanent stormwater management practices that follow state guidelines must be designed and installed during construction, and then maintained after that. In addition, the Phase 2 program enacted in 2003 applies to certain municipalities known as MS4s, which stands for municipal separate storm sewer systems (i.e., M and four S's.) MS4 municipalities are designated based on a formula that factors in total population and population density in specific census blocks, and are the same geographic areas that are defined as "urbanized areas" by the US Census. MS4 municipalities are required to implement a local stormwater program that includes six components, which are called "minimum measures." The six minimum measures are described, along with other details on these issues, in Section 4.1.

In addition to local governments that are subject to the MS4 requirements (towns, villages and cities, which are known as traditional MS4s with land use control), other entities are also regulated as MS4s. Counties are termed traditional non-land use control MS4s and must do certain things that are also required of the local MS4s. Non-traditional MS4s are public organizations that have physical facilities located within MS4 designated areas, which are regulated if they exceed certain thresholds regarding the type of facilities they have and how many people work or live on their property (they include state and federal prisons, office complexes, hospitals; state transportation agencies; university campuses, public housing authorities, and schools). Finally, there's an MS4 designation for industrial facilities, and if they meet regulatory thresholds they must comply with New York State's Multi-Sector General Permit (MSGP) for Stormwater Discharges Associated with Industrial Activities [1]. .

The Importance of Impervious Surface: The Phase 2 stormwater program requirements for construction sites originally focused on temporary erosion control measures for most sites, and for larger projects, permanent stormwater management practices that mostly utilized conventional designs (i.e., without much focus on green infrastructure.) More recently, in 2010, NYS DEC released updated permit requirements and design guidelines for stormwater planning and practices in new development. The state's program now includes a greater emphasis on minimizing the impacts of hydrologic changes caused by development. With the goal of preserving the natural functions of watersheds that help keep water clean, supporting healthy ecological systems, and keeping streams and riparian systems relatively stable -- although these are, inevitably, always changing. This newer green infrastructure approach to stormwater permitting and the design of stormwater plans and practices comes out of on an understanding of the impacts of impervious surfaces.

As land use changes in a watershed from undeveloped to developed, the impact of stormwater on water resources also changes. Land that is largely undeveloped, with no roads, parking or buildings, generally produces very little surface runoff. Forests, grasslands and other natural upland areas have a great capacity to absorb precipitation as it falls, or snow as it melts. Much of this water percolates down through the soil and recharges groundwater, and some of this groundwater flows underground and eventually re-emerges as surface water at lower points in the landscape, very often in streams. This flow of groundwater to streams, known as base flow,

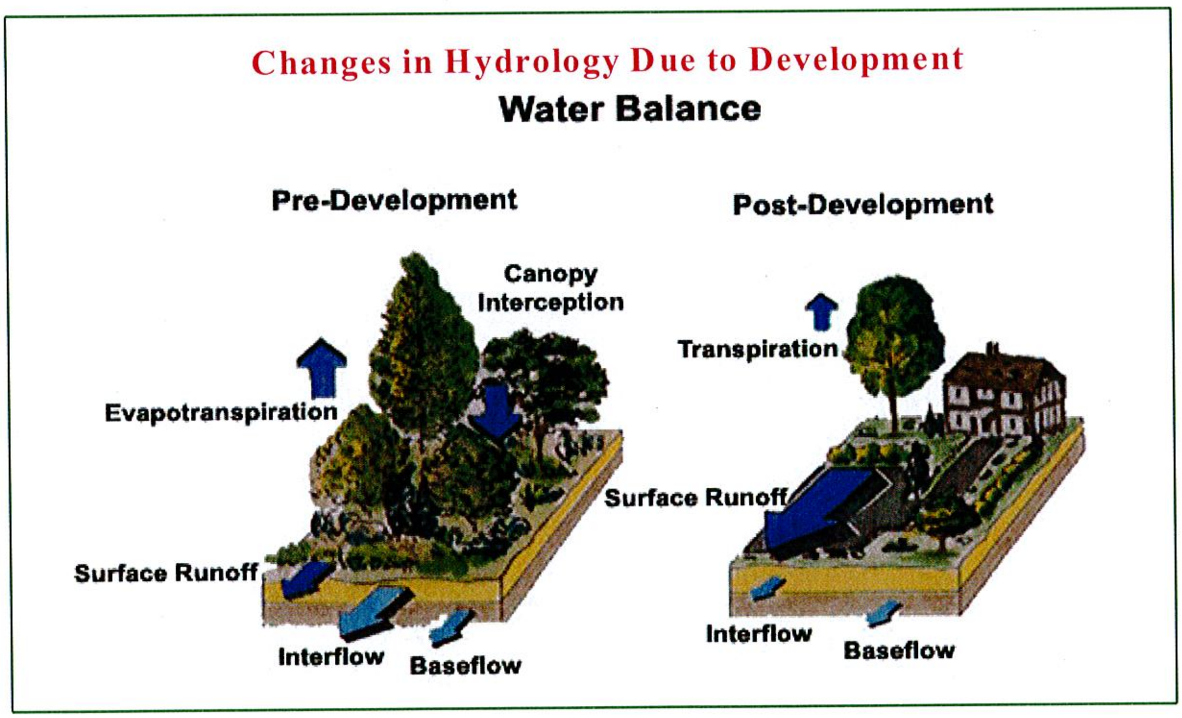


**Figure 4.2.1:** This diagram illustrates the increase in runoff and decrease in groundwater recharge (interflow and baseflow) that results from increased impervious surface.

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[1] http://www.dec.ny.gov/docs/water_pdf/gp0601.pdf

provides a large proportion of the total flow in smaller streams, especially in the summer and other dry periods when there's little rainfall. It can, however, take weeks or months for water to percolate through the ground before it reaches a stream.

Compare this scenario to what happens to precipitation in a highly-developed landscape. Roads, parking and other impervious surfaces typically prevent water from reaching the underlying soils, thus blocking the recharge of groundwater. Most water that reaches impervious surfaces simply flows downhill over the surface, relatively rapidly, until it reaches a stormwater collection system, stream, or other waterbody.

Another factor that affects how water moves through the watershed is trees and other vegetation. Trees intercept rainfall by temporarily storing water on their leaves and bark. This water eventually drips to ground or evaporates into the atmosphere. Trees and plants also pull water up through their roots and use it for their growth, and in the process water is released from the leaves as water vapor, a process called transpiration. The combination of plant transpiration and the evaporation of water from soil surfaces is called evapotranspiration. Evapotranspiration and rainfall interception in a vegetated landscape, has a major influence on the storage and movement of water through a watershed, and indeed on the local climate itself, including ambient temperature.

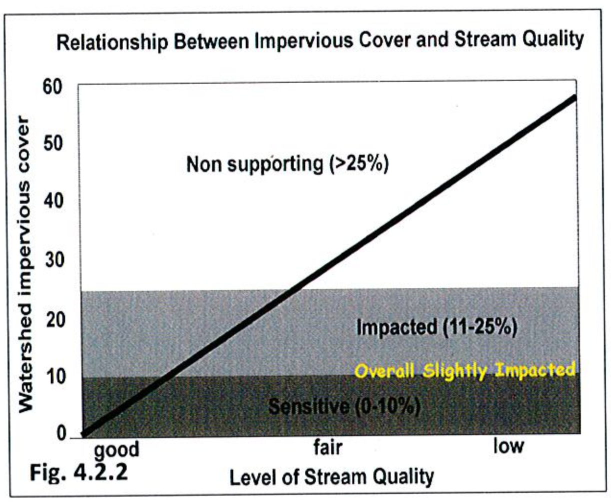


Fig. 4.2.2

Figure 4.2.1 depicts these concepts, including the fact that surface runoff is higher and base flow is lower in a more highly developed landscape.

As watersheds become more developed and impervious surfaces increase, major impacts occur to the hydrology of streams and other waterbodies, and on water quality itself. In a very lightly developed watershed, where the total impervious cover is well under 10%, there is little surface runoff and healthy groundwater recharge provides a relatively steady flow of water in streams. In more heavily developed watersheds, as the percentage of impervious cover rises above 10% and reaches 20% or higher, there is an increase in surface runoff and a decrease in infiltration resulting in less groundwater recharge. At 25% it is non-supporting of aquatic life. The Rondout watershed at 9.4% average impervious surface is overall only slightly impacted, and more easily protected because it does not also need to be remediated. The increase in volume of water reaching the stream channel causes stream flow to rise rapidly during storms, which often causes new erosion or flooding problems and can exacerbate existing problems. At the same time, the reduced groundwater base flow leads to lower stream

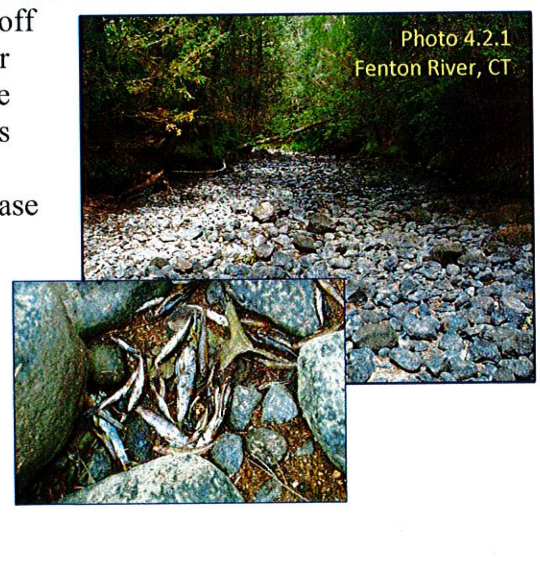


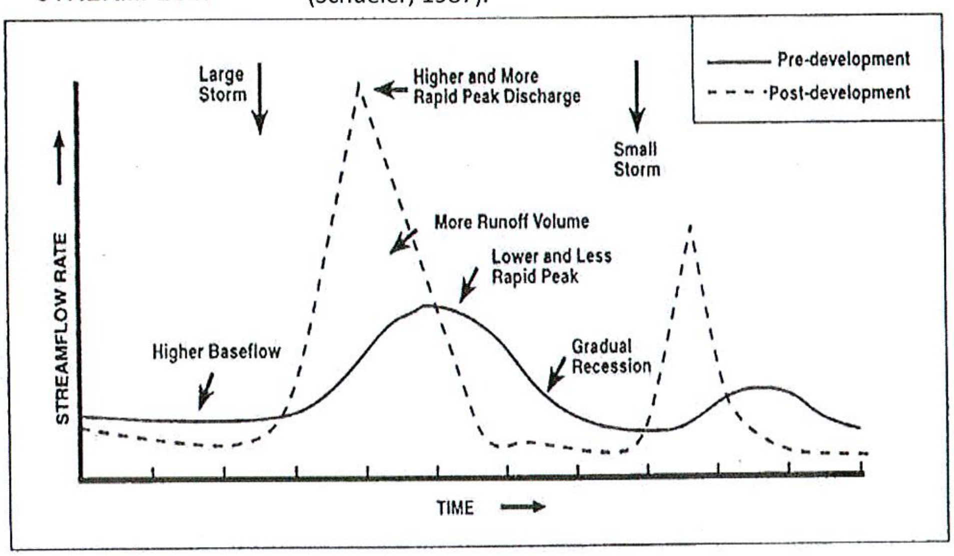
Photo 4.2.1
Fenton River, CT

flows during dry periods. Smaller streams that used to run year-round can dry up completely, as has happened in other watersheds.

