Wallkill River Watershed
Conservation and Management Plan

Project Staff:

Orange County Soil and Water Conservation District
Ulster County Soil and Water Conservation District
Orange County Planning Department
Orange County Water Authority
Ulster County Planning Department

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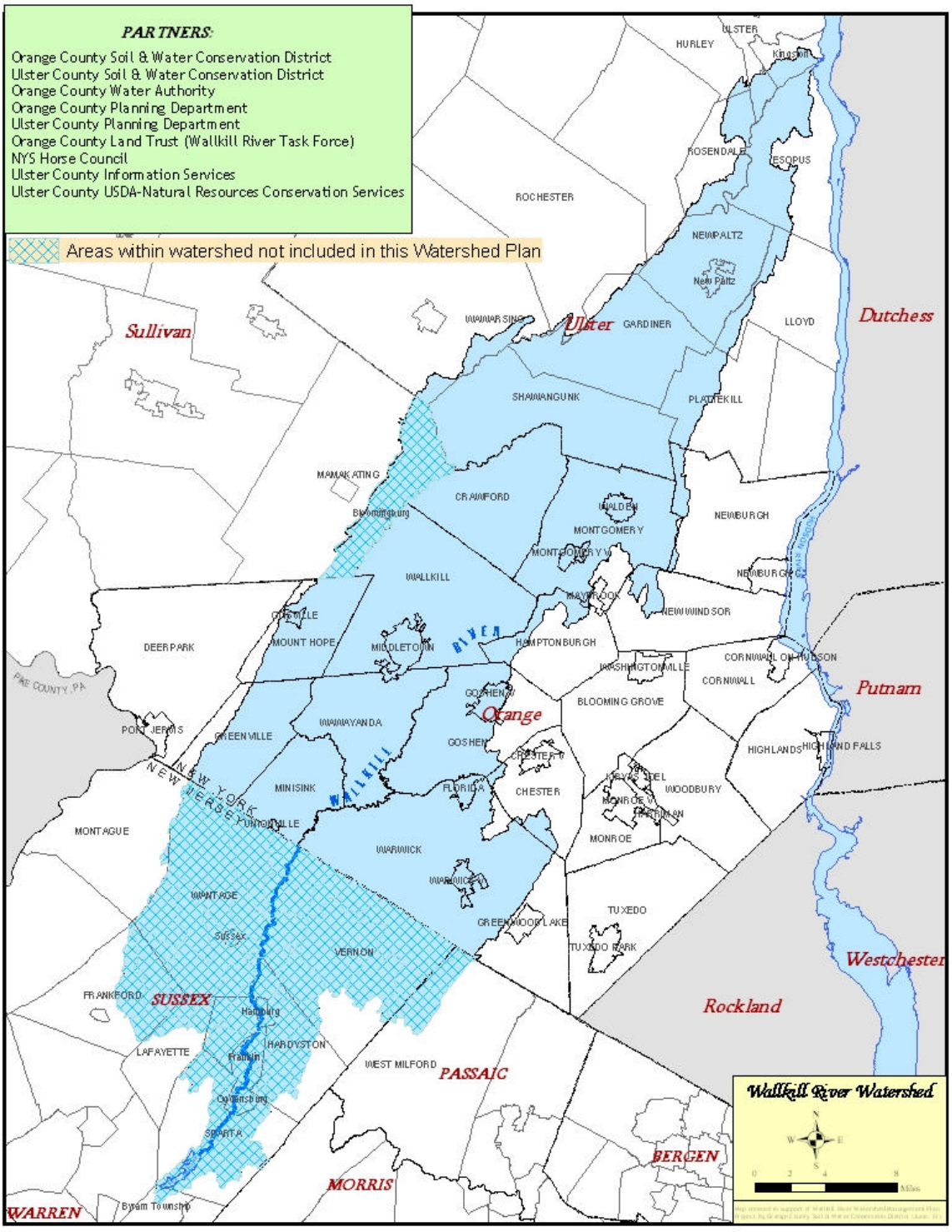

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ACKNOWLEDGMENTS

A crucial development in the history of Wallkill Watershed protection efforts was the scheduling of a Wallkill River conference in 1998. Held at Orange County Community College and organized by the Orange County Land Trust (OCLT), this conference could be considered the birth of the Wallkill River Task Force (WRTF) – a 'project' of the OCLT. While some focus on this Watershed was already occurring amongst government agencies, the WRTF created a non-governmental group that actively sought the volunteer participation of farmers, business people and other 'ordinary' citizens, in addition to government and conservation agency employees, to provide for broad-based leadership in protecting the Wallkill River and its watershed lands.

The first coordinator of the WRTF was Ann Botshon, and it would be difficult to overstate her contribution to Wallkill (and Orange County-wide) natural resource protection. Her impassioned efforts gave inspiration to many people, myself included.

Former OCLT Executive Director John Gebhards fostered the formation of the WRTF, and has actively participated in the Watershed Management Plan process. Former WRTF Coordinators Jill Knapp and Patricia Henighan have also provided invaluable support. Former Orange County Water Authority (OCWA) Executive Director, Jay Beaumont, provided generous technical support to the Project from his staff, notably Dan Munoz, and was a member of the Project Steering Committee (PSC). Jamie Lo, a former employee of OCWA and intern at Orange County Soil and Water Conservation District, provided crucial mapping assistance as well as contagious enthusiasm to the Project. Kelly Dobbins, a planner with the Orange County Planning Department, made huge contributions to many sections of the Plan, served on the Biodiversity and GIS/Mapping committees, and prepared many of the maps. Simon Gruber, an environmental consultant, provided key writing and research assistance. My colleague Kris Breitenfeld endured a seemingly endless barrage of additions and changes in the final editing process. Scott Cuppett and the NYSDEC Hudson River Estuary Program provided grant funding and 'hands-off' Project oversight that allowed us to make the Plan our own. Gary Capella and all his partners on the Ulster side helped us transcend municipal boundaries and more nearly approach a true *watershed* plan.

I would like to personally thank all these people, and let them know how much I valued working with them on this project. Finally, I would like to thank all the watershed residents, too numerous to list, who took time out of their schedules to attend Project Steering Committee meetings and review and comment on the working Plan, as well as those who quietly toil on projects - some of which are mentioned in the Plan, but all of which help to provide inspiration to the rest of us to continue working to protect and improve the Wallkill River and its Valley.

Kevin Sumner
Orange County Soil and Water Conservation District

Table of Contents

**NOTE: These two appendices are quite lengthy so are only available in digital format or by special request in hard copy format.

I. INTRODUCTION

Background

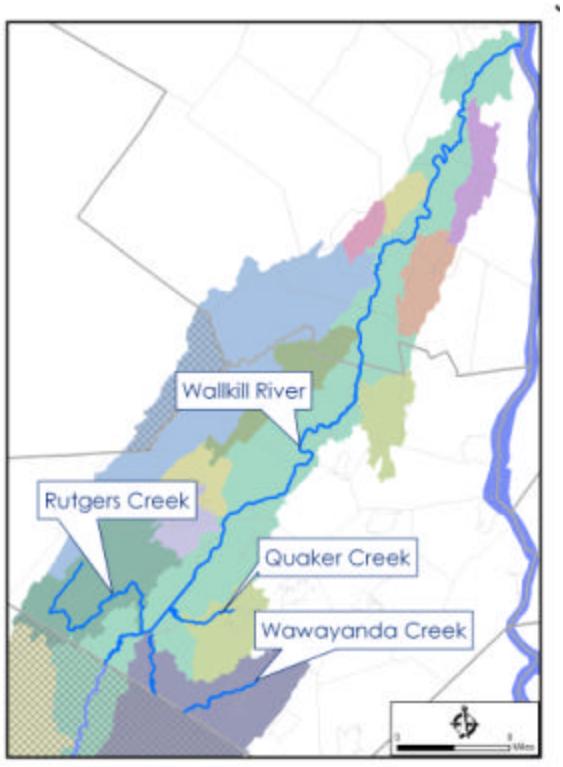
Conservation activities have been underway in the Wallkill Watershed for decades, as they have been in watersheds across the country. For example, farmers have been implementing runoff control practices, and developers have been required by most local planning boards to address stormwater management.

In recent years, though, financial and technical resources available to conservation agencies have increasingly been targeted to watersheds with documented water quality problems or with well-formulated plans that identify and prioritize management needs. Anticipating this trend, and recognizing the value of having a proactive long term plan, the Orange County Soil and Water Conservation District (SWCD) and USDA Soil Conservation Service (SCS) developed a water management plan for the Wallkill River Watershed in the late 1980's. Although not as sophisticated as current-day watershed management plans supported by computer-generated maps and other new technologies, this early planning effort began a twenty-five year period in Orange County of elevated attention on this watershed. Similar attention was being given to the Wallkill in neighboring municipalities as well.

The SWCD/SCS plan received no formal funding, but was a precursor to and impetus for the *Wallkill-Rondout USDA Water Quality Demonstration Program (1990-1998)* – a multi-agency and multi-county effort that directed in excess of $1 million in federal funding, primarily to agricultural water management. While generally deemed a great success – both in terms of enhancing interagency/inter-county coordination and accelerating the adoption of farm management practices (notably Integrated Pest Management in the Black Dirt Region) – project partners were frustrated with their limited ability to address other water quality issues including urban and suburban runoff. During this same time frame, a forward-thinking USDA employee named Malcolm Henning convinced the Wallkill Valley Drainage Improvement Association – a group of Black Dirt Region farmers charged with overseeing Wallkill River drainage matters – that nominating the Wallkill and several of its tributaries for inclusion on New York State's newly forming Priority Waterbodies List (PWL) (Map 1) was a good idea. Over the succeeding twenty years, many proposals involving the Wallkill have received more favorable review at least partially because of the emphasis placed on the PWL by current funding sources. More funding is available for agricultural **and** non-agricultural conservation work in both Orange and Ulster Counties.

Wallkill Watershed Waterbodies Listed on NYSDEC's Priority Waterbodies List:

- Upper Wallkill River Main Stem
- Quaker Creek
- Wawayanda Creek
- Rutgers Creek
- Lower Wallkill River Main Stem



Map 1: Priority Waterbodies

Purpose of the Plan

While water quality managers felt that problem sources were fairly well understood and significant resources were already being targeted to nonpoint source control programs, it was recognized that preparation of a comprehensive management plan for the Wallkill Watershed held the potential to direct existing resources more efficiently and increase the likelihood of securing additional resources. Various documents, including Water Quality Strategies prepared by County Water Quality Coordinating Committees (WQCC) and Nonpoint Source Assessments prepared by the Lower Hudson Coalition of Conservation Districts (LHCCD) had already begun the process of identifying and prioritizing management needs on a watershed basis. In September of 2001, Orange and Ulster SWCD's and the Orange County Land Trust, in cooperation with numerous other agencies, submitted a proposal to the New York State Department of Environmental Conservation's Hudson River Estuary Program (HREP) to prepare a Conservation and Management Plan for the Wallkill River Watershed. The proposal was approved, and work on the Management Plan formally began in spring of 2004.

Goals of the Plan

Specific goals of this Plan include:

- consolidating existing information on the watershed's resources, and establishing a foundation for future research and educational efforts;
- identifying gaps in information that are pertinent to future planning efforts, and developing a research strategy for obtaining needed data;
- assessing trends that will impact both water quality and quantity;
- presenting maps, tables and related informational formats that summarize key aspects of the watershed and management needs;
- **providing guidance to communities and other stakeholders on management practices that are environmentally, socially and economically sustainable; and providing assistance to them in the adoption of these practices; and**
- **providing a ready list of projects and actions that can be implemented to protect and improve the watershed.**

The last two items are in bold to reinforce the emphasis the authors wish to place on practical implementation measures. We are hopeful and confident that the data, maps and related information presented in the Plan will be useful for many purposes. More importantly, though, **we want the Plan to lead directly to action.** Many of the recommended actions, such as construction projects, will have direct expenses and will require dedicated funding to implement. Some ideas for sources of funding are presented. For other recommended actions, such as policy or program changes, costs may be more related to the personnel needed to promote and carry out the changes. These costs are sometimes less well recognized by potential funders, but are equally important to achieving goals.

Overall Planning Approach

Watershed stakeholders met in September 2004 at the first formal public meeting of this planning initiative. Approximately 40 individuals representing various organizations, municipalities and agencies in Orange and Ulster Counties and New Jersey attended and participated in a process to identify the important issues facing the watershed. The top issues identified as concerns by participants follow (not in priority order):

1. **Buffers**—suggested to protect water quality in streams and wetlands.

Grass strip buffers Rutgers Creek tributary from cropland.

2. **Biodiversity/Habitat** –identified as major concerns for both terrestrial and aquatic ecosystems in the watershed.

3. **Regulations - Implementation, Enforcement & Funding** – enforcing existing regulations and providing funding for implementation of practices was especially of concern.

4. **Recreation Opportunities** – increasing access to the river received widespread support.

5. **Wastewater Issues**– cited in various forms, including the need to revamp old infrastructure, the impacts of failing septic systems, the concern about managing development, and capacity of existing treatment facilities.

6. **Pesticides and other Pollutants** – received considerable attention and are tied closely with both the agricultural and the (sub)urban use of the land in the watershed.

7. **Agriculture** –listed regarding both concerns for maintaining the industry, as well as its impacts on water quality.

8. **Development/Sprawl** –associated with stormwater runoff, the need to implement local land use planning, the loss of habitat, and concerns about maintaining safe and adequate water supplies.

9. **Wetlands** –cited as an issue in terms of both loss and degradation.

10. **Groundwater** – ensuring sufficient recharge and concerns about contamination.

11. **Public awareness & local planning**.

12. **Non Point Source (NPS) Issues** –was mentioned separately and included in many of the other issues - particularly stormwater runoff.

It is the intention and the hope of the Plan writers that all of these issues have been addressed to the extent practical.

Guidance in the development of watershed plans has been presented by, among others, the Center for Watershed Protection (CWP) **(cwp.org)** and the US Environmental Protection Agency (EPA) **(epa.gov)**. Documents such as CWP's 'Rapid Watershed Assessment Planning Manual' and EPA's 'Community-based Watershed Management' were consulted by the preparers of this Plan. In addition, representatives from several of the project partners attended a two-day workshop on watershed planning in July of 2005 presented by staff from the CWP.

It goes without saying that the level of detail and scope of any watershed plan will be strongly influenced by the level of human and financial resources devoted to its preparation. The primary source of support for this Plan was a $40,000 grant from the NYSDEC Hudson River Estuary Program. An enormous amount of value was added to the project by contributions from many agencies and individuals who did not charge their time or expenses to the $40,000 grant. Nevertheless, we are dealing with a watershed nearly 800 square miles in size extending into four counties and two states. Even excluding the NJ portion, which received limited attention in this Plan, some 600 square miles remain. An example to put this issue in perspective is provided by guidance from CWP which suggests that $150,000 to $200,000 be budgeted for planning watersheds less than 50 square miles. Obviously then, given the size of the Wallkill and the available funding, a somewhat different approach was necessary.

As recommended by the Center for Watershed Protection, the Wallkill Watershed was divided into smaller watersheds, or subwatersheds (also called subbasins). The creation of smaller units of analysis enabled the project partners to assess different parts of the Watershed individually, and then make comparisons among the subwatersheds. (Map 2)

This approach yielded a total of 14 study areas for the Orange and Ulster portions of the Wallkill. For planning purposes, the direct drainage to the Wallkill (not via a major tributary) was treated as two sub-watershed areas, one each for Ulster and Orange. The name and size of these study areas is summarized in Table 1.

Although it is not defined entirely by drainage divides, the Black Dirt Region of Orange County will receive some attention as a separate study area given its unique, and in many ways homogeneous, characteristics.

One important factor in determining the approach to a given watershed plan is the percentage of impervious surfaces in the study area. Extensive research has been devoted to this topic. This research demonstrates that when 10% of a sub-watershed's land area has been converted to impervious surfaces, significant impacts will be discernable in the receiving stream. (Figure 1) When impervious cover exceeds 25%, stream impacts become more severe and difficult to mitigate. These numbers can provide guidance to planners. When imperviousness is in the 'threatened' 5 to 10% range, management efforts to avoid further stream impacts would be an important goal. Typically, such planning efforts would be done at a 'sub-watershed' level equating to approximately 10 square miles. When watershed imperviousness is lower (below 5-10 %), water quality degradation is likely caused by factors other than impervious land cover. Therefore, management efforts should take a different approach.

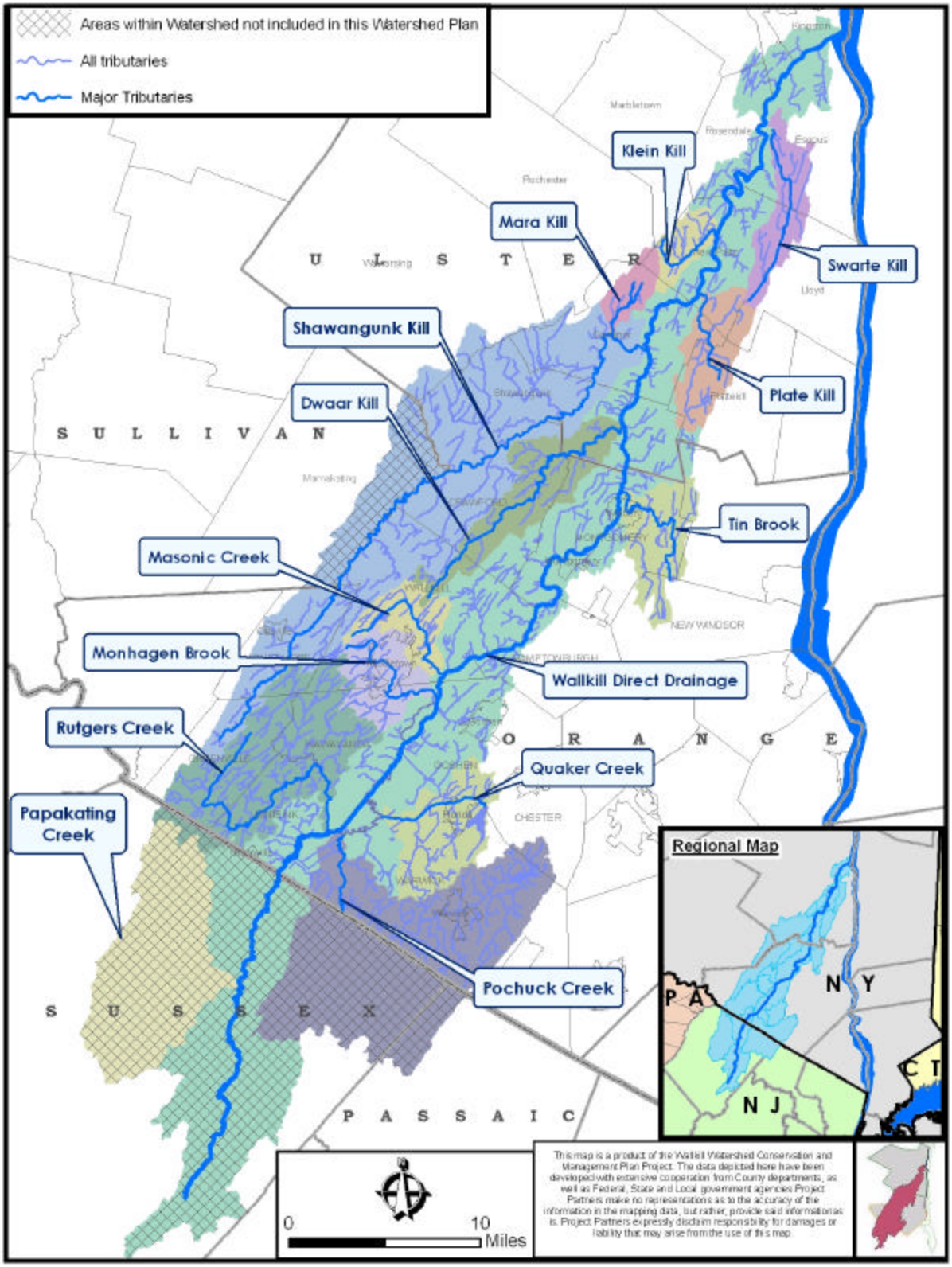
With this guidance in mind, the Plan Partners decided to make impervious surface mapping a priority project early in the planning process. To the extent possible, the Plan uses impervious area concerns as a primary factor in sections dealing with sub-watersheds.

Figure 1: As imperviousness approaches 10%, streams are likely to be degraded.

	area (acres)	% of Entire Wallkill Watershed (NY & NJ)	acres farmland (USDA)*	% Farmland (USDA)*	acres agricultural land (PCC)*	% agricultural land (PCC)*	% impervious cover	Land Cover within Subwatershed (%)			Land Cover within Stream Corridor (%)			Public access points to water
								Natural	Ag	Urban/ Suburb	Natural	Field/Ag	Urban/Suburban	
Dwaar Kill	17,916	3.5%	3,509	19.6%	3,312	18.5%		63	25	12	76	13	10	1
Masonic Creek	8,179	1.6%	389	4.8%	820	10.0%	10.3	50	19	31	57	18	23	0
Monhagen Brook	10,997	2.1%	1,385	12.6%	1,054	9.6%	12.3	54	16	33	48	14	34	1
Pochuck Creek	67,789	13.2%	5,772	8.5%	7,418	10.9%	4.7	68	21	11	33	58	9	1
Quaker Creek	16,338	3.2%	4,296	26.3%	5,933	36.3%	4.5	58	31	11	16	69	15	1
Rutgers Creek	38,184	7.4%	7,004	18.3%	8,264	21.6%	4.4				58	30	11	0
Shawangunk Kill	90,503	17.6%	4,528	5.0%	6,415	7.1%	4.2	77	13	11	67	21	12	1
Tin Brook	12,265	2.4%	1,759	14.3%	2,079	17.0%	4.9	69	15	16	56	17	27	1
Mara Kill	4,488	0.9%	330								59	9	26	2
Klein Kill	5,168	1.0%	310					90	6	4	77	16	7	1
Swarte Kill	10,381	2.0%	1,103					91	4	5	91	1	8	2
Platte Kill	11,996	2.3%	5,839					72	17	11	62	22	14	0
Direct Drainage (Orange)	180,326	35.1%	20,452	27.38%	27,536	36.86%		56	31	16	48	34	14	11
Direct Drainage (Ulster)											63	19	18	4

* For the purposes of this Plan, agricultural land use was examined using two distinct data sources. The Property Class Code data is assigned by local assessors. A given parcel is assigned only one PCC, even though large parcels normally contain multiple land uses. In some cases, a parcel that contains agricultural land may not receive an agricultural PCC. The USDA figures are based on actual farm field acreages within land tracts that normally encompass larger acreages. This data is derived from reporting that farmers make to local USDA offices. It is believed that most commercial farmers report their acreage into this system.

Table 1 – Subwatershed Characteristics



Map 2: Wallkill River Subwatersheds

II. EXISTING CONDITIONS

River and Watershed Characteristics

A tributary of the Hudson River, the Wallkill River flows through two states, from its source in Lake Mohawk in Sparta Township, New Jersey. Flowing 27 miles in New Jersey, the watershed drains 208 square miles in 13 municipalities. Approximately 96% of the NJ portion of watershed is in Sussex County, the remaining 4% in Passaic County. In Orange County, New York, the river drains 382 square miles, nearly half of the county, as it flows for 40 miles before reaching Ulster County. Twenty-two towns, villages and cities in Orange County drain wholly or partially to the Wallkill. In Ulster County, the river flows 26 miles draining 170 square miles before merging with Rondout Creek near Kingston, then flowing on to the Hudson River. The total watershed is about 785 square miles in size. In New York State, the Wallkill River is fed by 69 tributaries. In Orange County, there are 16 named tributaries. In Ulster County, there are 14 named tributaries. The water quality of the tributaries is variable (see sub-watershed sections of the Plan for more information).

Land use within the watershed is extremely diverse, ranging from agriculture and forestland to extensive commercial and residential development. Refer to Map 4 for land use breakdowns for the whole watershed and for major sub-watersheds. As can be seen from the comparison of 1993 and 2004 land use data, the trend in this watershed is towards decreasing agricultural land and increasing urban/suburban land use. This trend undoubtedly comes as no surprise to watershed residents, though presentation of these data provides greater validity and a degree of measure to this common understanding.

History of the Wallkill River

The Wallkill River main channel as it passes through the Orange County Black Dirt Region has undergone considerable modification over the last 200 years. Figure 2 shows the 'original' path of the Wallkill, before agricultural drainage improvement projects, and the current path. In addition to being rerouted, some sections of the channel have been enlarged and excavated below their natural bed. Major tributaries to the Wallkill in this Region have undergone similar modification.

An extremely interesting chapter of history occurred in this area in the 1800's, which is sometimes described as the Muskrat and Beaver War. (Appendix A**)** Landowners with agricultural interests (the muskrats) battled figuratively and literally with mill and related business owners (the beavers) over whether the Wallkill would be dug

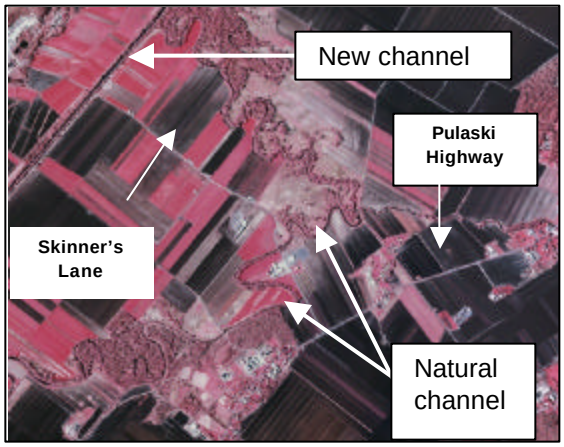
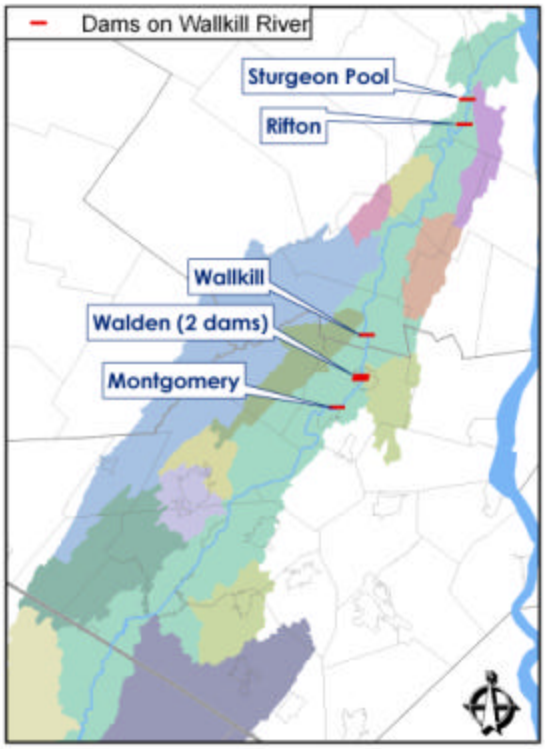


Figure 2: Natural and new channels of the Wallkill River

and maintained as an agricultural drainage channel or dammed for water power. Ultimately, the farmers won this war and additional drainage projects continued through the 1900's resulting in the agricultural landscape and drainage network we see today.

On the main stem of the Wallkill, there are dams at Montgomery, Walden, Wallkill, Rifton and Sturgeon Pool (Map 3). Dams clearly have major environmental impacts on river systems; at the same time they have served valuable historical functions such as hydroelectric power and mill operation. Most of the dams on the Wallkill continue to function in these capacities. This Plan inventories the Wallkill dams, but does not further evaluate their functions or future other than brief general mention of their environmental impacts. (Appendix F)



Map 3: Dams on the Wallkill River

Land Resources

1. Land Use Analysis

Land use/land cover may be analyzed in many different ways, dependant largely on available time, financial and data resources. The analysis done for this Plan was based on Property Class Code (PCC) information as assigned by local assessors. There are a number of issues with these data that must be kept in mind when interpreting these results. One is that, even though the PCC list is State-generated and each assessor has the same list, there is some variability in the approach individual assessors use in assigning these codes. An additional issue is that PCC's are assigned based on tax parcels. Therefore, any given parcel, regardless of size, receives only one PCC even though multiple land uses often occur on these parcels. With these limitations in mind, though, the PCC database offers a source of land use data that can be fairly easily used to generate land use maps for the Watershed. An additional advantage of this approach for the purposes of this Project is that PCC databases exist for the early 1990's (Orange County only), which can be readily contrasted with more recent data sets. Though somewhat generalized, the land use maps generated from these data use the same categories- therefore provide a fairly reliable evaluation of trends over the period covered by the two data sets. (Map 4)

A couple of modifications were made to the data in order to better meet the intent of the analysis. First, the 'residential' PCC was divided into 'large lot residential' and all other 'residential' using a threshold of 10 acres. Although there is a 'large lot residential' category available in the PCC system, this category appeared to be largely unused (at least by the OC data we reviewed). The thinking here was that residential parcels over ten acres were probably more accurately described as open space. This decision was independent of – and not based on – town zoning requirements. Instead, it assumes that the improvements for a typical residence would normally be concentrated on one or two acres, with the balance of the 'residential' parcel more likely to resemble the land cover associated with the undeveloped category. GIS technicians created a new 'field' in the PCC database, and used GIS tools to place the residential parcels greater than 10 acres in the new 'large lot residential' category. This adjustment proved to have a large influence on the results, given the large percentage of parcels that receive the residential PCC.

A cursory review of the 'community service (CS)' category was also undertaken. Normal procedure was to treat community service-coded parcels as 'developed'. However, where aerial photo review or other anecdotal knowledge of CS parcels indicated extensive open lands, a re-assignment into a new 'open community service' category was applied. Changes to the results from this adjustment were small compared to the residential code adjustment. Assignment of the various PCC categories to the headings of either 'developed' or 'undeveloped' also involved some judgment.

A summary of the results from this analysis are presented in Table 2 and in Map 4. In each of the nine Orange County subwatershed areas, 'developed' land increased (by from 4 to 9%). As expected, the land use category that showed the largest increase was residential. Roads increased significantly as well.

A small number of anomalies did emerge. For example, in several of the basins agricultural acreage increased considerably. Undoubtedly,

this was a result of revised PCC assignment on otherwise unchanged parcels, not actual increases in agricultural land use.

Watershed	1993 developed	1993 undeveloped	2004 developed	2004 undeveloped
Dwarr Kill	17%	83%	26%	74%
Rutgers Creek	21%	79%	28%	72%
Wallkill Direct Drainage	23%	77%	29%	71%
Tin Brook	26%	74%	30%	70%
Quaker Creek	23%	77%	30%	70%
Pochuck Creek	27%	73%	33%	67%
Shawangunk Kill	25%	75%	33%	67%
Masonic Creek	39%	61%	46%	54%
Monhagen Brook	45%	55%	51%	49%

Table 2: Comparison of developed & undeveloped land by subwatersheds.

In a few cases, categories such as industrial lands decreased in a particular basin from 1993 to 2004. Resources did not permit technicians to fully explore all these apparent anomalies. Overall, though, the results are reasonable and, we feel, can be considered useful within the set of cautions mentioned above.

2. Protected Lands

There are substantial protected areas within the Wallkill Watershed (Map 5). Notable blocks of protected lands include Highland Lakes State Park in the Towns of Wallkill and Crawford; the US Fish & Wildlife Shawangunk Grasslands National Wildlife Refuge (560 Ac); Mohonk Conservancy - home to more than 30 species of rare plants or animals (3500 Ac-roughly ½ total acreage); the Sam's Point Preserve - 1600 of 5400 acres in the watershed; Minnewaska State Park (roughly 1/3 of this 4000 acre park is in the Watershed); a portion of Stewart State Forest; four county parks; two county-owned water supply sites; and municipal water supply lands owned by the City of Middletown in the Town of Wallkill and the Village of New Paltz in the Town of New Paltz.

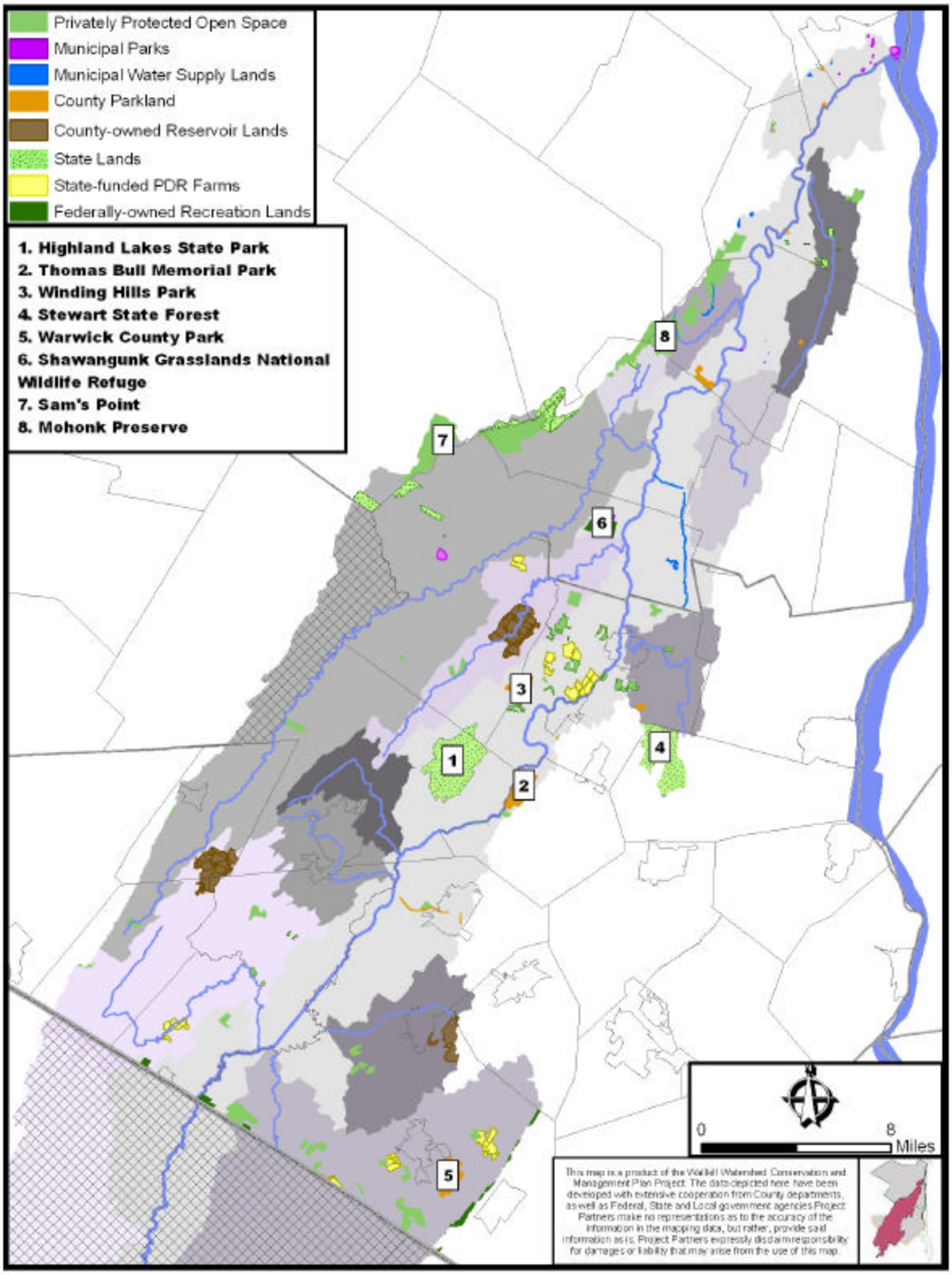
Protected lands on the Wallkill River itself are, in large part, clustered in the Town of Montgomery. The Town has taken initiative to protect the banks of the Wallkill through conservation easements within clustered subdivisions and partnered with other organizations to protect farmland on the River. There are also three municipal parks on the River in Montgomery: two smaller parks (Twin Island Fishing Spot and Riverfront Park) and the larger Benedict Farm Park. The Village of New Paltz has established a ¼ mile riparian greenway along the Wallkill River, which features a riparian buffer, community gardens and the Historic Huguenot settlement.