Figure 4.2.3 illustrates some of these concepts by comparing two different stream flow patterns. The pre-development scenario (solid line in this graph) shows that stream flow rises relatively slowly after a storm begins, and then gradually recedes after the storm. The post-development scenario (dashed line on the graph) represents a more highly developed watershed. The rapid flow of surface runoff to the stream causes a sudden spike in stream flow, followed by a rapid decline. Also, stream flow is lower during dry periods between storms in the post-development scenario, due to reduced base flow from groundwater.

STREAMFLOW

Figure 4.2.3. Change in Hydrograph following development. (Schueler, 1987).




The impervious surfaces and conveyance systems of developed sites result in an earlier and higher peak discharge rate.

Another key impact of impervious surfaces is also related to the fact that they seal off the natural infiltration process in which water percolates down through the soil and groundwater. As water seeps through the soil layer in a relatively intact, vegetated landscape, it comes into contact with the soil, the roots of trees and plants, and the diverse ecosystem of microbes and other life forms that live underground. These natural ecosystems provide tremendous filtering and uptake capacity for removing nutrients and other pollutants from water. Stormwater management systems of various kinds are intended to utilize some of these soil-based processes, as well as processes that occur in surface water bodies such as wetlands, ponds and streams. Green infrastructure, also known as low impact development, is a term describing practices and design concepts for stormwater and wastewater management that emphasizes replicating the processes that are at work in a healthy watershed. These practices purify water and return it to the local ecosystem while helping to maintain groundwater recharge and streamflow as much as possible.

The impact of impervious surfaces, and limiting the percentage of impervious cover in a watershed, is a key aspect of watershed planning, protection and restoration. Along with the effects of non-point source pollutants and point source pollutants on water quality per se, these hydrologic changes from development of the landscape are some of the most fundamental issues and challenges we face. As our understanding of the importance of these issues has grown over the past 10-20 years, watershed planning and restoration methods have emerged to try and limit these changes as new development takes place, and attempt to mitigate some of the impacts to water quality in areas that are already more urbanized.

Green Infrastructure for Stormwater Management: In the environmental planning, design and regulatory sectors, there is a growing focus on the concept of green infrastructure for managing water resources. Green infrastructure, in this context, refers broadly to a set of design principles and specific practices for using the inherent qualities and functions of soils, vegetation, and other components of natural ecosystems to provide a sustainable approach for managing water. US EPA, NYS DEC, and many other agencies and organizations have adopted policies and specific programs that clearly support the benefits and advantages of green infrastructure. The use of these practices are being encouraged over conventional gray infrastructure systems where stormwater treatment practices are usually added at the end of the pipe, to meet basic regulatory requirements. There are significant challenges, however, to fully implementing this approach. These challenges are discussed below in the Green Infrastructure for Wastewater Management section, because the most fundamental issues are common to both sectors.

Applying green infrastructure principles, in the broadest sense, should begin with a regional- and community-scale evaluation of streams and their associated floodplains as well as adjacent wetlands and ponds. The community's master plans should emphasize that preserving these riparian areas as largely or completely undeveloped is the most sustainable way of managing and protecting water resources and should focus new development in other areas. Protecting or restoring streambanks and stream channels, floodplains, wetlands, as well as forests and other uplands, preserves the natural functions of the landscape in areas that are planned to remain largely undeveloped or lightly developed, thus helping to maintain a healthy watershed.

At a site-specific scale, green infrastructure generally means stormwater management practices that are designed to replicate the natural functions and processes that occur in undeveloped landscapes as water is absorbed by the soil and percolates down to groundwater. Green infrastructure, therefore, places a great emphasis on the value of infiltrating water into the ground, instead of sending it over the surface or in underground pipes directly to a stream. Green infrastructure also includes a major focus on using trees and other plants, as part of engineered ecological systems to manage water, utilizing the nutrient uptake, evapotranspiration, and soil filtration functions of vegetated systems to more closely mimic natural watersheds. Some of the key physical, chemical and biological processes that are involved in the function and performance of green infrastructure practices include:

- settling of silt and sediment in ponds and wetlands;
- filtration and removal of solids as water travels through soils or other media;
- adsorption of certain nutrients and other substances to the surface of soil particles (this is one important mechanism for phosphorus removal, and for some other nonpoint pollutants);

- uptake of phosphorus and nitrogen compounds by vegetation as they grow (these materials act as fertilizers);
- evapotranspiration mechanisms (described above); and
- a number of biological and chemical processes involving microbes in the soil and groundwater that break down certain nutrients and other substances.


Photo 4.2.2 Rain Garden

Site-scale GI practices include:

- **Bioretention areas (including rain gardens):** designed to collect and infiltrate much or all of the water flowing into them.
- **Vegetated swales and vegetated filter strips**: designed to convey water, allowing it to flow overland to lower areas while providing some water quality treatment and infiltration along the way.
- **Planting and maintaining trees**: including trees planted in tree pits designed to provide enough available soil volume for trees to be healthy, especially along urban streets and sidewalks where trees typically don't have enough room to grow without damaging sidewalks or other hard infrastructure.

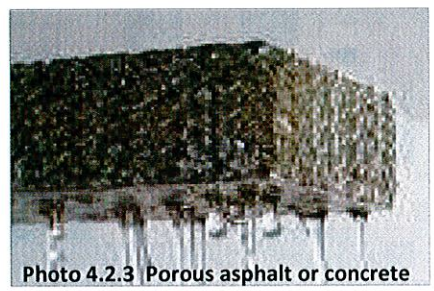


Photo 4.2.3 Porous asphalt or concrete

- **Pervious pavement, (including paving bricks, and porous asphalt and concrete:)** allows runoff to infiltrate into the ground.
- **Green roofs and green walls**: vegetated systems that are designed to be integrated with buildings or other structures and can provide substantial energy efficiency benefits in addition to managing stormwater runoff.
- **Rain barrels or cisterns**: capture water for storage and reuse

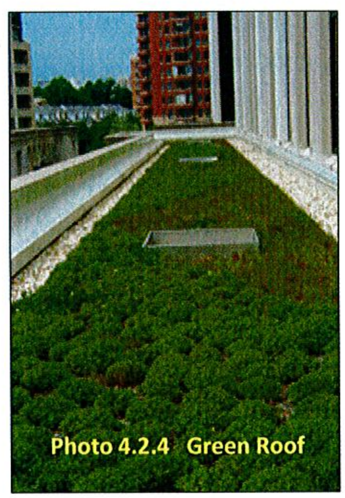
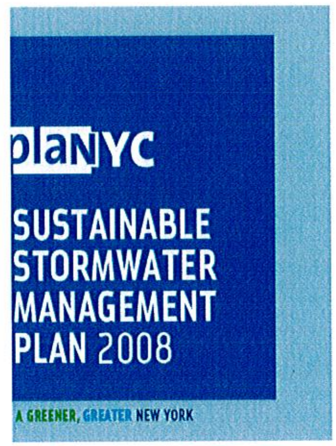


Photo 4.2.4 Green Roof

See Appendix L for more information about specific GI practices and related technical guidance.

Green infrastructure in the Hudson River Estuary Region: For several years, the NYS DEC Hudson River Estuary Program has provided education and technical assistance to encourage the use of low impact development (LID), which is in many ways the same as green infrastructure. Another term used for the same general set of ideas is Better Site Design. The Estuary Program has provided grants to support review of local codes to identify areas where existing codes make LID and GI challenging for developers and to recommend code revisions. The program has also supported implementation of a number of demonstration projects. More recently, the Hudson Valley Regional Council has partnered with Hudson River Sloop Clearwater and the Hudson River Watershed Alliance to initiate a regional green infrastructure planning program with Federal funding administered by the NYS DEC (see http://hudsonvalleyregionalcouncil.com/ for more information.) The Estuary Program has a number of GI demonstration projects in the Hudson Valley listed at this web page http://www.dec.ny.gov/lands/58930.html and more are being planned and implemented across the region.

Green Infrastructure Challenges and Opportunities: Green stormwater infrastructure practices of have great potential to restore water quality due to TMDLs exceedances to impaired waterbodies and to address infrastructure upgrades required to mitigate combined sewer overflows (CSO) or sanitary sewer overflows (SSOs) apply. These projects usually involve major capital expenditures, and the opportunity to invest a larger portion of funds in green infrastructure has proven both cost-effective and environmentally-sound in programs such as Philadelphia's Triple Bottom Line and PlaNYC's *Sustainable Stormwater Management Plan.* Although there are no CSO's in the lower, non-tidal Rondout watershed, there are in adjacent communities, notably Kingston in the tidal Rondout, where investments in GI can have significantly positive impacts on economic revitalization, public health and other benefits. A strong regional commitment to implementation of green infrastructure can also help reduce development pressure in the outlying watershed areas of the upper and lower the non-tidal Rondout. There are many economic and other implications that need to be considered, but GI practices are increasingly playing an integral role in Smart Growth planning.




**Measuring Success:** One challenge for municipal planners, engineers and regulators has been finding a way to accurately predict the efficacy of GI stormwater management practices, including the difficulty of measuring the ability of green stormwater infrastructure projects to efficiently divert, store and infiltrate adequate quantities of stormwater and to effectively remove key pollutants. The University of New Hampshire Stormwater Center has built an amazing field research site and has carefully measured results from five conventional systems (retention pond, stone rip-rap swale, vegetated swale, filter berm swale and deep sump catch basin), four manufactured treatment devices (MTDs) (ADS infiltration unit, Stormtech, Aquafilter and hydrodynamic separator), and seven Low Impact Development (LID) systems (surface sand filter, biorentention at 48" depth and at 30" depth, gravel wetland, porous asphalt, pervious concrete and tree filters). In addition to measuring quantity and hydraulic performance at peak and lag times, they measured the effectiveness at removing total suspended solids (TSS), petroleum hydrocarbons, dissolved inorganic nitrogen, zinc and total phosphorous. Porous asphalt and pervious concrete performed exceptionally well, with an average of 82% - 93% peak flow reduction and 1,200 minutes (20 hours) lag time.