The County of Orange, as well, owns 1.6 miles of Wallkill River frontage at Thomas Bull Memorial Park, Town of Hamptonburgh. Although access to the River within the Park is currently limited, a riverfront trail may be developed at this Park in the future. South of Thomas Bull Memorial Park, also in Hamptonburgh, the Orange County Land Trust owns a public nature preserve called Hamptonburgh Preserve and also holds a conservation easement (closed to general public) on a linear riverfront segment near Stony Ford Road. Ulster County maintains a ¼ mile stretch of the Wallkill River with public access for boating (car top) and fishing at the Fairgrounds on Libertyville Rd. There are other public access sites in Ulster County, identified on Map 12, for fishing and boating maintained by NYS DEC or assorted municipalities.

To date, the US Fish and Wildlife Service holds the most extensive amount of land along the Wallkill River, within the 5,100-acre Wallkill River National Wildlife Refuge. The majority of this land is in New Jersey, beginning as far south as Route 23, but extends north into the Town of Warwick, New York, where over 150 acres of black dirt are being engineered to revert back to their natural, frequently-flooded habitat.

The Wallkill River's major tributaries have few, but important, public access points. Protected lands along the major tributaries that are open to the public include Orange County Land Trust's Moonbeams Preserve on the Shawangunk Kill (Town of Wallkill), the Village of Walden's Wooster Grove Park on the Tin Brook, the Mohonk Preserve which protects the headwaters of the Kleine Kill and the Van Veederkill Park on the VanVeederkill in the Town of Shawangunk.

Conservation easements and municipal ownership



Map 5: Protected Lands

for water supply protect other lands containing major tributaries, but are not open to the public.

Open Space Values of Agricultural Lands

Although usually not formally protected, agricultural lands afford benefits to the community similar to those provided by public lands as described above. Therefore, a brief discussion follows on the open space values of agricultural lands.

Several portions of this Plan discuss the potential water quality impacts from agriculture. Poorly managed agricultural land clearly can negatively impact water and related natural resources. Well-managed agricultural land, though, is widely believed to be preferable to other land uses such as urban/suburban land use – both in terms of water quality and enhancement of other natural resources such as wildlife. One example that supports this contention is that of the New York City Watershed management program. Nationally recognized as a successful model for protecting drinking water supplies via land management (avoiding the more costly option of filtration plant construction), this program recognizes agriculture as a **preferred land use**. As regards wildlife, vast expanses of monoculture, it can be argued, do not provide the variety of habitats required by most wildlife species. In the Hudson Valley and the Wallkill Watershed, habitat loss from vast expanses of agriculture is hardly a concern. Instead, agricultural lands are being lost at an alarming rate – usually being replaced by residential and commercial development with much lower habitat value. Where farmlands can be maintained, they most often **enhance** wildlife habitat by providing food sources and cover types that would otherwise be in short supply in the local landscape. Farm water quality protection efforts in the Watershed are described in some detail in this Plan, and local farmer participation in these programs is quite high. Plan writers, therefore, are confidant in endorsing vigorous farmland preservation efforts as a major recommendation of this Plan.

Such efforts are well underway in the Watershed. Over **3,000 acres** of farmland in the Orange County portion of the Wallkill Watershed have been **protected via conservation easements** purchased with various combinations of State, federal and local funding. Momentum is gaining in Ulster County, also, where 400 acres are in the process of closing conservation easements.

It should be noted in this context that interest amongst landowners in these easement programs far out-paces available funding. This Plan, therefore, recommends active lobbying to study and secure additional sources and mechanisms of funding for farmland easement programs. Additionally, it must be recognized that deed-restricted farmland will be of limited value in preserving commercial agriculture if farming cannot remain profitable. Though largely outside the scope of this Plan, we also endorse vigorous support for farm profitability enhancement projects through such avenues as the Orange and Ulster County Agricultural and Farmland Protection Boards (AFPB's).

For both profitability support and easement purchase, we believe that Watershed residents will generally be supportive. The citizen survey conducted through this planning process, described elsewhere in the Plan, ranked "loss of family farms" and "expansion of housing developments into rural areas" as major concerns. Although this was an informal survey, it lends credence to the suggestion that the public will support such efforts. Further evidence is provided by recent public referendums in at least three Watershed Towns (Warwick, Goshen and New Paltz) that established locally generated funds to purchase farmland easements.

Preservation of a viable farmland base, in combination with other non-farm protected open space, should be considered a crucial and necessary element of a healthy Wallkill Watershed.

3. Impervious Surfaces Analysis

The importance of impervious cover to watershed planning is described earlier in this Plan. There are many potential approaches to such mapping – ranging from direct measurement from aerial photography to more generalized estimations derived by applying various coefficients to land use data such as Property Class Codes assigned by local taxing authorities. After extensive study and consideration, Orange County Water Authority and Plan partners decided to use a methodology for impervious cover calculation that is based on extent of roads in the given sub-watershed.

Through literature review, consultation with other experienced GIS users such as Rockland County government, and in-house testing, it was determined that a reliable relationship existed between linear feet of roads in any given spatial region (calculable by GIS tools) and percent impervious cover.[1] Using this relationship, OCWA technicians calculated % imperviousness for over 200 sub-watersheds and for major sub-basins. (Map 6)

Results

Map 6 presents the results of the impervious surface analysis for the Wallkill basin. Table 1 summarizes these findings by major sub-basins within the Wallkill. The 'Overall Planning Approach' section of this Plan describes the rationale for measuring imperviousness as part of the watershed planning process. In summary, it notes that watershed planning as it relates to imperviousness should be done at a sub-watershed level equating to approximately 10 square miles, and that impacts to receiving streams tend to become apparent when imperviousness reaches 10%. It also notes that when imperviousness is lower (below 5%), water quality degradation is likely caused by factors other than imperviousness. Watershed areas exceeding 10% imperviousness are depicted in red on Map 6. Areas in the 5 to 10% range are shown in yellow, areas below 5% are green.

An interesting sidebar to this issue is the relationship between impervious cover, feet of roads, and stream salinity (see, for example, Kaushal, et al in the September 20, 2005 PNAS). Work in Orange County by Kelly Nolan, Hudson Basin River Watch, described below in this Plan, also found a relationship between conductivity and macroinvertebrate community health.

While available resources limited the degree to which this impervious cover information could guide sub-watershed level planning, future efforts will benefit from its calculation as part of this planning effort.

[1] Beaumont, J. and O'Brien, D. 2005 Impervious Cover, Road Density, Land Use, and Population Density in Urban and Rural Areas in Orange County and Rockland County, New York. Orange County Water Authority.

4. Stream Corridor Study

Multiple studies have documented the relationship between streamside vegetation and stream health. In general, wider swaths of forest next to a stream are associated with higher water quality due to the capacity of natural vegetation to slow and filter water that flows on the ground surface. Streamside trees also help to shade the waterbody, thus lowering the water temperature, and create a more diverse stream habitat through the contribution of woody debris such as limbs and branches. Vegetated banks are also structurally more stable and thus less susceptible to erosion.

Because both stream corridor infringement and water quality problems have been well documented within the Watershed, this watershed planning effort included an inventory of land cover within 534 feet[2] of all 14 major tributaries within the Watershed and the Wallkill River itself. The data was created by visually interpreting 2004 aerial photography and defining the land as one of four major categories: Developed, Natural, Water, or Agriculture/Field. A summary of the resulting land cover information is included in Table 1.

The results of the study render useful comparisons between the major tributaries. For example, the Monhagen Brook, which flows through the City of Middletown, was found to have the highest proportion of developed land within the designated stream corridor, followed by the Tin Brook and the Mara Kill. This information suggests that these waterbodies should be priorities for streamside mitigation and restoration efforts. Conversely, the Swarte Kill has the highest percentage of natural land within its corridor, with the Klein Kill and the Dwaar Kill trailing slightly behind. These streams are therefore good candidates for stream corridor protection efforts that would maintain their ecological processes and integrity. Both the Quaker and Pochuck Creeks flow through the Black Dirt region, which led them to have the highest amount of agricultural land within the buffer area. These two streams should thus be priorities for restoration and mitigation efforts that

[2] Howard, T.G. (draft) 2004. Buffering natural communities for community persistence. September 6, 2004. NY Natural Heritage Program, Albany, NY.

seek to improve water quality while maintaining agricultural production.

Aside from assessing broad-scale trends for the Wallkill River and its major tributaries, this stream corridor study also initiated the process of identifying opportunities for future stream corridor protection, mitigation, and restoration projects. Since this component of the Planning project was entirely a remote sensing procedure with no on-the-ground verification of conditions, the resulting information and recommendations should be considered a screening of potential corridor opportunities, but by no means a complete list of possible protection/mitigation sites. (Map 7)

Potential sites for future work (i.e. potential project sites) were identified by reviewing the 2004 aerial photography in conjunction with the land cover information and, in some cases, the location of protected open space (e.g. parkland or land protected by a conservation easement). Potential project sites fell into one of seven categories. Provided below is a generic description of each category as well as typical protection/mitigation activities that might be appropriate for each. **To be clear, additional field inspection and interaction with the local community or site representatives would determine what, if any, further actions would be appropriate.** Implementation of this Plan would logically include expansion of this project.

A. Agricultural Lands – This category was used where substantial blocks of agricultural fields adjoined designated stream channels without the presence of a naturally vegetated buffer exceeding 20 or 30 feet in width. In general, agricultural lands are preferable to most urban land uses within stream corridors because of their ecological benefits (see Biodiversity section for more information). However, water quality can be impacted if certain agricultural uses occur too closely to streams. Ideally, a buffer of thirty feet or more is maintained between cropland and stream channels. While woody buffers offer more water quality and wildlife benefits than herbaceous buffers, they are often not compatible in agricultural settings when farmers wish to maximize their use of productive streamside soils. In certain agricultural settings, however, wider and more diverse buffers are possible.

Potential project options - In many cases, cost-sharing is available for farmland operators to install a wide variety of stream protection practices including: establishing grass buffers or tree/shrub buffers, livestock exclusion fencing, alternative watering facilities, protected stream crossings, wetland enhancement projects, wildlife plantings and related measures. Some programs, such as the Conservation Reserve Program (CRP) and the Wetland Reserve Program (WRP) also offer annual rental payments for properly protected riparian lands.

B. Agricultural Lands – Black Dirt –A primary issue in this area is streambank erosion (see Ag Issues section of this Plan) because of easily eroded soils. Very narrow natural buffers, or the absence of any buffer, exacerbate this dilemma and were common in the Black Dirt region because, understandably, farmers wish to maximize their use of the productive Black Dirt soils. In some cases, owing primarily to low position in the landscape (flood-prone) and/or poor soils, lands next to these waterways are already in forested or successional growth.

Potential project options - All of the cost-share options described above for Agricultural Lands are available for Black Dirt lands, although a shorter list of practices is suitable in this special setting. Efforts are already underway to fund and design streambank stabilization measures in this region (see Agricultural Recommendations section of the Plan). Additionally, planners can explore options for expanding protection/ mitigation measures beyond the stream-bank in conjunction with bank repairs.

C. Mitigation - Golf Courses – A number of golf courses are either bordered or traversed by streams in the Corridor study

area and, in some cases, fairways or other intensively managed areas extend into the stream corridor. The level of management often associated with golf course turf has the potential to have negative water quality impacts through pesticide, herbicide, and fertilizer applications.

Potential project options – Though cost-share/funding options are generally more limited for non-agricultural lands than for farmland, many of the same protection/restoration measures can be employed. These include: managed naturally-vegetated buffers, Integrated Pest Management (IPM) and Nutrient Management. Audubon International offers a program called the Audubon Cooperative Sanctuary Program that helps to enhance the valuable natural areas that golf courses can provide and minimize potentially harmful impacts of golf operations. The SWCDs and Cornell Cooperative Extensions in both counties provide technical assistance to local golf courses on water quality measures.

D. Mitigation - Stormwater Retrofit – Any reach of the Corridor study areas where extensive red zones (developed lands) were mapped would be a potential site to further investigate the need and feasibility of stormwater retrofits, especially where the development was built before current stormwater regulations were in place. Buffers of varying width often exist between the buildings/parking lots and stream channel.

Potential project options - In many cases, funding constraints and other logistical issues will limit options. Nevertheless, where sufficient will and creativity are applied, some communities have successfully installed such measures. Typical practice choices for these areas include higher cost, manufactured products such as water quality inlets (oil/grit separators) and hydrodynamic structures (eg. Stormceptor) that take up limited space, and built-on-site practices such as bioretention basins and water quality swales. See such technical documents as the *NY State Stormwater Design Manual* for more information on these practices.

E. Restoration/Mitigation - Commercial/ Industrial Sites - These sites are few in number but usually include large buildings, associated parking, and often outdoor storage of equipment within the stream corridor, leaving natural buffers of varying width. Most, if not all, of these facilities were built before modern stormwater management regulations were in place.

Potential project options These facilities could be ideal locations for construction of stormwater retrofits, which provide some level of stormwater quality treatment for older urban areas (see stormwater section of this Plan). As well, existing streamside buffers and land uses could be evaluated, and additional protection possibilities could be presented to site managers. Possible recommendations include: plantings, flow control practices (ie. level spreaders), and land management changes (ie. less mowing).

F. Conservation – This designation was used for stream corridor areas where extensive forest/natural cover was discerned in association with the existence of already protected or municipally-owned lands or significant biological resources.

Potential project options - Based upon the interest of relevant landowners, these could be focus areas for future land protection efforts.

G. Educational – This designation was used for stream corridor areas that appeared to be good locations for watershed and/or stream corridor public education activities to be undertaken because land alongside the stream is owned by a school, municipality or another appropriate public or nonprofit entity. Some sites were assigned the label of Restoration/Educational if the site

appeared to be in need of restoration and met the above criteria.

Potential project options - Activities/practices likely to be appropriate in these settings included educational kiosks, community planting projects, and stormwater management demonstration projects. These sites may also be appropriate for interpretive walks, with landowner permission.

(NOTE: Some Wallkill Watershed sites where similar measures have already been done or are in progress include: Benedict Farm Park and Riverfront Park [Town of Montgomery] – Community riparian restoration on Muddy Kill; Maple Street Park [Village of Walden] – stormwater management demonstration project; Town of New Paltz riparian restoration; and Twin Islands Fishing Area [Town of Montgomery] – educational kiosk.)

5. Agriculture - Black Dirt Region

Where the Wallkill enters New York in the southwest corner of Orange County, it passes through an unusual geologic region known locally as the Black Dirt. Encompassing some 16,000 acres, this area is an ancient, post glacial lake bed that has filled in over time with vegetation. This decomposed vegetation is the main constituent of the Black Dirt soils, which are in many places over twenty feet deep. Largely because of its lack of rocks and uniform texture and topography, these soils have proved to be very productive for agricultural use – especially for high-value vegetable crops.

However, a high level of management is required to realize their potential. In their natural condition, these soils have a high water table that must be lowered for crop production purposes. This is most commonly accomplished by closely spaced (~100 feet) open drainage ditches. Land between the ditches is crowned to enhance surface drainage toward the ditches. These 'field' ditches are connected to larger collector ditches that connect either to the Wallkill directly or to tributary streams such as the Pochuck, Rutgers Creek and Quaker Creek.

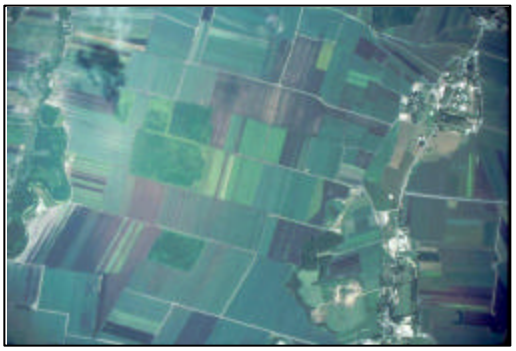


Figure 3: Black Dirt fields are in intimate association with the surface water via the drainage ditch network.

Flooding must also be controlled in order to allow agricultural production. Historically, a small and very meandering channel carried the flow of the Wallkill through this nearly flat region, with large storm events overwhelming the channel and flooding the adjacent land. Over the last several hundred years, the Wallkill's main stem and its tributaries in this region have been enlarged, and in some cases straightened, to reduce flooding and improve drainage for agricultural production. For example, Figure 2 shows the 'natural' course of the Wallkill through the Black Dirt Region and the 'Cheechunk Canal' through which the Wallkill was re-routed in the early 1900's.

Essentially this entire 16,000 acre region was designated as an **Agricultural Drainage District** by the State of New York in the late 1930's. Not only did this designation allow for the planning and construction of an ambitious network of drainage channels, it established **legally binding requirements for the maintenance of these channels.** The overall purpose of the District is to ensure that landowners within its boundaries have the drainage and flood protection necessary to allow for agricultural production.

As mentioned previously, the Black Dirt Region of Orange County was treated as a separate study area in this Plan due to its unique, and in many ways homogeneous characteristics.

6. Agriculture – Horse Farms

According to the New York Census of Agriculture, Orange County is third only to Dutchess and Erie Counties in number of horses at 2800 (USDA, National Agricultural Statistics

Service, 2002). One of the largest livestock operations in Ulster County is a horse breeding farm right along the Dwaar Kill, which has a rolling average of 500 horses year round. We believe the scope of this agricultural sector to be underestimated in this region of the state, since there are a burgeoning number of small recreational horse owners – who may not be reflected in the agricultural census numbers. A major initiative of this planning project was to better assess the status and needs of the horse industry in the watershed.

7. Other Agricultural Uses

Beyond Black Dirt and horse farms, a wide variety of agricultural enterprises occur in the Wallkill Valley. Historically, dairy farming has been the mainstay of agriculture in the Valley. The rocky, silty-textured glacial till soils that dominate the Watershed landscape have limited suitability for many types of agriculture such as vegetable production, but are well-suited to the hay, field corn and pasture needs of the typical dairy farm. While dairy farms have declined drastically in the last 25 years, they are still responsible for keeping significant Watershed acreage in agricultural use. Since dairy farmers commonly rent additional acreage beyond their home farms to supply the crop needs for their herds, we estimate that 60 dairy farms in the NY portion of the Watershed operate land tracts totaling some 15,000 acres.

In areas of the Watershed with ample deposits of lighter textured glacial outwash and alluvial soils, more diverse and intensive agricultural uses are common, including some fairly large commercial vegetable operations. These vegetable operations are most commonly located directly on the main stem of the Wallkill River and its tributaries. This holds especially true as the Wallkill River flows north and the tillable land narrows between the Shawangunk Mountains and Hudson Highlands. There are two large operations (Watchtower Farms and NYS Correctional Facility, Town of Shawangunk) which together control more than 2000 acres of field crops in the watershed. Orchards and vineyards occur on both till and outwash soils, benefiting from the air drainage afforded by sloping topography.

Various specialty or 'niche' operations also occur in the Watershed, such as Community Supported Agriculture (CSAs), nurseries, alpacas and meat goats. These types of operations hold the potential to contribute significantly to the agriculture industry, but currently are thought to manage only limited acreage. The interested reader may wish to refer to the Orange County Agricultural Economic Development Plan, available from the Planning Department's section of the Orange County Government website (co.orange.ny.us) or the Lower Hudson-Long Island RC&D website (http://www.nyrcd.org/LowerHudson/index.htm) for more detail on the agriculture industry. (Map 8)

Biological Resources

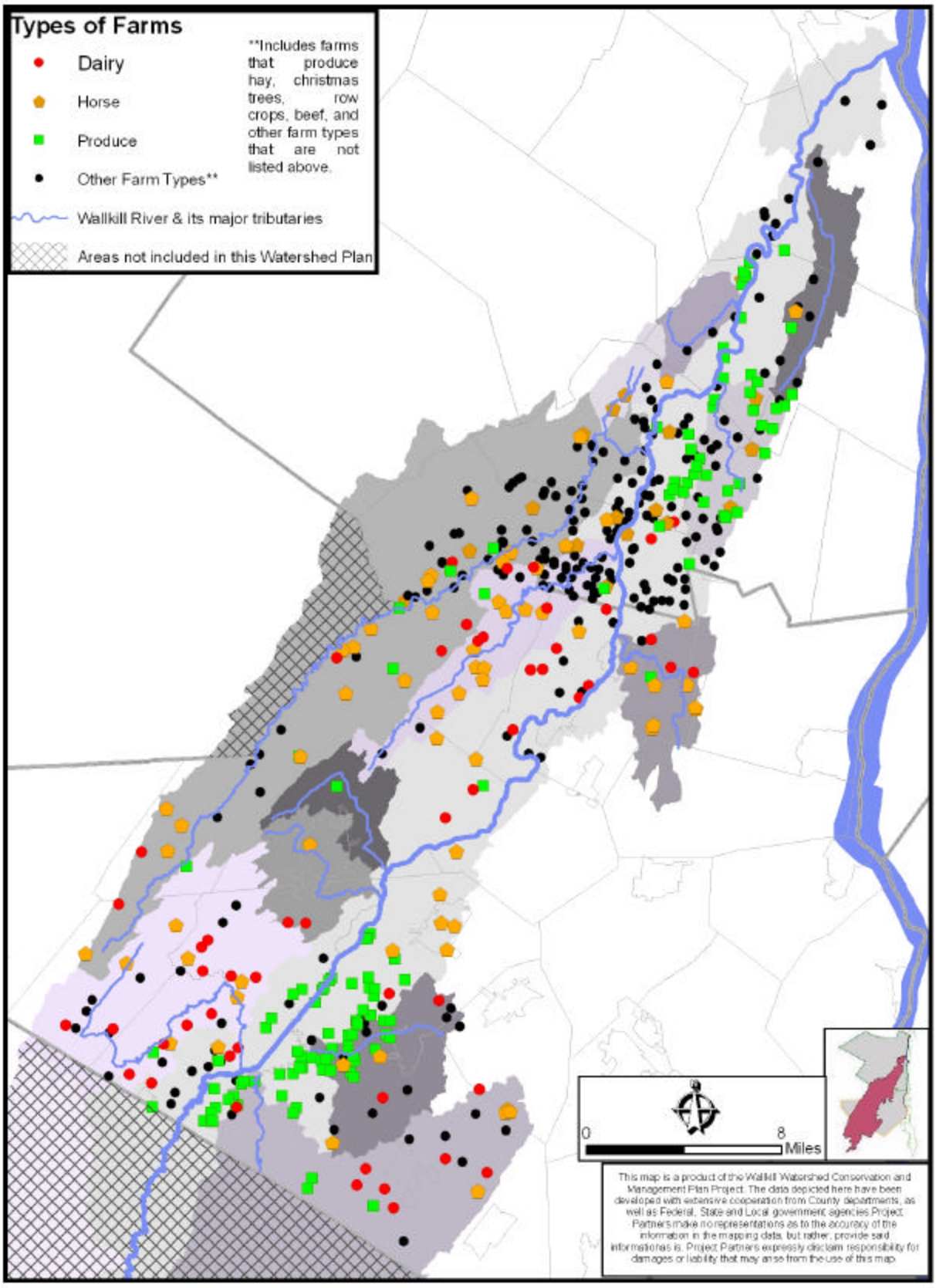
Watershed plans are an ideal opportunity to consider conservation of biological resources. The plants, animals, and habitats—or biodiversity—of the Wallkill Watershed are a significant part of the region's character and natural infrastructure. Forests, wetlands, and riparian areas are not only important wildlife habitats, but are also crucial for regulating the quality and quantity of water for the Watershed's streams and drinking water aquifers. Activities that protect biodiversity also protect water resources.

1. Biological Values of the Watershed

Analysis of the Watershed demonstrated that the biological diversity of the Wallkill Watershed is largely a legacy of its agricultural uses, past and present. Therefore, many of the watershed's important plants and animals are those dependent on early successional habitats, such as meadows and shrubby old fields. Some of the most biologically important habitats within the Watershed are:

Meadows, Pastures and Hayfields – These habitats, which are rapidly vanishing in New York, are important grassland bird habitat. They often contain wet areas supporting wetland plants and animals. Important species include bobolink; henslow's sparrow; eastern meadowlark; Baltimore, black dash, and Dion skipper butterflies; dragonflies; damselflies; ribbon snakes; spotted turtles; bog turtles; wildflowers; and rare sedges.

Shrubby Old Fields – The Watershed contains a higher number of shrubland breeding bird species



Map 8: Farm Locations. Please note that this map is a work in progress. Ulster County has completed more farm location mapping than Orange County.

compared to other regions, creating a greater responsibility for maintaining these populations. They are typically found in conjunction with agricultural land uses. Important species include Leonard's skipper; cobweb skipper; Aphrodite fritillary; yellow warbler; yellow-throated vireo; warbling vireo; and blue-winged warbler. Box turtles also utilize shrubby old fields. As their populations are declining in New York State, this resource should be given additional conservation attention.

Forests – Though largely fragmented by roads and urban areas, the Watershed includes substantial tracts of intact forest, the largest being on the Shawangunk Ridge. Forested land positively affects water quality by filtering water and stabilizing soils, and streamside trees help to shade and cool surface water. Many animal species require large, unspoiled forest and thus have become increasingly rare as the Watershed is developed. Smaller forest blocks of just 200 acres are significant to wildlife, particularly woodland birds such as scarlet tanager, wood thrush, and red-eyed vireo.

Wetlands – Wetlands are exceptionally important because of the myriad of services they provide to natural and human communities. These include habitat, groundwater recharge, water storage and flood mitigation, open space, and others. They also serve as transitional zones between land environments and water bodies. They house a unique assemblage of species. Wetlands are integral to healthy watershed function. They store and clean water and provide essential habitats. Stream-associated wetlands are important for riparian biodiversity. Notable wetland types in the Watershed include Atlantic white cedar swamp and the largely unprotected vernal pools (or seasonal woodland pools). Some of the most sensitive wetland animals found in the Watershed include the spotted turtle, bog turtle, blue-spotted salamander, Jefferson salamander, and northern cricket frog.

Streams - Stream corridors are one of the most diverse and extensive portions of the Watershed landscape. High quality stream habitat usually requires a patchwork of riffles, pools, and woody debris to maximize aquatic habitat diversity and maintain sufficient oxygen levels for aquatic life. Healthy stream corridors have naturally vegetated buffers and are undisturbed by development immediately adjacent to the channel. In addition to fish, stream channels are used by a number of species, including salamanders, turtles, mussels, and insects such as damselflies and dragonflies. Bats prefer to forage over stream channels and some birds nest almost exclusively near water. Sensitive species found within stream corridors of the Wallkill include brook trout, wood turtle, cerulean warbler, longtail salamander, rare plants, and rare freshwater mussels.

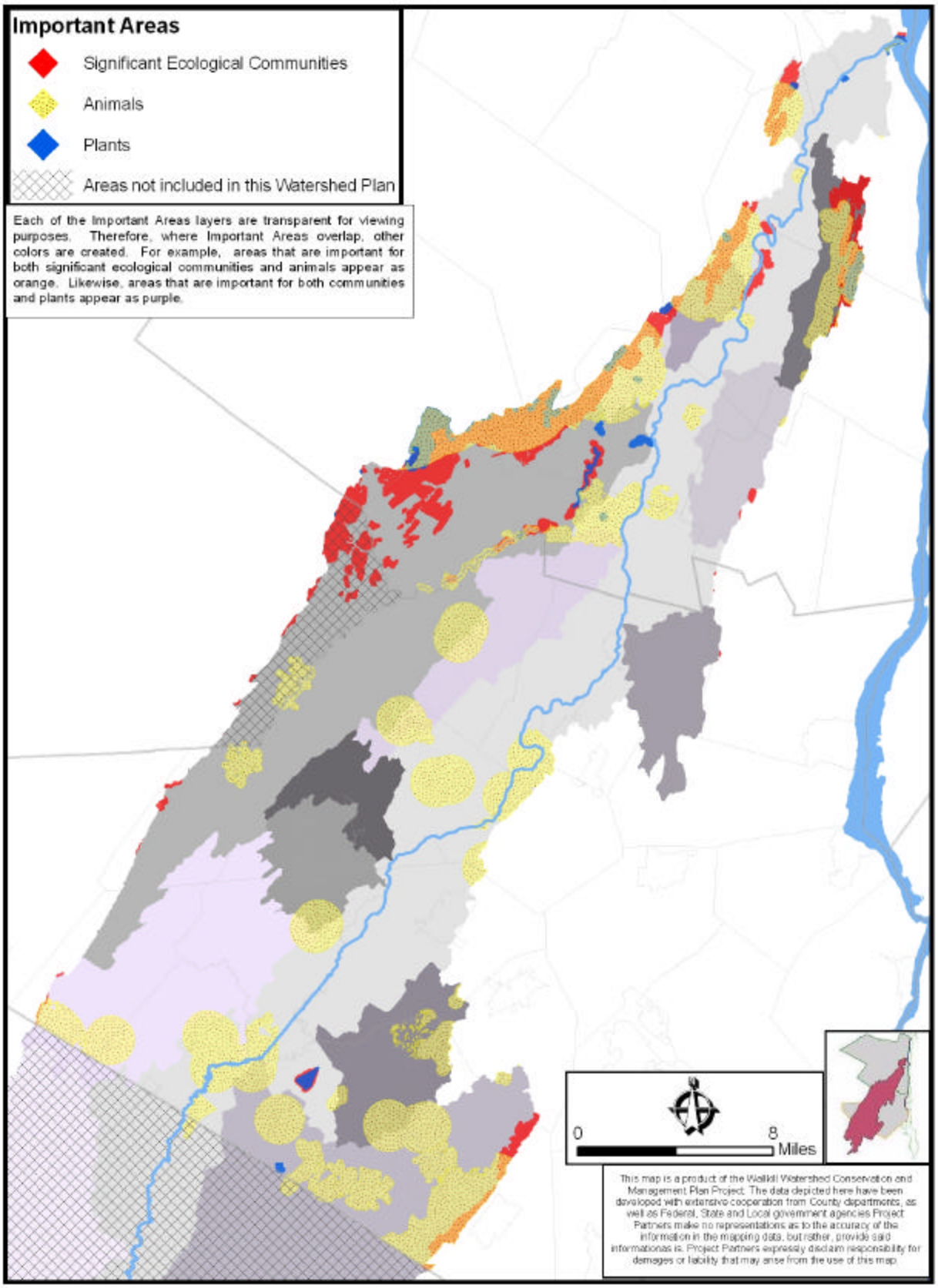
2. Subwatershed Analysis

Comparing the biological landscapes of the Wallkill River Watershed's subwatersheds helps to identify broad needs and impairments, as well as prioritize regions for restoration and protection. The following section outlines the known biological values of each subwatershed.

The New York State Department of Environmental Conservation's (DEC) Hudson River Estuary Program has partnered with the New York Natural Heritage Program to create maps that show areas important to the health of rare animals, rare plants, and significant ecosystems in the Hudson Valley. These maps, known as Important Areas maps, were developed to assist local land use decision makers in their planning for the protection of biological resources and will soon be available for all municipalities within the Wallkill River Watershed. Map 9 shows the Important Area data available for the Watershed, divided by subwatershed. The colored areas represent regions that are essential to the health of known locations of rare animals, rare plants, and significant ecosystems documented by the New York Natural Heritage Program.

Because Important Areas indicate where significant biological resources may be found, guidance in local planning and project review is strongly encouraged. Knowing where your Important Areas are is just one step in gathering biological information for your town's natural resource inventory, comprehensive plan, open space plan, or watershed plan. This map is useful as a general guide to areas within the Watershed that are known to be biologically valuable and should thus be prioritized for further biological research and/or protection.

The Natural Heritage Program's biological data-



Map 9: Biologically Important Areas

base was used in combination with the NYS Breeding Bird Atlas, NYS Amphibian and Reptile Atlas, and land use/land cover data to render the following descriptions of the major biological features of each subwatershed of the Wallkill River. The codes in parentheses following some species names indicate rarity: (sc) is a state species of special concern, (st) is a state threatened species, (se) is a state endangered species, (ft) is a federally threatened species, and (fe) is a federally endangered species.

Dwaar Kill

° *Habitats:*

A 67-acre red maple-hardwood and shrub swamp and another 367-acre partially forested wetland run along the Dwaar Kill. The Dwaar Kill's agricultural matrix of active crop fields, old fields, pasture, hay land, shrubland, and young forest co-exists with stands of hardwood forest, creating a diverse landscape.

° *Species of Concern:*

Wood turtle (sc), bog turtle (ft), red-shouldered hawk (sc), black-billed cuckoo, brown thrasher, willow flycatcher, scarlet tanager, wood thrush, red-eyed vireo, bobolink and Eastern meadowlark. Possible species of concern include Indiana bat (fe), Black rat snake, Eastern hognose snake (sc), Northern black racer, Northern red salamander, longtail salamander (sc), spotted turtle (sc).

Tin Brook

° *Habitats:*

Many stream-associated wetlands. Large wetland complex totaling over 200 acres form the headwaters of the largest tributary to the Tin Brook. Wetland encompassing over 325 acres within Stewart State Forest. Vernal pool complex at Stewart.

° *Species of Concern:*

Eastern box turtle, spotted turtle, wood turtle; blue-spotted salamander (sc), four-toed salamander, gray treefrog, Jefferson's salamander (sc), marbled salamander (sc), Northern dusky salamander, spotted salamander; Indiana bat (fe) roost trees and foraging area.

Monhagen Brook

° *Habitats:*

Two large wetlands (greater than 100 acres) are fragmented by rail and roads. Presence of spotted salamanders indicates vernal pools.

° *Species of Concern:*

Wood turtle (sc); amphibian concentration area; Upland sandpiper (st); Indiana bat (fe) roost trees and foraging area.

Masonic Creek

° *Habitats:*

Large wetlands (over 50 acres) are fragmented by roads and rail.

° *Species of Concern:*

Wood turtle (sc); Jefferson's salamander (sc); Red shouldered hawk (sc); Indiana Bat (fe) roost trees and foraging area.

Pochuck Creek

° *Habitats:*

Nearly intact 1165 acre Class I wetland in the eastern portion of the Watershed. The Wildlife Conservation Society has identified high quality habitat throughout this watershed in its Southern Wallkill Biodiversity Plan. Significant wetland communities: Inland Atlantic White Cedar Swamp (11 acres), Rich shrub fen (3 acres), Rich Graminoid fen (2 acres, 1.5 acre), Spruce –fir swamp (43 acres) Significant upland communities (all found on Bellvale mountain): Appalachian Oak-hickory forest (1565 acres), Hemlock – Northern Hardwood forest (570 acres), Chestnut-Oak Forest (981 acres).

° *Species of Concern:*

Bog turtle (ft), Eastern box turtle (sc), Eastern hognose snake (sc), ribbon snake, spotted turtle (sc), timber rattlesnake (st) wood turtle (sc); blue-spotted salamander (sc), chorus frog, four-toed salamander, Northern Dusky Salamander, Jefferson salamander complex, longtail salamander (sc), spotted salamander, wood frog; cerulean warbler (sc), Cooper's hawk (sc), red-headed woodpecker (sc), red-shouldered hawk (sc), sharp-shinned hawk (sc); Indiana bat (fe) roost trees and foraging area; Atlantic white cedar tree, blue tipped dancer damselfly; see also Southern Wallkill Biodiversity Plan (Miller et al, 2005).

Quaker Creek

° *Habitats:*

The Wildlife Conservation Society has identified high quality habitat throughout this watershed in its Southern Wallkill Biodiversity Plan.

° *Species of Concern:*

Eastern box turtle (sc), five-lined skink, spotted turtle (sc); longtail salamander (sc), Northern Cricket Frog (se), wood frog; Upland sandpiper

(st); Indiana bat (fe) roost trees and foraging area; falcate orangetip butterfly; See also Southern Wallkill Biodiversity Plan (Miller et al, 2005).

Rutgers Creek

° *Habitats:*

Mt. Hope has 390 acre wetland. Vernal pools are scattered throughout subwatershed, which also has many stream-associated wetlands. There is a matrix of active crop fields, old fields, pasture, hay land, shrubland, and successional habitats that coexist with stands of hardwood forest, creating a diverse landscape.

° *Species of Concern*:

Bog turtle (st), Eastern Box turtle (sc), spotted turtle (sc), timber rattlesnake (st), wood turtle (sc); Amphibian concentration area, Jefferson's salamander (sc), Jefferson's salamander complex, marbled salamander (sc), northern dusky salamander, wood frog, spotted salamander; cerulean warbler (sc), Cooper's hawk (sc), Indiana bat (fe) roost trees and foraging area.

Shawangunk Kill

° *Habitats:*

Large forest areas on the Shawangunk Ridge: vernal pools, Chestnut-oak forest, Hemlock-northern hardwood forest, pitch-pine oak heath rocky summit, acidic talus slope woodland. See also maps of conservation targets from the Shawangunk Ridge Biodiversity Partnership. The Shawangunk Kill is the only stream where we have documentation of a high quality stream biodiversity. Significant natural communities found there are confined river, and floodplain forest.

° *Species of Concern:*

Black rat snake, Eastern box turtle (sc), Northern black racer, spotted turtle (sc), wood turtle (sc), timber rattlesnake (st); four toed salamander, Jefferson's salamander (sc), gray treefrog, Northern red salamander, spotted salamander, wood frog; Acadian flycatcher, American kestrel, American redstart, barred owl, black throated green warbler, Eastern towhee, Eastern wood-pewee, field sparrow, least flycatcher, Louisiana waterthrush, ovenbird, spotted sandpiper, veery, Northern goshawk, red-shouldered hawk (sc), scarlet tanager, worm-eating warbler; brook floater mussel, brook snaketail dragonfly, Rapids clubtail dragonfly, beakgrass, Davis' sedge.

Mara Kill

° *Habitats:*

390 acre wetland in the Town of Gardiner, vernal pools.

° *Species of Concern:*

Bog turtle (st), Eastern Box turtle (sc), spotted turtle (sc), timber rattlesnake (st), wood turtle (sc); Amphibian concentration area, Jefferson's salamander (sc), Jefferson's salamander complex, marbled salamander (sc), northern dusky salamander, wood frog, spotted salamander; cerulean warbler (sc), Cooper's hawk (sc), Indiana bat (fe) roost trees and foraging area.

Swarte Kill

° *Habitats:*

Exceptional habitat for northern cricket frog (se) within NYS; large 1546-acre Class 1 regulated wetland complex and 421-acre Class 2 regulated wetland along the Swarte Kill; 206-acre red maple-hardwood swamp (Grand Pond) and marshes on tributary to the Swarte Kill; 52-acre lake and marsh complex (Auchmoody Pond); other 50-70 acre wetlands; vernal pools; mature, undisturbed hemlock-northern hardwood forest, Appalachian oak-hickory and beech-maple mesic forests on Shaupeneak Mountain extending south.

° *Species of Concern:*

Northern cricket frog (se), Jefferson salamander (sc), four-toed salamander, worm-eating warbler, Louisiana waterthrush, black-throated green warbler; black-billed cuckoo, northern flicker, Eastern wood pewee, wood thrush, yellow-throated vireo, blue-gray gnatcatcher, black-and-white warbler, cerulean warbler (sc), scarlet tanager, rose-breasted grosbeak, red-shouldered hawk (sc); large twayblade (st).

Platte Kill

° *Habitats:*

Small part of Red maple hardwood swamp that extends from Town of Plattekill to Town of Newburgh.

° *Species of Concern:*

Spotted turtle (sc), Northern cricket frog (se).

Klein Kill

° *Habitats:*

Chestnut Oak Forest, vernal pools.

° *Species of Concern:*

Timber rattlesnake (st), black rat snake, five lined skink, Eastern box turtle (sc), Northern copperhead, spotted turtle (sc), Northern black

racer; Jefferson's salamander (sc), spotted salamander, wood frog.

Wallkill Direct Drainage (Orange)

° *Habitats:*

Highland Lakes State Park has Appalachian oak hickory forest, oak-tulip tree forest, Hemlock-Northern hardwood forest, successional southern hardwoods, successional old field, successional shrubland, red maple-hardwood swamp, vernal pools, shallow emergent marsh, shrub swamp, rocky headwater stream. The Southern Wallkill Biodiversity Plan identifies high quality habitat in the portions of this watershed within the towns of Goshen and Warwick (Miller et al., 2005).

° *Species of Concern:*

Eastern Box turtle (sc), Eastern Hognosed snake (sc), spotted turtle (sc), wood turtle (sc); blue spotted salamander (sc), gray treefrog, N. dusky salamander, N. red salamander, spotted salamander, wood frog; American bittern, Cerulean warbler (sc), Cooper's hawk (sc), Grasshopper sparrow (sc), least bittern (st), Northern harrier (st), red-headed woodpecker (sc), red-shouldered hawk, short-eared owl (se), Upland sandpiper (st); Indiana bat (fe) roost trees and foraging areas; blue-tipped dancer, cobra clubtail dragonfly, midland clubtail dragonfly, spine-crowned clubtail dragonfly; see also Southern Wallkill Biodiversity Plan (Miller et al, 2005).

Wallkill Direct Drainage (Ulster)

° *Habitats:*

Floodplain forest remnants on Wallkill River, Shawangunk Ridge: vernal pools, chestnut oak forest, high quality grassland bird habitat.

° *Species of Concern:*

Bog turtle (st), Eastern box turtle (sc), spotted turtle (sc), timber rattlesnake (st), wood turtle (sc), gray treefrog, spotted salamander, wood frog, American kestrel, American redstart, American woodcock, bald eagle (ft), Baltimore oriole, blue-winged warbler, bobolink, brown thrasher, Eastern meadowlark, Eastern towhee, Eastern wood-pewee, field sparrow, Northern harrier (st), ovenbird, prairie warbler, savannah sparrow, scarlet tanager, sedge wren (st), short eared owl (se), upland sandpiper (st), willow flycatcher, wood thrush; rare plant species on Shawangunk ridge.

Water Resources

Water resources in the Wallkill River Watershed include surface water in streams, lakes, and wetlands, and groundwater. Groundwater and surface water resources, while they may appear to be separate and distinct, are really interconnected and influence each other both in terms of quantity and quality. Groundwater aquifers, whether in sand and gravel formations or in the fractures and cracks in bedrock, are recharged by the downward flow of precipitation from the surface. Surface water bodies including streams and wetlands, conversely, are also supplied by groundwater in some cases. A significant portion of the dry weather flow in smaller streams, for example, originates from groundwater that flows laterally and upward into streams, which is known as base flow. Developing a complete perspective on protecting and managing water resources, therefore, requires knowledge of the interactions between groundwater and surface water bodies in the Watershed and consideration of how these interactions may be impacted by changes in land use, withdrawal of water, and other activities. In many areas, existing information about these interactions is not adequate to enable development of detailed protection plans for groundwater, streams and wetlands and one recommendation is for more research and monitoring to fill these gaps. (See Water Supply, Quantity and Allocation section for more information.)

A detailed analysis of existing information about water resources and drinking water supplies was beyond the scope of this management plan. Some of the studies and data available include completed and/or ongoing studies by the Orange County Water Authority of groundwater, municipal water supply systems, and of surface water quality in streams; data available from the County's Department of Health; studies by the US Geological Survey, NYS DEC, and other agencies; studies and reports done for individual municipalities; and data included in environmental impact statements or other documents for proposed development projects. Below are summaries of several research, monitoring and regulatory programs relevant to water resources planning and protection in the watershed.

1. Priority Waterbodies List

The Priority Waterbodies List (PWL), published and maintained by the NYSDEC, provides

summaries of water quality conditions for a great number of lakes, streams and rivers in New York. The initial inclusion of the Wallkill and several of its tributaries on the PWL is described briefly in the introduction to this Plan. While some waterbodies on the original list were removed due to inadequate documentation, the Wallkill and several of its tributaries have remained on the List through several updates. (Map 1) Better documentation of water quality conditions has been added over this period. To some extent, the often turbid appearance of the Wallkill, especially in the Black Dirt Region, has caused public concern about water quality. This is reflected by the PWL's listing of aesthetics as being stressed. It is unclear, however, how much of this turbid appearance is a result of human influences and how much is a natural condition owing to the

Beyond aesthetics, though, work done in 1997 by Dr. Simon Litten of the DEC detected the presence of DDT residues in the Wallkill, starting around the NJ line, at levels above those found in other Hudson Valley rivers. This work is summarized in the PWL.

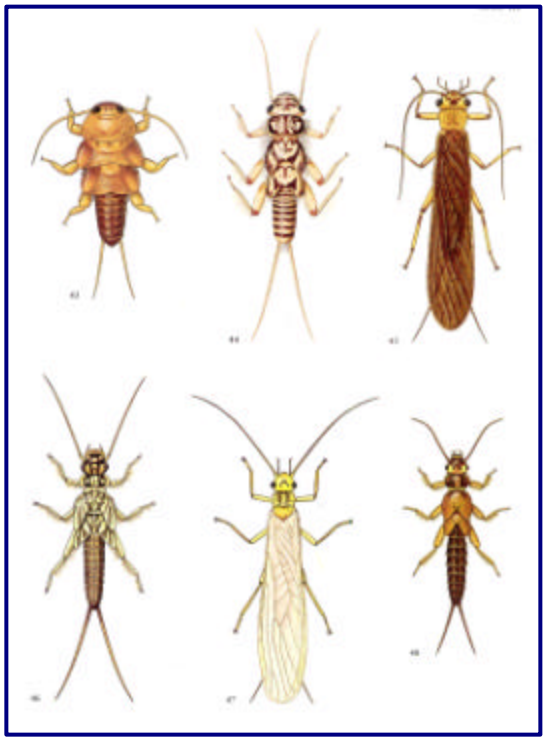


Figure 4: Stoneflies suggest good water quality

2. Macroinvertebrates as Indicators of Water Quality

How much information is there about existing water quality and trends over time? A detailed picture of water quality in streams in the Watershed is emerging from studies using macroinvertebrates as indicators of water quality.

Benthic macroinvertebrates are small aquatic insects, crustaceans, worms, and other animals that live in the bed (or benthos) of streams. There are many species of macroinvertebrates and their tolerance to pollution varies greatly. Because these species cannot move around much the way fish can, and because they live in one location for weeks or months, they are impacted by the overall water quality conditions at that site during their lifespan. In contrast to taking a single water sample, which only reflects water quality at a single point in time, macroinvertebrate sampling provides a cumulative view of water quality at each sampling site and thus provides a very cost-effective and reliable way to assess overall water quality. When a diverse assortment of species, including sensitive species, is found in a controlled sampling and analysis procedure, this indicates that the water quality at that site is high,

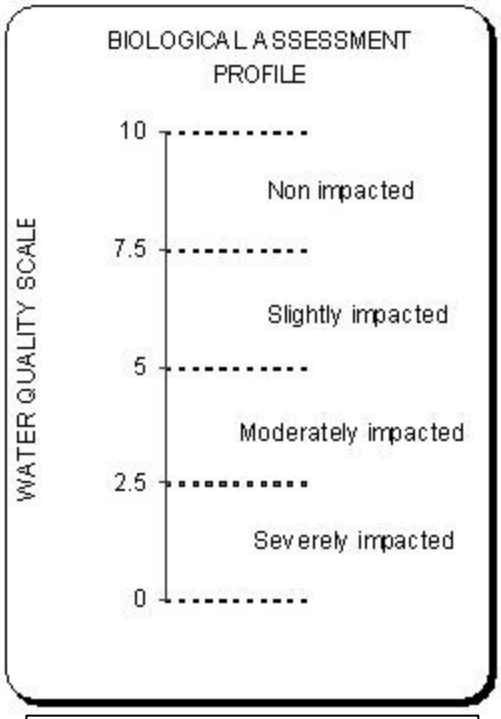


Figure 5: BAP Scale

whereas when only a few pollution-tolerant species are present water quality is assessed as low. Where problems are found, more research

can be focused on those specific areas. The NYS DEC has refined this method for streams in New York to enable measuring water quality on a scale of 0-10, called the Biological Assessment Profile (BAP), where 10 is the best water quality. (Fig, 5)

A study by Hudsonia in 1994, titled "*Environmental Quality of the Wallkill River* in *Orange County, NY*", concluded that the macroinvertebrate community was "...under considerable habitat and pollution stress" (see Appendix B). Macroinvertebrate samples have been collected by NYS DEC's Stream Biomonitoring Unit (SBU) at a number of sites in the Wallkill River Watershed including the main stem and tributaries. The findings of this work, based on sampling beginning in 1994, are summarized in a 30-Year Trends report for the state, and for the Wallkill main stem it concludes that "most of the impact in the river is due to agricultural nonpoint source nutrient enrichment." It also notes that water quality has improved since earlier studies in 1972 and attributes the likely cause of this improvement to wastewater treatment upgrades to the Middletown, Wallkill, Montgomery and Walden treatment plants from 1985-1989. A three-year sampling program using the same methods, currently being implemented by the OC Water Authority, has found evidence, however, that municipal wastewater discharges may still be causing significant water quality impacts in certain locations. (Map 10)

When considering the NYS DEC SBU data, and the data from Orange County discussed below, it's important to remember that the terms used have a very specific meaning. In particular, the DEC's term "slightly impacted" can be misleading if not considered in context. The DEC's protocol scores water quality on a scale from 0-10, with 10 being the highest and best. The slightly impacted category includes scores from 5.1 – 7.4, so even sites where water quality is only marginally better than 5.0, which is halfway down the scale from best to worst, will be termed "slightly impacted." It's important, therefore, to look at the numerical BAP score for each site to better understand its actual water quality. Figure 6 depicts the 2005 BAP scores for six sites on the Wallkill River main stem in Orange County.

Figure 6 depicts the Biological Assessment Profile scores for six water quality monitoring sites in the main stem of the Wallkill River in Orange County, NY. Macroinvertebrate samples were collected in July 2005. The monitoring sites included a site just downstream of the New Jersey state line (site 463), several other sites in the center of Orange County, and one site just upstream of the Ulster County boundary (site 538) that indicated severe water quality impacts. Follow up monitoring is being conducted in 2006. The BAP score combines four metrics ((EPT, SR, HBI, and PMA/SD) that measure various characteristics of the macroinvertebrate community structure to assess overall water quality. For more information on these metrics and the methodology used, see the NY State Dept. of Environmental Conservation's *2002 Quality Assurance Work Plan for Biological Stream Monitoring in New York State* or contact the Orange County Water Authority.

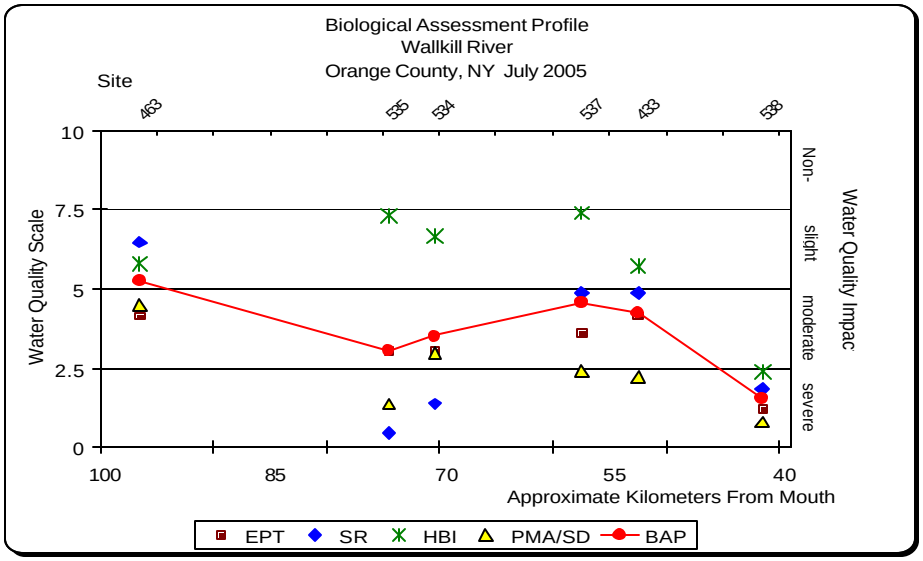


Figure 6: Biological Assessment Profile (BAP) scores
Source: Orange County Water Authority

The Orange County Water Authority's ongoing water quality survey is providing more detailed information than ever before. Field work and

analysis for this Water Quality Biomonitoring Project is being conducted by Hudson Basin River Watch, and this project is using the same methodology developed by NYS DEC and approved by US EPA so the results are comparable to the State's data. Over 60 samples were collected in 2004, 2005, and 2006 in the Wallkill basin in Orange County. Data for 2004 and 2005 is summarized and briefly discussed in this section; 2006 data analysis will be completed by spring of 2007. Of those sites that showed water quality impacts, the most common sources of impact indicated by the Impact Source Determination (ISD) method were non point source nutrient enrichment, but the ISD indicates that sewage is the primary problem at a number of sites indicating moderate or severe impacts. The NYS DEC 30 Year Trends report notes that many wastewater treatment plants built or upgraded in the 1970s and 1980s are now aging and suggests that older wastewater infrastructure "functioning beyond capacity or at reduced levels of efficiency" is the cause of water quality impact at some sites across NY State.

Notably, in 2005, one site in the Wallkill River just south of the Ulster County border indicated severely impacted water quality (BAP score 1.56). While the specific cause(s) for this impairment are not yet known, the ISD measured at this site strongly indicates that sewage is a primary cause, and follow-up monitoring during 2006 is underway at this site and others nearby.

In Ulster County, the NYS DEC has sampled a number of sites in the Wallkill River and its tributaries. Most of these sites were assessed as non-impacted. A site on the Dwaar Kill, a tributary of the Shawangunk Kill in Ulster County, was assessed as slightly impacted in 2002. (Note: There are two Dwaar Kills – the other one begins in Orange County and joins the Wallkill River in just north of the hamlet of Wallkill. In 2006-2007, the Hudson River Estuary Program is sponsoring a Watershed Assessment project for several basins, also being conducted by Hudson Basin River Watch in collaboration with local watershed groups and other stakeholders, that includes macroinvertebrate sampling for 23 sites in the Ulster County portion of the Wallkill River Watershed. This project will provide updated assessments for several sites previously sampled by NYS DEC and assessments for a number of new sites as well.

A compilation of recent biomonitoring data for both Orange and Ulster counties, including data from NYS DEC and the Orange County Water Authority, provides an overall perspective on water quality in the watershed that is sobering. The pie chart below illustrates that during 2002-2005 in the Wallkill and some of its tributaries, only 11% of the sites were non-impacted (ie. BAP of 7.5 or higher) and more than a third were either moderately or severely impacted (BAP of 5.0 or lower). It is important to note that most of this data is from sites in Orange County because far more data is available for that area. (Figure 7)

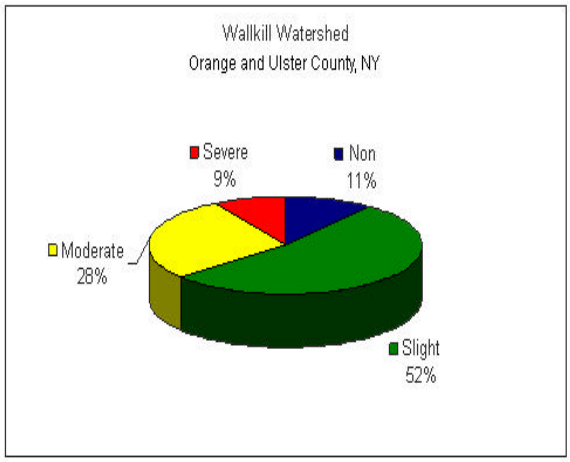
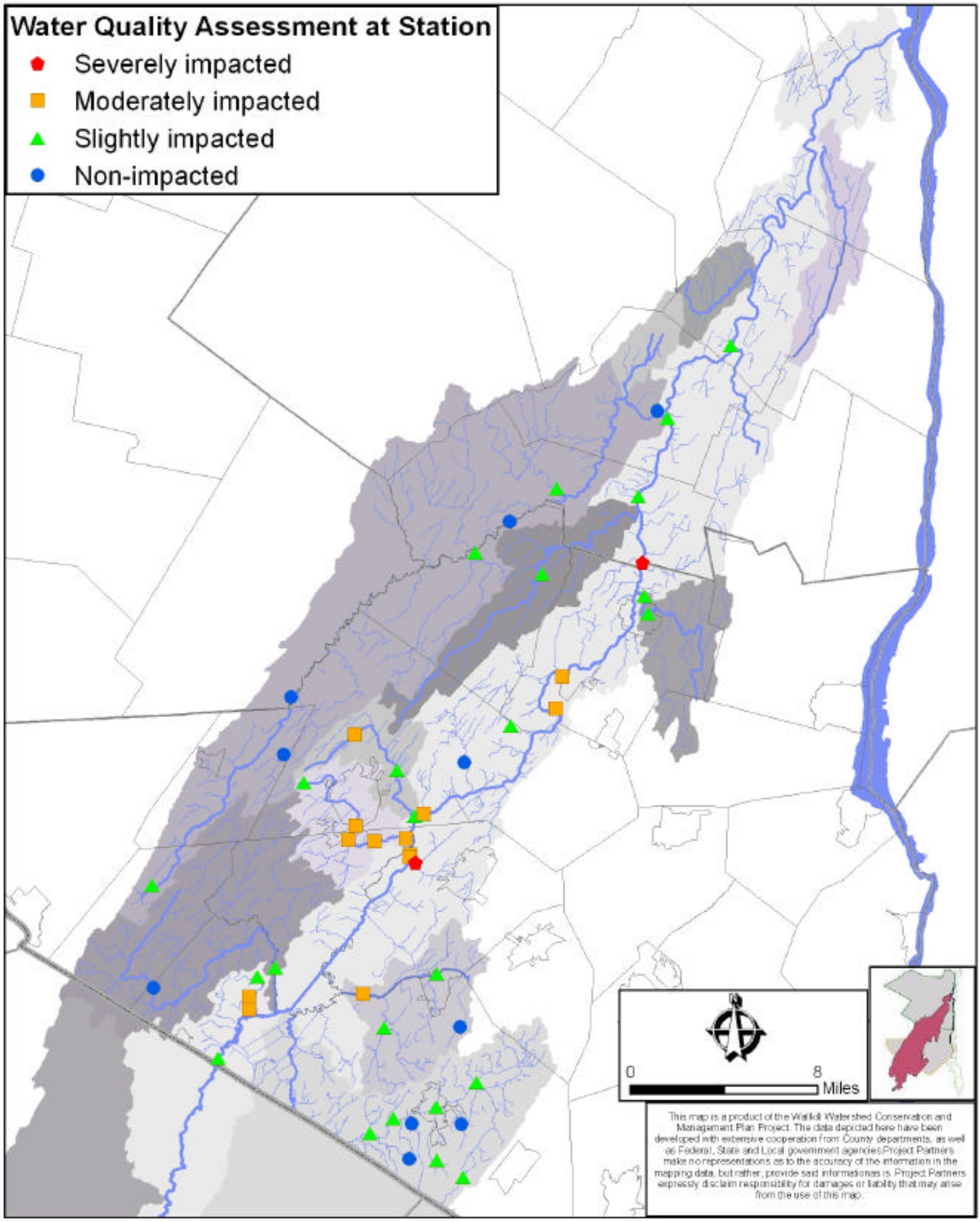


Figure 7: This chart illustrates the distribution of stream biomonitoring assessments for sites in Orange and Ulster counties sampled from 2002-2005. Most of the data used for this chart is from Orange County. See discussion above for more details about interpreting biomonitoring data.

3. Chemical Data

The Hudsonia study did include a chemistry component, but it was limited to single grab samples at each site. The NYS-DEC SBU and K. Nolan also collected limited chemistry data during their biomonitoring studies.

Research by US Geological Survey staff has found elevated levels of arsenic in the Wallkill River's bottom sediments and its water at sites in New Jersey. These conditions apparently originated from historical zinc mining activity at the Sterling Hill and Franklin mines in Franklin, NJ, both of which are now closed (there are



Map 10: Stream Biomonitoring Sites

museums on both sites). At times, the arsenic concentration in the river's water has slightly exceeded New Jersey's standard for drinking water, which is 5 micrograms/liter, as measured at a monitoring site south of Unionville. Zinc concentrations in sediments also were elevated. Some of the data collected in this research has been published in USGS annual reports for 2004 and 2005. Several articles have been submitted to scientific journals for publication, and a summary report will be published by USGS in late 2006. Contact for more information: Julia Barringer, US Geological Survey, jbarring@usgs.gov or 609-771- 3960.

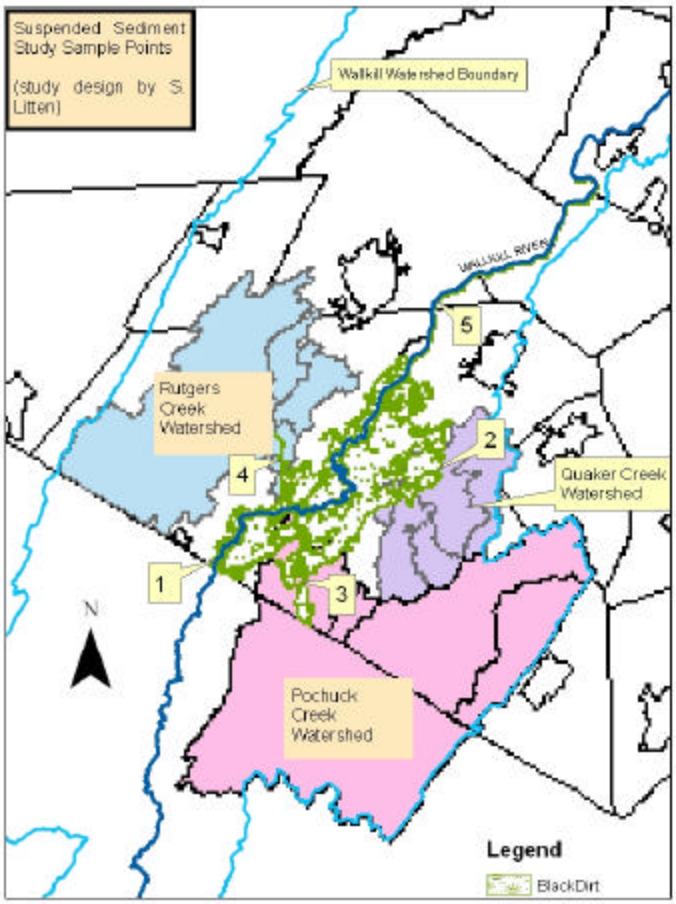
"In 1997 NYSDEC conducted a monitoring effort on Hudson River tributaries as part of the Contamination Assessment and Reduction Project (CARP) to evaluate potential sources of toxic chemicals to the Hudson and New York Harbor. Results from this monitoring found the Wallkill to have the highest concentrations of DDT (by a factor of 10) and dieldrin of all tribs tested. Follow-up monitoring indicate (sic) the DDT source is located in the 'black dirt' area (see Wallkill River segment 1306-0017). The study concludes that while the impact of this source on the Hudson is unclear, it does affect the entire length of the Wallkill. (Toxics Organics Survey: Hudson, Wallkill and Hackensack Rivers – DRAFT, Litten et al, DEC/DOW, BWAR, October 1999)." (*The 1999 Lower Hudson River Basin Waterbody Inventory and Priority Waterbodies List, NYSDEC, June, 2000, pp 127-128)*

We believe that there are other chemical monitoring data in existence for the Wallkill, but they were not readily available. Our conclusion is that a more formal and accessible program of chemistry sampling and evaluation should be pursued in order to draw reliable conclusions about the conditions of the Wallkill in this respect.

4. Suspended Sediment Study

Partially as a follow up to Dr. Litten's 1997 DDT study, and also because of general elevated concern about sediment in the River, the Wallkill River Task Force (WRTF) and OCSWCD partnered with NYSDEC to undertake a Suspended Sediment Study of the Wallkill and several of its tributaries in the Black Dirt Region. One of the main purposes of this study was to assess whether sediment loads in the Wallkill were coming disproportionately from one or more areas of the watershed. An additional goal was to determine if volunteers could contribute in a significant way to a formal water quality study.

Unlike biological assessments, which offer flexibility in terms of when samples can be selected[2], suspended sediment analysis requires 'event-based sampling' since the bulk of a river's sediment load is associated with runoff events. The fieldwork for this study took place primarily in 2004 and 2005.



Map 11: Suspended sediment study sampling sites

In summary, the study concluded that suspended sediment in the main channel of the Wallkill was not coming disproportionately from the upland In summary, the study concluded that suspended sediment in the main channel of the Wallkill was

[2] DEC SBU protocols require sampling to take place from July-September, but within this time frame sampling can occur at any time.

not coming disproportionately from the upland portions of major tributaries (Pochuck, Rutgers, & Quaker). The main researcher postulated, at the December 2004 meeting of the Project Steering Committee, that the banks of the River itself and the banks of major drainage channels within the study area were the major contributors. (See Black Dirt section for more on this issue and how it impacts recommended actions of the Plan).

It is worth noting that all involved with the study agreed that the volunteer component of the study worked extremely well. Despite being required to visit sampling sites (Map 11) on short notice during often inclement weather, volunteer samplers (4 out of 5 of which were Black Dirt farmers) performed their duties accurately and reliably. The success of the effort can also be attributed largely to the diligence of OCSWCD's Kris Breitenfeld, who coordinated the sampling locally.

5. Water Supply, Quantity and Allocation Issues

Water for human use in the Wallkill basin is obtained from private wells and municipal supplies. Municipal systems in Orange County are supplied by reservoirs (which serve the City of Middletown and the villages of Florida, Warwick, and Goshen) and by municipal wells. Municipal wells are located both in sand and gravel aquifers, which tend to be relatively shallow and can provide high yields, and in bedrock formations, which are generally deeper. Some of these wells are located close to the Wallkill River and water levels and water quality are directly affected by the River. While water consumption from the municipal systems has not increased significantly in most cases over the past 10-15 years, Orange County is currently working with a number of communities, including Crawford, Goshen, Middletown, Wawayanda and Wallkill, to study the potential for new drinking water supply projects. These projects will potentially lead to increased withdrawals of water from the Wallkill River, some of its tributaries, and/or from groundwater aquifers. Some farmers will also take water for irrigation.

In Ulster County, New Paltz's upland reservoirs are an auxiliary source of supply for the Village of New Paltz and Town of New Paltz water district. The contributing watersheds of these surface supplies lie within the Wallkill Watershed and serve 6000 customers in an emergency capacity. The hamlet of Wallkill relies on municipal wells located on the eastern edge of the Town of Shawangunk. This area is recharged by a pitted outwash plain extending from Wallkill south into Orange County. The majority of the residents of this area rely on individual wells drilled into bedrock or driven into unconsolidated aquifers. The average depth of these wells in the unconsolidated aquifers is 73' and yield an average of 93 gallons per minute (gpm). When, however, a bedrock well is required, the depth increased to 200' and the yields dropped to 33 gpm. The Water Supply Study 1989, prepared by Stearns and Wheler, evaluated existing and long range needs of the county and recommended system improvements and consolidations to satisfy those needs. It is projected that at the current rate of growth, all of the municipalities will experience a water deficit. The only exception to this is New Paltz, which has access to water from the NYC-DEP Aqueduct System.

Water-Related Recreation

When people are able to enjoy a water resource through recreational opportunities such as swimming, boating, or fishing, they are more likely to be concerned about the health and welfare of that resource. Even hiking along a river or viewing a water body from a park can create a feeling of ownership that can lead to greater public stewardship of the waterway. The Wallkill River has long suffered from a low public profile as a recreational resource, due to many factors. Only recently have riverside parks and river access points become a focus for communities along the Wallkill, but today there are many points where the public can enjoy the River (Map 12).

Public access points to the Wallkill River in New York, from south to north, consist of:

1. Wallkill River National Wildlife Refuge (Warwick) – The 5,100-acre Refuge is mainly in New Jersey, but its New York acreage includes a riverfront parcel with interpretive signage, benches and a boat launch.
2. Orange County Land Trust's Hamptonburgh Preserve (Hamptonburgh) – A nature preserve consisting of forests,

fields, and wetlands, with an emerging trail system. Presently, there is no designated access point to the River.

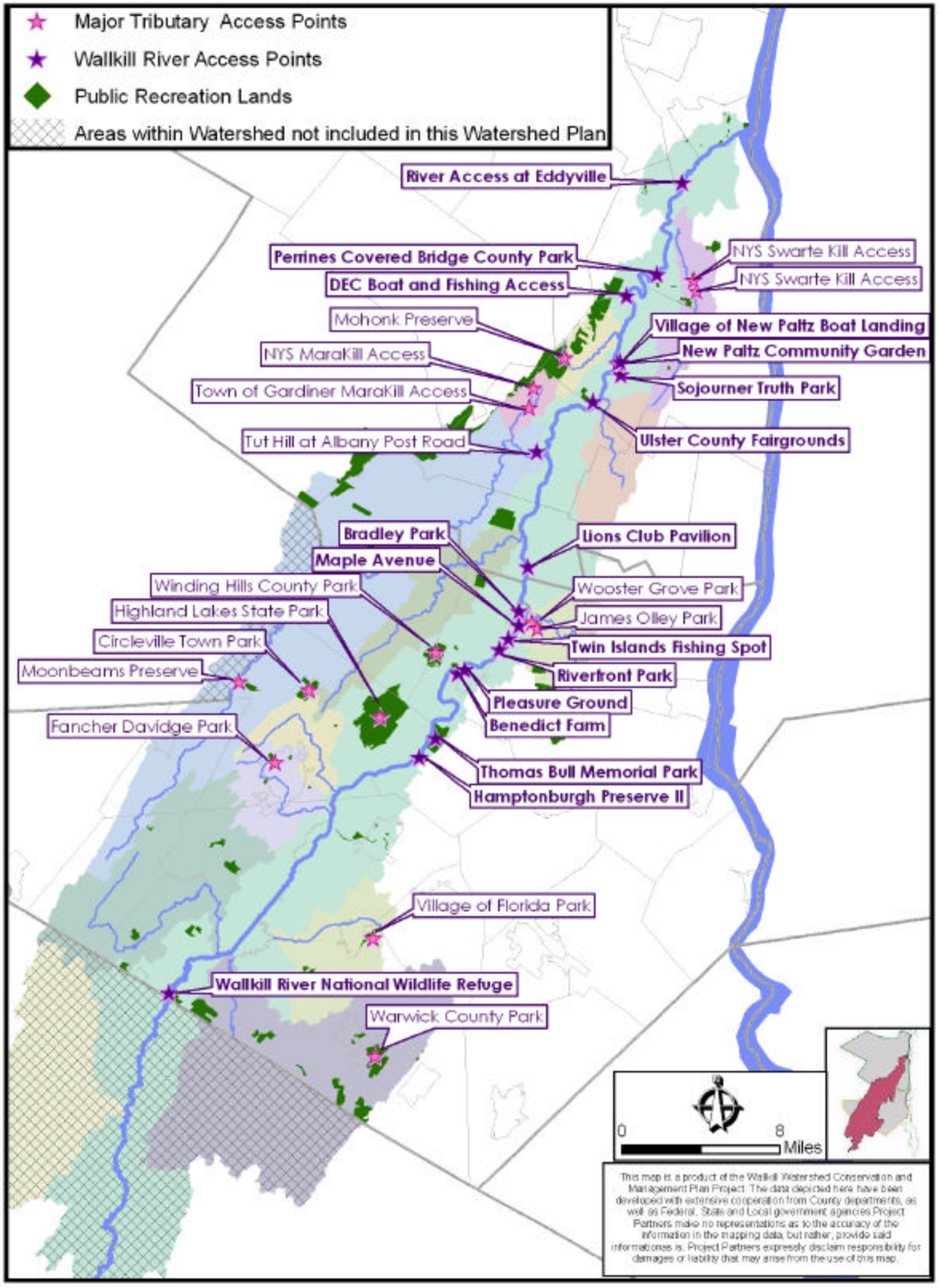
3. Thomas Bull Memorial Park/Orange County Park (Hamptonburgh) – Orange County owns 1.6 miles of forested Wallkill River frontage within this popular park. Although no designated access point to the River currently exists, a boat launch will be installed in late 2006 or 2007.
4. Benedict Farm (Montgomery)– A Town Park that boasts 3,500 feet of continuous frontage to the River. The Park has a boat launch, with plans for active recreation facilities.
5. Pleasure Ground Park (Village of Montgomery) – A forested park with a pavilion and boat launch on the River, with ball fields and interweaving pedestrian trails.
6. Riverfront Park (Montgomery) – A mid-sized park whose principal feature is its prime access to the Wallkill River. The Park has a picnic grove on the waterfront.
7. Twin Islands Fishing Spot (Montgomery)- A small linear park on the Wallkill River, popular for fishing.
8. Maple Street Park (Walden) – This small park at the foot of Maple and Pine Street in the Village of Walden is available for cartop boat launching.
9. Bradley Park – This active recreation park in the Village of Walden has ballfields and almost 1500 feet of Wallkill River frontage[3], but no current designated access point to the River.
10. Lions Club Pavilion (Shawangunk) – A small parcel with a picnic pavilion and fishing access.
11. Ulster County Fairgrounds (New Paltz) – A DEC-sponsored cartop boat luanch and fishing area, which also houses the Ulster County Fairgrounds.
12. Village of New Paltz – Privately-owned, access by permission.
13. Village of New Paltz Community Garden – A quarter-mile riparian greenway along the Wallkill River, which features a riparian buffer, community gardens and the Historic Huguenot settlement.
14. +DEC Boat and Fishing Access (Rosendale) – A small parcel with a cartop boat launch.
15. Perrines Covered Bridge County Park (Rosendale) – Has the oldest covered bridge in New York State. The bridge was built in 1835 and is listed on National Historic Register. The Park also has scenic view and fishing access.
16. DEC River Access at Eddyville – Within the Town of Ulster, this spot provides fishing access and has a boat lanch with a gravel ramp to accommodate trailers.