**Photo 4.2.5** Aerial photo of University of New Hampshire Stormwater Center.

The average year-round volume reduction for pervious concrete was 95%. Subsurface gravel wetlands also performed exceptionally well. More information is available at http://ciceet.unh.edu/news/releases/unhsc_report_2009/report.pdf

Green Infrastructure for Wastewater Management:

While using green infrastructure for stormwater management has gained relatively broad acceptance among regulatory agencies and other stakeholders, the same cannot be said for wastewater systems. There is growing support and interest for using certain green infrastructure practices, such as constructed wetlands among regulators and design professionals. A broader, more comprehensive implementation of GI principles for wastewater planning and management, however, raises questions and challenges that remain daunting.

A green infrastructure approach for wastewater utilizes many of the same principles and strategies that underlie a GI strategy for stormwater:

- Manage water onsite or close to the source,
- Minimize the use of gray infrastructure to move water longer distances,
- Use the natural capacity of soils and vegetation to filter and treat water,
- Place a very high priority on dispersing water into soils instead of directly discharging it to a stream or river, and
- Ensure the water recharges groundwater to maintain pre-development hydrology and base flow to streams as much as possible.

If this framework is followed, the resulting treatment infrastructure can protect water quality, maintain groundwater recharge, and provide a relatively energy efficient, sustainable approach for managing wastewater. The existing approach for managing wastewater, by contrast, tends to favor larger, centralized sewer systems that convey wastewater to larger treatment plants serving entire communities, or even regional-scale systems serving a number of municipalities. Regulatory agencies are traditionally much more comfortable with this centralized approach, because it is simpler to maintain regulatory oversight and enforcement on a single discharge point for treated water, rather than monitoring dozens or even hundreds of smaller discharges distributed throughout the community. Yet this distributed (or decentralized) paradigm is basically inherent in a green infrastructure approach to stormwater, and to wastewater.

It is possible to use some elements of green infrastructure concepts and principles even in a larger, more centralized wastewater system. The treatment plant itself, for example, could use reed beds or constructed wetlands for treatment, and the dispersal of treated effluent can be done using land application, such as spray irrigation or drip irrigation systems, to discharge water to soil-based systems that include vegetation. Spray irrigation is widely used for treated wastewater at a number of locations in the US, including some in NY State. Yet many of the benefits of more complete implementation of a green infrastructure approach to wastewater management are not available using this centralized model. The capital costs and other impacts, including energy and chemical usage, of building and maintaining larger networks of sewers in a centralized collection system are high. The cost of the pipe network can be 60% or more of the total system cost. At a time when financial resources for maintaining or restoring infrastructure are very tight, these issues should warrant a serious re-consideration of assumptions that underlie the centralized wastewater management paradigm, which dates from the 19th century or earlier and has basically not been revised in over 100 years.

There are other major impacts of centralized wastewater systems, which tend to go unrecognized. Larger sewer systems, especially as they get older, tend to allow a lot of groundwater and surface runoff to enter the system during wet weather through cracks, joints, manholes, etc., a problem known as infiltration and inflow. Less well known is the tendency for these failures to allow raw sewage to leak out into groundwater. Installation of larger sewer lines also changes the watershed's hydrology in several ways, including moving wastewater longer distances, and also creating preferential flow paths for groundwater along sewer lines and other underground utility corridors that can lower the local water table and drain smaller wetlands and streams. Larger systems may also facilitate land use and development patterns that contradict local or regional planning goals, in part by encouraging sprawl.

In sum, the conventional approach to wastewater planning and infrastructure development that has been followed by most communities in our region for decades has many substantive problems and adverse impacts, which are not widely discussed. The strong and widespread support for a green infrastructure strategy for stormwater that has emerged in recent years provides a new opportunity for dialogue about the same basic set of ideas and goals as they apply to wastewater management.

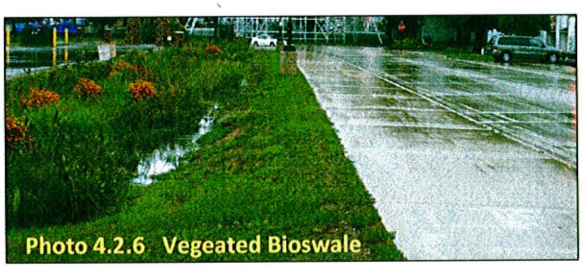


Photo 4.2.6 Vegeated Bioswale

Meeting the Challenge of State and Local Policies for Green Infrastructure

There are significant challenges to implementing green infrastructure for stormwater and for wastewater. While the new NYS DEC stormwater regulations and design guidance prioritize green infrastructure for new development, DEC has reservations about how effective green infrastructure for stormwater management may be in addressing long-term control plans to meet regulatory goals of combined sewer overflow (CSO) in many area cities. The central challenge seems to be establishing a framework that provides adequate assurance for effective maintenance and quality control for hundreds of smaller, local (decentralized) stormwater practices. The same challenge exists for wastewater planning for unsewered areas, and is also relevant for wastewater infrastructure upgrades in existing sewer systems. Unless state agencies and local government can collaborate to find solutions for this challenge, the full potential of green infrastructure as a more cost-effective, sustainable and beneficial approach for environmental restoration and economic revitalization will not be realized.

There have been some recent policy developments in NY State that are directly relevant to these issues. The NYS Environmental Facilities Corporation (the agency that administers funding for municipal water and sewer infrastructure), NYS Energy Research and Development Authority (NYSERDA), NYS DEC, and the NYS Department of Health co-authored an infrastructure planning and policy memo in 2008, Promoting Smart Growth and Energy Efficiency through the State Revolving Funds[2], and a related document, New York Clean Water State Revolving Fund

[2] http://www.dec.ny.gov/press/43508.html

Sustainability Initiative Advisory Group Recommendations, June 2010.[3] These policies go a long way towards incorporating many of the green infrastructure principles and goals described above, including the linkages to land use planning and avoiding sprawl, and energy efficiency benefits. While the value of decentralized approaches is noted in them, they do not include any focus on the benefits of returning water to local ecosystems for groundwater recharge, avoiding larger pipe networks and their attendant adverse impacts, or the importance of using soils and vegetation as energy efficient, sustainable components of the water treatment process. Further development of these state policies to recognize and include these hydrologic and water quality benefits of green infrastructure for wastewater management is a key next step that can be supported by watershed management programs such as those for the Rondout.

Even more recently, a new state law was enacted in NY, the Smart Growth Public Infrastructure Policy Act[4], which supports some of the same principles and goals. This law requires state agencies to develop policies to integrate land use, environmental, economic, and historic preservation, into funding decisions regarding infrastructure investments.

Integrated Water Management

Integrated water management is an emerging concept that recognizes that decision-making about water infrastructure and water resources planning has traditionally been done in a compartmentalized way. Drinking water supply, stormwater management, and wastewater management have almost always been done separately. As research and experience in the field increases, more sophisticated watershed planning and management perspectives have taken hold. It is becoming clear that a compartmentalized approach is not adequate to implement a sustainable, long-term planning framework for water resources. Managing these sectors separately has major limitations for achieving water resources goals, such as water quality protection and restoration, maintaining adequate quantities of water for human and ecosystem needs, and limiting flooding, erosion and other adverse impacts. In addition, there are significant linkages between water infrastructure and other issues, including energy use and efficiency potentials, energy production, economic development and revitalization, meeting other infrastructure needs (e.g., transportation, solid waste management, food production, etc.), habitat protection and restoration, and recreation. Work is currently taking place to identify opportunities for greater energy efficiency and cost savings and exploring the possibility of creating revenue streams by producing energy from wastewater or solid waste, recapturing nutrients from wastewater, or producing hydropower in municipal drinking water systems where water is flowing downhill and generators can be installed in the system. These ideas have important potential for leveraging available resources to invest in better watershed protection strategies. Another term being used to describe integrated water management is sustainable water infrastructure, and, where other infrastructure components, such as solid waste and energy production potentials are included, integrated resource management.

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[3] http://www.nysefc.org/dotnetnuke/AboutUs/SRFSustainabilityInitiative.aspx

[4] www.assembly.state.ny.us/leg/?default_fld=&bn=A08011%09%09&Summary=Y&Text=Y

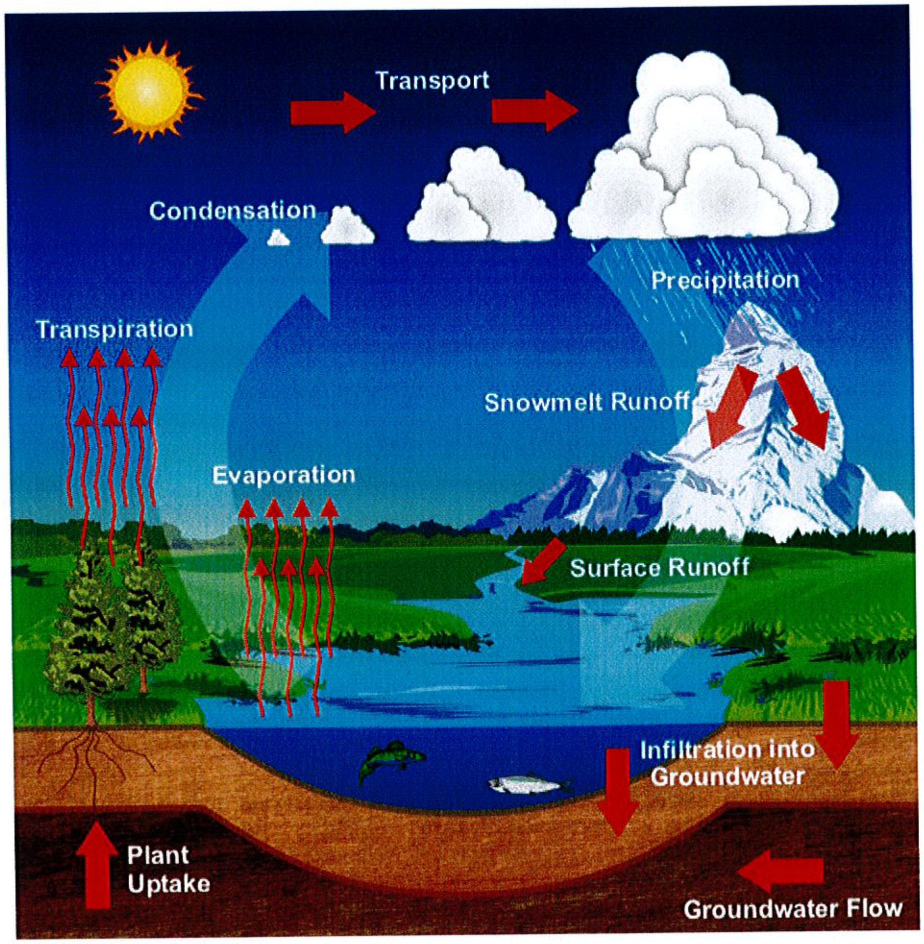


Figure 4.2.4 Green Infrastructure utilizes natural systems and/or incorporates engineered practices that mimic them. Working with the natural water cycle, a variety of GI storm and wastewater systems can be used beneficially to reduce run-off and pollution, as well as beautifying a neighborhood and mitigating climate change impacts.