Shooting the Rapids, near Pine Island, NY.

Although there are many public spaces where people may enjoy the River, substantial geographic areas are void of such opportunities. Large stretches of Wallkill River's shoreline remain in private ownership, thus inaccessible to the general public. In Orange County, the residents of Minisink, Goshen, Wawayanda, and Wallkill currently have no access to the Wallkill River. The prevalence of active agriculture operations in the Black Dirt region of Orange County may impede the establishment of public parks or access points on the banks of the Wallkill River within some of these towns, but opportunities should neverthless be explored.

Public stewardship of the Wallkill River could be heightened if more opportunities for public enjoyment were made available, especially in those geographic areas that are void of access points.

[3] Some of this frontage includes land used by the Village of Walden's wastewater treatment plant and therefore may not be suitable for public recreation.



Map 12: Public Access Points

At present, the public has five opportunities to enjoy the major tributaries of the Wallkill River. The Orange County Land Trust's Moonbeams Preserve provides public access to the Shawangunk Kill, which is stocked with trout by the DEC. The Village of Walden's Wooster Grove Park is enveloped by the Tin Brook and provides an opportunity for Village residents to wade and fish in the Brook. The NYS DEC provides multiple access points to major tributaries in Ulster County: one on the Mara Kill and two on the Swarte Kill. These areas are typically for fishing and for launching cartop boats. The Town of Gardiner also has an access point to the Mara Kill and the Mohonk Preserve has a small access point on the Klein Kill.

Other water-related recreation opportunities within the Watershed include public parks with lakes and ponds that the public can appreciate through fishing, boating, or swimming. The towns of Minisink, Goshen, and Wawayanda, unfortunately, have no opportunities for the public to enjoy water-related recreation. While these towns may have small tributaries flowing through some of their public parks, such natural features may or may not be promoted and used as a public resource. It is therefore important that land with access to water within these geographic areas be prioritized for future parkland acquisitions.

Wastewater Management

Wastewater discharges in the Wallkill watershed include individual onsite systems (commonly referred to as septic systems) and municipal collection and treatment plants (Map 13 depicts areas served by municipal wastewater systems.)

Larger municipal discharges in Orange County include systems owned by Middletown, Town of Wallkill, Town of Montgomery, Town of Crawford (serving Pine Bush), and villages of Florida, Warwick, Goshen, Montgomery, and Walden. There are also other smaller systems, some of which are privately owned and operated. In Ulster County, municipal systems serve the hamlet of Wallkill and two prisons in the Town of Shawangunk, part of the Town of Gardiner, and the Village of New Paltz. Several smaller privately owned systems serve the Watchtower farm in the Town of Shawangunk and the Maple Ridge Bruderhof in Esopus. The Town of Rosendale has a municipal system that discharges to the Rondout Creek downstream of the confluence with the Wallkill.

All of these systems discharge to the Wallkill River or to tributaries of the Wallkill. Outside of these communities, with the exception of some small community systems, all wastewater is managed using individual onsite systems that discharge to subsurface absorption fields.

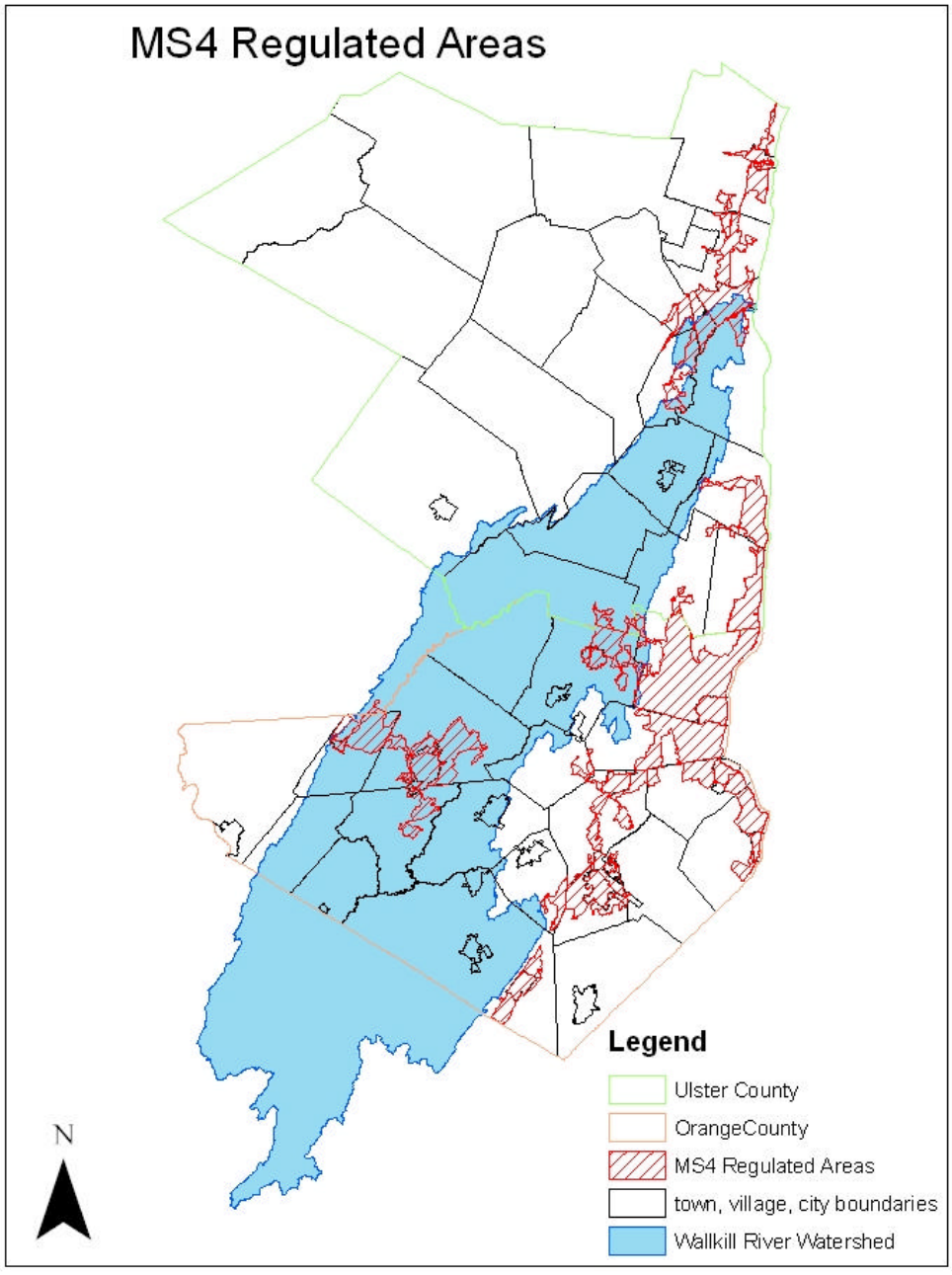
Depending on their daily flow, wastewater discharges are regulated either by each county's Department of Health for smaller systems or by the NY State Department of Environmental Conservation. Regulations governing municipal systems generally require regular inspections, monitoring and reporting to ensure that treated wastewater meets certain standards in the discharge permit. For individual onsite systems, however, there is no state requirement for any regular inspection, monitoring, or maintenance activities. It is up to individual property owners to conduct inspections, pump septic tanks and take other steps to ensure that systems are operating properly. More information on wastewater management issues can be found in the Watershed Issues section.

Stormwater Management

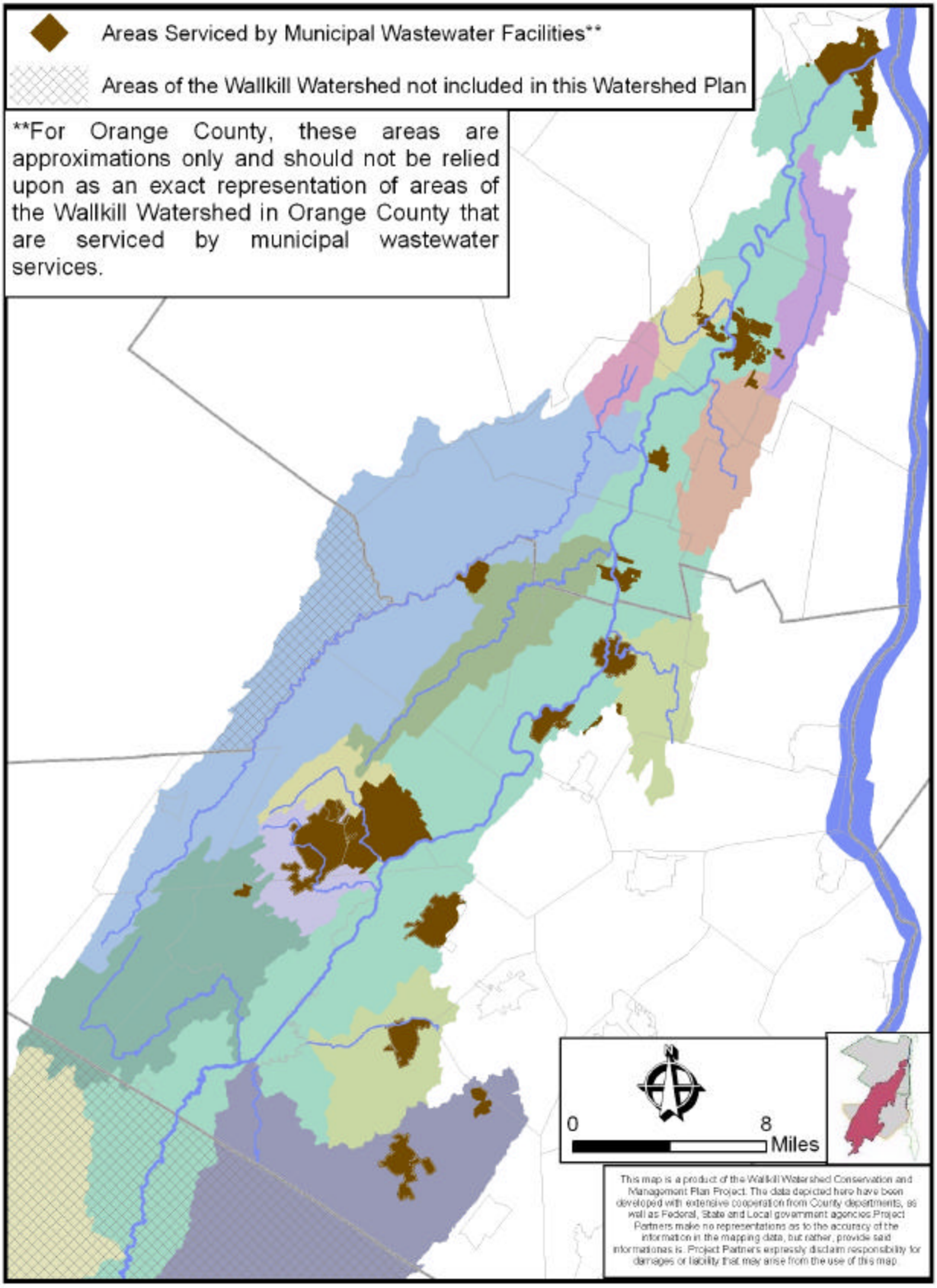
The original focus of many water quality programs growing out of the 1972 Clean Water Act was wastewater treatment for municipal and industrial discharges, which are termed point sources because they emanate from a pipe. More recently, a whole array of contaminants known together as non-point source pollution have been recognized as a major cause of impairment to many waterbodies. It's estimated that non-point source pollution now comprises somewhere between 50-90% of the total pollution load in many water bodies. These pollutants include silt and sediment, fertilizer, pesticides, automotive fluids, road salt, pet waste, septic effluent, and others. These materials are carried to streams and lakes in rainwater and snow melt when it runs off the land.

Current water quality programs, therefore, now include a major focus on reducing non-point source pollution and managing stormwater. These programs include education for property owners

and other audiences and regulations. One new set of regulations known as the Phase II stormwater requirements include permit requirements for operators of construction sites involving disturbance of 1 acre or more of soil, and separately for municipalities and other owners of stormwater systems known as Municipal Separate Storm Sewer Systems, or MS4s (these are designated based on population size and density). These requirements are designed to prevent pollution, capture and treat stormwater runoff from construction sites, implement permanent stormwater management practices (like retention ponds and/or other treatment systems) for development projects over 5 acres, and locate and eliminate certain existing sources of pollution reaching stormwater systems (known as illicit discharges.) There are 17 **(**12 in Orange County and 5 in Ulster County) designated MS4 municipalities that are at least partially located in the NY State portion of the Wallkill watershed. (Map 14) For more information on these regulations and programs, visit the NYS DEC's website: www.dec.state.ny.us



Map 14: Regulated MS4 Areas (Orange and Ulster Counties Only)



Map 13: Areas Serviced by Municipal Wastewater Facilities

III. WATERSHED ISSUES

Citizen Survey

Early in the Management Plan development, the Project Steering Committee (PSC) decided that they wanted to formulate a survey that assessed people's attitudes, knowledge of, and important issues relating to the Wallkill River and its watershed. Several other management plans reviewed by the PSC had done so, and it was deemed to be a useful process for our project. The education sub-committee of the PSC developed a survey form, which was distributed to the full PSC for review and input.

The method of distribution of the survey was an additional topic of discussion. Given the generally low return rate that can be expected from mailed surveys, the PSC decided that a large mass mailing was not a good use of Project resources. Therefore, it was decided that PSC members would individually make efforts to distribute the surveys at various events such as county fairs, farm markets, street festivals, chance meetings, etc. Using this approach, **230** citizen surveys were completed.

An example of the Citizen Survey form, and a summary of the survey results are presented in Appendix C. Though it is not surprising that land development was cited more than any other as a watershed concern, the degree to which this concern outweighed the others is noteworthy. **73** respondents listed land development as their top watershed concern, the next highest concern was litter and debris dumping with **48** respondents listing it as their top concern. Similarly, **112** respondents ranked "expansion of housing development into rural areas" as a "serious problem", while only **10** indicated that this was "not a problem". The next highest ranked "serious problem" was "loss of family farms" (**107** survey respondents). Only **11** of **230** respondents ranked loss of family farms as "not a problem".

It is not the intent of this Plan to suggest that land development be stopped. Despite these survey results, Plan writers realize that this would be an unrealistic and undesirable recommendation. However, we do feel the results lend increased emphasis to and support for other recommendations in the Plan, such as accelerated adoption of smart growth/low impact development techniques, farmland/open space preservation programs, regional planning approaches, and related measures that more effectively control the myriad negative impacts of unbridled (sub)urban development.

Agricultural Issues

1. Black Dirt Region

The high productivity of the muck soils in the Black Dirt Region has led farmers to convert – through methods such as channelizing natural waterways and creating ditches to drain fields – most of the Region from swamp to some of the most productive agricultural land in the area. The high degree of land alteration that has occurred in this Region, however, has been accompanied by many challenges. Natural resource management concerns in this Region are, in many respects, unlike the remainder of the Watershed. The intent of this Plan, as it relates to the Black Dirt Region, will be to promote continued agricultural production while mitigating any associated natural resource impacts to the greatest extent feasible.

In nearby mineral soil areas of the Watershed, farms are inexorably being replaced by homes and related urban development. One might assume that Black Dirt farms were much more secure due to their poor suitability for urban development. However, despite the lack of high land speculation pressures, the economics of farming the Black Dirt is by no means without challenges. Over the past two years, nearly 1,000 acres have been voluntarily removed from production by Black Dirt landowners for a period of ten to fifteen years. Entered into USDA's Conservation Reserve Enhancement Program (CREP), these lands will be maintained in grass/legume cover while the landowner receives an annual rental payment from USDA. There are laudable benefits associated with such land conservation programs, but the extent of acreage removed from crop production raises serious concerns about the economics of farming in the Region.

Farmers that have varied from the traditional practice of raising one primary crop (onions) to more diversified operations such as fresh market vegetable crops have, in general, done very well financially. However, these fresh market crops carry their own set of production and marketing challenges.

These inter-related, and often complex, issues require that natural resource management recommendations take into account their impact not only on natural resources but on all aspects of Black Dirt farming. While economic development is beyond the scope of this Plan, we believe that maintaining a healthy agricultural industry is a desirable goal for the Watershed. To the extent possible, profitability should be pursued in concert with conservation.

° **Flooding**

While channels can be enlarged and straightened to accommodate a larger flow of water, the gradient of the land through which the channels pass cannot be significantly changed. Therefore, a large enough storm will overwhelm even these improved channels. In addition, development in the upper reaches of the Wallkill Watershed sends ever-increasing quantities of water through the Region. These impacts are, in theory, mitigated by modern stormwater management practices. However, while peak runoff rates may be controlled by retention/detention ponds on new development sites, new impervious areas inevitably increase the **volume** of water entering the Wallkill surface water network. Most stormwater management plans do not address these increased volume issues. In addition, imperfect construction and maintenance of stormwater facilities and variable enforcement of stormwater management regulations still allow for potential increases in peak flows.

° **Soil Erosion**

When drained for agricultural production, organic soils become more subject to wind and water erosion. They also tend to oxidize and become diminished in volume as a result of the exposure of the organic material to an aerobic environment. Black dirt areas are generally deemed to be poorly suited for urban development due to their flood hazard and the instability of the soil for structural purposes.

A wide range of practices has been developed to address erosion on agricultural land, but many of them do not lend themselves to the unique black dirt setting. For example, Conservation Tillage has been, perhaps, the most widely used and enthusiastically embraced conservation practice in recent years. The key principle of this practice involves maintaining protective residue on the soil surface throughout the year. This is normally accomplished by reducing the use of conventional tillage implements that bury surface residues. This practice is well suited to commodity crops such as corn, soybeans and small grains, but is much more difficult to implement with small-seed vegetable crops that require a meticulously prepared seedbed. Many other soil conservation practices,

Erosion in the Black Dirt Region occurs when bare soil, dry weather and wind combine.

for example diversion ditches, terrace systems and tree windbreaks, would not be compatible with the regular system of drainage ditches employed on the Black Dirt.

Traditionally, the most common soil conservation practice on the black dirt has been winter cover crop. A number of small grains, including oats and barley, are utilized. It is planted as soon as possible after the crop is harvested, and ideally maintained until spring field operations commence. Within the last twenty or so years, a practice known as spring cover crop has gained widespread use. Barley is sown before onions are planted, and allowed to come up along with the onion seedlings. While still small and manageable, the barley is killed with a light dosage of a grass-specific herbicide. This practice provides soil erosion control, while protecting the small, delicate onion seedlings from the abrasive

action of wind-born soil particles. Winter cover crop application rates vary from year-to-year, but probably average around 50% of black dirt acreage. Spring cover crop is utilized on nearly 100% of fields planted to onions.

Within the last ten years, a practice known as ditch bank seeding has emerged. Up until this time, the banks of the regularly spaced drainage ditches were most often maintained in a vegetation-free condition. A small number of growers began experimenting with the use of a fine-fescue grass mixture for stabilization of the tops and sides of the ditches. This practice holds enormous potential to control erosion and sedimentation in the unique black dirt setting. This is largely because, in addition to stabilizing the actual bank of the ditch, the seeding tends to create a small tuft, or 'berm', of grass at the edge of the field. Soil which moves from the crowned growing bed tends to be trapped by this berm – preventing its entry to the ditch network. There are still a number of management issues with this practice that will require continued attention and experimentation. Currently, approximately 30% of Black Dirt cropland is protected with the ditch bank seeding practice.

Black dirt ditch banks well protected by vigorous sod.

° **Subsidence**

Due to the organic nature of Black Dirt soil, once the water table is lowered for agricultural production it becomes subject to oxidation. This process, combined with other losses such as erosion, causes the surface of the soil to subside at a low, though insidious rate. Careful soil management can slow the long-term subsidence rate.

° **Streambank Erosion**

According to NYSDEC's Priority Waterbodies List (PWL), silt/sediment is the primary pollutant in the Wallkill. Common sources of excess sediment include cropland, urban construction sites, and streambank erosion. Although all of these sources are a factor in the Wallkill Watershed, quantification of the relative contribution of each source was beyond the scope of this Plan.[4]

However, research performed recently and presented in greater detail separately as part of this Plan suggests that streambank erosion is a major source of the sediment load in the Wallkill.

John Gebhards pounds in rebar to allow monitoring of bank erosion, while Kelly Dobbins records site data.

This finding is corroborated by surveys of the Wallkill undertaken by the WRTF and OCSWCD (Appendix D). These surveys were limited to the reach of the River from Oil City Road (near the NY/NJ border) to Pine Island Turnpike. While some significant streambank erosion sites may be present on other reaches of the River, they were not evaluated.

Controlling streambank erosion can take many forms ranging from 'hard' engineering such as durable channels or rip-rap, to 'natural channel design' - including 'geomorphic' approaches. While both approaches can be expensive, there are pre-design expenses associated with the geomorphic approach – required to characterize

[4] See Construction Site Assessment section of Plan that provides a generalized evaluation of construction site activity (and associated sediment generation) in the Watershed.

the stream type and appropriate channel design – that increase the cost of this methodology.

Application of a natural channel design approach to this reach of the Wallkill would seem likely to be a highly challenging proposition given the unique nature of the setting geologically, the amount of drainage manipulation, and the intense agricultural land use. In lieu of the resources and support for such an approach, a more intermediate approach is currently being pursued.

In the mid-eighties, the US Army Corps of Engineers undertook a clearing and snagging project on the Black Dirt section of the Wallkill that included the reach described above. At this time, a number of bank segments were stabilized with rock. A small number of sites received the more 'traditional' rip-rap' approach – with large rock extending up most of the river bank. A greater number of sites were stabilized with much smaller rock placed only at the 'toe' (bottom) of the bank. This less aggressive approach appears to be very effective as the rocks have stayed in place and the banks above them are stable.

Small rock at the toe of the bank has proven effective on this reach of the Wallkill

Projects of this nature will require trained engineer involvement, and will involve custom designs based on the individual characteristics of each site. This Plan recommends that the less aggressive approach be utilized to the greatest extent possible. On sites where extensive erosion has already occurred, considerable bank shaping and sloping is expected to be necessary. With employment of appropriate sloping and vegetative stabilization for upper banks, it is hoped that the small rock toe stabilization will provide adequate protection without resorting to full-scale bank armoring.

OCSWCD and the Wallkill Valley Drainage Improvement Association (WVDIA) have been studying this issue for many years and have sought support and financial resources for dealing with it from multiple sources. A maintenance agreement for this section of the River, which was required as a condition of the Corps project, is in place to maintain basic channel capacity and flood control functions. The agreement is funded by the four benefiting towns (Warwick, Wawayanda, Minisink and Goshen) and the County of Orange. It generally does not allow for capital improvements such as the bank stabilization measures described above. The Corps has been contacted to determine if they can revisit the Project area to better address bank erosion concerns as well as more general agricultural water management concerns.

In October of 2005, OCSWCD submitted a proposal to the New York State Agricultural Nonpoint Source Abatement and Control Program. The proposal included several bank stabilization projects in this eroding section of the Wallkill. Funding for this proposal has been approved, and the streambank projects are in the design phase. It is hoped that these projects will provide a foundation for continued stabilization of this section of the River. Not only will these projects help to maintain agricultural drainage functions, they will address one of the primary sources of pollutants to the River.

Similarly in Ulster County, soil erosion due to streambank degradation is a significant concern. Establishment of riparian buffers along the Wallkill River and its tributaries is a high priority in the Ulster SWCD annual plan of operations. The SWCD, in conjunction with the New Paltz Environmental Commission, has established a greenway along the Wallkill River to provide habitat diversification, streambank stabilization, and provide a buffer for runoff into the Wallkill River. This is a three year project of assessing the effectiveness of different native species in a buffer setting.

A considerable amount of acreage devoted to sweet corn grown in Ulster County is found within the Wallkill River Watershed. There is also a significant amount of grain corn grown within

the areas primarily devoted to sweet corn. From these land uses, there is notable soil erosion and nutrient runoff from many areas. There was also an increase of nine percent between 1997 and 2002 for acreage that received commercial fertilizer, lime and soil conditioners.

Undercutting of the toe eventually results in huge sections of River bank collapsing into the channel.

During wet periods, many crop fields in low-lying areas are water saturated and are in need of drainage. This further exacerbates erosion and nutrient runoff. This affects farms, home owners and municipal officials. The sediment in streams impairs fish habitat and carries pollutants into streams, degrading water quality. It also becomes an economic issue when excess sedimentation drives up operational costs of municipalities. This can lead to additional taxation, which is a major operational constraint for many farmers. Many identified problem areas can often be mitigated through the introduction of riparian buffers and other field borders. Protection of stream banks from erosion with riparian plantings and structural reinforcement is a high priority in Ulster County.

2. Ulster County – Agricultural Environmental Management Program

Agriculture has long been identified as a contributor to non point source pollution. In an effort to address this issue nationwide, the United States Environmental Protection Agency (EPA), has asked each state to come up with a plan for compliance. The two state agencies charged with preparing New York State's response are the NYSDEC and the State Department of Agriculture and Markets. These two agencies approached their other conservation partners to enlist their expertise in preparing a plan. These partners include, but are not limited to: the New York State Soil and Water Conservation Committee (NYSSWCC), the USDA-NRCS, and Cornell Cooperative Extension (CCE).

The conclusions made, and the approach developed by this collaboration was that the best results could be attained via a program that would be based upon voluntary participation. This program was named Agricultural Environmental Management, or AEM. It was also decided that the bulk of the program would be coordinated and administered at the local County field office level, primarily by the County SWCDs, USDA-NRCS, and CCE. Each County was charged with developing a five year Strategic Plan for the period of 2005-2010. The developed plans were to be implemented on a prioritized watershed basis.

The Ulster County AEM Strategy Team identified the Wallkill/Rondout Planning Unit as its highest priority watershed as it is the largest in Ulster County, and has the most agricultural operations. This watershed is also experiencing serious development pressures, particularly in southern Ulster County. There has been a substantial increase in the number of new homes and other developments. This has considerably reduced the overall amount of vegetative cover and open space. Lack of sufficient riparian buffer, reduced forest cover, an increased amount of impervious area, along with poorly drained, flood prone soils in many areas, adversely impact the quality of surface water, ground water recharge and contribute to wetland degradation.

The increasing trend toward urbanization is often in conflict with traditional agricultural activity, and often in competition for available natural resources. The Ulster County SWCD, USDA-NRCS and CCE are working with the agricultural community to assess and identify any situations that may adversely impact the quality of surface water runoff and ground water recharge, and to minimize any impact that agricultural operations may have within this watershed.

For example, the horse farm industry is rapidly growing in Ulster County and has been identified as one of the groups that will be a part of its AEM Strategy, which will assess the status and environmental needs of horse farm owners within

the watershed. The Ulster County AEM team has already begun the process of extrapolating the results of the Horse Farm Survey that was carried out during the development of this plan. This effort is described in greater detail below. Survey respondents are now being engaged in the AEM process. Tier I and II will build upon the preliminary data gathered from the Horse Farm Surveys, and identify operational components in need of planning and ultimately corrective implementation, such as manure disposal and composting that are also described below.

3. Horse Farm Issues

A perceived issue at the beginning of this project was a need for better management of the manure generated by horses. While dairy farmers generally grow ample acreages of feed crops to which their manure can be safely applied as a soil amendment, horse farms, in general, do not manage extensive crop acreages and were thought to often lack adequate land resources and farming equipment suitable for manure application.

Chip Watson, a horse owner and chairperson of the New York State Horse Council and the Orange County chapter of the Mid-Hudson Horse Council, joined the Project Steering Committee early on, and worked closely with Project staff to formulate a plan to reach horse owners, and assess their current management and needs.

A short survey form was developed (Appendix E) and distributed through numerous avenues. Towards this end, a noteworthy partnership was established with Nutrena Feeds, a major supplier of horse feed. Nutrena agreed to send our survey mailing to all the customers in the watershed- a total of 631 surveys. In addition, as an incentive to complete the survey, horse owners were offered a free bag of feed. Although the response to this mailing was not overwhelming, Project staff were very pleased with the willingness of Nutrena to work with us on this project, and the establishment of a partnership with the private business community. The survey was also promoted on 'Horse Talk", a local radio show which Ms. Watson co-hosts, and at other educational events, such as a composting seminar at Cornell Cooperative Extension in 2004.

To date, 104 surveys have been completed and returned, reflecting 2049 horses. See Appendix E for a summary of the horse surveys. These surveys by no means provide a complete picture of the extent of land managed by horse operations or horse numbers in the watershed, as we had originally hoped to do. However, they did prove to be very useful in assessing issues of importance to horse owners.

° **Technical Assistance to Horse Owners**

One of the issues this survey documented was the need by horse owners for agronomic and engineering technical assistance. This was no surprise to Project staff - it is common knowledge to conservation planners that confining large animals often results in sloppy and muddy conditions which, depending on site characteristics, can sometimes lead to water quality concerns. Solutions usually involve structural engineering practices. In addition, with land resources limited and horses often stocked in pastures at higher than recommended rates, the need for pasture management/agronomic advice was also not an unexpected finding. SWCD, USDA and CCE staff have assisted horse owners with these needs, but only to a limited extent as a consequence of staffing constraints. More 'traditional' agriculture, such as dairy and vegetable farms, has received most of the available technical and financial assistance.

° **Manure Management**

The horse farm issue that Project staff were particularly interested in was that of manure management – what horse owners were doing with their manure. As can be seen in the compilation of survey responses, approaches are quite varied. In many cases, horse owners have found creative and/or environmentally sensitive ways to utilize the manure generated by their horses.

However, 63.5% of survey respondents indicated an interest in a 'regional horse manure management project, such as a regional composting facility'. Horse manure readily composts, and could be put to favorable use both on commercial agricultural lands and in the home landscape setting in cases where horse owners do not have adequate land resources – which seems to be a fairly common scenario in this watershed. The key to making such an idea work lies in exploring the economic and logistical issues associated with transporting the horse manure

from its points of generation to planned composting facilities.

This issue has been explored at some length by Project staff. Since the economics of moving the material long distances clearly was a factor, especially given current fuel prices, the idea of somewhat smaller 'satellite' composting areas has been explored and is thought to be feasible. Some potential users of compost, such as vegetable farmers and landscapers, were interviewed and some indicated a preliminary interest in receiving and composting horse manure – especially if financial assistance were available for construction of the composting area. Many horse

Composting in a greenhouse structure.

owners, likewise, would be happy to give away their manure, even pay a reasonable fee for the service. In fact, some horse owners are currently paying haulers to cart away their manure. The destination of this carted manure is not entirely clear, but is thought in many cases to be a sanitary landfill – an unfortunate use of limited landfill space for a material that could be an asset in the right situation.

We have even canvassed commercial haulers to assess their potential participation in a regional horse manure management project, and at least one indicated a willingness to work with us on reduced-rate hauling from horse farms to composting areas. The attractiveness of this option is that carts would be delivered and picked up by the hauler – no special or expensive loading equipment would need to be maintained by the horse owner. Alternatively, landscapers or other owners of small scale dump equipment might be contracted to pick up horse manure. This option could be especially attractive where the horse owner already has a loader tractor that could be made available to the contractor.

It is worth noting in this context that the Black Dirt soils, described above, provide a potentially huge sink for usage of horse manure. Although this idea has not been discussed at length with black dirt owners, it is well recognized that the black dirt resource diminishes over time as a result of oxidation and related mechanisms of loss. Replacement of organic matter via horse manure could partially offset these losses. Horse manure is inherently more dry and stable than dairy manure, when composted even more so. These characteristics would tend to lessen concerns associated with placement of animal manure in the black dirt setting with its intimate surface water association.

4. Other Agricultural Issues

One of the primary resource concerns with the silty-textured, often strongly sloping soils that dominate the Wallkill Valley is soil erosion from surface runoff. The Erosion and Sediment Inventory Study prepared by the Soil Conservation Service in 1975 (updated 1985) documented average soil erosion rates on cropland in the Upper Wallkill watershed at 10.5 tons/acre/year. The soil loss limit that is considered to be tolerable on these soils is 3 tons/acre/year. Not only do excessive erosion rates compromise the long-term productivity of the land resource, they contribute to degraded water quality when eroded soil and associated pollutants find their way to streams, lakes or other water resources.

There are additional potential water quality impacts associated with livestock farms resulting from improper management of barnyard facilities, manure and feed storage. Animal holding areas typically experience high levels of animal and tractor traffic, and manure deposition. In addition, farmsteads may discharge wastewater (for example from milking centers) and store feeds that produce tainted runoff. Animal manures spread on fields using proper management practices improve soil tilth and fertility; however, poor spreading practices can result in water quality degradation.

In general, the above concerns are decreasing in the Watershed as commercial livestock operations

go out of business and associated cropland areas go out of agricultural use. As noted elsewhere in this Plan, there are ample and important reasons for trying to preserve agriculture. Hopefully, existing and future efforts to maintain a viable agricultural industry will be successful, and resources will continue to made available for agencies such as Soil and Water Conservation Districts and USDA NRCS to assist these remaining farms in addressing soil quality and runoff control measures.

Education

The importance of education efforts – for municipal officials, builders, engineers and others – in effecting improved watershed protection is mentioned in several sections of this Plan. An area of education often neglected, though, is that of youth education. It can be argued that instilling natural resource stewardship values in young people is an effective, if not essential, component of watershed protection. Yet financial resources available to support such efforts can be very difficult to secure. Orange County SWCD has found this to be one of the most challenging program areas to fund.

Despite these challenges, Orange County has to be considered a leader in terms of youth conservation education efforts. Currently, a full-time staff person at OCSWCD devotes most of her time to youth conservation education (focused largely on the formal school setting), and two contract educators from the Orange County Water Authority conduct complementary programming. Many other organizations deliver conservation education programming, though the availability of these programs often seems to depend on the vagaries of annual budget decisions.

As our young people grow up and become decision makers in their communities, we are convinced that locally oriented lessons they experienced will stay with them and influence their adult behavior.

Challenges to Biodiversity

Major impacts that humans have had on the watershed's biological diversity can be outlined as:

° **Degradation of Habitat**
Few, if any, habitats in the Wallkill Watershed are unaffected by the presence of humans. We eliminate natural cover such as trees or shrubs to make way for buildings, pavement, or non-native plant life, while polluting or disturbing other habitats that we don't remove. Even areas that are out of direct human reach are still vulnerable to acid precipitation, groundwater pollution, and the effects of human-induced global warming.

° **Creation of a Fragmented Landscape**
Construction of roads, canals, railroads, airports, drainage ditches, dams, power lines and fences; a dramatic rise in the rate of housing construction and tree removal, notably in the last few decades; and increases in the average residential lot size (which spreads the impacts across more area) all slice the natural landscape into smaller, less valuable tracts of land. Fragmentation reduces the ability of individual animals to move from one place to another and can lead to habitat isolation. Wildlife populations in isolated fragments are stressed more readily than populations with more land area, food, water, and habitat. Fragmentation and isolation seriously threaten biological diversity and the functioning of natural systems.[5]

° **Wetland Degradation and Loss**
Though wetlands serve many valuable functions, they are frequently assaulted through contamination, isolation (from adjacent habitats), drainage, filling, or other destruction. A historic example is the Black Dirt Region in southern Orange County, which was originally a vast Atlantic white cedar swamp. It was cleared and drained for agricultural uses due to its fertile muck soils. Today, there are only a handful of Atlantic white cedar swamps in the County. This natural community is extremely rare elsewhere in New York State as well.

° **Channelization of Wallkill River**
In the 1940s, the Army Corps of Engineers created an alternate route for the Wallkill's channel, digging a straighter, deeper channel in order to move water downstream faster and

[5] Soulé, M. 1991. Land use planning and wildlife maintenance: Guidelines for conserving wildlife in an urban landscape. Journal of the American Planning Assoc. 57(3):313-323. Forman, R. 1995. Land Mosaics: The Ecology of Landscape and Regions. Cambridge University Press, Cambridge.

alleviate much of the frequent flooding the Wallkill triggered. Unfortunately, this channelization has reduced species diversity and impaired water quality in the River. Channelization directly removes fish, invertebrate, amphibian and reptile habitat. In addition, it aggravates stream sedimentation that smothers habitat. Today, fish species are minimal and a high percentage of those present are not native to the River. In 1936, there were 48 species of fish in the River; in the early 1990s, only 16 species were found and at number totals just one quarter of the total fish population that was present in 1936. As well, water levels and biological diversity of wetlands flanking the river have also decreased, because the channelization has separated them from the water flow.

° **Modifications to Riparian Zone**
The greatest threat to stream biodiversity may be the total clearing of riparian vegetation for residential or commercial development. Forested areas along streams have many crucial functions. They act as wildlife refuges; provide shading and woody debris important to the stream ecosystem; mitigate flood damage; help protect the stream bank from erosion; and filter out pollutants from upland runoff.

° **Creation of Impervious Surface**
Construction of buildings and the paving of the ground not only displace species by eliminating habitat, but increase impervious surfaces that directly impact water quality and local species distribution.

Water Quality Degradation

Some symptoms of impaired water quality for fish and wildlife include:

° **Sedimentation** is excess suspended sediments in surface water caused by soil erosion along stream banks or in upland areas of the watershed. It can smother the nests of fish, salamanders, and invertebrates eaten by predatory fish such as trout.

° **Excess nutrients** in surface water results from sewage outfalls into streams as well as from land uses that involve fertilizers. Too many nutrients (mainly nitrogen and phosphorous) cause algal blooms that lead to **low dissolved oxygen levels**, often killing large populations of fish and other aquatic life.

° **Temperature increases** result from deforestation along stream banks, eliminating shade, and increasing warm surface water runoff into streams. Warming of water changes the species composition within streams.

° **Toxic substances** have the potential to accumulate in the tissues of animals and cause harmful effects. Though little is known about toxins in the watershed, potent chemicals continue to be discovered throughout the area. DDT and PCBs have already been documented within the Wallkill River, while substances such as dioxin, polycyclic aromatic hydrocarbons (PAHs), prescription and over-the-counter drugs, brominated diphenyl ethers (BDEs), and other endocrine disruptors all have the potential to be harmful and require more study to determine their effects on wildlife.

° **Stormwater contaminants** arrive in many streams through storm drains that empty runoff from streets and parking lots. Myriad pollutants, liquid and solid, in this water impair the health of streams and stream banks.

° **Dam construction** – Of all of the dams that were installed along the rivers and streams to produce hydropower for mills, scores of them were never demolished. Presently, there are four major dams in the watershed, located at Montgomery, Walden, Wallkill and Rifton, which are still used to generate hydroelectric power for industrial and other users. Dams impede migration of fish and other aquatic species. They increase water temperature, lower the amount of oxygen dissolved in the water, decrease water flow, and ultimately change the aquatic environment. (Appendix F)

Wetlands Degradation

There are thousands of acres of mapped wetlands in the Wallkill Watershed. In addition, many thousand more acres that have not been mapped could be expected to meet federal wetland criteria based on soil and vegetation if watershed-wide mapping were to be done. As an example, new development sites of any substantial size commonly contain federal jurisdictional wetlands

once they are studied by a qualified wetlands delineator. A full discussion of wetland regulations is beyond the scope of this Plan, but it is noted that wetland regulation takes place at the federal, state and, in some cases, local levels. This system is by no means fool-proof at eliminating wetland losses – multiple small areas are filled or otherwise destroyed under exemptions and permits and, undoubtedly, illegal operations remove additional acreage. Nevertheless, it can be argued that **wetland quality** may be more of issue in the Watershed than **wetland losses**. A great many of our present wetlands are dominated by non-native and invasive species – most notably Purple loosestrife, Phragmites and Reed Canary Grass.

In some cases, the watershed has actually **gained** wetlands as farms have gone out of business and wet fields that were formally drained by the farm operator revert to wetland conditions. Typically, though, these areas would be colonized by the species mentioned above as opposed to the plant communities that comprised the wetland before human intervention. Although some reputable authors have suggested that these species are not as valueless as commonly believed (see, for example, writings by Eric Kiviat in *"News from Hudsonia"*, Volume 14, Number 2, 1999), we believe that historically natural wetlands in this region supported more diverse plant communities, and that such communities were more beneficial to a wider variety of wildlife.

In fact, the NYSDEC ranks their wetlands into three classes, and domination by non-natives such as Purple loosestrife would normally give a wetland the lowest (Class III) level of protection.

It should also be noted that runoff from (sub)urban development threatens to further degrade existing wetlands, especially where no local regulations exist to provide for buffers between wetlands and site improvements.

Stormwater Management

The Orange County - southern Ulster County area is currently one of the fastest growing regions in New York State. With a population that is inexorably increasing, and with the Rte.17/I-84/I-87 'Golden Triangle' road network continuing to foster commercial growth, erosion and sediment control, and stormwater management, have to be considered leading water quality concerns in the Wallkill Watershed.

Technical reviews on behalf of local governments focused on erosion and sediment control and stormwater management have been available through the SWCD since the building boom of the 70's and 80's. However, these reviews occurred only at the request of local government, and only a small fraction of development projects received SWCD review. A far higher percentage of project proposals receive water quality-related review by private consultants representing the local municipalities, but the success of this system in protecting water resources is much in question. Casual observation of construction sites by local technical staff has, for many years, suggested that very little knowledgeable attention was being paid to erosion and sediment control. (Witness, for example, the common construction site benchmark of the silt fence – as often as not 'flapping in the breeze' while silt flows underneath, or, improperly installed up-and-down the hill – concentrating runoff and **causing** erosion rather than controlling it.). More recently, largely as a result of funding made available through NYSDEC which supports SWCD technical staff, scores of in-depth construction site reviews in the Watershed have reinforced earlier casual observations. Some sites have poorly designed erosion and sediment control plans on paper, while others have fairly good ones. In both cases, though, results in the field have been quite dismal. Site contractors either pay limited attention to the site's erosion control plan, or lack the knowledge and training to install and maintain the practices described in it.

Uncontrolled urban erosion.

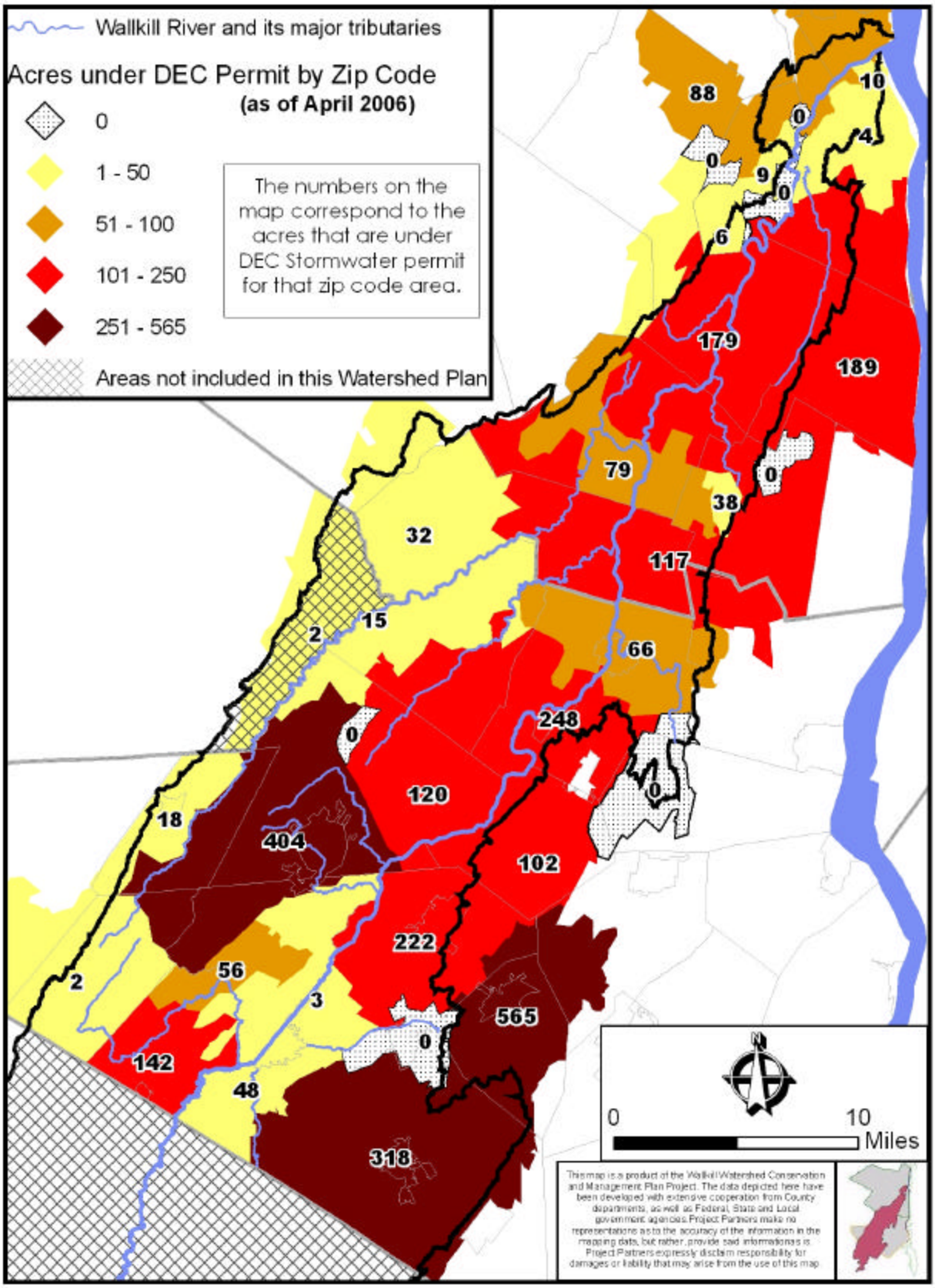
While the erosion and siltation associated with urban construction activities are primarily limited to the active construction phase when large areas tend to be disturbed and unprotected with vegetation, the impacts can be severe. For example, the *New York Standards and Specifications for Erosion and Sediment Control* offers sample calculations for a typical NY construction site where the erosion rate during the active construction phase is over 100 tons per acre per year (page A.2). For comparison purposes, erosion from a forested or grassy area would be expected to be less than 1 ton per acre per year. Where water resources such as streams are associated with the construction sites, there is high potential for movement of soil and related pollutants to enter and degrade the aquatic system.

The suggestion that urban pollutants are impacting water resources in the Wallkill Watershed is corroborated by NYS DEC's Priority Waterbodies List. The Wallkill River, and a number of its tributaries, are listed in this document. Silt/sediment is cited as a primary pollutant (of the Upper Wallkill), and urban runoff is cited as a suspected source. So far as we know, no research has been conducted to assess the portion of the Wallkill's sediment load that originates from (sub)urban as opposed to other sources. But given the documented high rates of erosion from construction sites, the rapid pace of development in the Watershed, and the questionable effectiveness of erosion and sediment control efforts on these sites as alluded to above, targeting urban sources must be considered a prudent management goal. See page 31 of this Plan for a summary of the suspended sediment study that was undertaken on the Wallkill in 2004/2005.

In an effort to gain a slightly greater understanding of urban erosion threats and where they are most concentrated in the Watershed, an investigation was made using construction permit data from the NYSDEC. For convenience of GIS analysis, the map (Map 15) is organized by zip code areas (note that some areas outside the Watershed boundary are included in this study area). The map shows which zip code areas have the highest acreage under construction as reported in NYS's stormwater phase II general permit database. While calculation of tons of sediment generated was not possible, this procedure at least provides a general measure of construction activity. Given the potentially huge per acre erosion rates from urban construction sites, as described earlier in this Plan, this evaluation underscores the need for accelerated urban erosion and sediment control efforts.

It is well recognized that, even after urban development projects have completed construction and stabilized bare soils, water quality threats continue. These impacts will not be elaborated here since they are well described already in many publications (see, for example, the *New York State Stormwater Management Design Manual*), but include both **quantity** (eg. flooding, streambank erosion), and **quality** (eg. eutrophication, bacteria) issues.

Construction phase **and** post-development water quality concerns are regulated in NYS by the Stormwater Phase II program mentioned above, but regulation does not automatically mean adequate protection of water resources. As of 4/06, there were approximately **222** (Orange County) active construction permits in the zip code areas intersecting the Watershed. (All sites disturbing more than 1 acre are required to gain coverage under this general permit. Given this low threshold and the relative newness of the regulation, it is thought that many additional construction sites are operating without having gained coverage under the permit program; therefore are not reflected in these numbers). Despite accelerated efforts of NYSDEC and SWCD's, technical staffing is currently far inadequate to allow for comprehensive oversight of this program. It is worth noting that the construction permit includes, for most sites, a requirement that weekly inspections be done by a 'qualified professional'. Unfortunately, despite enormous costs associated with these weekly inspections, it can be argued that these required inspections are of limited usefulness in improving water protection efforts. The reasons for this lack of effectiveness are as described above, combined with the fact that the consulting engineering firms performing the inspections have limited authority/influence to enforce their inspection recommendations. As with site operators/ developers, education is also an issue with some private inspectors. While the regulation states that the inspections will be done by a 'qualified professional' (or a technician working under



Map 15: NYSDEC Construction Permits

proper supervision), the qualifying titles (eg., professional engineer, landscape architect) do not assure that the qualifying individual commands a thorough understanding of the art and science of erosion control and stormwater management.

This parking lot borders and drains into a tributary of the Wallkill.

Current Post-construction Water Quality Treatment Criteria

An additional stormwater management concern is the degree of pollutant reduction (or increase?) that can be expected from new developments. New York State's *Stormwater Management Design Manual* establishes the minimum requirements that must be met on new developments. For projects required to provide post-construction stormwater management (generally, those that disturb more than five acres), a list of "acceptable stormwater management practices" is provided. Use of one of these practices is "…presumed to meet water quality requirements set forth in (the) manual..." (Page 5-1). While practices on this list are expected to provide 80% removal of Total Suspended Solids, they are only expected to be capable of 40% removal of Total Phosphorus. The removal rate for other 'dissolved' pollutants (as opposed to those attached to settleable solids) can be expected to be in a similar range. Since a significant portion of typical urban pollutants are dissolved, and since the land cover and land use changes associated with new development tend to significantly increase pollutant loading relative to the pre-development condition, the efficacy of this approach to addressing stormwater impacts from new development comes into question. While the Manual does encourage the use of auxiliary practices to improve overall pollutant removal efficiency, they are not required; therefore little incentive is provided for water quality protection efforts beyond the employment of one of the "acceptable practices".

Outdated Stormwater Systems

An additional urban issue, often overlooked, is the contribution of older urban areas to water quality stresses. While current governmental guidance encourages officials in urban areas to consider improved management measures for existing developed areas, such measures are not required. Such a requirement would be a near unfathomable economic burden and engineering challenge. Nevertheless, as financial concerns and logistical issues allow, stormwater *retrofits* are being pursued and further opportunities for them should be thoroughly studied, especially in urban areas which drain to stressed water bodies.

Water Supply, Quantity and Allocation Issues

In addition to demand for additional water supplies created by new development, several other factors may influence the future availability of water and affect streamflow, groundwater levels, and the hydrology of wetlands in the watershed. One key factor will be how much new impervious surface cover, which will affect groundwater recharge capacity, is created as the watershed is developed. Others include the extent to which water conservation measures are implemented in new and existing development, and whether wastewater treatment systems are designed to recharge groundwater or include other wastewater reuse options. Several groundwater studies in the region have found that use of central sewers can potentially lead to depletion of ground water supplies because water is effectively exported out of the local watershed. When combined with increased impervious surface cover, this effect could potentially lead to lowered groundwater levels, reduced baseflow to streams, and adverse impacts on wetland hydrology.

Another major factor that may cause significant changes to the watershed's hydrology is climate change, which is predicted to cause changes in the pattern of precipitation including less frequent but more intense storms. While the total volume of precipitation may not change significantly, and

there is significant uncertainty about these issues, these predicted changes could lead to higher volumes of surface runoff and reduced groundwater recharge. As the watershed continues to experience population growth and development, the combined issues of increased consumption of water, new impervious surfaces, and possible changes in precipitation patterns will potentially result in water shortages. These trends will also potentially lead to conflicts between competing uses and demands for water. For example, if water supply systems are expanded, this may lead to lower streamflows and/or groundwater levels as water is withdrawn from streams and/or wells. This will potentially affect streamflow in the Wallkill River and its tributaries. Pumping of municipal wells located near to the Wallkill River, which are closely connected to the river, would have a direct effect on water levels. As noted above, decisions about whether to use centralized sewers or decentralized strategies for wastewater management also can affect groundwater levels and streamflow patterns. (Figure 8)

Information on stream flow, precipitation patterns, groundwater levels, and other basic data needed to consider water supply issues and trends are very patchy and incomplete. There is currently no monitoring station to collect and archive precipitation data in the Orange County portion of the Wallkill Watershed (data is reportedly collected at the Orange County Airport in Montgomery but is not retained or archived). There is no operating stream gauging station to measure stream flows in the Wallkill Watershed in New Jersey or in Orange County (an old station south of Unionville in NJ is no longer operating due to budget cuts). There is one gauging station on the Wallkill River in Ulster County at Gardiner. Few, if any, municipal wells have equipment to measure groundwater levels.

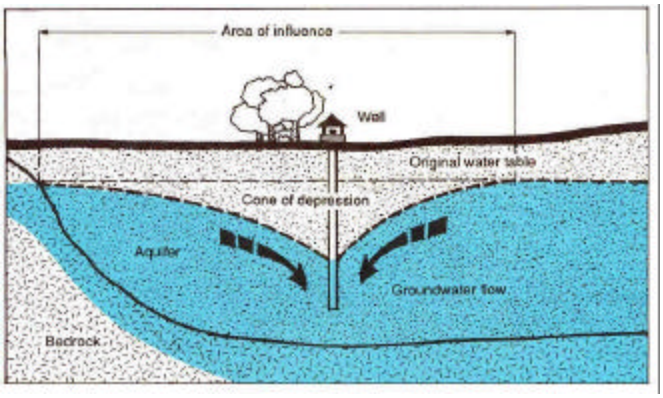


Figure 8: Groundwater being pumped into a well lowers the water table near the well. Diagram from Bulletin No. 1 "What Is Groundwater?" Lyle S. Raymond, Jr., NYS Water Resources Institute, Center for Environmental Research, Cornell University.

Increased funding and other resources are needed to address these data gaps. Some of these measures may be implemented at a local or county level, but some will likely require state or Federal funding.

Quality of Existing Wastewater Infrastructure

State regulations require a discharge permit for any wastewater system discharging 1,000 gallons per day (GPD) or more to the soil (such as onsite or small community systems using soil absorption fields). This permit is called a State Pollutant Discharge Elimination System, or SPDES, permit. A SPDES permit is also required for direct discharges to a stream or river of any size. Onsite systems discharging to the soil smaller than 1,000 GPD are regulated by separate regulations- the NY State Sanitary Code, part 75A.

Information about existing treatment systems with a SPDES permit is available from the state and Federal governments.

Beginning in 1972 and ending c. 1990 large Federal grants were available for wastewater infrastructure, and many of the existing municipal sewer systems and treatment plants in the watershed were constructed or upgraded between the 1970's and 1980's. Since 1990, almost all available funding is in the form of loans from the State Revolving Fund and grants are generally not available in most cases. Wastewater infrastructure, like all technology, has a limited lifespan before it must be replaced. Some of the sewer systems and treatment plants constructed 20-30 years ago are or will soon be reaching their estimated life span. As they age their function can decline and it is believed that the quality of discharges may begin to decrease unless and until major improvements are made. As a result, large new capital investments are likely to be necessary in coming years.

Another well-known issue that affects the quality of wastewater discharges and the ability of infrastructure to protect water quality is known as infiltration and inflow, or I&I. This results when rainwater at the surface or underground leaks into sewers and manholes. In larger storms, this can lead to large volumes of stormwater flowing to wastewater treatment plants, sometimes causing overflows of untreated sewage when the flow exceeds the plant's capacity.

Another problem that receives less attention is the reverse – when wastewater leaks out of sewers through leaky joints or cracks. This can lead to discharges of raw (untreated) wastewater to groundwater. These problems are generally hard to measure so their extent is not well documented, but it stands to reason that water will flow through cracks and leaky joints in either direction. Finally, centralized sewers may cause another problem – localized lowering of the water table because the trenches in which sewers are installed act as large French drains.

While these problems are generally known to exist throughout NY and the US, the specific locations and extent of such problems in the Wallkill watershed is not well-documented. The Village of New Paltz recognizes this condition exists with their infrastructure and is researching the remediation and funding required to address this situation.

One preliminary analysis of the larger SPDES discharges to the Wallkill River in Orange County was conducted recently by the Wallkill River Task Force. This study, based only on data available from routine reports submitted by the municipal permitees, found that several municipal systems are apparently very often in violation of their discharge permits for various parameters. This analysis, and other scientific and anecdotal information suggesting that wastewater discharges may be causing significant water quality problems, indicate the need for more detailed research on these questions.

In any case, it's quite clear that there is a major gap between existing resources and funding needed to upgrade existing wastewater infrastructure, let alone build new systems. This is true nationwide, and NY alone needs about $20 billion for wastewater system upgrades over the next 20 years, the largest funding shortfall of any state.

Individual onsite (septic) treatment systems, as noted above, are permitted by the Departments of Health (DOH) in most counties in NY State, including Orange and Ulster. The regulations focus on system siting and design and there are certain differences between the two counties. In general, though, unlike larger treatment systems, there are no regulations requiring ongoing monitoring, inspection, or maintenance of onsite systems. It is up to property owners to decide whether and how often to have septic tanks inspected and pumped out. Nationally, 10-20% of septic systems are estimated to be failing at any given time, but this is based on very incomplete data and may not be reliable. Anecdotal reports suggest that even today, septic systems are being installed and/or operated improperly in the Wallkill Watershed and other parts of NY State. In any case, there is general agreement that more training is needed for installers and inspectors, and the NY State Onsite Training Network, based at SUNY Delhi, is a partnership of NYS DEC and other organizations that provides training workshops around the state to address this need. The US EPA and NYS DEC are also encouraging local municipalities to develop management programs for onsite systems.

The NYS DEC and SUNY-Delhi co-sponsor a statewide training program, called the Onsite Training Network, intended to improve the quality of onsite wastewater system siting, design, inspection and management. Workshops are held around NY State and can be arranged at the request of local governments or other organizations. Information about this program is available online at: **http://www.delhi.edu/corporateservices/otn_wastewater_programs.asp**, or at 800-96-DELHI.

Natural Resources Management in a Home Rule System

New York is a 'Home Rule' state, a factor that impacts the delivery of environmental protection programs as much or more than it does other public policy. This is evidenced perhaps most in the role of local planning boards.

While developers are obligated to comply with both federal and state regulations in the areas of,

for example, wetlands protection, transportation issues, and sewer and water, the local planning board holds enormous influence over the nature and specific characteristics of Site/Subdivision plans that come before the municipality. Admittedly, the rules/guidelines under which the planning board operates may have been designed by another municipal entity such as the Town Board. In any event, the potential impact in terms of successful natural resource protection programming, of an effective partnership with local municipal government cannot be overstated. For example, wetland and watercourse protection beyond the minimum protections offered by state and federal regulations is most commonly and effectively done by local law or ordinance. Local government employees can obviously keep much closer tabs on activities in their own jurisdiction than federal or state employees with often wide-ranging geographic areas of responsibility. Other innovative [but not mandatory] land use principles such as Low Impact Development, which hold tremendous potential to mitigate the negative impacts of (sub)urbanization on natural systems, can best be brought into the mainstream by local governments.

To understand how municipalities compared to one another in terms of local regulations, the Planning Departments from Ulster and Orange Counties completed a review of municipal plans and codes. Both Orange and Ulster County Planning Departments examined the master plans, zoning codes, subdivision regulations, and other relevant municipal land use documents for all municipalities within the Watershed during this planning process. The intent of this study was both to develop an inventory of existing municipal land use goals and regulations, as well as to determine if any generalizations could be made in regards to local environmental regulations within the Watershed. Appendix G contains the spread-sheet developed by the two Planning Departments.

A primary finding of the research was a widespread disconnect between master plans and the local codes and regulations that were meant to implement the visions within the master plans. Master plans were nearly unanimous in their support for maintaining rural character and protecting natural features, while activities within the municipality (development and construction activities, for example) did not support the stated vision.

There are myriad explanations and reasons for this trend - which was not a surprising find - and there are indeed many courses of action that could be taken to improve this scenario. The development of focused advisory councils, such as conservation advisory councils (CACs), could potentially help to make this connection if those councils were both comprehensive in their inventories of natural and cultural resources, as well as effective at protecting these resources through their advisory role to the municipal boards and officials.

Other key findings include:

- A lack of adequate protections for wetlands, watercourses and steep slopes
- A higher proportion of Ulster County communities have a council committed to environmental or natural resource protection as compared to Orange County communities
- Few communities required that sensitive or unbuildable environmental areas be subtracted from net area during calculation of lot number during the subdivision process
- Orange County communities are more likely than Ulster County communities to utilize overlay zones as methods of protecting natural resources

IV. RECOMMENDATIONS AND IMPLEMENTATION STRATEGY

Black Dirt Region

1. Soil Conservation

Continued promotion and support for black dirt soil conservation measures, especially winter cover crop and ditch bank seeding, is necessary. In addition to financial support for implementing these practices, resources are needed to support staff to work with growers on practice adoption, address technical issues, develop new practice approaches and perform related administrative functions.

2. Streambank Stabilization

Given the clear identification of sediment as a priority pollutant in the Wallkill, and the contribution of streambank erosion to this problem, we recommend efforts **to identify potential stream corridor restoration and streambank stabilization sites, and to conduct additional planning on promising sites.**

Stabilization of already-failing bank sections as well as a continued maintenance program is expected to be a long-term effort. Staff will be needed to manage all technical, regulatory and administrative matters. Identification of additional funding sources will be important since work of this nature, even if full-bank rip-rap is not undertaken, will involve considerable expense. Combining funding from multiple sources will most likely be necessary to make the projects feasible. The exact approach taken to stabilize the River banks may undergo adjustment as projects are completed and evaluated, but this issue clearly needs continued attention and resources in order to address documented water quality conditions.

Starting new projects and meeting the involved stakeholders inevitably leads to ideas for additional projects. As feasible, new staff would allow for consideration of more extensive stream corridor restoration projects as investigations are undertaken for identified bank stabilization projects.

3. Flood Control

The importance of effective flood measures to continued agricultural use of the Black Dirt is discussed in the Issues section of this Plan. While the planning and procurement of improved flood control measures is largely beyond the scope of the Plan, we do advocate for such initiatives. There are conflicting opinions regarding human activities in flood-prone areas. For example, while new development in floodplains is widely recognized to be undesirable, what should be done about existing commercial, residential or agricultural development in these areas is a more complex issue. The values of having agriculture in the watershed landscape are discussed at some length in this Plan, as is the high productivity of the Black Dirt soils. Therefore, **this Plan supports continued efforts to implement flood control measures for protection of the Black Dirt agricultural lands.**

In 2005, the Orange County SWCD requested that the USDA NRCS investigate the feasibility of a Public Law 566 flood control project for the Black Dirt. This investigation is still in the early stages. In addition, the Army Corps of Engineers, who undertook a clearing and snagging project on the Black Dirt section of the Wallkill in the mid-eighties, has been asked by local growers and legislators to evaluate which current programs under their purview could be accessed to address Black Dirt flooding, drainage and soil stabilization issues. Ideally, the various federal agencies with program responsibilities in these areas would coordinate and combine their efforts. Continued strong lobbying by local growers and officials will undoubtedly be necessary, given the limited staffing and other priorities these agencies are facing.

Horse Farms

Recent investigations indicate that there are over 600 horse owners in the Watershed. While many of these are smaller, 'backyard'-type operations, the sheer number of owners argues for more attention to this issue. In addition, there are approximately 100 'commercial' horse operations in the watershed – many of them concentrated along the main stem of the Wallkill.

1. Coordinate Regional Manure Composting System

We recommend efforts to coordinate and foster partnerships between horse owners and potential composters by various means including meetings, mailings, web postings and direct farmer/horse owner contacts. We would also provide technical assistance on manure holding/transfer facilities, composting methods and manure utilization. We would also explore opportunities for equipment borrowing and demonstration projects – for example, compost turners, and promote the use of composted manure in the ever-growing home landscape setting as a beneficial use, as well as in the commercial agriculture setting. This outreach and partnership initiative will also be aimed at commercial landscapers who may play a role in the collection, composting and beneficial use of manure. An initial short term (2 year) goal would be to establish three composting facilities that receive manure from neighboring horse owners.

2. Identify Habitat Enhancement Opportunities

The outreach and dialogue with horse owners will also include discussions about habitat enhancement methods that are compatible with horse farming, with an initial short term goal of identifying 25 owners interested in participating in habitat enhancement projects on their land. Longer term goals would include seeking funding for these projects and implementing them.

Other Agriculture

Similar to the Black Dirt Region, erosion is an ongoing resource concern throughout the Watershed. In addition, animal agriculture beyond horse farms (for example, dairy, dairy replacement, beef and miscellaneous other livestock) maintains a respectable position, and demands attention to associated water quality concerns. **This Plan recommends maintaining strong levels of staff support from SWCD's, USDA-NRCS and Cornell Cooperative Extension to ensure that all interested farmers receive technical support and access to funding opportunities for erosion control, water quality protection, and related natural resource management projects.**

Ulster AEM

Through the Tiered AEM approach, both watershed enhancement opportunities and prospective partnerships will be identified, which can facilitate overall improvement in water and environmental quality. Through the application of the County AEM Strategies, both restoration (C-corrective) and protective (P-preventative) actions will be defined on each agricultural operation which include but are not necessarily limited to: 1) Evaluating the potential for increased participation in USDA Farm Bill, NYS Ag Non Point Source Water Quality Grants, and other available programs for conservation. (C); 2) Work with the Ulster County Agricultural and Farmland Protection Board and the local citizens working groups to update the Farmland Protection Plan for Ulster County, which can identify new issues and opportunities. (P); 3) Inventory and identify critical wetland and buffer areas in the vicinity of agricultural operations. (C); 4) Provide additional outreach and education to agricultural producers and the community (and groups such as Citizens Advisory Committees) on watershed stewardship issues. (P); 5) Implement USDA Farm Bill, NYS Ag Non Point Source Water Quality Grants and other available conservation programs. (C); and 6) Participate with local municipal boards in updating town master and open space plans, (P).

Among the long term goals that will hopefully be derived as a result of actively implementing the County AEM strategies would be the following:

1. Promote Vegetative Cover and Riparian Buffers

Establish and enhance vegetative cover, and riparian buffers in identified areas that will reduce cropland erosion, overall loss in forest and vegetative cover, and streambank erosion.

2. Address non point source runoff attributed to agricultural activity.

3. Education and Outreach

Strive to improve community relations between agricultural producers and new arrivals from urban areas through education and outreach, as needed.

Education

The greatest cost of a viable youth conservation education program is associated with staffing. The continuation of these programs should not depend on grants or other soft, unreliable funding streams. Conservation Educators should be considered essential staff for local conservation agencies. School budget issues, by and large, make it very difficult for schools to pay for conservation educators to come in to the classrooms. Therefore, we believe it is incumbent on conservation agencies to secure funding support for these programs. Achieving success will likely require creative funding efforts, combining both locally generated base funding and continued pursuit of grants and other opportunities. We hope, and recommend that, governments and other funding agencies maintain a commitment to youth conservation education programs such as that demonstrated by Orange County.

The Town of Montgomery and the Wallkill River Task Force have proposed the development of a Wallkill River Watershed Interpretive Center at the Benedict Farm Park, a town-owned site on the banks of the Wallkill River that is being developed for recreational and educational uses. This site is centrally located in the northern part of Orange County, accessible to people in Ulster County, and includes several existing buildings as well as ample open space that can house interpretive trails, indoor exhibits, workshops and meetings, and other educational programs. The development of this Interpretive Center, which could potentially also house a small office for organizations working on watershed issues, would provide a good centerpiece and foundation for ongoing implementation of watershed projects and programs and is recommended as an action item in this Plan. The site can also include demonstration projects for low impact development stormwater practices and other strategies needed to protect water quality, habitat and open space, and can be used for training workshops for local officials, engineers, planners, and other audiences.

Stream Buffers/Riparian Corridors

1. Protect Valuable Intact and Restore Degraded Riparian Corridors

We recommend that all municipalities within the Watershed adopt regulations to protect riparian areas from encroachment. We advocate for a tiered approach to stream protection and adoption of all or selected elements of the Stream Buffer Model Ordinance that is referenced in Appendix I to this Plan. The tiered approach in the Model Ordinance has three buffer zones; regulations are stricter for zones closer to the stream. Streams with certain features, such as being a high order stream or being bordered by steep slopes, are given protections supplemental to the standard zone protections.

We urge the completion of further investigation and study of the projects sites shown on Map 7 to determine which sites are appropriate for future work.

2. Outreach to Municipalities on Stream Buffers

Local Planning Boards have authority to regulate streamside activities through the subdivision and site plan review process, but their power is constrained by the content of both the local master plan and the local zoning code. Project partners should work cooperatively to educate municipalities on both the values of stream corridors as well as the tools they can use to protect these resources.

Stormwater Management

1. Increase Erosion Control Compliance at Construction Sites

As noted already, current regulations require that an erosion control plan, prepared by a qualified professional, be prepared and implemented at every construction site disturbing more than one acre. Also noted is the observed poor performance of, or lack of, erosion and sediment control measures at the majority of sites visited by erosion control specialists from the SWCD. In many cases, though, once deficiencies are explained to site contractors, significant improvements are observed in subsequent site visits. We therefore believe that providing more staff for site visits would result in major improvements to overall construction site erosion and sediment control efforts and, consequently, to water quality protection. We believe that vast improvements can be expected by expansion of current initiatives such as the cooperative NYSDEC-

SWCD arrangement whereby non-regulatory SWCD staff visit sites as an alternative to visits from State inspectors. Non-regulatory stature often facilitates SWCD staff efforts to establish a good working relationship with site representatives. Nevertheless, a close working relationship between SWCD, NYSDEC **and** local municipal (e.g. Town, Village, and City) officials is considered essential in order for SWCD construction site inspections efforts to be successful.

It should be noted that some site operators are not responsive to non-regulatory efforts to improve erosion and sediment control measures. Therefore, continued education about – and enforcement of – existing stormwater runoff regulations will be necessary to fully address erosion control compliance issues. As municipalities adopt local laws to comply with Stormwater Phase II regulations, local inspection and enforcement activities will, assumedly, become more commonplace and effective. However, not all Watershed municipalities are required to adopt these measures (see map 14 of regulated MS4 areas), leaving a potentially large gap in compliance efforts. Plus, even regulated municipalities will need technical and related assistance to achieve compliance goals.

The Plan recommends that expanded staffing be sought, primarily at Soil and Water Conservation District offices, to assist with construction site erosion and sediment control compliance programs, and to generally assist communities with improving erosion and sediment control and stormwater management programs.

2. Stormwater Retrofit Planning

As noted, current Stormwater Phase II regulations require stormwater controls on new development, but do not require treatment of runoff from existing urban areas. Given the extensive urban areas in our Watershed that were in place before current regulations went into effect, we **recommend that a stormwater retrofit opportunity survey** be a priority action for all municipalities in the Watershed. Since technical and financial resources will almost certainly be limited for such an initiative, we recommend that this survey focus on sites with amenable features (ie, room for more affordable, above-ground facilities; publicly owned land or a cooperative private landowner). The Orange County MS4 Cooperation Project, funded by NYSDEC and currently underway, will conduct a preliminary retrofit survey, but only in MS4 regulated areas. Ulster County is in the process of further developing an intermunicipal agreement pertaining to shared services between some of its MS4 municipalities as well. Similar opportunities need to be explored in non-MS4 areas in both counties. Plus, site identification is only the first step. Considerable time and effort is required to build community support, secure necessary funding, and undertake technical investigations. **We propose that this Plan include a component designed to pick up where the MS4 Cooperation Project left off.** This will require devotion of staff time and related resources to fostering further planning of potential retrofit sites identified through the MS4 Cooperation Project, and to similarly assisting non-MS4 communities.