## SECTION 5 – ECONOMIC DEVELOPMENT IN THE WATERSHED

Watershed conditions are continuously changing and the Rondout Creek watershed is defined by its diversity, complexity and changes to the landscape and land use.

Economy growth occurs on both a local government and community level. Growth and development that accounts for changes in local economy, population growth and environmental stresses can also provide economic opportunities, incentive and green jobs to the extent that adaptive economic innovations can be implemented to enhance watershed protection. The process of revisions and edits in the local zoning and planning codes and ordinances is one indicator of changes on local land use. This dynamic is important because watershed economy is highly dependent on the local government's decisions and priorities, and political considerations are key determinants to successful watershed management.

Economic initiatives, if designed to consider conservation and environmental pressures, can reduce the chances of having watershed protection potentially hampered by future economic development.

In rapidly growing watershed economies, key determinants to successful management are:

- Effective local government support and,
- Community-initiated change, involving a broad range of local stakeholders and with broader support from all the communities of the watershed.

It is important to recognize existing groups and professional organizations in the watershed that promote sustainable development and economic incentives that protects water resources within the boundaries of the Lower Non-tidal Rondout Creek watershed:

- Ulster County Chambers of Commerce
- Greater Wawarsing Local Development Corporation
- Ellenville - Wawarsing Chamber of Commerce
- Kerhonkson - Accord Chamber of Commerce
- Rosendale Chamber of Commerce
- Marbletown Business Owners Association
- Ulster County Farm Bureau[1] gives farmers and non-farmers alike the opportunity to be part of an organization dedicated to supporting and enriching the rural way of life. It provides an opportunity for individuals involved in agriculture to join together and make their voices heard.
- The Rondout Valley Growers Association is a non-profit community organization comprised of local farmers, residents, and businesses that are committed to strengthening the region's family farms and preserving open space for future generations.
- Ulster County Development Corporation (UCDC), a private not-for-profit organization, is the lead economic development agency for the County with a mission of creating and maintaining jobs through the attraction of new business or the retention and expansion of

[1] http://www.ucfbny.org/

existing business. In order to accomplish this objective, UCDC offers and administers financial programs and loan funds, assists with site selection, and provides overall guidance and assistance with general and specific business problems, issues and opportunities.

## 5.1 Ulster County Economy and Demographics[2]

As of the census of 2009, there were 181,440 people, 67,499 households, and 43,536 families residing in the county. The population density was 158 people per square mile (61/km²). There were 77,656 housing units at an average density of 69 per square mile (27/km²). The racial makeup of the county, as of 2008, was 83.2% White, 6.50% Black or African American,0.3% Native American, 1.7% Asian, 0.03% Pacific Islander, 2.15% from other races, and 1.70% from two or more races. 7.6% of the population were Hispanic or Latino of any race. 19.2% were of Italian, 16.8% Irish, 15.5% German, 6.8% English and 4.7% American ancestry according to Census 2000. 90.3% spoke English, 4.5% Spanish, 1.2% Italian and 1.0% German as their first language.

There were 67,499 households out of which 30.70% had children under the age of 18 living with them, 49.20% were married couples living together, 10.90% had a female householder with no husband present, and 35.50% were non-families. 27.90% of all households were made up of individuals and 10.20% had someone living alone who was 65 years of age or older. The average household size was 2.47 and the average family size was 3.03.

In the county the population was spread out with 23.50% under the age of 18, 8.70% from 18 to 24, 29.70% from 25 to 44, 24.70% from 45 to 64, and 13.30% who were 65 years of age or older. The median age was 38 years. For every 100 females there were 99.10 males. For every 100 females age 18 and over, there were 96.60 males.

The median income for a household in the county was $42,551, and the median income for a family was $51,708. Males had a median income of $36,808 versus $27,086 for females. The per capita income for the county was $20,846. About 7.20% of families and 11.40% of the population were below the poverty line, including 13.00% of those under age 18 and 8.70% of those age 65 or over.

*Town of Wawarsing*[3]*:* Current population of the Town of Wawarsing as of July 2009 was 13,535 and density trends show that since 2000 there has been a population increase of +5.0 %. The estimated median household income in 2008 was $46,244, a incremental increase from $35,872 in 2000. The per capita income[4] of Wawarsing is $22,484. The average cost of living index[5] in

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[2] http://en.wikipedia.org/wiki/Ulster_County,_New_York#Cities.2C_towns_and_villages

[3] http://www.city-data.com/city/Wawarsing-New-York.html

[4] Per capita income is the numerical quotient of national production by population, in monetary terms. It is a measure of the monetized production per person an economic aggregate such as a country, not of the actual distribution of income or current net wealth in that aggregate. This is what each individual *would* receive if the periodic income were divided equally among everyone. http://en.wikipedia.org/wiki/Per_capita_income

[5] This value doesn't directly represent what it cost to live in any given community but is used to make comparisons between two or more communities.

Wawarsing is 93.2; less than the US average of 100. The racial demographic is not as diverse as the other 3 communities of the Non-Tidal Rondout Creek Watershed (Table X) with only 1,277 residents are foreign born (4.9% Latin America, 3.8% Europe).

*Town of Rosendale*[6]*:* The current population of the Town of Rosendale was 6,220 as of July 2009 and density trends show that since 2000 there has been decease of 2.1%. The estimated median household income in 2008 was $57,085, which was an increase from $44,282 in 2000. During 2008 the estimated per capita income of Rosendale was $29,008. The cost of living index in Rosendale is 91.9; less than the U.S. average of 100 The racial demographic in Rosendale is not diverse with only 233 residents are foreign born (3.0% Europe).

*Town of Marbletown*[7]*:* The current population of Marbletown was 5,986 as of July 2009 and density trends show that since 2000 there has been an increase of 2.3%. The estimated median household income was $59,623 in 2008, which is an increase from $46,250 in 2000. The per capita income of Marbletown is $32,629.The cost of living index in Marbletown is 98.6; near the U.S. average of 100. The racial demographic in Marbletown is less diverse than Wawarsing and Rosendale with only 169 residents are foreign born (2.4% Europe).

*Town of Rochester*[8]*:* The population of Rochester was 7,018 as of 2000. The median household income in 1999 was $43,071. In 1999 the per capita income was $21,065. The racial makeup of the town was 93.42% White, 2.51% African American, 0.54% Native American, 0.51% Asian, 0.04% Pacific Islander, 0.83% from other races, and 2.15% from two or more races. Hispanic or Latino of any race were 4.83% of the population.

## 5.2 Local and County Economic Development Clusters

The Ulster County Planning Board (UCPB), comprehensive planning efforts have resulted in the creation and adoption of plans that address housing, economic development, agriculture, open space, transportation, etc. The plans contain policies, goals and objectives that the UCPB utilizes in the referral process and to further the development of the five targeted industry clusters.

### Ulster County Agriculture

The Municipalities of Wawarsing, Rochester, Marbletown and Rosendale are wholly contained in the Rondout Creek watershed. Rondout Creek watershed 's economy, landscape, and political environment exemplify tensions between rapid population growth, economic changes and environmental concern. Recent growth in agribusiness has spurred changes in land use and economic and social structures. Section 3.5: Agriculture and Forestry focuses on programs for buffer zone management and agriculture best management practices. The following subsections discuss the innovative programs that have been established in the watershed.

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[6] http://www.city-data.com/city/Rosendale-New-York.html

[7] http://www.city-data.com/city/Marbletown-New-York.html

[8] http://factfinder.census.gov/servlet/SAFFFacts?_event=ChangeGeoContext&geo_id=06000US3611163011&_geoContext=01000US|04000US36|16000US3663000&_street=&_county=Rochester++town+&_cityTown=Rochester++town+&_state=04000US36&_zip=&_lang=en&_sse=on&ActiveGeoDiv=geoSelect&_useEV=&pctxt=fph&pgsl=010&_submenuId=factsheet_1&ds_name=DEC_2000_SAFF&_ci_nbr=null&qr_name=null&reg=null%3Anull&_keyword=&_industry=

Total Agricultural Output Value* for Ulster County is on the rise. Orchard and vineyard crops, vegetables, and nurseries and greenhouses are responsible.

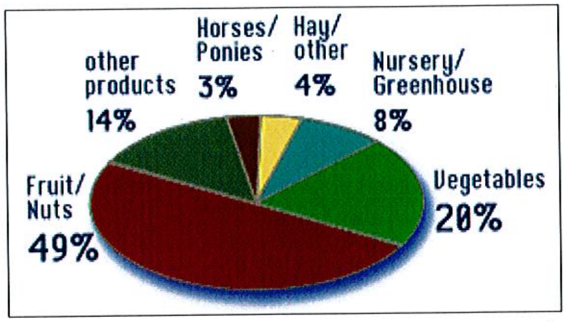


Figure 5.1.1 In 2000, these sectors represented 50% of Ulster's agriculture, rising to 85% 2010. $3 billion + annually / 64,000 jobs. *American Farmland Trust*[1]

*Abundant farmland*: Farming provides Ulster communities with access to fresh local food, add to our economic diversity, protect our heritage and offer their beautiful landscape for the enjoyment of residents and visitors alike. Orchards, vineyards, farm stands, cornfields and pastures of grazing livestock help define Ulster County's unique sense of place.

*Creative strategies* have helped farmers keep their businesses viable. Its proximity to New York City enables direct delivery to restaurants and gourmet and health food stores. New product innovations like hard fruit ciders and small batch liquors are current entrepreneurial ventures.

*Agrotourism:* Pick your own fruits and vegetables, farm stands, hayrides, corn mazes, harvest festivals, and wine trails are flourishing a regional family pastime.