Impervious Surfaces Analysis

As more detailed watershed planning occurs in the future on the major sub-basins within the Wallkill, said planning should pay special attention to the Map 6 'red zones' to ensure that planning efforts in these areas address imperviousness concerns. And while efforts to minimize the creation of new impervious areas should be promoted throughout the Watershed, planning in areas of lower imperviousness should thoroughly examine threats originating from agriculture, streambanks and other sources not related to impervious cover.

The Plan recommends that the future percent impervious cover be studied through a build out analysis of the Watershed.

Biological Resources

1. Protect Stream-associated Wetlands

Stream-associated wetlands are especially important natural areas to protect due to their intimate relationship with the water quality and biodiversity of the stream. Practices that would benefit both water quality and streamside wildlife include:

- maintaining natural flows and flooding regimes,
- leaving buffers around wetlands to prevent water contamination, and

° minimizing disturbance and development within riparian zones.

The Plan recommends that existing mature and/or wide forest buffers be considered for conservation easement, as they are particularly valuable for wildlife.

2. Promote Biological Research within the Watershed

While some subwatersheds have a substantial amount of biological data available, other subwatersheds have had very few surveys conducted within their bounds. While all subwatersheds could benefit from further research, we recommend that those subwatersheds with the least amount of information be prioritized for future biological research. These include:

- Tin Brook
- Dwaar Kill
- Masonic Creek
- Monhagen Brook

3. Protect Important Habitats

The most biologically important habitats within the Watershed were outlined in the Biological Resources section of this Plan. Protecting these areas from encroachment, degradation, and destruction will help to ensure that the biological health and diversity within the Watershed is enjoyed by future generations. Protection can occur via conservation easement, purchase by a conservation organization, local regulation, incentive programs, and beneficial development and land management practices.

In addition to land protection, the following land management actions are beneficial to biological diversity:

?? directing development away from sensitive and large, intact habitats,

?? maintaining early successional (grassland and shrubland) habitats,

?? encouraging mowing and haying schedules that avoid disruption of grassland bird breeding,

° implementing water management practices that maintain the hydrology of vernal pools and other wetlands, and

° implementing forestry practices that maintain woodland buffers around vernal pools. Woodland buffers around vernal pools and other wetlands are needed for specialized frogs and salamanders to complete their life cycles.

4. Create or Maintain Buffers Around Water Resources

Buffering these habitats is an essential step in protecting their functionality, health and quality, as well as the plants and animals that utilize them. Buffers preserve transition zones between land and waterbodies. Protecting and maintaining this connectivity is especially important to those species requiring both habitats during their life histories.

5. Reduce Fragmentation and Maintain Habitat Connectivity

Maintaining connectivity between similar habitat types within the watershed is important since transportation networks and other impervious surfaces commonly bisect otherwise contiguous habitats. This fragmentation often creates habitat islands within the landscape. Isolation and habitat degradation eventually lead to population decline, especially for those species characterized as having low motility, high sensitivity to habitat edge, or requiring large tracts of habitat for their survival. One way of enabling the persistence of species over time is by protecting large tracts of contiguous land while restoring connectivity in fragmented landscapes through the utilization of land use buffers and migration corridors.

6. Educate Landowners and Land Use Decision makers

Natural resource protection measures must occur over time and at multiple spatial scales. One method of ensuring such protection is by reaching out to landowners and land use decision makers. These two groups play a crucial role in deciding how land is managed within the watershed. Tailoring technical assistance and outreach programs to their particular needs promotes best management practices and better understanding of conservation issues and needs. In addition, cost sharing and collaboration commonly result as conservation goals are selected and as management plans are implemented.

Wetlands Degradation

We would like to see a more formal evaluation/compilation of the quality and health of existing wetlands in the watershed. Some of this information may be available from NYSDEC and/or other sources. Some additional fieldwork will likely also be needed to complete such an

evaluation.

In addition, **we recommend a program to identify candidate wetland areas for improvement projects.** There are numerous existing government programs that include wetland improvement as eligible projects, including but not limited to the USDA's Wetland Reserve Program (WRP) and Wildlife Habitat Incentive Program (WHIP) and US Fish and Wildlife's Partners for Wildlife program. However, utilization of these programs in the watershed is limited by the attention existing staff can devote to promoting these programs due to other workload demands. We believe that, with adequate outreach and dedicated attention, many more WRP, WHIP and other wetland-benefiting projects could be developed and implemented in the Watershed.

Improvement projects could take many forms, but some examples are water table manipulation, biological controls (eg. release of loosestrife-eating beetles), other forms of non-native/invasive plant control, plantings of selected desirable species, or even controlled grazing to provide improved conditions for certain desired species such as bog turtles.

Wetland losses must continue to be controlled via existing regulatory and educational efforts. In addition, though, **we believe that accelerated efforts to identify, plan and implement wetland improvement projects should be considered a necessary component to a comprehensive watershed conservation plan.**

Targeted Assistance to Municipalities

There are 30 towns, villages and cities in the New York portion of the Wallkill Watershed. Local municipal boards play a crucial role in land use planning and can therefore have a major impact on addressing many of the priority watershed issues identified by the Watershed Project Steering Committee such as wetland protection, open space, biodiversity, stream protection, riparian buffers, sprawl and stormwater runoff. While the MS4 Cooperation Project mentioned elsewhere in this Plan will help to address some of these issues, biodiversity, wetland and stream protection are largely beyond the scope of the Phase II Stormwater Regulations.

1. Provide Technical Assistance to Municipalities on Natural Resource Protection

Promoting higher levels of natural resource protection via proactive local programs is a goal identified in the Management Plan. **We propose to provide targeted technical support to all receptive municipalities in the watershed** directed at fostering such local efforts, which may include new local ordinances, or incentive-based programs such as Purchase of Development Rights or riparian buffer establishment where participants may receive financial or other incentives for participation. For example, in Ulster County, as mentioned above, there is already collaboration ongoing between the Village of New Paltz, the Soil and Water Conservation District, and USDA-NRCS which has resulted in the establishment of, and on-going maintenance of a riparian buffer system along the Wallkill River that is approximately one quarter of a mile in length. This effort is now in its second year.

2. Coordinate Local Conservation Advisory Councils (CACs)

CACs exist in four of the 20 municipalities in the Orange County portion of the Watershed and in seven Ulster County municipalities. **We propose to form a loose affiliation between the existing CAC's** where applicable to enhance exchange of ideas, promote the formation of additional CAC's, and identify implementation projects similar to the above mentioned riparian buffer system established in the Village of New Paltz. Since CAC's typically have limited resources, we propose to provide networking, training and related support to CAC's. Ideas such as sample watercourse/wetland protection local laws, low impact development approaches, and stream-front landowner riparian improvement projects will be shared and highlighted, through a targeted newsletter aimed at – and contributed to by – CAC's.

Where no potential seems to exist for CAC formation, we will work directly with the appropriate municipal body to promote the same goals. This initiative will also include initial outreach to other potential partners for ideas. This would include, but not be limited to, landscaping contractors, garden centers, garden clubs, growers of landscaping plants, and others who can be involved in educating landowners and other decision-makers about landscape management

practices that can protect water quality and biodiversity.

Low Impact Development (LID) and Better Site Design (BSD)

The issues section of this Plan raises concerns with current New York State technical requirements for water quality treatment. Beyond water quality, concerns exist regarding other impacts of new development such as loss of open space and wildlife habitat, and other, less easily defined 'quality of life' considerations. LID (low impact development) and BSD (better site design) describe conceptual approaches to site design that attempt to minimize these potentially adverse impacts. Full discussion of these concepts is beyond the scope of this Plan, but plugging either term into an internet search engine will yield copious references and examples. A related term is 'stormwater treatment trains', which denotes routing stormwater runoff through multiple treatment practices, thereby offsetting the reduced pollutant removal efficiency of single-practice treatment, and providing insurance against poor performance of a single practice as a result of lack of maintenance or other reasons.

The NYSDEC is currently working on a guidance document dealing with LID/BSD related concepts and how they can be employed within the framework of current stormwater management regulations.

This Plan encourages local municipalities to fully explore opportunities to incorporate principles such as LID, BSD and stormwater treatment trains into the site plan approval process, and supports increasing local agency technical support to municipalities to provide education and assistance on these approaches.

Increase Water-Related Recreational Opportunities

Access to the Wallkill River:
We recommend that those municipalities with no current access to the Wallkill River establish at least one public access point in order to increase public awareness and stewardship of the River. These municipalities include:

1. Town of Minisink
2. Town of Wawayanda
3. Town of Goshen
4. Town of Wallkill
5. Town of Gardiner
6. City of Kingston

Access to Major Tributaries
Few major tributaries of the Wallkill River enjoy public usage due to scarce public lands along their banks. **We recommend that the following tributaries, which have no current public access point, be prioritized for future public access:**

1. Rutgers Creek
2. Pochuck Creek
3. Quaker Creek
4. Monhagen Creek
5. Masonic Creek
6. Platte Kill

Access to All Water-related Recreation Opportunities
We recommend that water-related recreation opportunities, including access to lakes and ponds, be created in those municipalities without any such access. These municipalities include:

1. Town of Minisink
2. Town of Wawayanda
3. Town of Goshen

Research and Monitoring

As discussed in the Plan, existing data on basic questions such as precipitation, stream flow, and groundwater levels is very patchy and incomplete in the Wallkill Watershed. The number of USGS stream gauging stations in the watershed and elsewhere has declined. Funding for basic monitoring of these and other parameters, including ambient water quality monitoring, is not sufficient.

Water Supply

Decisions about water supply planning, including development of new municipal and private water supply systems, are generally made incrementally by individual municipalities and developers. Since the Orange County Water Loop project was abandoned in the early 1990's due to high cost and apparent lack of demand, there had not been any major intermunicipal water projects until

Orange County Executive Edward Diana convened the ongoing Mid-County committee to consider water supply and other infrastructure options. The Orange County Water Authority will also potentially be developing the county's first Water Master Plan during 2007. These plans and projects should consider watershed hydrology, including the long-term sustainability of existing and proposed water supply sources and ways of designing new development and new water supply projects to maximize groundwater recharge using low impact development/better site design practices. New water supply projects should prioritize protecting streamflow, maintaining pre-development hydrology, and protecting water quality in surface and groundwater resources. Water conservation measures can be used in new development to reduce the need for additional water supplies. Water reuse and efficiency measures can be considered, including strategies currently being developed by NYS DEC, NYS DOH and other agencies under a state law adopted in 2005.

At the state level, according to available information, it seems that there is insufficient attention being paid to the sustainability of water resources, particularly groundwater. The existing permitting system does not include real consideration of the cumulative impacts of multiple groundwater withdrawals on a regional basis. Existing permitting processes and policies also do not include provisions to protect in-stream flows that may be reduced or altered by increased impervious surfaces, diversions, groundwater withdrawals, etc. These issues should be addressed either at the local, county or state level, but this is probably best done at a regional or state level, at least in the near term, because local municipalities are not currently organized to work on an intermunicipal level to address these kinds of challenging issues.

Protecting Streamflow, Groundwater, and Wetlands

As discussed in various sections of this Plan and in other recommendations, land use and land cover changes caused by development can lead to dramatic changes in watershed hydrology. Open space conservation strategies including purchase of development rights, clustering, transfer of development rights, and local laws to protect aquifer recharge areas, stream buffers, wetlands and other resources should be used to protect sensitive areas that are needed to maintain in-stream flows and recharge groundwater. For individual development projects, low impact development/better site design (LID) practices should be used as much as possible to support these goals. Unless and until state regulations are adopted to address gaps in existing wetlands and stream protection laws, local laws are needed to protect smaller wetlands and riparian buffers. Providing training, model ordinances and other tools for local government to support local protection measures for these resources are high priority action items in this Plan. Demonstration projects incorporating these ideas and issues into new development will also be useful to broaden awareness and acceptance among engineers, developers and planning officials. Technical assistance, funding, and education about why and how existing local ordinances and design standards should be revised to allow LID practices is also a priority.

Wastewater Management

Much of the existing wastewater infrastructure in the Wallkill Watershed is nearing the end of its design lifespan and requires upgrades or replacement. Some of this work is currently being done but it is almost certain that for the next 3-5 years and potentially beyond, the funding needed to fully implement needed upgrades will not be available from state or Federal sources. Local officials, therefore, are faced with the hard choices involved in funding very expensive projects in their municipal budgets. At the same time, a number of municipal wastewater systems are implementing sewer line extension projects that will lead to increased flows to treatment plants, and private developers are proposing small (package) treatment plants for individual projects. Many such small systems, especially when privately owned and operated, have historically had a poor track record in terms of their operations, maintenance, and performance. For all of these upgrades, expansions, and new treatment systems, more attention should be given to addressing the full life-cycle costs and environmental impacts before plans are finalized. Decentralized strategies for managing wastewater **that are properly designed and effectively managed** can potentially provide better

performance, lower costs to the end users, and better protection of water resources than larger centralized systems. Decentralized wastewater strategies that maximize the potential for groundwater recharge and nutrient removal using soil-based discharges should be strongly considered whenever new infrastructure is planned. Even in urbanized areas with existing centralized sewer systems, decentralized technology for new or existing development can be used to mitigate excessive flows that cause overflows during wet weather. Stormwater catchment systems and repairs to leaking sewer lines should both be priorities to address wet weather overflows (which cause release of partially treated sewage) where they exist in the Wallkill watershed. At the state and Federal level, increased funding to repair existing infrastructure is a high priority. At the state level, revised regulations and policies can help enable full consideration of decentralized wastewater strategies. The current development of water reuse and efficiency regulations by NYSDEC and other agencies will potentially be a useful step in this direction. For individual onsite systems, better training and oversight is needed to ensure that systems are properly sited, designed, installed, inspected and maintained. Local municipalities, especially in sensitive watershed areas, should consider local laws and/or other programs to require regular pumpout, maintenance and inspection of private onsite systems. Municipalities should also consider formation of management districts for onsite and small community/decentralized systems to provide municipal oversight.

Local Planning and Regulations

1. We recommend increased use of overlay zones within municipal zoning codes as a method of protecting natural resources. Overlay zones are an appropriate approach to natural resources protection due to their flexibility in following natural boundaries and their relative simplicity to understand and implement.

2. We recommend the use of incentive zoning as a way to make natural resource protections more palatable and widespread. Incentives could include density bonuses during the subdivision review process, a waiving of certain fees (such as recreation fees during the subdivision review process), and a decrease in the amount of time taken to secure a municipal approval.

3. We recommend the creation of a county-wide environmental management council (EMC) for Orange County. The regulatory review pointed out how CACs, by that or some other name, were more abundant in Ulster County than in Orange and we feel that a county-wide EMC could advocate for, organize, and coordinate municipal conservation advisory councils (CACs) in Orange County. An EMC would also have a unique position to tackle politically-sensitive environmental issues of County-wide concern. (It is noted that, in lieu of an Orange County EMC, the OCSWCD has proposed a project to provide staff assistance and coordination services to CAC's. The Orange County Planning Department anticipates devoting accelerated staff resources to this area as well.)

4. We recommend the adoption of the NYS Model Law for Sediment and Erosion and Stormwater by all municipalities. There should be a clear responsible party within each municipality, such as a building inspector, to ensure that the regulations are being enforced. Additional study will be needed to determine how best to achieve the necessary program oversight given the already large scope of responsibilities maintained by local building officials. A clear penalty schedule would also help to ensure compliance, with a clear benchmark for the issuance of a stop work order. A 'level playing field' for developers and their consultants is a concern that has been raised by the local engineering community, and wide adoption of the NYS model law would help to achieve such a situation from town to town.

5. We recommend municipal protection of wetlands and watercourses. State and national laws should be supplemented by local ordinances that establish buffers for or otherwise protect these surface water resources from degradation.

6. We recommend increased protections for steep slopes. Most important is prohibition of development on steep slopes, especially those in excess of 25%. Also critical is the subtraction of steep areas when a calculation of net area is done during the subdivision review process.

7. We recommend that municipalities require that all nonbuildable areas be subtracted from the calculation of net area during the subdivision review process. Nonbuildable areas should at least include steep slopes, wetlands, hydric soils, and floodplains. Other potential subtractions could include rare species habitats, a wellhead protection area, and buffers of waterbodies & wetlands.

V. CONCLUSION

Not only is the Wallkill Watershed large, it is extremely diverse – ranging from the unique Black Dirt farming region to the orchards of New Paltz, suburban landscapes dotted with high-value homes, and highly urban cityscapes like Middletown and Kingston. Crafting a management plan that thoroughly addresses the myriad special issues and needs encompassed by these diverse settings would be a challenge, indeed, even with a generous supporting budget. The funding constraints with which this project was faced are described in some detail in the preceding sections.

Despite these constraints, Plan writers worked vigorously to add innovative and useful elements to the Plan. The stream corridor study, conceived by Kelly Dobbins of the Orange County Planning Department, combined advanced remote sensing and GIS techniques with local knowledge of land use to produce a extensive list of potential future water quality and habitat improvement projects. Skillful and diligent efforts by technicians at the Orange County Water Authority and others produced a detailed map of % imperviousness in the Watershed. The importance of this parameter is now common knowledge amongst all watershed protection professionals. The collective knowledge and experience of Soil and Water Conservation District and USDA/NRCS staff regarding farm operations in their respective counties allowed for in-depth treatment of agricultural issues and needs.

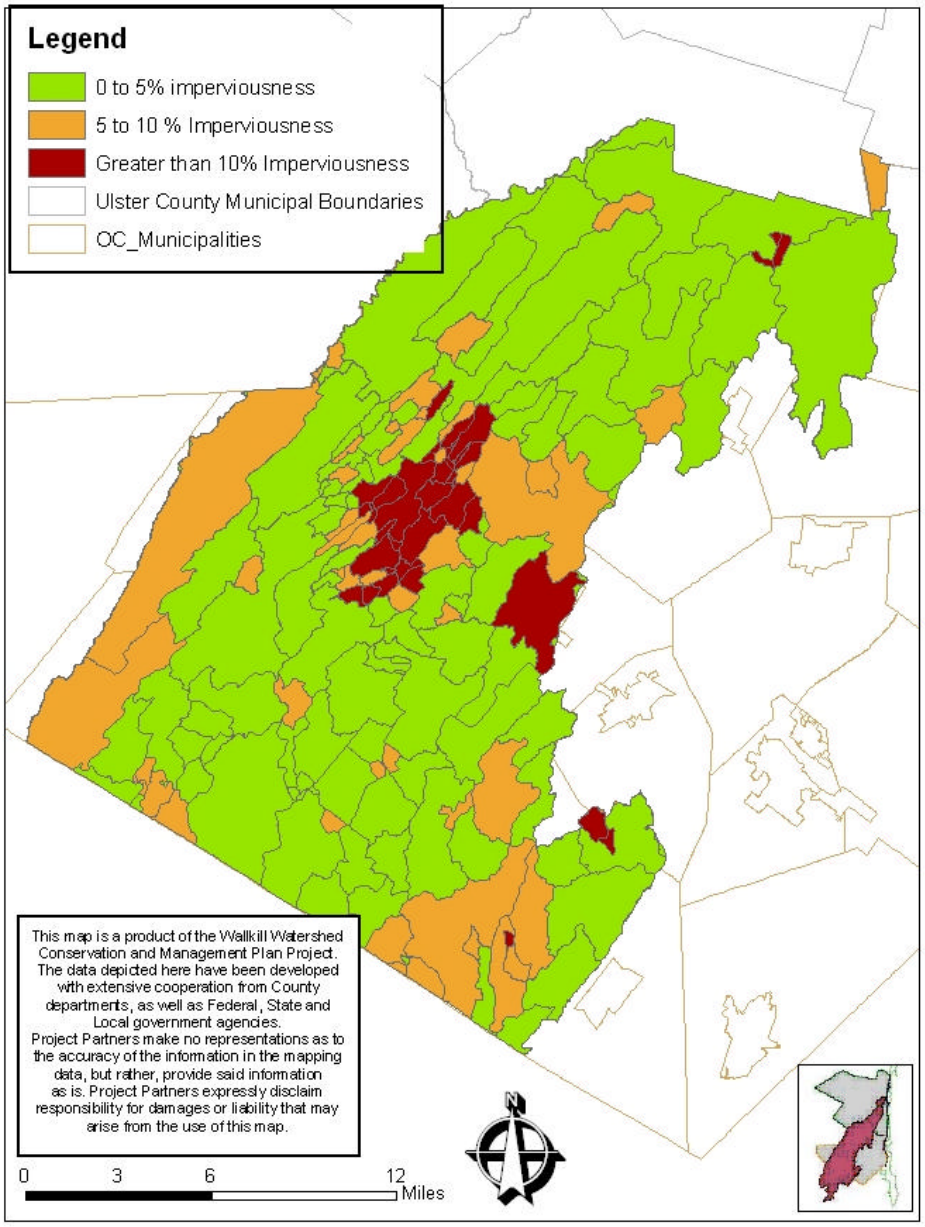
Ideally, funding and qualified staff will be available to both expand on important topics given limited treatment in this Plan, and to conduct more detailed planning in the sub-basins of the Wallkill using the imperviousness, biodiversity and related data in this Plan as a starting point. Even in lieu of more detailed planning efforts, though, an emphasis of this Plan was to produce recommendations that could lead directly to actions that will protect and improve the Watershed. We believe this goal was achieved in the Recommendations section of the Plan. In fact, an implementation project funded by the Hudson River Estuary Program is expected to follow closely on the heels of the completion of this Plan. This Plan will not be a success if other recommended action items, beyond those included in the HREP implementation grant project, are not embraced and pursued by Wallkill Watershed communities.

A final issue that deserves reinforcement is the importance of **dedicated staff** to the level of accomplishments that can be expected of any project of this scope. Many of the agencies and groups partner to this Plan are committing, and will continue to commit, staff resources to watershed protection efforts. We firmly believe, though, a watershed of this size demands a full-time coordinator to orchestrate partner agency activities, garner public support, seek and secure funding, and generally advocate for the River and its watershed. **Seeking support for, and securing, such a position is a major recommendation of this Plan.**

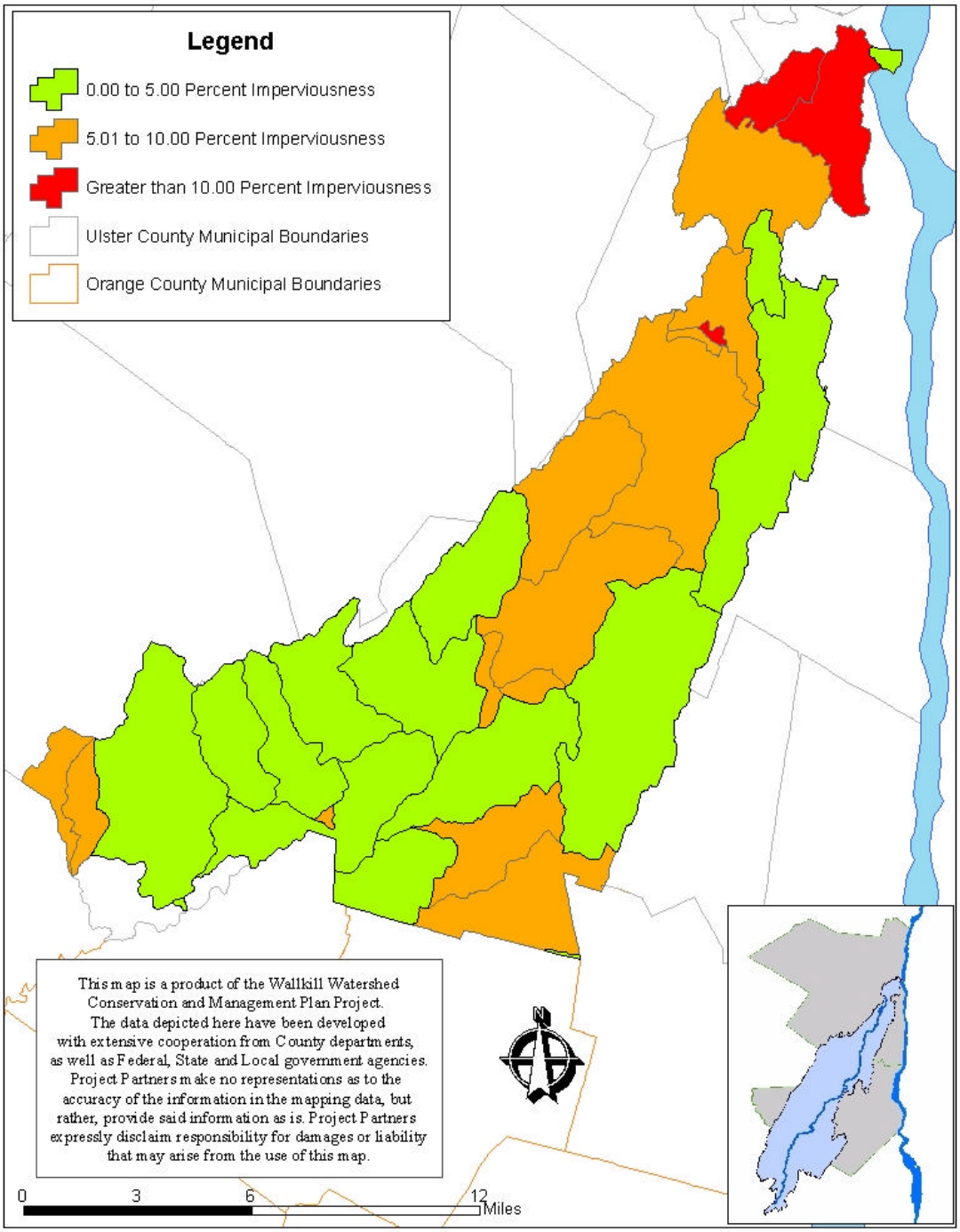
The Wallkill Watershed is fortunate to have a large number of dedicated and knowledgeable people working to balance human needs and interests with environmental stewardship. We hope this Plan in some small way fosters these efforts.

LIST OF ACRONYMS

ACOE	Army Corps of Engineers
AEM	Agricultural Environmental Management
AFPB	Agricultural and Farmland Protection Board
BSD	Better Site Design
CAC	Conservation Advisory Council
CCE	Cornell Cooperative Extension
CREP	Conservation Reserve Enhancement Program (USDA)
CRP	Conservation Reserve Program (USDA)
CS	Community Service (a property class code)
CSA	Community-Supported Agriculture
CWP	Center for Watershed Protection
DEC/NYS DEC	New York State Department of Environmental Conservation
DOH	Department of Health
EMC	Environmental Management Council
EPA/US EPA	United States Environmental Protection Agency
EPT	Ephemeroptera Plectoptera Tricoptera
GIS	Geographic Information System
GPD	Gallons Per Day
HBI	Hilsenhoff Biotic Index
HREP	Hudson River Estuary Program (NYS DEC)
IPM	Integrated Pest Management
ISD	Impact Source Determination
LHCCD	Lower Hudson Coalition of Conservation Districts
LID	Low Impact Development
MS4	Municipal Separate Storm Sewer Systems
NRCS	Natural Resources Conservation Service
NYC-DEP	New York City's Department of Environmental Protection
NYSSWCC	New York State Soil and Water Conservation Committee
OCWA	Orange County Water Authority
PCC	Property Class Code
PMA/SD	Percent Model Affinity/Species Dominance
PSC	Project Steering Committee-Wallkill River Watershed Conservation & Management Plan
PWL	Priority Waterbodies List
RC&D	Resource, Conservation & Development Council
SBU	Stream Biomonitoring Unit of the NYS DEC
SCS	Soil Conservation Service (USDA)
SPDES	State Pollutant Discharge Elimination System
SR	Species Richness
SUNY	State University of New York
SWCD	Soil & Water Conservation District (OC- Orange County UC- Ulster County)
USDA	United States Department of Agriculture
USGS	United States Geological Survey
WHIP	Wildlife Habitat Incentive Program (USDA)
WQCC	Water Quality Coordinating Committee
WRP	Wetland Reserve Program (USDA)
WRTF	Wallkill River Task Force
WVDIA	Wallkill Valley Drainage Improvement Association



Map 6a – Imperviousness by Subwatershed – Orange County



Map 6b – Imperviousness by Subwatershed – Ulster County

APPENDIX A

HISTORY

OF

SUSSEX AND WARREN

COUNTIES, NEW JERSEY,

WITH

ILLUSTRATIONS AND BIOGRAPHICAL SKETCHES

OF ITS

PROMINENT MEN AND PIONEERS.

COMPILED BY JAMES P. SNELL,

(Author of "History of Hunterdon and Somerset Counties, N. J.").

ASSISTED BY PROF. W. W. CLAYTON AND A NUMEROUS CORPS OF WRITERS.

PHILADELPHIA:

EVERTS & PECK,

1881.

PRESS OF J. B. LIPPINCOTT & CO., PHILADELPHIA.

the not unfrequent appearance of fossiliferous rocks from the Delaware valley, makes it evident that the movement of the materials was towards the southeast. At the northeast, along the Wallkill, the drift and other formations are covered by the Drowned Lands.

On the summits of the Kittatinny Mountain the glacier for the most part simply ground down and polished the more prominent ledges, without leaving much deposit of materials. Indeed, much of the materials carried to the lower portions of the country consist of the débris of these summits, ground down and carried along by the ice. At Culver's Gap the elevation of the drift is about one thousand feet, and at the Water Gap it is from seven hundred to nine hundred feet, above tide-level.

Many of the smaller lakes and ponds of Sussex County were formed by the glacial débris choking the outlets and making basins, which were not subsequently filled in the distribution of materials by the waters of the Champlain epoch. The old glacial dams were not disturbed beyond a leveling of their surface and a sorting of the materials at the top.

In the valley of the Delaware and those of Flatbrook and Millbrook the drift is so thick that there are no outcrops within a breadth of one-seventh of a mile from the New York line to Walpack Bend.

"In the Kittatinny and Wallkill valleys deposits of marl are numerous. They are found, several feet in thickness, at the bottom of the lakes and ponds, marshes and meadow-lands, so abundant in these districts. A very common name for these collections of water is 'White Pond,' of which several are so called in the district. This name is given to them on account of the deposit of shells distinctly visible at their bottom."

MINES AND ORES.

Zinc Ores.—The only zinc ores which have been found in workable quantities in the State are in Sussex County. One of the mines is at Stirling Hill, near Ogdensburg, in the township of Sparta; the other is on Mine Hill, at Franklin Furnace, Hardyston township. The Stirling Hill ore has its outcrop at a height of one hundred feet above the valley of the Wallkill. The largest proportion of mineral matter in the vein is a variety of calcite, in which the carbonate of lime is replaced by the carbonate of manganese. Disseminated through this rock are the minerals which contain the zinc. The most important of these are franklinite, red oxide of zinc, and willemite.

"*Franklinite* is a mineral of iron-black color, metallic lustre, and about as hard as feldspar. It is slightly magnetic, and might easily be mistaken for magnetic iron ore. . . . Its crystals are regular octahedrons." The following analysis of this mineral is from Professor Cook's "Geology of New Jersey:"

Sesquioxide of iron	68.3
Oxide of zinc	24.8
Red oxide of manganese	10.5
	103.6

Red Oxide of Zinc.—"This mineral is of a deep red color, varying in some specimens to orange-yellow." Its lustre is not metallic. Occasionally specimens are found which are partially transparent, but generally the substance is quite opaque."

Willemite, troostite, or *anhydrous silicate of zinc* is a name given to a mineral found in abundance at both Stirling Hill and Mine Hill. "It is of various colors, from an apple-green to flesh-red and to grayish white, and when weathered it is of a manganese-brown color. It is not quite as hard as feldspar, but very nearly so."

IRON MINES.*

The iron mines in Sussex County are:

1. *The Franklin Mines,* in Hardyston township, near Franklin Furnace.
2. *Andover Mine,* in Andover township, three and a half miles from the Roseville mines.
3. *Wawayanda Mine,* in Vernon township.
4. *Green Mine,* in Vernon township.
5. *Ogden Mine,* in the township of Sparta.
6. *Roseville Mine,* at Roseville, in Byram township.
7. *Glendon or Chapin Mine,* in Green township.

V.—DROWNED LANDS OF THE WALLKILL.

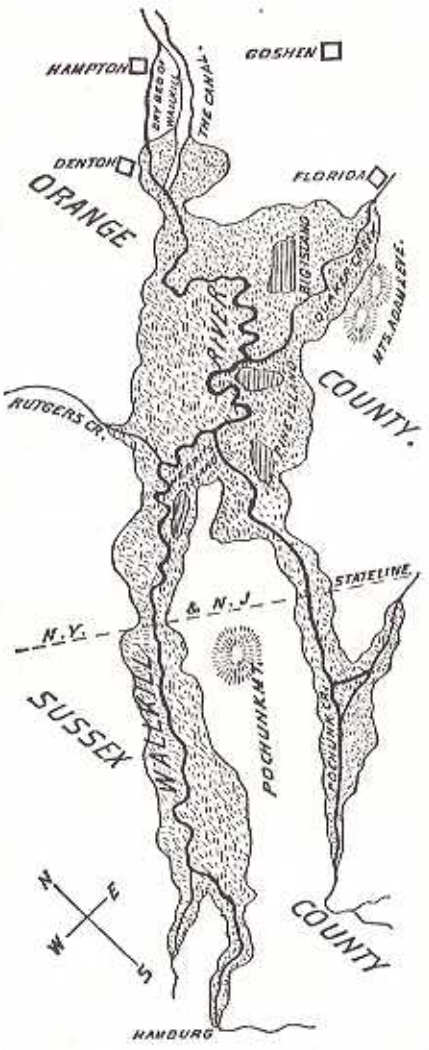
"The valley of the Wallkill from Hamburg, Sussex Co., N. J., to Denton, Orange Co., N. Y., is unlike that of any other stream in the State. The Wallkill River rises in Sussex County and has a somewhat rapid flow until it reaches Hamburg. Then for twenty miles the bed of the stream is a succession of limestone reefs from five to ten feet high.

"The Wallkill is one of the crookedest streams in the State, and its fall from Hamburg to Denton is only eleven feet. For twelve miles west of Denton the valley of the Wallkill is four miles wide and on a level with the river. The northern extremity of the Pochunk Mountain protrudes into the valley there, and divides the low-lying country into two strips. The portion on the eastern base of the mountain is six miles long and about a mile wide. It is drained by the Pochunk and Wawayanda Creeks. The western strip is eight miles long and nearly two wide, and coursed by the Wallkill. Pochunk Creek enters the Wallkill from the southwest, Rutgers Creek flows into it from the northwest, and Quaker Creek enters the river from the east, between Denton and Hamburg. The beds of these tributaries are of the same jagged character as that of the main stream, but their fall is heavier and their currents rapid. They enter the Wallkill at abrupt angles, and their waters are forced both up and down the river, the current of the latter being insufficient to carry them off. Besides the obstruction to the flow of the Wallkill caused by its irregular bed and almost imperceptible fall, a high wall of granite bowlders and drift stretches across the val-

* Accounts of these mines will be found in the histories of the several townships in which they are located.

† From the New York *Sun*, Oct. 19, 1879. Map changed and re-engraved by the publishers of this work.

ley at Denton and forms an impregnable dam. This deposit must have been carried here on glaciers from the Shawangunk Mountains, twenty-five miles distant, in the ages of which only geology furnishes any record. Of insufficient force to cut a passage through this rocky impediment,—as the Delaware River did through the opposing wall of the Kittatinny Mountain at the Water Gap,—the accumulated waters of the Wallkill were forced back over the low country bordering its course and that of its tributaries, the surplus water pouring over the crest of the wall and continuing then in uninterrupted flow to the Hudson at Kingston. Thirty thousand acres of land in Orange County and ten thousand in Sussex were thus converted into an impenetrable marsh covered with rank vegetation. In time of freshets the entire valley from Denton to Hamburg became a lake from eight to twenty feet deep. The following outline of the immediate country will explain, it being understood that the shaded lines indicate the condition of the 'Drowned Lands' prior to the construction of the canal:



"The country surrounding this great swamp was settled at a very early day. The settlers called the submerged tract 'The Drowned Lands of the Wallkill.' The tract was all taken up in the course of a few years. During the dry season the islands were reached without great difficulty, and the wild grass that grew on the marshy meadows afforded excellent pasturage for cattle. Owners of drowned land derived considerable revenue by letting out pasturage to the cows of neighboring farmers. Through the summer season thousands of cows were turned upon the waste acres. Sudden freshets frequently came, and the water rose so rapidly that many cattle were annually lost before the herdsmen, in boats, could drive them to the uplands. The cows that reached the islands were kept there until the water had subsided. The main duty of the farmers' boys in the early days was to watch the cattle feeding among the treacherous meadows of the Drowned Lands.