*Community Supported Agriculture (CSA):* Driven by local and regional support CSA farms are proliferating, especially in the organic sector.

**Creative Arts**

The arts are a potent force in our economic life, and play a key role as a direct and indirect contributor to our economy.

A vibrant arts community is just as important to us as having sound roads. Ulster's not-for-profit and for-profit creative enterprises are in and of themselves thriving businesses. A study issued in 2007 by Americans for the Arts show that the not-for-profit arts sector in Ulster County generated nearly $4 million in economic activity.

**Photo 5.1.1** Ulster County Performing Arts Center

The arts are well integrated with other sectors of our business economy:

- Enabling businesses to thrive by providing a vibrant place for employees after work.
- Attracting tourists who spend significantly on facilities such as restaurants and hotels.
- Enhancing property values and maintaining vitality in downtown areas.

- Creative industries themselves are employers.
- Our local artists often work for clients all over the region, in NYC, and all over the world.

Ulster County's music, theater, dance and visual arts enjoy national reputations. We have the largest concentration of artists per capita in the state outside of New York City. And in 2007, Business Week listed Kingston as one of the Top Ten Best Cities for Artists.

**Green Industry**

Green technology is growing in Ulster County. Companies are producing products, services and processes that harness renewable materials and energy sources.

Ulster County is home to The Solar Energy Consortium[9] (TSEC), founded in 2007. The first organization of its kind for the photovoltaic industry, this not-for-profit is attracting companies to the region, and providing technical and business support for the development of solar energy. Prism Solar Technologies and Solar Thin Films are among the County's first major manufacturers to take advantage of TSEC's programs. Together, they expect to create hundreds of jobs over the next few years.

Joining in on building green profits and jobs in the region are the many architects, contractors and builders of the county who are turning to greener processes and technologies, and colleges and universities teaching a new generation the skills of clean technology. The State University of New York at New Paltz, SUNY Ulster and BOCES are among the educational institutions with innovative new programs.

- TSEC was awarded $8.176 million in grant money in 2009 - including $5 million from the Empire Development Corporation.
- Projected funding for 2009 includes $3.5 million Department of Defense
- For 2010, $4 million alone is estimated from the U.S.

**Innovative Technology**

Among New York state's investments:

- Since 1995, more than $1 billion has been committed to high tech research & development projects.
- $280 million to increase the availability of venture capital for emerging businesses
- $1.7 million in a program to help employers attract qualified technical workers

Ulster County sits in the center of New York's Tech Valley, which stretches from the Mohawk Valley in the north to Westchester County in the south. Over the last decade, we've grown in recognition as one of the nation's leading regions for technology and innovation. Large established players and entrepreneurial start-ups benefit from the resources provided for technology to thrive. The manufacturing sector uses the combined efforts of government, industry, academia and economic development leaders.

[9] http://thesolarec.org/

### Workforce

Given the Rondout Creek Watersheds natural beauty, cultural amenities and outdoor recreation, workers tend to remain in the region, providing employers with stability.

In the Ulster County region, approximately 102,000 people can be categorized as underemployed. Reported findings about this group of underemployed workers reveal:

- About 10% of these individuals would change jobs for under $10.16 per hour
- 33% would change jobs for less than $14.72 per hour
- 50% would change for $17.79 or less[10].

Work development programs and educational institutions help to provide educated, well-trained workers to match the key industries found in the region.

### Tourism

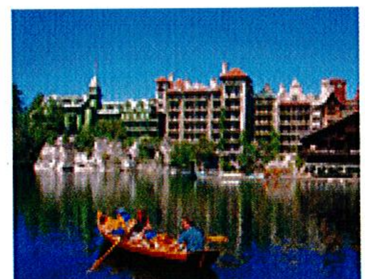

**Photo 5.1.2** Boaters at Mohawk Mountain Resort.

Culture, outdoor beauty and history are just a few of the reasons why tourism in Ulster County is a growth industry. From campgrounds to sky diving, and home-spun farm u-picks to nationally-recognized arts fairs, businesses that cater to tourists thrive because of Ulster's diverse range of experiences. There are a multitude of economic development based tourism activities in the Lower nontidal portion of the Rondout Creek Watershed.

## 5.3 Local Development Projects and Initiatives

- Village of Ellenville, Phase II ('07) New York Main Street (NYMS) Programs. RUPCO is working "at large" with the 20 towns, 3 villages, and 1 city, which make up Ulster County. We take an "asset based" community building approach to provide planning, and promote revitalization, sustainability and smart growth

## 5.4 Recommendations

1. Explore the potential for development of community-endorsed social contract to effectively implement buffer zone management techniques and programs. This can be based on a collaborative approach, which centers on formation of small local groups used to effectively disseminate agroforestry and conservation farming information and technologies. These groups can assist farmers in making effective management decisions and local government in setting priorities, as well as helping to focus research and education related the multiple functions of trees, environmental services, and policy innovations.

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[10] http://www.ucfbny.org/

2. Office of Employment and Training Summer Youth Employment Program in collaboration with SUNY Ulster has developed a program that engages businesses willing to employ youth for the summer. Local Environmental Conservation Commission or Councils can work with this youth population to further their goals and initiatives for watershed management. The youth wages are paid by American Recovery and Reinvestment Act (stimulus dollars). All that is required is that the business must provide a safe and constructive working environment and adequate supervision.

3. A strong workforce incentive program is the SUNY Workforce Development Grant, provides any company with two or more employees the opportunity to apply for a SUNY Workforce Development Grant. The grant requires a cash match of a minimum of 10% of the total amount of funds. The grant is written and administered by Ulster County Community College on behalf of the applicant company. The once-a-year application deadline is usually in June but is somewhat dependent on the state budget. In terms of watershed management this would require a sponsor business to apply hire employees to work toward implementation of watershed initiatives.

4. The Value-Added Producer Grants (VAPG) should be explored as a agro-forestry incentive. The grant can be used for planning activities and for working capital for marketing value-added (to increase the products price or value) agricultural products and for farm-based renewable energy. Eligible applicants are independent producers, farmer and rancher cooperatives, agricultural producer groups, and majority-controlled producer-based business ventures.

## SECTION 6 – EDUCATIONAL AND RECREATIONAL ASSETS

### 6.1 Educational

Educating the public is important when discussing management practices to improve watershed health because people's actions directly affect the quality and quantity of water in the lakes, streams and rivers. Everyone lives within a watershed and without the basic knowledge of what practices and policies affect the health of the watershed, an effective management plan cannot be implemented. The design of a watershed education program that creates awareness is of fundamental importance.

**6.1.2** DEC's Trees for Tribs program helps connect community members with watershed restoration efforts in Rosendale, NY.

Four types of watershed education programs are:

- Watershed awareness: raising basic watershed awareness using signs, storm drain stenciling, stream walks, maps
- Personal stewardship: educating residents about the individual role they play in the watershed and communicating specific messages about helpful and harmful behaviors and practices.
- Professional training: educating the development community on how to apply the tools of watershed protection
- Watershed engagement: providing opportunities for the public to actively engage in watershed protection and restoration.

Collaboration between towns and citizens information exchange, expanding the audience, and learning from current and past mistakes. The Rondout watershed currently is home to many not-for-profit, private, and government funded organizations that currently educate and promote watershed stewardship. Appendix M presents an annotated list of the organizations and groups currently active in the watershed including:

**Photo 6.1.3** Families learn how to measure the health of their creeks at the Stream Monitoring Day hosted by RCWC at Camp Epworth in High Falls, NY.

a. Local Conservation Advisory Councils or Committees

b. Ulster County Government Contacts and Organizations

c. City/State Agencies and Contacts

d. Local Education Centers and Organizations

e. Relevant Non-profit Organizations

f. Recreational Organizations and Contacts

g. Tourism Resources

h. Schools

The Rondout Creek Watershed Council is committed to protecting water resources, increasing community awareness through education and improving conservation efforts throughout the Rondout Creek Watershed.

**Recommendations:**

The following recommendations take into consideration the feasibility, finances and what's best for the protection of the Rondout Watershed and its culture. An example of a long-term goal is environmental education for children. If our children are taught about the problems that threaten our livelihoods, they will be informed and prepared to make changes now and in the future to protect and preserve the environment. Short-term goals are one's that can be implemented now with benefit the present and the future. For instance, the "Great Outdoors Initiative" that is currently in Washington, "will promote and support community-level efforts to conserve outdoor spaces. (http://www.doi.gov/americasgreatoutdoors/Press-Release.cfm)." This bill has the potential to create jobs, raise revenue for local businesses while protecting our planet. Local businesses and people are encouraged to participate in completing goals in order for the community to feel sense of ownership, entitlement and that they are directing their own future.

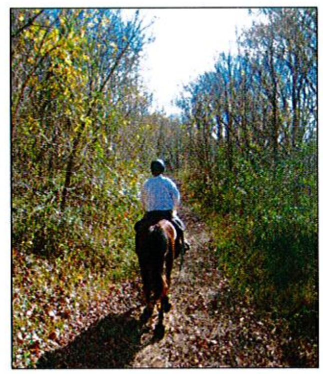

**Photo 6.2.1** Recreational horseback riding.

Once a management plan is developed, communities still need to invest in strategies for ongoing watershed stewardship. The goals of watershed stewardship are to increase public awareness about watershed management efforts and to increase participation in the process to ensure stewardship on their own property and within their communities. There are six basic principles that should be addressed to promote greater watershed stewardship:

1. Watershed advocacy
2. Watershed education
3. Pollution prevention
4. Watershed maintenance
5. Indicator monitoring
6. Watershed restoration

Create public access maps of the Rondout Creek that are easily read and straightforward. Hardcopies should be available in addition to making them available on the internet. The maps should also include recreational assets and watershed delineation. People with professional training in watershed management should create the maps in collaboration with Ulster County Tourism and each municipality. Communication between stakeholders (landowners, citizens), and policy makers (town boards, CAC's, non profits) should be improved to foster cooperation trough the use of town hall meetings. In order to promote awareness Service Learning Projects such as water monitoring, habitat restoration, and removal of invasive species, by volunteers with write ups of each projects given to schools and organizations so interested students can use these projects to complete community service requirements, Eagle Scout badges, or internships. In addition to the previously mentioned volunteer projects, monitoring and regulating development that threatens sensitive areas of the Rondout Watershed could be done by a volunteer group lead by members of the CAC's or the town board. Advertising and sponsoring Earth Day events and Clean up days are also great ways to raise awareness. Creating eye catching and attractive physical signs for access points will foster increased use of recreational assets within the watershed. To increase media exposure a marketing campaign with a logo that is used through the county that addresses the goals of RCWC and the management plan should be used. A tag line that could be used to identify the project is "It's about our quality of life-we need to appreciate, enjoy and take actions to protect our watershed home." In addition to advertisements a mailer package that contains an educational section, a local threat section and a children's coloring book is a possibility for raising awareness. The establishment of a basic set of watershed stewardship principles that include community engagement and education principles should be located on the website of RCWC and each municipality to keep everyone focused on the goals of the plan. An easement or land trust workshop should be created to educate land owners of the ways they can preserve the natural beauty of their land.