"As early as 1804 the Drowned Lands proprietors in Orange County, believing that by altering the course of the Wallkill River, and removing certain of the obstructions in its bed, the lands could be drained to a great extent and large portions of them made tillable, began the laying of plans to accomplish the work. In 1807 they secured the passage of an act of the Legislature authorizing the raising of money 'to drain the Drowned Lands of the Wallkill.' The expenses of the work were to be defrayed by assessing the owners of the lands. A board of commissioners was named in the act to apportion assessments. From that year up to 1826 forty thousand dollars had been expended by the proprietors in efforts to drain the lands, but with little success. Ditches were dug along the bed of the stream. About the only result of the work was the starting of eels down the stream in unusual quantities. The fall of 1807 was remarkable for the numbers of eels that came down the ditches. Eel-weirs were plenty, but there was hardly a night that season in which every one was not filled to overflowing with eels, some of which weighed eight pounds apiece. One weir in Hampton milldam captured over two thousand in one night. George Phillips salted down twenty barrels. He bought the first four-wheeled wagon ever seen in this region for the express purpose of peddling eels in the surrounding country. The wagon was the wonder of western Orange County, and made a sale for thousands of eels. The Wallkill yielded abundantly of eels until 1826, when a law prohibited the placing of weirs in the stream.

"In April, 1826, the Legislature again came to the aid of the Drowned Lands owners by authorizing the construction of a canal to be dug from the river at Horse Island around the great obstruction at Denton, and to enter the river again below New Hampton,—a distance of three miles. The water of the Wallkill that found its way over the rocky dam at Denton had a fall of twenty-four feet in about two miles. This

afforded a valuable water-power, the right to which was vested in Gabriel N. Phillips. Several mills and factories had been called into existence near New Hampton by the water-power which had been utilized by the construction of a dam at the above place. This dam was a great obstruction to the drainage by ditches in 1807. The farmers agreed with Phillips to pay him a certain sum if he would lower the dam. He lowered it as desired. The farmers failed to fulfill their part of the contract. Phillips raised his dam to its original height. This was one of the main causes of the failure of the plan of river-bed ditching.

"The canal project of 1826 alarmed Phillips. He claimed that a canal would necessarily divert the water from its natural channel, and greatly injure the water-power, if not destroy it. Two hostile parties therefore arose. Those interested in the factories fought the canal scheme, and the Drowned Lands proprietors were determined that it should succeed.

"According to the act of 1807, a board of five drowned-land commissioners was to be elected every year at the court-house in Goshen. The ownership of ten acres of drowned land entitled the owner to one vote. On every twenty acres, up to four hundred, a proprietor could deposit one vote, and one vote for every fifty acres above four hundred. At the election of 1829 the issue was 'canal or no canal.' Two tickets were in the field. Gen. George D. Wickham was a prominent candidate on the canal ticket; John I. McGregor led the forces of the anti-canallers. On the 15th of June, 1829, the election was held. A beaver hat was used for a ballot-box. John I. McGregor claimed the right to cast twenty-six votes on proxies he held from other proprietors. He also demanded that the inspector receive from him eighty-two votes on a tract of three thousand five hundred acres, which belonged to an uncle of his in England who had just died. He claimed, besides, the right to vote on two thousand acres of this tract, under an alleged agreement with the dead uncle to work the two thousand acres for twenty years. These votes were all challenged by the supporters of the canal ticket. The inspectors of election refused to receive them. A stormy scene followed. John I. McGregor seized the hat containing the votes that had been cast, and declared that no vote should be counted unless those he offered were counted too. Every one entitled to vote had voted, with the exception of two persons. They demanded their right to a voice in the election. The assessors announced that they would hold a new election. McGregor's adherents attempted to prevent this, but failed. Another hat was borrowed, and the voting was commenced over again among the voters who remained in the room. When the polls closed McGregor returned the hat he had captured, and demanded that it be accepted as the legal ballot-box. The assessors refused to accept it. The tickets in the stolen hat were counted unofficially. The canal men had a majority. The new election also gave them the victory, but the anti-canal men claimed it. The certificate of election was given to the commissioners. They at once gave out a portion of the canal work on contract. They assessed the Drowned Lands owners to the amount of twenty-six thousand dollars to meet expenses. Some of the proprietors who were opposed to the canal refused to pay. Suits were about to be begun, but John I. McGregor, G. N. Phillips, and others filed a bill to restrain the commissioners from proceeding with the work. The complainants alleged that the commissioners had not been legally elected, and were wrongfully attempting to drain the Drowned Lands by a canal, when the work could be best done in the bed of the Wallkill. The matter came before Chancellor Walworth. He decided in favor of the commissioners. The canal was commenced. Gen. Wickham owned all the land through which it was to pass. He was also a large owner of drowned lands. The canal was dug under his superintendence; it was completed in 1835. Gen. Wickham asked no pay for the land taken by the canal; he relied on its success so to increase the value of his drowned lands that he would be more than repaid for the damage done to his meadows by its construction.

"To protect the water-power at New Hampton, the act of 1826 provided for the construction of a flood-gate-dam in the canal, which was to be closed whenever it was necessary to flood Phillips' Pond, at New Hampton. The canal gradually undermined its banks and washed them away until from a ditch twelve feet wide and eight deep it became a river in places seven hundred feet wide. Hundreds of acres of the best land in Orange County were thus carried away by succeeding freshets. The canal, increased in size, depth, and fall, took all the water from the river between the inlet and outlet of the ditch. More than ten thousand acres of swamp were converted into the most productive land in the county. As the canal deepened and widened the drainage of the swamp enlarged in extent. Where, a few years before, the farmers could get about only in boats, solid roads were made possible. Fragrant meadows took the place of almost unfathomable mire. The increase in the value of the property thus drained is to-day put down at over two millions of dollars. The draining cost the landowners sixty thousand dollars.

"What brought wealth to the Drowned Lands farmers, however, sent disease and ruin to the mill-people. To turn back the water to its original channel, George Phillips, who succeeded his father, G. N. Phillips, as owner of the water-right, constructed a dam across the canal. This had the desired effect, but it soon began to flood the reclaimed lands. Then the farmers mustered in force and destroyed the dam. It was rebuilt, and again destroyed. The dam-builders were called the 'beavers'; the dam-destroyers were known as 'muskrats.' The muskrat and beaver war was carried on for years. Finally,

Squire J. M. Talmage and Amos M. Ryerson purchased the Phillips property. In 1857 the drowned-land commissioners paid them five thousand dollars for the water-right. The canal thus became master of the situation. The Wallkill, from the head of the canal to New Hampton, was changed from a rapid stretch of stream, three miles in length, to a series of stagnant pools and beds of decaying vegetable matter. Denton and New Hampton, situated in the very midst of Orange County's fragrant meadows and mountain-air, became seats of malaria. The mills and factories were closed.

"In 1869, G. D. Wickham, George C. Wheeler, and O. D. Wickham purchased the Phillips property of Ryerson and Talmage. They then purchased a strip of land on both sides of the canal, a short distance above its entrance into the Wallkill. There they constructed a high and substantial dam across the canal for the purpose of throwing the water back into the old channel of the river. Then the muskrat and beaver war was renewed. A hundred farmers, on the 20th of August, 1869, marched upon the dam to destroy it. A large force of armed men guarded the dam. The farmers routed them and began the work of destruction. The 'beavers' then had recourse to the law; warrants were issued for the arrest of the farmers. A number of their leaders were arrested, but not before the offending dam had been demolished. The owner of the dam began to rebuild it; the farmers applied for an injunction. Judge Barnard granted it, and cited the owner of the dam to appear and show cause why the injunction should not be made perpetual. Pending a final hearing, high water came and carried away all vestige of the dam. In February, 1871, Judge Barnard decided that the dam could not be legally constructed. Since then no water has flowed in the Wallkill between Denton and New Hampton, and the canal has greatly increased in size. A prominent resident of Denton assures the writer that there have been at one time as high as one hundred cases of malarial fever in Denton and New Hampton and along the old bed of the Wallkill this season. Three cases in one house, he says, is a common occurrence, and he pointed out one house in Hampton where there had been seven persons prostrated with fever at the same time. 'This festering bed of the Wallkill causes it all,' our informant declares, 'and property hereabout can hardly be sold at any price.'

"The continued increase in malarious diseases and the depreciation of property along the Wallkill's old channel have alarmed those directly affected. Last year they had a survey made of the former bed of the stream. The engineer assured them that the obstructions could be so removed from the channel that the drainage of the Drowned Lands would be perfect, as it is by the canal. The cost of the work was estimated at twenty-five thousand dollars; this was more money than the people could raise. They applied for an appropriation of fifteen thousand dollars from the State. A legislative committee was appointed to look into the matter. Nothing was done beyond recommending that State Engineer Seymour be authorized to make a survey of the Wallkill to ascertain if the proposed improvement was practical. Engineer Seymour was authorized to make the survey; he began the work two weeks ago. The matter of an appropriation will be pressed again the coming winter, and the question will be a leading one in the politics of this Assembly district this fall. The drowned-land farmers will oppose the work until they are assured beyond all question that it will be fully as valuable to them as the canal. Even then they are not expected to give the measure any tangible support, as they have the canal, and the new work will confer no increased benefit upon them.

"The Drowned Lands of the Wallkill abound in curious things. Rising from the morass are numerous elevations of land resting on the limestone that underlies this whole marsh; they have been given the name of islands. Before any draining was done these islands were accessible only in boats during freshets. Pine Island, near the site of a flourishing village, and the terminus of the Pine Island branch of the Erie Railway, Big Island, Merritt's Island, and Walnut Island are the principal ones. These elevated tracts contain from forty to two hundred acres. Some of them are fertile and in a high state of cultivation; others are covered with forests of cedar and other evergreen trees. On the southwestern border of the swamp, in the town of Warwick, two lofty and isolated mountains rear their summits. They are called Adam and Eve. Formerly they swarmed with rattlesnakes, but these the inhabitants have exterminated. Mount Eve abounds in caverns of great extent, one having been explored for nearly a mile. High up the side of this mountain there are bowlders weighing hundreds of tons apparently so lightly lodged that a push might send them thundering down into the swamp beneath. A singular characteristic of the marsh is the existence in it of large and remarkably cold springs. One of these, in the vicinity of the early home of the late Secretary Seward, near Florida, is seventy-five feet in diameter. The water is ice-cold and unfathomable. The muck in the swamp is very deep in places. Cedar logs of immense size, and as sound as if fallen but yesterday, have been found near Warwick, thirty feet below the surface."

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Environmental Quality of the Wallkill River in Orange County, New York

Report to Orange Environment

by Erik Kiviat, Gretchen Stevens, Robert E. Schmidt, and Spider Barbour

Hudsonia Ltd.

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1 Abstract

At the request of Orange Environment, Hudsonia conducted a biological and water quality survey of the Orange County (New York) portion of the Wallkill River in 1991 and 1992. We sampled fishes and macroinvertebrates and analysed summer and early fall water samples from 10 stations along the mainstem, and we reconnoitered riparian areas for vascular flora and significant habitats. The Wallkill was very turbid during the study period, with total suspended solids at or above 14 mg/l at all but three stations. Phosphate-phosphorus concentrations were extremely high (to 0.71 mg/l). Chloride levels were also high (24-51 mg/l), but were comparable to other Hudson Valley streams with developed watersheds. Nitrate and sulfate were surprisingly low for an agricultural stream. We found a diverse but sparse fish community; the dominant species was spotfin shiner, usually uncommon in Hudson River tributaries. We confirmed the presence of two state-listed rare fish species, the tadpole madtom and the eastern mudminnow; this may be the northernmost population of the eastern mudminnow in North America. We used three indices to help assess the macroinvertebrate community: the MTQ (derived from Winget (1985), a community analysis following Kurtenbach (1990), and the BCI (Winget 1985). All three indicated a macroinvertebrate community under considerable habitat and pollution stress. We found 7 species of state-listed rare plants, and at least 10 species of regionally rare plants in the Wallkill corridor. The influences of calcareous soils and the dynamics of a large stream may combine to create particular riparian habitats not found elsewhere in the Hudson Valley. We identified three areas in the river corridor that we feel deserve special protection. Further surveys should be conducted to identify other rare species and significant habitats; surveys should be extended to the New Jersey and Ulster County portions of the river.

Land use practices, storm water management, and point sources of pollutants must all be addressed and remediated if the Wallkill River stream water quality and instream habitats are to be restored to acceptable levels. We recommend preservation and restoration of riparian habitats wherever possible, to provide an ecological buffer zone for the river, and to provide important habitats for many native species of plants and animals. A continuous protected corridor along the river could also be used as a walking trail or a canoe trail. Restoration and maintenance of a wooded buffer zone between the river and land uses such as pastures, cropland, and golf courses would help protect the river from nutrient and pesticide contamination. Introduction and maintenance of instream snags along the length of the river would probably improve fish densities by improving cover and fish-food productivity. Halting the apparently massive silt loading into the Wallkill would improve both fish-spawning and invertebrate habitats.

2 Introduction

The quality of any stream and its biological communities reflect human activities in the surrounding landscapes. The watershed of the Wallkill River contains agriculture, urban areas, industry, landfills, and other land uses that generate water pollutants. Because the Wallkill is one of the largest Hudson River tributaries and it collects pollutants from a large area, it is more susceptible to degradation than smaller streams. The purpose of this study was to survey water quality and organisms in the channel of the Wallkill mainstem and associated riparian habitats, to compare the environmental quality of the river with other Hudson River tributaries, and to identify some of the major problems and opportunities for management of the Wallkill in Orange County.

Because of widespread decline and loss of populations and genetic variants of native plants, animals, and other organisms, and because of the great importance of biological diversity to humankind, we have paid much attention in our study of the Wallkill to the occurrence of rare species and their habitats. In addition to pollution and its effects on the river biota, we also looked for rare species and relatively intact habitats that are deserving of conservation action.

We studied the Wallkill in 1991 and 1992, focusing on 10 stations representing different reaches of the mainstem and potential sources of pollution. We sampled aquatic macroinvertebrates by means of Dendy plate samples and Surber samples. We conducted fish surveys using seines. We made field measurements of stream water conductivity, temperature, and dissolved oxygen, and collected a series of water samples for analysis of phosphate-phosphorus, nitrate, sulfate, chloride, and total suspended solids. We also reconnoitered riparian areas for vascular flora and significant habitats. Our report includes a discussion of the results of these surveys, as well as recommendations for conservation and management.

This project is funded in part by Orange County through a court-awarded Conservation Project. Additional support was provided by the J.M. Kaplan Fund through Orange Environment. We acknowledge the assistance of David Church, Molly Gallagher, Lianna Hoodes, Mike Edelstein, and Marty Borko. We would also like to thank Camo Laboratories for analyzing water samples at reduced rates.

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Metric units of measurement are used in this report. English equivalents are:

1 cm (centimeter)	= 0.39 inch
1 m (meter)	= 3.28 feet
1 km (kilometer)	= 0.62 mile
1 km^2 (square kilometer)	= 2.59 square miles or 100 ha
1 ha (hectare)	= 2.47 acres

3 The Wallkill River Study Area

The Wallkill River rises in northern New Jersey and flows ca 105 km north through Orange and Ulster counties in New York to its confluence with Rondout Creek, a tributary to the Hudson River. The Wallkill drains an area of ca 3300 km^2. The total change in elevation is ca 655 m, from 698 m above mean sea level at its headwaters to 43 m at its mouth (Waines 1967). The study area for this project was the river, selected tributaries, and riparian areas within Orange County only, and is mapped on the following USGS 7.5 minute quadrangles: Unionville, Pine Island, Middletown, Goshen, Pine Bush, and Walden.

Most of the Wallkill valley is underlain by shales of the Normanskill Formation. In southern Orange County, an area of perhaps 90 km^2 is underlain by Wappinger Group limestones and dolostones (Fisher et al. 1971). This area contains the most striking surficial feature of the Wallkill Valley, the thick organic deposits of the "Black Dirt" area, now substantially drained and intensively cultivated for row crops. Glacial till covers much of the remaining watershed in Orange County, with pockets of lacustrine silt and clay and scattered kame deposits (Cadwell et al. 1986).

Land uses and potential pollution sources in the Orange County portion of the Wallkill Valley include dairy farms, vegetable farms, residential and urban areas, sewage treatment plants, private and public landfills, golf courses, and roads.

4 Methods

Locations of sample stations and other observation areas mentioned in this report are shown in Figure 1. Station locations were chosen to represent various reaches and habitats of the river, and several potential pollution sources.

4.1 Water Quality

Water samples were taken at stations 1-3 on 8 October; the most recent rainfall, a trace, had been ten days earlier. Stations 4 and 5 were sampled on 14 August; the most recent precipitation, 1.57 cm, had been on 9 August. Stations 6-10 were sampled on 20 July 1992; there had been a heavy rainstorm (6.27 cm) on 16 July and a lesser storm (0.25 cm) on 18 July. Dissolved oxygen (DO), conductivity,

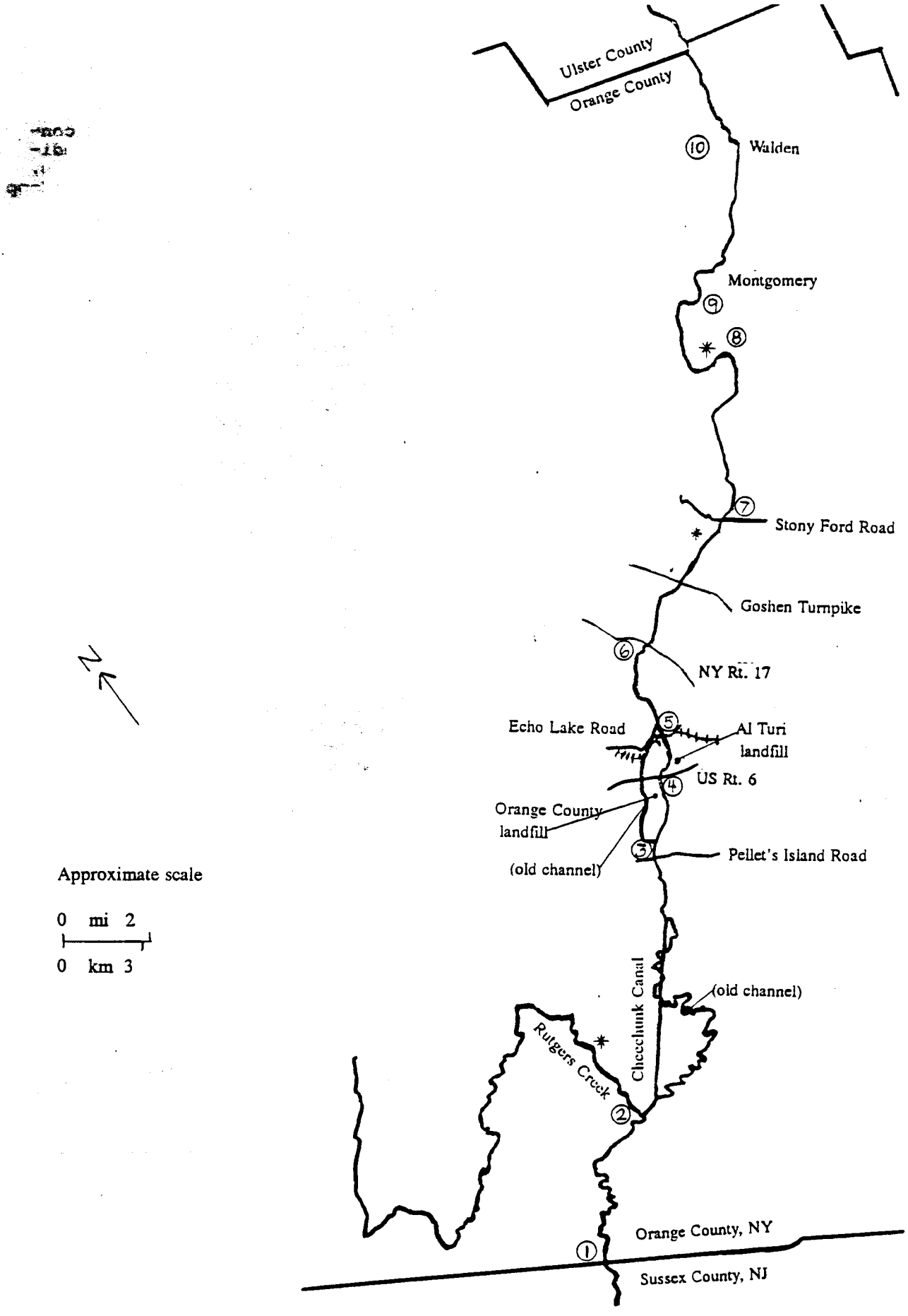


Figure 1. Location of sampling stations (1-10), other observation areas (A-F) and three special areas (*) along the Wallkill River, Orange County, New York.

and temperature were measured in the field using a YSI DO meter and a YSI conductivity probe. At each station, a water sample was collected, placed immediately in a portable cooler, and transported the same day to Camo Laboratories, Poughkeepsie, NY. Samples were analyzed by Camo using EPA standard methods (Kopp and McKee 1983) for total suspended solids (TSS), nitrate (NO_3^-), phosphate-phosphorus (PO_4^{3-}-P), sulfate ($SO_4^=$), and chloride (Cl^-).

4.2 Fishes

We intended to sample fishes quantitatively, but turbidity, water depths, and poor accessibility made quantitative sampling unrealistic for several reasons. First, although much of the study area is shallow and wadable, the Wallkill is too wide to adequately sample with our gear. Kurtenbach (1991) stated that a 5000 Watt boat shocker is the minimum gear necessary to sample fishes in rivers comparable to the Wallkill. Access with a boat shocker to some reaches of the Wallkill with a boat shocker would be very difficult. Second, the turbidity of the Wallkill rendered electrofishing gear ineffective. Shocked fish must be seen to be captured and the water clarity was typically very poor. Third, sampling fishes with a seine was very difficult in the channelized station 4 and impossible at station 3. The substrate was covered with irregular cobble and the channel was steep-sided and deep.

We sampled as thoroughly as we could with a 10-ft seine. We sampled fishes at stations 1,2,3, and 8 on 8 October, stations 4, 5, and 9 on 14 August, and stations 6,7,8, and 10 on 20 July 1992. We attempted to sample all available habitats at each station and we believe we obtained a good picture of the fish fauna in the Orange County section of the river. All fishes were identified in the field by Robert E. Schmidt.

4.3 Macroinvertebrates

Much of the Wallkill was unsuitable for Surber or travelling kick sampling techniques for macroinvertebrates due to the absence of cobble substrates, the slow current and silty bottom, and the channelization of some reaches. Instead we used Dendy plates; these are ranks of masonite plates that provide a 1-ft^2 artificial substrate for invertebrates to colonize. In addition, on 9 November 1992 we took triplicate Surber samples at station 8, the only station with a cobble bottom, to provide a comparison with our Dendy plate data.

We placed three Dendy plates at each station on 9 November 1991 and retrieved them on 21 December 1991. Each array was tied to the shore with a length of twine. Due to an early freeze, many areas were iced over at retrieval; we had to chop through ice to recover some of the samplers. Some samplers were unusable due to stranding, and one was entangled and could not be recovered. We retrieved two usable samplers at stations 2, 3, 6, and 7 and all three samplers at the other stations.

The Dendy samplers were removed from the water, the exposed surfaces were immediately scraped clean with a knife and the samplers were placed in a plastic bag and labelled. Samplers were transported to the lab and refrigerated. The following day, samplers were disassembled, all sediments were washed into a dissecting pan, and organisms were removed and preserved in 70% ethanol. Organisms were identified by Kathleen A. Schmidt to the lowest practical taxon and counted.

4.4 Flora

At the beginning of our study in the fall of 1991, Kiviat and Stevens canoed segments of the river from Station 1 (Oil City Road) up to the state line, and from Station 3 (Pellets Island) down to Station 6. For portions of the reconnaissance we were accompanied by Robert E. Schmidt, Dave Church, Molly Gallagher, and Ted Fink. In 1992, contemporaneous with other field work, Stevens and Kiviat conducted single-visit surveys, on foot, of the vascular flora at Stations 4 through 10. Barbour also reconnoitered, on foot, 6 other areas and revisited our Stations 7 and 8. During these surveys we made lists of the flora we could identify confidently in the field, and collected specimens of other species. Stevens identified most of the specimens in the laboratory, and all specimens were then submitted to consulting botanist Jerry C. Jenkins for further identification or verification. Specimens of rare species, locality

records, and other selected specimens will either be retained in the herbarium of the Bard College Field Station or deposited at the New York State Museum. A list of the flora is in Sect. 12. Common and scientific names in this report mostly follow Mitchell (1986).

5 Results and Discussion

5.1 Water Quality

Stream water chemistry is affected by seasonal changes in the stream and watershed, by the timing and magnitude of runoff events, by non-point source fluctuations, and by the nature and timing of point-source pollution discharges. The effect of storm or drought conditions on pollutant concentrations will vary according to the nature of the pollutant and the timing and nature of the discharge. Low stream flows tend to concentrate existing pollutants in stream water, including those from constant point discharges. Lack of precipitation and runoff during drought periods may reduce the overall pollutant load from non-point sources such as agricultural fields, golf courses, and urban streets. Storm events tend to increase the pollutant load from non-point sources, but may also dilute the concentration in the stream such that the increased load may be obscured in water sample analysis. For these reasons, specific knowledge of the contribution of point and non-point sources to the pollutant load of the particular stream is essential to understanding of the effects of precipitation and runoff events on chemical concentrations in stream water.

Because water is continuously moving through a stream, the water chemistry in any particular water sample reflects only momentary conditions. Pulses of pollutants or other substances are easily missed by infrequent sampling, even though the immediate and long term effects on stream biota or downstream water quality may be substantial. The more frequent the sampling, the more informative the analysis for general stream conditions.

In the Wallkill study we collected water samples only once at each station over an 11-week period. Therefore we cannot analyze upstream-to-downstream or seasonal trends in water quality. We suspect that water quality changes dramatically in the course of a year, depending on runoff events, agricultural activities, and other activities in the watershed contributing to non-point source pollution. In this study we have only a glimpse of the stream conditions at each of the stations. Table 1 gives the results of our water chemistry analysis. Below we present our results in the context of data from other Hudson Valley streams, and discuss the implications for overall stream integrity in the Wallkill.

Table 1. Water chemistry data from samples taken at Wallkill River stations, Orange County, New York. TSS = total suspended solids; $SO_4^{=}$ = sulfate; Cl^- = chloride; NO_3^- = nitrate; PO_4^{3-}-P = phosphate-phosphorus; DO = dissolved oxygen; oxygen sat. = dissolved oxygen saturation.

STATION	TSS (mg/l)	$SO_4^{=}$ (mg/l)	Cl^- (mg/l)	NO_3^- (mg/l)	PO_4^{3-}-P (mg/l)	DO (mg/l)	Oxygen Sat. (%)	Conductivity (micromhos/cm)	Temp °C	Sample Date
1	6	22	51	1.02	0.19	10.0	92.7	303	12.0	8OCT92
2	10	29	44	0.83	0.14	11.3	106.0	325	12.5	8OCT92
3	7	29	44	1.06	0.05	11.1	105.3	345	13.0	8OCT92
4	22	13	24	4.90	0.71	7.6	82.7	350	19.5	14AUG92
5	19	10	24	4.00	0.71	8.6	94.0	355	19.7	14AUG92
6	21	4	41	1.06	0.34	8.8	106.5	340	25.0	20JUL92
7	7	2	40	0.26	0.28	8.9	105.9	380	24.1	20JUL92
8	18	5	41	1.06	0.34	6.9	80.4	350	23.0	20JUL92
9	14	5	39	1.00	0.34	8.8	107.4	380	25.5	20JUL92
10	22	5	37	1.10	0.34	9.2	109.5	340	24.1	20JUL92

Phosphorus is essential for the growth of plants, but excessive amounts can lead to exorbitant plant growth and blooms of algae whose decomposition can deplete dissolved oxygen and produce substances toxic to other stream biota. Phosphorus is present naturally in some soils and bedrock. Phosphorus is present in streams almost solely as phosphates (Clesceri et al. 1989). Cultural sources of phosphorus in streams include runoff containing lawn and cropland fertilizers, septic leachate, industrial and sewage treatment plant effluent, and eroded soil from construction sites and agricultural land. Phosphate-phosphorus (PO_4^{3-}-P) concentrations in unpolluted surface waters are generally in the range of 0.01-0.10 mg/l (Wetzel 1983). Parsons and Lovett (1993) found PO_4^{3-}-P concentrations ranging up to 0.27 mg/l in Hudson Valley streams of primarily urban watersheds. Hudsonia found concentrations as high as 0.43 mg/l downstream of an aging sewage treatment plant in an Orange County stream (Stevens et al. 1994). By contrast, Parsons and Lovett (1993) and W.C. Nieder (Hudson River National River Estuarine Research Reserve, unpublished data, 1991-92) found three streams of mainly forested watersheds had PO_4^{3-}-P maxima of only 0.01-0.04 mg/l PO_4^{3-}-P.

In our Wallkill samples, phosphate-phosphorus concentrations ranged from 0.05-0.71 mg/l, but were mostly in the range of 0.14-0.34 mg/l. These are very high levels for Hudson Valley streams. In the studies cited above, even streams in highly urbanized or agricultural watersheds had PO_4^{3-}-P concentrations well below 0.20 mg/l for most of the year. It is interesting that the highest PO_4^{3-}-P levels were found at stations 4 and 5, which also had the highest TSS and NO_3^- concentrations. Because these were the only stations sampled in August, we do not know if other reaches of the Wallkill were similarly stressed at that time. Whigham et al. (1988) found that most of the phosphorus moving from agricultural fields is sorbed to soil particles, so it not surprising that high TSS in the Wallkill is associated with high PO_4^{3-}-P.

Nitrogen can occur in streams as ammonia (NH^{4+}), nitrite (NO_2^-), and nitrate (NO_3^-). Nitrate is the form most available to plants. Nitrogen is essential for plant growth, but it is often present in freshwater systems at concentrations in excess of what plants can use; unlike phosphorus, nitrogen is not limiting to plants in many freshwater aquatic environments. The major sources of nitrate in streams are drainage from fertilized croplands, livestock yards and pastures, lawns, gardens, and other fertilized lands, urban street drainage, construction sites, and sewage treatment plants. Nitrate concentrations in unpolluted fresh waters generally range from near 0 to 44 mg/l (Wetzel 1983). The maximum allowable concentration under the current federal drinking water standard is 44 mg/l NO_3^-. Parsons and Lovett (1993) found NO_3^- concentrations up to 11.8 mg/l in their study of Hudson Valley streams. The highest levels were in streams of agricultural and urban watersheds. In the most undisturbed streams, Nieder (unpublished data) and Parsons and Lovett (1993) found NO_3^- maxima of only 1.8 mg/l.

Nitrate concentrations in our Wallkill samples ranged from 0.3-4.9 mg/l, but at 6 of the 10 stations were in the range of 1.0-1.1 mg/l. These are surprisingly low levels for a stream draining a predominantly agricultural watershed. The highest concentrations were in the August samples at stations 4 and 5. We wonder if laboratory or reporting errors might be responsible for these low values.

Sulfate ($SO_4^=$) is present in certain kinds of sedimentary rock, and in rainwater, especially rain containing industrial emissions. Other major cultural sources include agricultural fertilizers, septic leachate, some industrial effluents, and sewage treatment plant effluent. Nieder (unpublished data) found $SO_4^=$ concentrations up to 85 mg/l in a Dutchess County stream receiving municipal sewage effluent, but levels in most Hudson Valley streams seem to be in the range of 10-40 mg/l. In three streams of predominantly forested watersheds, Parsons and Lovett (1993) and Nieder found $SO_4^=$ maxima of 13, 15, and 20 mg/l.

In our Wallkill River samples we found high sulfate levels (22-29 mg/l) in the October samples (stations 1, 2, and 3) and moderate to low levels (2-13 mg/l) in the July and August samples. Removal of crop cover and fall tillage could account in part for the high concentrations in the fall. The low $SO_4^=$ in July and August is surprising because $SO_4^=$ tends to be high in streams such as the Wallkill which suffer from other forms of pollution.

Chloride in unpolluted fresh waters is normally in the vicinity of 8 mg/l (Livingstone 1963). Major cultural sources of chloride include municipal and industrial effluents, sewage treatment plants, septic leachate, and road runoff. Hudsonia and others have found that chloride levels are high in Hudson Valley streams, and especially in Orange County. In our 1988-89 study of three Hudson River tributaries (Stevens et al. 1994), chloride in most of our samples was less than 80 mg/l, but we found concentrations up to 222 mg/l in one Orange County stream. By contrast, Nieder (unpublished data) and Parsons and Lovett (1993) found chloride maxima of 3-6 mg/l in undisturbed Hudson Valley streams of forested watersheds. In our 1988-89 study we found that the integrity of the macroinvertebrate community showed a substantial decline at chloride levels exceeding 25 mg/l.

In the Wallkill River, concentrations were high in all samples, never less than 24 mg/l and mostly in the range of 37-44 mg/l. Extravagant road salting practices may be responsible in part for these high levels. De-icing salts deposited on road shoulders and in ditches in winter can be mobilized by rain storms throughout the year.

Dissolved oxygen (DO) is essential to all stream fauna, but some organisms are more sensitive than others to low DO levels. Oxygen is added to stream water from the atmosphere and from aquatic plants as a by-product of photosynthesis. The concentration in water depends on temperature, ion concentrations, and biological and chemical interactions (Wetzel and Likens 1991). Oxygen is usually near saturation in small turbulent streams, and at the base of dams and natural waterfalls. Periods of high discharge in larger streams are often accompanied by increases in DO. Supersaturation occurs in many streams in spring as photosynthesis increases in aquatic plants and adds oxygen to the water. Oxygen saturation often declines in summer with increasing water temperatures, and the resulting higher metabolic rates of aquatic animals and higher rates of decomposition of organic matter. Dissolved oxygen may also be depleted by the oxygen demand created by increased turbidity which can reduce photosynthesis, and by winter ice cover which reduces atmospheric exchange. Dissolved oxygen concentrations of 8-12 mg/l are typical for freshwater streams. Concentrations below 5 mg/l are considered dangerous to fish and certain other aquatic organisms.

In the Wallkill River, dissolved oxygen was at moderate to high concentrations in most of our samples. The highest DOs (10.0-11.3 mg/l), as we would expect, were in the October samples when water temperatures were only 12-13 ^{o}C. Oxygen saturation exceeded 100% in most samples. The lowest DO (6.9 mg/l, 80% saturation) was at station 8 (July).

Conductivity is the magnitude of current which water can conduct. Any water containing ions (electrically charged atoms) will conduct an electrical current. The magnitude of the current at a given temperature is directly proportional to the total concentration of dissolved ionic substances in the water, thus conductivity measurements provide an indirect measure of dissolved ions. High conductivities may have geologic causes, or may be associated with pollutants.

Conductivities in our Wallkill samples ranged from 303 to 380 micromhos/cm. These are in the mid-range of conductivities that we have seen in other Hudson Valley streams.

Total suspended solids (TSS) is a measure of soil particles, organic matter, and other solid materials suspended in the water column. Soil erosion from agricultural fields and construction sites, and runoff from urban streets are three of the primary sources of suspended solids in streams. TSS tends to be elevated during runoff events. High turbidity in a stream can have many damaging consequences to the stream ecosystem. It reduces the light available for photosynthesis, and thus tends to reduce the phytoplankton and phytobenthic populations. It may also interfere with feeding mechanisms of zooplankton (Hynes 1970), and can discourage sight-feeding fish species. Nutrients and toxins sorbed to soil particles can be damaging to many stream organisms. High TSS is usually associated with eventual deposition of sediments on the stream bottom. Sediments can smother plants, fish eggs, aquatic insects, mollusks, and other stream organisms. The instability of a sandy or silty substrate prevents the buildup of large invertebrate populations; invertebrates are a basic food source for many

freshwater fish. Sedimentation can also elevate stream beds and reduce pool sizes and depths, thus raising summer water temperatures and reducing suitable spawning and nursery areas for some fish species.