**Photo 6.2.2** Children playing at stream morphology table – Rosendale Earth Expo.2010.

## SECTION 7 – SUMMARY OF RECOMMENDATIONS FOR KEY WATERSHED ISSUES

### 7.1 Introduction

RCWC hosted two well attended community-based watershed planning workshops held in November of 2009 and February of 2010. As a result of these collaborative processes local community members and stakeholders reached consensus on four key concerns or watershed protection in the Lower non-tidal Rondout Creek Watershed. The identified management areas of concern are stormwater, floodplain, agriculture and forestry, and outreach and education.

In the following sections the recommendations from Sections 3, 4, 5 and 6 have been grouped according to those areas of concern. The details of the outlined recommendations can be found in its cross-referenced section.

### 7.2 Stormwater Management

- The NYSDEC provides storm water management guidance to municipalities through its "Municipal Separate Storm Sewer Systems" (MS4) program.
    - Public Education and Outreach;
    - Public Involvement/Participation;
    - Illicit Discharge Detection and Elimination;
    - Construction Site Runoff Control;
    - Post-Construction Runoff Control; and
    - Pollution Prevention/Good Housekeeping at municipal sites and operations. (See section 4 for detailed explanation of these 6 practices).

- Other municipalities in the watershed can follow the examples set by Marbletown and Rosendale to educate and involve the public in stormwater issues and implement practices that eliminate illicit discharges and reduce stormwater runoff and resulting non-point source pollution from construction sites, new developments, and municipal operations (see section 4 for examples of what Marbletown and Rosendale are currently doing to control stormwater).

- Conduct water quality assessments up and downstream of SPDES discharges. Assess water quality upstream and downstream of any significant stormwater discharges that are detected, or of stormwater runoff control measures that are implemented. This will help determine whether water quality impacts are coming from point sources or non-point sources of pollution.

- More research on WWTPs as a source of nutrients such as phosphorus. The ISD indicated nutrients as the most common source of impact in the watershed. WWTPs are usually required to remove organic and toxic materials from their effluent, but often not required to remove nutrients such as phosphorus.

- Conduct an assessment of coliform bacteria on the Rondout. Each community along the river could provide input on what areas are used for swimming, and a study could be designed accordingly, using NYS Department of Health standards for coliform bacteria at bathing beaches. This assessment would be especially useful in the High Falls area, where swimming is popular and no water quality assessment has ever been conducted.

- Further study is needed along Sandburg Creek and the Rondout in Wawarsing. A study that included assessments of the Lackawack, Honors Haven, Canal Street, Ellenville WWTP, Eastern Correctional, and Port Ben Road sites, plus an additional site on the Rondout upstream of Sandburg Creek but downstream of the Hamlet of Napanoch, would help determine the following:

    - The level of impact in the Sandburg Creek
    - Where the impact may be coming from (Honors Haven golf course, Village of Ellenville urban runoff, or Ellenville WWTP).
    - The level of impact in the Rondout Creek in Napanoch and East Wawarsing.
    - Where the impact may be coming from (Sandburg Creek, Napanoch area urban runoff, or the Napanoch WWTP).

- Preserve as much undeveloped land as possible during the site design process

- Manage stormwater runoff onsite and take a decentralized approach to wastewater treatment by using Green Infrastructure practices (see section 4.2 for more details)

**7.3 Floodplain Management**

- Climate change (see section 3.3 for more information about Climate Change)
    - Based on the ClimAID Sea Level Rise Projections, the municipalities of the lower non-tidal Rondout Creek watershed should revise land use and zoning ordinances to require a buffer between mean high water and any proposed structures.
    - Adopt NYS Sea Level Rise (SLR) projections as guideline measures from which to base strategies for addressing climate change and the affects of flooding on land use. Incorporate climate change and increased vulnerability to flooding into local emergency management planning.
    - All communities bordering the Rondout should adopt the Climate Smart Communities Pledge (Appendix I.)
    - Join and be an active member of the Hudson Valley Climate Change Network of the DEC Hudson River Estuary Program
    - Get involved in the 10% Challenge.
    - Pass a local law to insure that the predevelopment runoff must be equal to post development runoff for all proposed projects in your community.

- Require that all proposed development designs include tree plantings to prevent the expansion of impervious surfaces.
- Map vulnerable stream bank areas that need to be revegetated and collaborate with state partners to rehabilitate them over a set period of time.
- Pass a local law to increase the protection of wetlands in your community.
- Engage CACs in reviewing development proposals and providing guidance to the planning board on ways to reduce the impact of development on natural systems.
- Limit development in the 100-year floodplain and/or require developers to show how they will be addressing the projections of sea level rise in their proposal.
- Direct new development away from high risk areas and develop programs to fund elevation and/or relocation of structures or systems in high-risk areas.
- Work on seeking funding through joint projects or proposals with neighboring municipalities.
- Make use of mapping tools to identify at risk areas. Define areas of both greatest current and future vulnerability to flooding with the intent of reducing vulnerability in high-risk areas and transition to long-term cost-effective measures that emphasize natural flood protection systems.

- Biodiversity (see section 3.4 for more detailed information about the importance of biodiversity)
  - Consider habitat and biodiversity concerns early in the planning process.
  - Direct human uses toward the least sensitive areas, and minimize alteration of natural features, including vegetation, soils, bedrock, and waterways.
  - Protect large, contiguous, and unaltered tracts of habitats wherever possible.
  - Protect contiguous habitat areas in large, circular or broadly-shaped configurations within the larger landscape.
  - Preserve links between habitats on adjacent properties via broad connections, not narrow corridors.
  - Create, restore, and maintain broad buffer zones of natural vegetation along streams, along shores of other water bodies and wetlands, and at the perimeter of other sensitive habitats.
  - Maintain buffer zones between development and land intended for habitat.
  - Prioritize higher-quality habitats for protection, as degraded habitats decrease the biological value of the larger ecological landscape.
  - Preserve natural processes such as forest fires, floodplain flooding, and beaver flooding to maintain the diversity of habitats and species dependent on such processes.
  - Preserve farmland potential.
  - Protect habitats associated with resources of special economic, public health, or aesthetic importance to the community. These include aquifers or other sources of drinking water, active farms, and scenic views.
  - In general, encourage development of altered land instead of unaltered land.

- Concentrate development along existing roads; discourage construction of new roads in undeveloped areas.
- Promote clustered and pedestrian-centered development wherever possible, to maximize extent of unaltered land and minimize expanded vehicle use.
- Minimize extent of impervious surfaces (roofs, roads, parking lots, etc.), and maximize onsite groundwater infiltration. Minimize areas of disturbance.

## 7.4 Riparian Vegetation and Forestry

- Riparian buffers (see section 3.5 for detailed explanation the importance of riparian buffers)
  - Identify and prioritize potential riparian planting sites using a combination of mapping techniques and field surveys.
  - Develop a network of volunteers that can be trained to assist in assessing sites, planting trees along riparian buffers, eradicating invasive species, and monitoring for forest pests such as the Asian longhorned beetle. Establish a subcommittee that focuses on coordinating plantings for target areas, and eradicating invasive species.
  - Develop education programs focused on farmers as well as smaller landowners that raise awareness about best management practices in the riparian areas.
  - Coordinate a Visual Stream Assessment. (The Lower Hudson Coalition of Conservation Districts offers a Streamwalk program http://www.lhccd.org/streamwalk2004.html that a stream assessment can be modeled after.) This will assist in determining location of invasive species as well as potential planting sites in the riparian corridor
  - Use GIS technology to map land use in riparian areas

- Agriculture (see section 3.5 for more detailed information about forestry in the Watershed)
  - Agricultural Management Assistance (AMA) provides cost share assistance to agricultural producers to voluntarily address issues such as water management, water quality, and erosion control by incorporating conservation into their farming operations. Producers may construct or improve water management structures or irrigation structures; plant trees for windbreaks or to improve water quality; and mitigate risk through production diversification or resource conservation practices, including soil erosion control, integrated pest management, or transition to organic farming.
  - The Cooperative Conservation Partnership Initiative (CCPI) is a voluntary conservation initiative that enables the use of certain conservation programs along with resource of eligible partners to provide financial and technical assistance to owners and operators of agricultural and non-industrial private forest lands.
  - The Environmental Quality Incentives Program (EQIP) was approved in 1996 by amending the Food Security Act of 1985 (Farm Bill), reauthorized in the

Farm Security and Rural Investment Act of 2002 and again reauthorized in the Food, Conservation and Energy Act of 2008. EQIP provides a voluntary conservation program for farmers, ranchers and owners of private, non-industrial forest land that promotes agricultural production, forest management and environmental quality as compatible national goals. EQIP offers financial and technical help to assist eligible producers install or implement conservation practices on eligible agricultural land.

a. The five EQIP national priorities are:
    i. Reductions of nonpoint source pollution, such as nutrients, sediment, pesticides, or excess salinity in impaired watersheds consistent with Total Daily Maximum Loads (TMDLs), where available; the reduction of surface and groundwater contamination; and reduction of contamination from agricultural point sources, such as concentrated animal feeding operations (CAFOs);
    ii. Conservation of ground and surface water resources
    iii. Reduction of emissions, such as particulate matter, nitrogen oxides (NOX), volatile organic compounds, and ozone precursors and depleters that contribute to air quality impairment violations of National Ambient Air Quality Standards
    iv. Reduction in soil erosion and sedimentation from unacceptable levels on agricultural land and
    v. Promotion of at-risk species habitat conservation.

- The Wildlife Habitat Incentive Program (WHIP) is a voluntary program for conservation-minded landowners who want to develop and improve wildlife habitat on agricultural land, nonindustrial private forest land, and Indian land.
- The purpose of the Emergency Watershed Protection (EWP) program is to undertake emergency measures, including the purchase of flood plain easements, for runoff retardation and soil erosion prevention to safeguard lives and property from floods, drought, and the products of erosion on any watershed whenever fire, flood or any other natural occurrence is causing or has caused a sudden impairment of the watershed.
- FSA makes direct and guaranteed farm ownership (FO) and operating loans (OL) to family-size farmers and ranchers who cannot obtain commercial credit from a bank, Farm Credit System institution, or other lender. FSA loans can be used to purchase land, livestock, equipment, feed, seed, and supplies. Our loans can also be used to construct buildings or make farm improvements.

- Forestry (see section 3.5 for more detailed information about forestry in the Watershed)
  - Educate and promote the use of Best Management Practices ( BMPs). These are actions that have been determined to be the most effective and practicable means of preventing negative impacts of silvicultural activities, such as in reducing erosion and sedimentation of water bodies.
  - Municipalities should work toward adopting a current and relevant comprehensive plan. This municipal tool is intended to guide future growth and development as well as identify important natural & cultural resources that should be protected and sustainable managed.
  - Land use ordinances should promote sustainable forestry practices. The biggest single problem ordinance is the one that simply fails to identify forest management and harvesting as allowed uses.
  - Suburban towns are advised to adopt land-clearing standards to help them demonstrate compliance with the Phase II Stormwater requirements of the Clean Water Act.
  - The DEC and other professionals recommend that timber harvesting be preceded by a well-thought-out harvest plan that protects soil and water resources and fish and wildlife habitat.

## 7.5 Outreach and Education

- Create straightforward, easily read maps of the Rondout Creek: (hardcopies as well as via internet)
- Improve communication between stakeholders, policy makers and the general public
- Collaborate with other organizations and municipal groups to incorporate watershed education into pre-existing community events
- Development of a watershed awareness and protection marketing campaign
- Develop on-going educational and volunteer programs
- Service Learning Projects (ex. volunteer water monitoring): Write ups of each
- Identify current and potential access points to the creek to foster recreation

## SECTION 8- GUIDE TO IMPLEMENTATION

### 8.1 Role of RCWC in Implementation

The Rondout Creek Watershed Council is committed to continuing its partnership with the four municipalities of the Lower Non-Tidal portion of the watershed. Hands on collaboration with municipal CAC and ECC's is essential during the implementation phase of this plan in order to create reasonable timelines for all protection efforts. RCWC will continue their ongoing research to identify future funding sources as well as develop programs to cultivate volunteers and watershed internships.

### 8.2 Trends in Recommendations

Below is a summary of recommendations that were repeated in multiple sections of the management plan. While recommendations specific to different topics are important and should be considered, the authors feel that these recommendations have broad relevance for the entire watershed.

1. Continue to facilitate the functioning of the RCWC and form an intermunicipal council to oversee and coordinate the work that is already being done by the committee.

2. Promote ordinances designed to protect the natural resources of the watershed

3. MS4 communities should continue to work toward meeting all MS4 requirements. Where feasible, towns that are currently not MS4 communities (Wawarsing and Rochester) should adopt regulations under the MS4 program. Specifically, this means implementing Best Management Practices that satisfy the six minimum control measures: 1) Public education and outreach, 2) Public Participation and Involvement, 3) Illicit discharge detection and elimination, 4) Construction Site Runoff Control, 5) Post-Construction Runoff Control, 6) Pollution prevention. (Section 4)

4. Create a Rondout Creek Watershed Atlas using uniform maps that inventories the natural resources in the watershed, identifies areas at risk due to climate change and development, identify access points to the creek and other recreational opportunities, and delineates local watershed boundaries.

5. Use Zoning and Planning tools to manage for open spaces, biodiversity, forestry, agriculture, and the protection of riparian and other sensitive areas. Promote education and outreach specifically to town Planning boards and other municipal advisory groups and agencies.

6. Adopt Better Site Design principles to manage stormwater runoff and reduce impervious surfaces in the watershed.

7. Increase the focus on riparian zones and coordinate efforts to protect these areas throughout the watershed. This includes: mapping and identifying potential sites for restoration, creating zoning that will stop development in the floodplain, reducing impervious surfaces in these areas, increasing education about the importance of these areas.

8. Assure local food security and the rural character that graces much of the landscape in this portion of the watershed by promoting local agriculture and preserving farmland, as well as forestry and other open space, that serve to protect water quality.

9. Promote public education and outreach programs by collaborating with organizations that currently exist to raise awareness and garner support for watershed issues and best management practices. Issues to focus on include: invasive species, non-point source pollution, biodiversity, climate change

10. Intermunicipal collaborations should be explored to identify funding and cost-sharing opportunities that can further this Plan's objectives throughout all four municipalities .

**8.3 Promoting Watershed Economy**

1. Explore the potential for development of community-endorsed social contract to effectively implement buffer zone management techniques and programs. This can be based on a collaborative approach, which centers on formation of small local groups used to effectively disseminate agroforestry and conservation farming information and technologies. These groups can assist farmers in making effective management decisions and local government in setting priorities, as well as helping to focus research and education related the multiple functions of trees, environmental services, and policy innovations.
2. Office of Employment and Training Summer Youth Employment Program in collaboration with SUNY Ulster has developed a program that engages businesses willing to employ youth for the summer. Local Environmental Conservation Commission or Councils can work with this youth population to further their goals and initiatives for watershed management. The youth wages are paid by American Recovery and Reinvestment Act (stimulus dollars). All that is required is that the business must provide a safe and constructive working environment and adequate supervision.
3. A strong workforce incentive program is the SUNY Workforce Development Grant, provides any company with two or more employees the opportunity to apply for a SUNY Workforce Development Grant. The grant requires a cash match of a minimum of 10% of the total amount of funds. The grant is written and administered by Ulster County Community College on behalf of the applicant company. The once-a-year application deadline is usually in June but is somewhat dependent on the state budget. In terms of watershed management this would require a sponsor business to apply hire employees to work toward implementation of watershed initiatives.

4. The Value-Added Producer Grants (VAPG) should be explored as a agro-forestry incentive. The grant can be used for planning activities and for working capital for marketing value-added (to increase the products price or value) agricultural products and for farm-based renewable energy. Eligible applicants are independent producers, farmer and rancher cooperatives, agricultural producer groups, and majority-controlled producer-based business ventures.

## 8.4 - Comparison of Municipal Natural Resources and Land Use Objectives

The RCWC has reviewed existing management plans, guidelines and ordinances for each municipality. The findings of this review process is a set of recommendations grouped under two categories below: stormwater management and floodplain management. These summarized recommendations were not crafted by the RCWC and were cited from specialized management plans already in existence for each municipal member of the Lower Nontidal IMA. To better compare these findings matrix located at the end of this section was created. The matrix is broken down into the natural resource and land use objectives each town has committed to addressing. RCWC compiled these objectives to assist each municipality in easily identifying the areas in need of improvement, , the objectives that still need to be completed and the progress that has been made. Showcasing each municipality's goals and objectives will also allows for intermunicipal sharing of strategies that are currently in use or in the process of being developed.

### Stormwater Management

Marbletown and Rosendale both have ordinances to decrease stormwater runoff and pollution from land development. The reduction of stormwater runoff will reduce flooding, siltation, stream bank erosion and maintain the integrity of stream channels. Marbletown, Rochester, Rosendale, and Wawarsing all acknowledge that development should be concentrated and reduced where possible. Marbletown has its developments in areas that are sensitive to erosion include plans to prevent erosion which none of the other town's have. Rochester acknowledges the need to reduce density where aquifers are sensitive to development but lacks the complete and developed plans to do so. Aquifers need open space above them so they are able to receive water from above ground, and recharge. Building high-density developments on areas that do not contribute to groundwater filtration into aquifers should be encouraged and promoted by the town board and zoning commission. Wawarsing plans have suggested implementing cluster development and zoning in addition to concentrated nodes instead of strip malls. This should be done in conjecture with using smart growth development, which channels development into areas already served by existing infrastructure. In addition to using concentrated nodes, the nodes should only have one entrance and exit to reduce the amount of impervious surfaces within developed areas. Rosendale and Wawarsing have plans that suggest implementing pedestrian centered developments, while all towns suggest concentrating commuter and residential traffic on existing roads. To decrease the amount of roads needed while reducing traffic, locating commercial centers within hamlets will increase pedestrian traffic and reduce the amount of people driving. Rosendale however, includes in their plans to keep a balance of at least fifty percent of land as development and open space that will help reduce runoff and aid aquifer recharge. To decrease the amount of impervious surfaces within the town, Marbletown and Wawarsing should include this objective in their ordinances, like Rosendale and Rochester. However, Rosendale does have plans to increase onsite runoff retention and infiltration that should be implemented by all towns. Rosendale also realizes the full potential of using their zoning map with their Comprehensive Plan and Open Space plan to prevent development that will damage excising natural resources and impair watershed management.

**Floodplain Management**

Rosendale, Wawarsing, Marbletown and Rochester all need to plant riparian vegetation that provides a buffer zone of at least 100 feet around all waterbodies, including wetlands, within their town. Planting native flora and fauna will stabilize the stream banks, reduce runoff and erosion and act as a filtration and purification system for any runoff that reaches the waterbody. Marbletown, Rosendale and Rochester all acknowledge the need to control and prevent the alteration of natural floodplains; stream channels and natural protective barriers that reduce flood damage. Rochester proposes achieving this goal through the establishment of local Purchase of Development Rights programs, and Rosendale and Marbletown suggests land use planning to preserve significant and unaltered tracts of land that contain ecological communities and habitats, and open space. Marbletown also has a commission called the Preservation and Investment Commission that will advocate for conservation based development, and educate the public on land protection strategies. Wawarsing, Rosendale and Rochester should consider implementing a board or council to oversee the protection of open space and natural resources. Rosendale included within their plans the goal of restoring degraded habitats wherever possible. Each town should consider including this in their management strategy to improve the environmental quality of the whole town, not just the areas around the waterbodies.

**RCIWMP Recommendations**

Marbletown, Rochester, Rosendale and Wawarsing need to create a town water budget that will estimate the volume of water that the water table is producing and, has the capacity to produce compared to existing and projected rates of consumption. This will provide the town with an accurate portrayal of the amount of water available to their current residents and the supply available to the future residents. The water budget can help town's determine how changes in impervious surfaces will affect the amount of water available for residents. . The water budget can also provide assistance is the placement of wells because it will identify areas where there are supply problems. The water budget is not limited to municipalities with sewer systems because it focuses on the town's water table, which is how saturated the ground is by water, not how residents use water (Appendix O. Rosendale's Town Plan). Each town's Environmental Conservation Commission can oversee the budget and provide yearly reports back to each town's board. Rochester, Rosendale and Wawarsing need to create an open space plan. Rochester and Wawarsing need to create a biodiversity assessment and maps of the wetlands and floodplains located within the town. Wawarsing also needs to create density maps, land use surveys and maps, a study of the geology and soils found in the town, and a creation of an aquifer map. Wawarsing cannot further their development goals in as sustainable and environmentally friendly manner until they become aware of the unique features of their town. A part of Marbletown's natural resource objectives was to create a forest plan, which any town with significant amounts of forested land should also do. This will provide town planners and developers with another source of information about the natural resources found in their town. Marbletown, Wawarsing, Rosendale and Rochester should revise their zoning regulations to prevent the spread of impervious surfaces into floodplains and groundwater and aquifer recharge areas. The amendments to the zoning regulations should also include the reduction in use of impervious surfaces when alternatives are unavailable or inappropriate. Also each town's reduction of density where aquifers are located and the use of concentrated nodes instead of strip malls will greatly improve the health of the Rondout Creek Watershed. Rosendale, Rochester, and Wawarsing need to create a management strategy for the protection of wetlands once all of their studies and mapping are completed. One of Rosendale's natural resource objectives is to reduce the amount of pesticides and herbicides that enter the waterbodies located in their town. To accomplish this goal it is recommended that Rosendale and any town with the resources available, offers incentives to any farmers who practice organic agriculture and stop using fertilizers, herbicides and pesticides that degrade the health and quality of the watershed. Marbletown and Rosendale currently follow the MS4 requirements developed by the EPA, and the RCIWMP strongly recommends that Wawarsing and Rochester adopt the MS4 requirements so that the Rondout Creek Watershed is protected as much as possible.

## Municipal Resource and Land Use Existing Objectives and RCIWMP Recommendations

| Municipality | Natural Resource Objectives | Land Use Objectives | RCIWMP Recommendations | Criteria for Evaluating Success |
|---|---|---|---|---|
| **T/Marbletown** | ❖ Stabilization of banks through the use of riparian vegetation.<br>❖ Control the alteration of natural floodplains, stream channels, and natural protective barriers, which can minimize flood damage.<br>❖ Ensure the protection of native flora and fauna to preserve ecological functioning.<br>➢ Use of native plants in landscaping<br>➢ Suitable species selection and species diversity should also be used<br>❖ Discover ways to reduce wetland fragmentation and preserve buffer zones.<br>❖ Create program to purchase development rights to sensitive lands.<br>❖ Preservation and Investment Commission will advocate for conservation based development, educate the public and landowners on land protection strategies.<br>➢ Provide landowners with conservation funding opportunities<br>❖ Develop a town forest plan. | ❖ Decrease stormwater runoff and pollution from land development to reduce flooding, siltation, stream bank erosion, and maintain the integrity of stream channels<br>❖ Promote high-density development in development areas.<br>❖ Development plans in areas sensitive to erosion must include plans to prevent erosion<br>➢ Prohibit development in high-risk areas.<br>❖ Require land development activities to follow the requirements of the New York State Department of Environmental Conservation SPDES General Permit for Construction Activities.<br>❖ Prevention of stormwater runoff from developed areas by maintaining predevelopment conditions.<br>❖ Continued commuter and residential traffic concentrated on existing high traffic roads. | ❖ Continue meeting MS4 requirements<br>❖ Create a Town Water Budget<br>➢ Estimates the volume of water that the water table can produce compared to existing and projected rates of consumption.<br>➢ Designate oversight of budget to the Environmental Conservation Commission.<br>❖ Reduce density where aquifers are sensitive to development.<br>❖ Revise zoning regulations to minimize the use of impervious surfaces.<br>➢ Alternatives to pavement should be adopted if appropriate.<br>❖ Use concentrated nodes as alternatives to strip malls.<br>➢ Access to the road from a single site.<br>❖ Develop timber-harvesting regulations.<br>❖ Construct buffer zones of 100ft.<br>❖ Develop a town forest plan | ❖ Quarterly reports tracked through municipal CAC<br>❖ Quarterly reports by the Planning and Zoning Committee.<br>❖ Citizens are kept up to date on progress. |

| Municipal Resource and Land Use Existing Objectives and RCIWMP Recommendations | | | | |
|---|---|---|---|---|
| **Municipality** | **Natural Resource Objectives** | **Land Use Objectives** | **RCIWMP Recommendations** | **Criteria for Evaluating Success** |
| **T/Rochester** | ❖ Produce a set of maps of the wetlands and floodplains found in the town.<br>❖ Establishment of local Purchase of Development Rights programs and/or Transfer of Development Rights programs to preserve farmland and open spaces.<br>❖ Create standards to protect surface water quality and stream bank protection.<br>❖ Control the alteration of natural floodplains, stream channels, and natural protective barriers, which can minimize flood damage. | ❖ Reduce density where aquifers are sensitive to development.<br>❖ Build houses and business at the edges of fields.<br>❖ Use concentrated nodes as alternatives to strip malls.<br>➢ Access to the road from a single site.<br>❖ Revise zoning regulations to minimize the use of impervious surfaces.<br>❖ Continued concentration of high intensity traffic on high intensity roads. | ❖ Adopt MS4 requirements and practices<br>➢ Create stormwater management ordnance(s).<br>❖ Create a Town Water Budget<br>➢ Estimates the volume of water that the water table can produce compared to existing and projected rates of consumption.<br>➢ Designate oversight of budget to the Environmental Conservation Commission.<br>❖ Promote high-density development in development areas.<br>❖ Revise logging regulations to ensure residents cannot cut down trees that serve important ecological roles (e.g. riparian vegetation)<br>❖ Ensure the protection of native flora and fauna to preserve ecological functioning.<br>➢ Create riparian zones of 100 ft<br>➢ Use of native plants in landscaping<br>➢ Suitable species selection and species diversity should also be used<br>❖ Generate an open space plan and a biodiversity assessment.<br>➢ Produce a set of maps of the wetlands and floodplains found in the town. | ❖ Quarterly reports tracked through municipal CAC<br>❖ Quarterly reports by the Planning and Zoning Committee<br>❖ Citizens are kept up to date on progress. |

**Municipal Resource and Land Use Existing Objectives and RCIWMP Recommendations**

| Municipality | Natural Resource Objectives | Land Use Objectives | RCIWMP Recommendations | Criteria for Evaluating Success |
|---|---|---|---|---|
| **T/Rosendale** | ❖ Implement the creation and maintenance of riparian vegetation.<br>❖ Careful planning of development to minimize biological stress on streams<br>❖ Preserve significant tracts of ecological communities and habitats.<br>➢ Land use planning to maintain large uninterrupted and unaltered habitat areas<br>▪ Safeguard links between habitats on adjacent properties<br>❖ Restore degraded habitats wherever possible<br>❖ Prevention of herbicides and pesticides from entering any reservoirs or waterways. | ❖ Decrease stormwater runoff and pollution from land development to reduce flooding, siltation, stream bank erosion, and maintain the integrity of stream channels<br>❖ Facilitate pedestrian centered developments<br>➢ Connect districts by sidewalks and bike trails.<br>❖ Concentrate development along existing roads.<br>➢ Defer construction of new roads in undeveloped areas<br>➢ Keep balance of land, at least 50 percent, whenever feasible as open space<br>❖ Minimize areas of impervious surfaces<br>➢ Increase onsite runoff retention and infiltration.<br>❖ Utilize zoning map to provide insight into how development can affect existing natural resources and watershed management.<br>➢ Use to update the Comprehensive Plan and Open Space Planning.<br>❖ Apply non-regulatory tools to protect open spaces.<br>❖ Voluntary conservation easements, direct acquisition of land by government or conservancies. | ❖ Continue Meeting MS4 requirements.<br>❖ Create Town Water Budget<br>➢ Estimates the volume of water that the water table can produce compared to existing and projected rates of consumption.<br>➢ Designate oversight of budget to the Environmental Conservation Commission<br>❖ Reduce density where groundwater is sensitive to development.<br>❖ Create a management strategy for the protection of wetlands<br>➢ Buffer zones around wetlands and streams of 100 feet.<br>❖ Amend zoning regulations to prevent the spread of impervious surfaces into floodplains and groundwater recharge areas.<br>➢ Revise zoning regulations to minimize the use of impervious surfaces.<br>➢ Alternatives to pavement should be adopted if appropriate.<br>❖ Promoting the use of organic agriculture practices to limit the use of pesticides and herbicides.<br>❖ Create an Open Space Plan | ❖ Quarterly reports tracked through municipal CAC<br>❖ Quarterly reports by the Planning and Zoning Committee.<br>❖ Citizens are kept up to date on progress. |

| Municipal Resource and Land Use Existing Objectives and RCIWMP Recommendations | | | | |
|---|---|---|---|---|
| **Municipality** | **Natural Resource Objectives** | **Land Use Objectives** | **RCIWMP Recommendations** | **Criteria for Evaluating Success** |
| **T/Wawarsing** | ❖ Preserve agricultural and wooded areas.<br>❖ Protect natural waterways<br>❖ Create and maintain riparian buffers. | ❖ Promote cluster development and zoning.<br>❖ Incorporate pedestrian access within hamlets.<br>❖ Implement conservation subdivision process.<br>➢ Include information to protect waterways, scenic areas and natural resources.<br>❖ Encourage smart growth which channels development into areas already served by existing infrastructure.<br>➢ Include pedestrian access, and bike trails.<br>▪ Expand bike paths so residents can use bikes for recreation and transportation.<br>❖ Replace strip malls with concentrated nodes with one entrance.<br>❖ Require shared driveways, and internal circulation roads to direct and reduce traffic to specific areas.<br>❖ Locate existing commercial centers within hamlets to reduce traffic and increase pedestrian traffic.<br>❖ Develop integrated network of local roads instead of multiple cul-de-sacs | ❖ Adopt MS4 requirements and practices<br>➢ Create stormwater management ordnance(s).<br>❖ Create a Town Water Budget<br>➢ Estimates the volume of water that the water table can produce compared to existing and projected rates of consumption.<br>➢ Designate oversight of budget to the Environmental Conservation Commission.<br>❖ Amend zoning regulations to prevent the spread of impervious surfaces into floodplains and groundwater recharge areas.<br>➢ Minimize use of impervious surfaces when appropriate.<br>❖ Develop management plans.<br>➢ Open Space, Biodiversity Index<br>❖ Include information into the zoning map to create a more comprehensive tool for planning<br>❖ Creation of density maps, land use surveys and maps<br>❖ Commission study of geology and soils present in the town<br>❖ Authorize creation of aquifer map<br>➢ Reduce density where groundwater is sensitive to development. | ❖ Quarterly reports tracked trough municipal CAC<br>❖ Quarterly reports by the Planning and Zoning Committee.<br>❖ Citizens are kept up to date on progress. |

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