Parsons and Lovett (1993) found TSS mostly in the range of 0.1-2.5 mg/l in their study of Hudson Valley streams. Only two of their fifteen study streams exceeded 3 mg/l during non-storm sampling periods. TSS in storm flow samples from four streams ranged from 0.6 mg/l in a largely undeveloped forested stream, to 39.4 mg/l in a stream of a forested and urban watershed.

In our Wallkill samples, TSS ranged from 6-22 mg/l. All but three stations had TSS exceeding 14 mg/l. These are very high levels. Stations 6-10 were sampled on the fourth day following a significant rainstorm, which may account for the high TSS at those stations. Stations 4 and 5, however, had equally high TSS but had not received recent large rainfall. Agricultural streams in the Parsons and Lovett study never exceeded 2.5 mg/l except during a storm event when one reached 5.1 mg/l TSS. The vast amount of land in intensive agricultural uses sets the Wallkill River apart from other streams studied in the Hudson Valley.

Summary. The most unusual aspects of the Wallkill River water quality were the very high turbidity and phosphate-phosphorus concentrations. Total suspended solids were consistently at levels associated only with storm events in other Hudson Valley streams. Phosphate-phosphorus concentrations in 7 or our 10 samples were higher than those in the worst of the 15 streams studied by Parsons and Lovett (1993). Chloride was also consistently higher than in any of the non-urban streams in that study. Soil erosion and agricultural fertilizers may be responsible for the high TSS and phosphorus. Road salting, municipal sewage and septic field leachate, and possibly agricultural runoff may be the source of elevated chloride.

Because we took water quality samples only once at each station, we recommend confirmatory sampling and analysis before too much weight is placed on our data. The macroinvertebrate indices, however, also seem to indicate high pollution levels. We believe that the high phosphate and chloride concentrations are not simply artifacts of a large stream in a large drainage, but are due to excessive pollution entering the stream from numerous sources.

The Wallkill may be particularly susceptible to water quality degradation because of characteristics of the bedrock geology, especially in the southern part of the county. The dolomitic bedrock underlying and surrounding the Black Dirt region is highly soluble and is characterized in some places by sinkholes, sinking streams, and the lack of a continuous ground water table; instead the ground water resides in or flows through irregular underground solution cavities. (This region is identified as "karst" by some geologists.) Where these conditions are present, the groundwater and receiving surface waters are especially vulnerable to pollution because contaminated surface runoff may flow directly into the groundwater with no filtering by soil or bedrock (Edelstein and Makofske 1985). Also, limestone inliers in some of the shales outside the karst (Offield 1967) could act as water conduits to the solution cavities of the karst region (Waller 1981, cited in Edelstein and Makofske 1985).

5.2 Fishes

We collected a total of 22 taxa of fishes in this survey of the Orange County portion of the Wallkill River (Table 2). This is a large list of species for a Hudson River tributary. The species richness at a single station ranged from a high of 12 at station 8 to a low of 4 at station 10.

In 1977, NYSDEC sampled four Orange County stations in the Wallkill using a boat shocker, and reported a total of 18 species of fish (Pierce 1978). The NYSDEC stations were located as follows: at the NY-NJ border (our station 1), in the Cheechunk Canal (between our stations 2 & 3), a pool at Montgomery (our station 9), and the impoundment at Walden (between our stations 9 & 10). NYSDEC collected three species that we did not see in our 1992 study: eastern chubsucker (Erimyzon oblongus), carp (Cyprinus carpio), and white perch (Morone americana). We collected 7 taxa that NYSDEC did not report. Differences in collecting methods can easily explain the disparities in the two species lists.

Table 2. Fishes collected by seine in the Orange County segment of the Wallkill River, 1992. Effort not equal at all stations; see Methods. Station 3 was inaccessible by seine due to steep, riprapped banks.

Scientific Name	Common Name	Station									
		1	2	4	5	6	7	8	9	10	Total
Cyprinella spiloptera	spotfin shiner		5	4	7	15	60	25			116
Notemigonus crysoleucas	golden shiner							3		2	5
Notropis hudsonius	spottail shiner			1	14	3	4			2	24
Rhinichthys atratulus	blacknose dace					1					1
Rhinichthys cataractae	longnose dace					18					18
Catostomus commersoni	white sucker				1	2	5	3			11
Ictalurus natalis	yellow bullhead	1			3			4	1		9
Noturus gyrinus	tadpole madtom	2									2
Esox americanus	red fin pickerel							1	1		2
Esox niger	chain pickerel		1								1
Umbra pygmaea	eastern mudminnow								1		1
Fundulus diaphanus	banded kill fish				3		1	2	6		12
Ambloplites rupestris	rock bass					1					1
Lepomis auritus	redbreast sunfish	1	3		2						6
Lepomis auritus x gibbosus	(sunfish hybrid)	1									1
Lepomis gibbosus	pumpkin seed	17	10		1		7	19	2		56
Lepomis macrochirus	bluegill	26	3		3	4		2	12	2	52
Micropterus dolomieui	smallmouth bass				1		1	2			4
Micropterus salmoides	largemouth bass	1			1		2	6	2		12
Pomoxis nigromaculatus	black crappie	1				1		1		4	7
Etheostoma olmstedi	tessellated darter		3			4	6	4	1		18
Perca flavescens	yellow perch				1						1
Totals		50	25	5	37	49	86	72	26	10	360

Combined with the fishes found in the Wallkill tributaries, including the Shawangunk Kill, the species list for the Wallkill is the largest of any Hudson River tributary. This species richness is partially due to the large drainage size of the Wallkill; larger geographic areas are expected to contain more species (Sheldon 1988). There is also a biogeographic component to the species richness in the Wallkill. Because the Wallkill drains northeastward from northern New Jersey, an unusual drainage pattern, it may be a dispersal corridor for generally more southern species, such as the comely shiner (Notropis amoenus) which reaches its northeastern range limit on the U.S. East Coast in the Shawangunk Kill (Lee et al. 1980).

5.2.1 Fish Habitat

The distribution of fishes within stations suggests that the Wallkill in Orange County has very patchy fish habitat. Much of the substrate in the main channel of the river is sand. Uniformly sandy streams typically have a depauperate fish fauna. The fishes we collected over sandy bottoms were almost entirely a single species, spotfin shiner (Cyprinella spiloptera). We found most of the other taxa in scattered locations where the open sandy bottom was interrupted by other substrates. At station 5, for instance, most of the fishes were taken along an undercut bank and we caught nothing over the shallow sandy bottom in the middle of the creek. At other stations, fishes were concentrated around rocky riffles (e.g., stations 6 & 8). Fishes were fairly dense in the riffle area at station 6, but we caught very little in the sandy area upstream of the riffle, despite sampling several dense patches of submerged aquatic plants. The relatively high species richness at station 8 (Table 2) can be explained by the extensive rocky substrate at that location. In other areas, fish were found in silty backwaters or around fallen snags or bridge piers.

We did not note any major incidence of disease or poor condition in the fishes we collected. Because aging of fish was not within the scope of this project, we do not know if there were growth anomalies among the fishes we collected. The main stress indicator that we observed in our samples was at the community level: the dominance of spotfin shiner. This phenomenon is discussed further below.

5.2.2 Stream Modification and Pollution

There have been two major channelization projects in the Orange County section of the Wallkill. The largest is the Cheechunk Canal. We did not sample fish in the canal, but Pierce (1978) stated that "... the Cheechunk Canal is an excellent example of how a productive stream can be destroyed by stream channelization." He reported only four species of fish from the channelized area.

The reach of the Wallkill extending from upstream of our station 3, past the two landfills, to just upstream of our station 5 has also been channelized to direct the flow around the landfills. This channelization was not as severe as in the Cheechunk Canal; the Wallkill was allowed to curve somewhat through this area, but the banks have been riprapped. We were unable to sample fishes at station 3 because of this modification. At station 4 we caught only two species, in part because the riprapped bottom interfered with our ability to seine, but we think also because the channelization has severely degraded the fish habitat.

Our ability to detect pollution effects using fish communities was hampered by our inability to sample quantitatively and by the confounding effects of channelization. One station, however, was clearly degraded by water pollution and this degradation was reflected in the fish community. In Walden (station 10) the river had an extensive rocky riffle with a moderate gradient which should have had a rich fish community, yet we collected only four species and very few individuals. The rocks in the middle of the river were coated with a dense mat of midge (Chironomidae) tubes. Chironomids are found in all kinds of stream habitats, but are most abundant in organically polluted and nutrient-enriched waters. We think the sewage treatment plant upstream of this station has severely affected the fish community.

5.2.3 Rare or Interesting Fishes

Two species of fish collected in this study deserve further comment. The eastern mudminnow (Umbra pygmaea) (S3), collected at station 9, probably represents the northernmost population in North America. Smith (1985) documented this population very close to our collecting site. It is encouraging that the population still persists. Animals at the extremes of their ranges are often instructive objects of study because that is where the greatest genetic variability may occur, and the species is most likely to be vulnerable to natural or human-caused stress.

At station 1, we collected 2 specimens of the tadpole madtom (Noturus gyrinus) (S3), a small, secretive catfish. Smith (1985) recorded this species from the upper Wallkill but had no recent records from that area. Tadpole madtoms prefer dense submerged vegetation which is precisely the habitat we sampled. We have noted that this species has disappeared from Quassaic Creek (Orange County), so it is gratifying to document its presence in the Wallkill.

5.2.4 Historical Data on Fish Communities

The Wallkill in Orange County was surveyed by NYSDEC in the 1930s, along with every other major stream in the state. Lists of species collected were transcribed from NYSDEC files by M. Gallagher. The 1930s survey reported 24 species; we and Pierce (1978) together documented 25. Species reported in the 1930s survey that we did not collect were: fallfish (Semotilus corporalis), cutlips minnow (Exoglossum maxillingua), common shiner (Luxilus cornutus), creek chub (Semotilus atromaculatus), brown bullhead (Ictalurus nebulosus), American eel (Anguilla rostrata), and silvery minnow (Hybognathus regius). The first four of these species are common small stream fishes in the Hudson Valley. Neither we nor Pierce sampled tributary streams where these species are likely to be found. We do not know whether the 1930s survey teams sampled tributaries or caught

these species in the mainstem. The brown bullhead and American eel are surely present in the Wallkill but were not accessible to our gear. The record of the silvery minnow is interesting. Currently this species seems to be limited to the Hudson estuary where it is rarely seen.

Species that we and Pierce (1978) reported that were not seen in the 1930s survey were tadpole madtom, eastern mudminnow, white perch, black crappie, chain pickerel, yellow perch, and banded killifish. The first two species were discussed earlier in this report. The next four species are all considered sport fish and may have been stocked since the 1930s or simply missed in these early surveys. The banded killifish was a popular baitfish in the Hudson Valley and upland populations may have been introduced by fishermen.

We see no major overall change in the fish community since the 1930s survey. The biggest change may be an increase in species due to stocking activities for sport fishing.

5.2.5 Biology of the Spotfin Shiner

Spotfin shiners were a dominant species wherever we collected them, ranking either first or second in abundance. They comprised an average of 42% (range 17-80%) of the individuals collected at those stations where they were present. It is unusual for this species to be so common in a Hudson River tributary. We have recorded them elsewhere in the Hudson Valley (Schmidt and Kiviat 1988) but always as a rarity.

Much of the literature written on this species preceeded a recent major taxonomic re-evaluation of North American minnows. Thus the literature refers to the spotfin shiner by its older junior synonym, Notropis spilopterus, rather than the current Cyprinella spiloptera.

The spotfin shiner is a small to moderate size minnow, often reaching 6.5 cm standard length (Gibbs, 1957) and recorded as large as 9 cm (Thiesing 1989). This species can reach an age of three years but most individuals do not live beyond two (Thiesing 1989).

Spotfins are characterized as fractional crevice spawners (Gale and Gale 1977), a characteristic common to the genus Cyprinella. Spotfins have been observed depositing eggs in a variety of crevices: under bark of submerged logs (Hankinson, 1930), under tree roots and flat rocks (Stone, 1940; Pflieger, 1965), and in disintegrating bridge abutments (Gale and Gale, 1977). The term fractional describes the females' release of only part of their eggs in each spawning act. Total numbers of eggs per female can be as high as 7500 (Gale and Gale, 1977).

Of more significance to the Wallkill is this animal's habitat selection and feeding behavior. Vadas (1992) considered the spotfin shiner a habitat generalist (i.e., found in many habitat types), an observation supported by Thiesing (1989). Vadas suggested that habitat generalists should be more common than habitat specialists in fluctuating environments such as the flooding and drought intermittancy of his Goose Creek, Virginia, study area.

Spotfins have been reported to consume a large amount of terrestrial insects (White and Wallace, 1973; Thiesing, 1989). More careful studies (Vadas, 1990; and particularly Mendelson, 1975) indicated that, in addition to terrestrial insects, spotfins feed almost exclusively on insect drift in the water column. Thiesing (1989) suggested this possibility but did not sample drift in her study in the Shawangunk Kill.

5.3 Macroinvertebrates

Stream macroinvertebrates are thought to be good indicators of environmental conditions in part because they cannot move away from pollution or leave the stream altogether (except as adults of some taxa). The sensitivity of macroinvertebrate taxa to various pollutants is determined to a large extent by their feeding and reproductive habits, and their strategies for obtaining oxygen. Organic pollutants tend to reduce the abundance of some species and permit others to survive or even thrive, thus reducing diversity and altering community structure, but not necessarily reducing overall abundance. Because we understand the general tolerances of some mocroinvertebrate taxa to organic pollution, analysis of community structure can be useful for obtaining information on the

status of organic pollution in a stream. Siltation and toxic pollutants, on the other hand, tend to have a non-selective impact on the macroinvertebrate community; that is, they tend to deplete the abundance of all species without necessarily altering species composition of the community. The abundance and structure of the macroinvertebrate community present at any time is dependent on hatching cycles and on immediate and longer term water quality and substrate conditions.

Numbers of individuals and densities of macroinvertebrate taxa in our samples are given in Table 3. We collected low numbers of macroinvertebrate individuals and taxa on the Dendy samplers. Dendy samplers tend to be colonized more sparsely than instream rocks, but ours and other studies seem to show that the taxon groups that colonize Dendys, although reduced, are fairly representative of the stream as a whole.

We used three indices to derive stream habitat quality information from our macroinvertebrate data and to compare that information to other studies: the Mean Tolerance Quotient (derived from Winget 1985), a community analysis following Kurtenbach (1990), and the Biotic Condition Index (BCI, Winget 1985). Figure 2 compares the BCI and community index results.

5.3.1 Mean Tolerance Quotients (MTQ)

Winget (1985) studied the physical habitats and macroinvertebrates in 28 streams in western states, and conducted correlation analyses of the physical and chemical parameters with macroinvertebrate density, biomass, and diversity. He established what he calls "Tolerance Quotients" (TQs) for many macroinvertebrate taxa, denoting their sensitivity to and tolerance thresholds for gradient, substate roughness, alkalinity, and sulfate concentrations. TQs range from a low of 4, denoting the greatest habitat sensitivity, to a high of 108, denoting high tolerance for pollution and habitat stress. Hudsonia uses an index we call the "Mean Tolerance Quotient" (MTQ) to represent the overall pollution tolerance or intolerance of the macroinvertebrate community sampled. The MTQ ranges from 4 (least tolerant) to 108 (most tolerant), and is simply a weighted average of the Tolerance Quotients for all taxa in a sample.

The MTQs calculated from our Wallkill samples were uniformly poor; all but one station had MTQs of 100 or greater. The highest score, 90, was at station 1, the upper-most station in Orange County.

5.3.2 Kurtenbach's Community Analysis

The second index we used was a community-based index that had been used in the New Jersey section of the Wallkill by Kurtenbach (1990). This index consists of five metrics; each is described below. A number is calculated for each metric and then the metric is assigned a score of 0, 3, or 6, a zero implying poor water quality and a six implying good water quality (Table 4). For each station, the sum of the scores of the 5 metrics are designated as "non-impacted" (total score = 24-30), "moderately impacted" (9-21), or "severely impacted" (0-6).

The first metric is taxon richness measured by the total number of families of macroinvertebrates in the sample. This is one component of the standard measure of diversity which is known to be affected by water quality. A decrease in water quality tends to reduce taxon richness by eliminating the more pollution intolerant taxa.

The second metric measures the number of families of generally pollution intolerant aquatic insects. "EPT richness" is calculated by counting up the number of families of mayflies (Ephemeroptera), stoneflies (Plecoptera), and caddisflies (Trichoptera) excluding the trichopteran family Hydropsychidae, a very pollution tolerant group.

The third metric, percent dominance, is a measure of evenness. In unpolluted streams, abundances of taxa are usually relatively equal (or even). If a single taxon comprises a high percentage of the sample, there may be a water quality problem. Percent dominance is calculated by dividing the number of individuals of the most abundant taxon by the total number of individuals in the sample.

Table 3. Numbers of individuals, densities, and Tolerance Quotients (Winget 1985) of macroinvertebrate taxa in a Surber sample (station 8A only), and in Dendy samples (all other stations) in the Wallkill River, fall of 1991. Three Dendy plates were recovered from stations 1,4,5,8,9, and 10, and two plates were recovered from stations 2,3,6 and 7. "#" = total number of individuals collected in three replicates. "msf" = mean density per square foot.

		TQ	STATION																					
			1		2		3		4		5		6		7		8		8A		9		10	
			#	msf	#	msf	#	msf	#	msf	#	msf	#	msf	#	msf	#	msf	#	msf	#	msf	#	msf
DIPTERA																								
Chironomidae	Undetermined	108	2	0.7	12	6.0	13	6.5	1	0.3	14	4.7			1	0.5			158	52.7			7	2.3
Chironominae	Chironomus riparius group	108							3	1.0									1	0.3				
	Cryptochironomus fulvus group	108																	5	1.7				
	Dicrotendipes neomodestus	108							1	0.3									1	0.3				
	D. nervosus	108	1	0.3															4	1.3				
	Glyptotendipes lobiferus (?)	108																	39	13.0	2	0.7		
	Polypedilum sp.	108							1	0.3														
	Pseudochironomus sp.	108	1	0.3																				
	Rheotanytarsus exiguus group	108													4	2								
	Tanytarsini, undetermined	108									1	0.3	1	0.5					11	3.7	11	3.7	12	4.0
Tanypodinae	Thienemannimyia group	108	2	0.7			3	1.5			2	0.7					1	0.3	13	4.3				
Orthocladiinae	Cricotopus bicinctus group	108																	1	0.3				
	Corynoneura sp.	108			1	0.5							1	0.5										
	Parametriocnemus sp.	108											1	0.5										
Empididae	Hemerodromia sp.	95																	2	0.7			1	0.3
Ceratopogonidae	Culicoides sp.	108							1	0.3														
Tipulidae	Undetermined						1	0.5																
TRICHOPTERA																								
Hydropsychidae	Cheumatopsyche sp.	108					1	0.5			4	1.3	4	2.0			29	9.7	66	22.0				
	Hydropsyche betteni	108									1	0.3	1	0.5										
Polycentropidae	Polycentropus nr. cinereus	72	1	0.3	2	1.0																		
	Phylocentropus sp.		1	0.3																				
Leptoceridae	Mystacides sp.	54																	1	0.3				
	Oecetis nr. cinerascens				1	0.5																		
Hydroptilidae	Hydroptila sp.	108																	2	0.7				
NEUROPTERA																								
Sialidae	Sialis sp.	72	1	0.3																				
PLECOPTERA																								
Taeniopterygidae	Taeniopteryx sp.						1	0.5			2	0.7					1	0.3						
Capniidae	Allocapnia sp.						6	3.0	1	0.3														
COLEOPTERA																								
Elmidae	Ancyronyx variegata	104																	1	0.3				
	Dubiraphia sp.	104							3	1.0									58	19.3				
	Macronychus glabratus	104					1	0.5																
	Stenelmis sp.	104							1	0.3									2	0.7				
Haliplidae	Undetermined	54																	1	0.3				

(continued)

(Table 3, continued)

		TQ	STATION 1		2		3		4		5		6		7		8		8A		9		10	
			#	msf	#	msf	#	msf	#	msf	#	msf	#	msf	#	msf	#	msf	#	msf	#	msf	#	msf
ODONATA																								
Coenagrionidae	Argia spp.	108	1	0.3			2	1.0			1	0.3			1	0.5	1	0.3			2	0.7		
	Coenagrion/Enallagma complex																				2	0.7		
	Enallagma sp.	72	7	2.3																				
Macromiidae	Macromia illinoiensis																		1	0.3				
EPHEMEROPTERA																								
Heptageniidae	Stenacron sp.						1	0.5			5	1.7											1	0.3
	Stenonema sp.	48									3	1.0					2	0.7	1	0.3				
Undetermined											1	0.3			1									
NON-INSECTS																								
Gastropoda	Amnicola limosa	108							1	0.3									5	1.7	1	0.3		
	Ferrissia rivularis	108							2	0.7									1	0.3				
	Ferrissia sp.	108																	1	0.3				
	Fossaria sp.	108							2	0.7														
	Menetus dilitatus	108							1	0.3									3	1.0	2	0.7		
	Physa heterostropha	108							7	2.3	4	1.3	1	0.5	1						3	1.0	4	1.3
	Undetermined	108																						
Bivalva	Sphaeriidae, undetermined																		31	10.3				
	Undetermined								1	0.3														
Isopoda	Caecidotea r. racovitzai		2	0.7																				
Amphipoda	Gammarus fasciatus	98			26	13.0	11	5.5	3	1.0	1	0.3	2	1.0	6	3	4	1.3	69	23.0	4	1.3	59	19.7
Turbellaria	Dugesia tigrina	108																	5	1.7	13	4.3		
	Undetermined	108																	5	1.7				
Ostracoda	Hydracarina, undetermined		1	0.3																				
	Lebertia sp.																		1	0.3				
Cyclopidae	Undetermined		1	0.3																				
OLIGOCHAETA																								
Tubificidae	Bothrioneurum vejdovskyanum(?)	108					1	0.5	82	27.3									55	18.3				
	Undetermined	108	1	0.3			1	0.5											141	47.0				
Nematoda	Undetermined	108																	2	0.7				
Undetermined		108	1	0.3			6	3.0	20	6.7							1	0.3	24	8.0	6	2.0	5	1.7
TOTAL			23	7	42	21	48	24	131	43.7	39	13	11	5.5	14		39	13	711	237	46	15.3	89	29.7
MTQ				90		100		105		108		102		106		103		104		106		107		101

The fourth metric also addresses evenness, but only of the pollution-intolerant forms. Low percent composition of these taxa may indicate a decline in water quality. This metric is calculated by summing the number of individuals of Ephemeroptera, Plecoptera, and Trichoptera (excluding the tolerant Hydropsychidae) and dividing the total by the total number of individuals in the sample.

The fifth metric is called the Hilsenhoff Biotic Index. This, like the MTQ, is essentially a weighted average of the tolerance values for taxa in each sample. Each taxon is assigned a tolerance value ranging from 0-10 reflecting the organism's ability to tolerate pollution. A zero implies no pollution tolerance and a ten implies high tolerance. Tolerance values were taken from Bode et al. (1991) and Kurtenbach (1990). The number of individuals of each species is multiplied by the species' tolerance value, products are summed for a given sample, and the sum is divided by the total number of individuals of all species in the sample.

Table 4. Scoring criteria for the macroinvertebrate community-based index, from Kurtenbach (1990).

Metric	Score 6	3	0
1. Number of families	>10	5-10	0- 4
2. Number of EPT* families	> 5	3- 5	0- 2
3. Percent dominance	<40	40-60	> 60
4. Percent EPT*	>35	10-35	< 10
5. Hilsenhoff Biotic Index	0-4	>4- 6	>6-10

*EPT = Ephemeroptera, Plecoptera, and Trichoptera

We calculated the community index for each of our stations and for each sample reported by Cooper and Neuderfer (1973), who sampled the entire New York portion of the Wallkill. Kurtenbach (1990) used the travelling kick method and based his calculations on the first 100 macroinvertebrates identified (as specified in the Rapid Biological Assessment [RBA] protocol).

Kurtenbach (1990) reported that the Wallkill was not polluted in the vicinity of Hamburg, NJ, but was moderatedly polluted (community index of 15) at the two stations closer to the New York border. By the same community index, all of our stations were classified as moderately or severely impacted. Two of our stations (3 and 5) had community index values of 15 or higher (maximum or best is 30). Four of our stations (4, 6, 9, and 10) fell into the "severely impacted" category. Stations 4 and 6 also had the lowest BCI values. The community index also showed the same general decline upstream to downstream (within Orange County) as we saw with the BCI (Fig. 2), although the community index decline was less pronounced. At station 10, where the fish population was very poor, the community index was also poor (one of the two lowest values).

5.3.3 Biotic Condition Index (BCI)

The BCI compares the actual invertebrate community composition with one predicted from knowledge of the station's substrate, gradient, alkalinity, and sulfate concentrations. Winget (1985) assigned Tolerance Quotients (described above) to a substantial list of aquatic invertebrates, according to their apparent response to those four stream parameters. He predicted that, under extreme conditions (fine substrates, low gradient, high alkalinity, and high sulfate concentrations), the invertebrate community would comprise only the most pollution tolerant taxa. Under less extreme conditions, more taxa that are intolerant of those conditions would be found. The further the *observed* community tolerance deviates from the *predicted* community tolerance, the more likely it is that some other pollution or stress (i.e., not related to gradient, alkalinity, sulfate or substrate) is affecting the community. This deviation is expressed as a percentage (predicted ÷ observed). A BCI score of 100 means that the observed community matches Winget's (1985) predictions for the observed stream conditions and there is no additional pollution stress. A BCI score of less than 100 indicates some additional pollution stress; the lower the value,

the greater the stress. The BCI can thus be useful for detecting the presence of organic compounds, heavy metals, or other common pollutants not necessarily associated with the four parameters listed above.

We calculated a BCI for the triplicate Surber samples taken at station 8 and for the Dendy plate data at each station (including station 8). We also calculated BCI values for each of the Orange County mainstem Wallkill stations sampled by Cooper and Neuderfer (1973). They used a Surber sampler at these stations without replication. We did not calculate BCIs for Kurtenbach's (1990) data for the Wallkill in New Jersey because he did not report identifications of invertebrate taxa to an adequate level for the BCI.

BCI values for the Dendy plate samples from the Wallkill in Orange County ranged between 49 and 67. We expect BCI values greater than 80 in relatively unpolluted water. The minimum values attainable (fauna composed entirely of the most tolerant organisms) were 54 (for stations 1, 2, 7, and 9) or 49 (for the rest of the stations). Station 6, with a BCI score of 49.9, had nearly at the lowest possible value.

The BCI results suggested a decline in water quality from upstream to downstream stations (Fig. 2). The two stations with the lowest BCI scores were station 4 (downstream of the Orange County landfill) and station 6 (at Cemetery Road). Surprisingly, the station just below the Al-Turi landfill (station 5) was one of the better macroinvertebrate stations in this study.

The BCI value calculated for the Surber sample at station 8 (52.7) was similar to the BCI for the Dendy samples (59.3) at that station. The Dendy plates thus appeared to provide reasonable BCI results, although the BCI score may be somewhat inflated.

BCIs calculated for the 1973 Surber data (Cooper and Neuderfer, 1973) were very similar to those from this study (53.7-61.5). The similarities are apparent in Fig. 2 where the BCI values from the two studies are juxtaposed. These results suggest that Wallkill water quality has changed little in the last 20 years.

Our sampling design did not permit reliable spatial or temporal comparisons of the data. The most important result is that scores for all macroinvertebrate indices were very poor, including those calculated for the Surber sample at station 8. The very high MTQs indicate a macroinvertebrate community that is very tolerant of pollution. Indeed, only 6 of the 44 taxa collected had Tolerance Quotients less than 90 (maximum = 108). The moderate to low Community Index values reflect both low diversity and high pollution tolerance. The uniformly low BCI scores suggest significant levels of unidentified pollutants.

In our study of three other Hudson Valley streams (Stevens et al. 1994), we found strong negative correlations between macroinvertebrate indices and chloride, sulfate, phosphate-phosphorus, and conductivity; high concentrations of any of those compounds or high conductivity were associated with very tolerant macroinvertebrate communities (high MTQs). Correlations of fish and diatom indices with water chemistry parameters were poor or inconsistent. We concluded that analysis of macroinvertebrate communities may be the best means of ascertaining the overall stream "health". Water chemistry samples reflect only momentary conditions, and most research and monitoring studies only analyze a small set of potential pollutants. The macroinvertebrate community, on the other hand, presumably integrates changing levels of water quality, and also responds to the full range of pollutants, not just the pollutants analyzed.

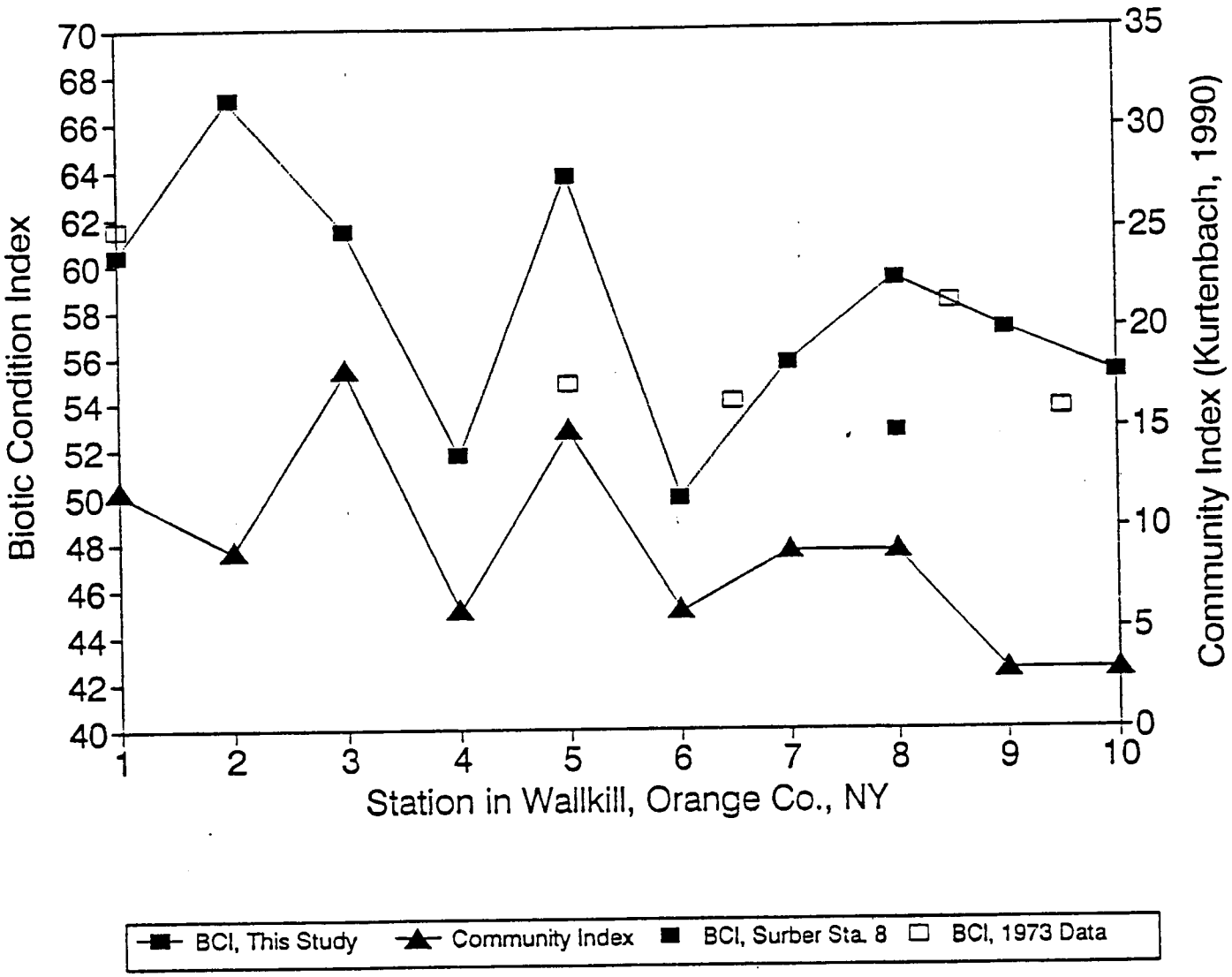


Figure 2. BCI and Community Index values from Wallkill River macroinvertebrate samples, 1973 and 1991.

6 Flora

We focused our botanical surveys both on representative reaches of the river and on localities we thought likely to support rarities. We did not survey the entire riparian zone; there may be additional occurrences of the rare plants we discuss, or occurrences of other rare species elsewhere along the river. For example, the Black Dirt area, because of its considerable extent, may yet contain rare species and significant habitats in undrained wetlands, abandoned farm fields, islands, and the old channel of the river (Black Walnut Channel).

We found several native plant species listed as rare statewide (ranked S1, S2, or S3 by the New York Natural Heritage Program [NHP], or on the NHP Watch List) (Young 1992, and addenda), and several native species we believe to be regionally-rare in Orange County and in other the Hudson Valley counties. Our criteria of rarity are discussed in Sect. 13. The following discussion does not give exact locality data for the rarer species in order to protect them from potential collectors or vandals. Further information is available from NHP or Hudsonia.

The rare plants we found were in floodplain and riparian habitats but not in the main river channel. These plants may be protected somewhat from the pollution and hydrological alteration of the river because they are perched above the main channel where the greatest concentrations of pollutants and the most intense flood scouring occur. The presence of these rarities does not indicate that all is well with the Wallkill, or that the degradation of the river is not a threat to native biological diversity. We think that a return to lower levels of pollution in the Wallkill would be favorable to these and perhaps many other rare plants and animals, and would foster the development of native plant communities in the riparian zone.

It is interesting that we found a number of rare plants but few rare fishes in the Wallkill, that the river channel and riparian areas are generally degraded and in many places have introduced flora forming a prominent component of the vegetation, and that many of the rare plants are indicative of calcareous habitats. Large rivers often have plants that small rivers and streams do not have (Nillson 1989). We think the Wallkill offers important habitats for rare flora because it is one of the largest nontidal rivers in the Hudson Valley and because of the evidently calcareous nature of its soils.

6.1 Statewide Rare Plants

Cattail Sedge (*Carex typhina*) is ranked S1S2 by NHP. There are old records from Sullivan, Dutchess, Columbia, and Westchester counties, from Long Island, the New York City area, and from the Southern Tier of New York (New York Flora Association 1990), but there are only four extant sites known in the state (Steve Young, NY Natural Heritage Program, pers. comm.). This species has not been documented previously in Orange County, and none of us had previously seen cattail sedge in the Hudson Valley. Its habitats in NY range from marshes, river flats and rich hardwood swamps to forested rocky ledges with calcicolous flora. We found cattail sedge in a sedge meadow near Rutgers Creek.

Red-root flatsedge (*Cyperus erythrorhizos*) is ranked S2 by NHP. There are recent records from Putnam, Nassau, and Suffolk counties (New York Flora Association 1990), but no previous record from Orange. Its habitats in New York range from brackish coastal ponds, freshwater wet meadows, and pond and stream edges to steep oak-pine forest and cliff communities on limestone outcrop. We found it on a young floodplain forest along the Wallkill.

River birch (*Betula nigra*) is ranked S3 on the NHP Watch List. Although very rare east of the Hudson River, this species is widespread but uncommon to rare along the Wallkill River and occasional elsewhere in Orange and Ulster counties. It is essentially restricted to river and stream floodplains, lake shores, and freshwater tidal swamps, where it apparently depends on a degree of natural disturbance from flooding and bank erosion.

Small-flowered agrimony (*Agrimonia parviflora*) Small-flowered agrimony is ranked S2S3 by NHP. In the last several years, this species has been found at a number of localities in Orange and other Hudson Valley counties. Nonetheless, we still consider it rare statewide and in the region. Small-flowered agrimony grows in sunny or semi-sunny, moist-to-wet, mildly to moderately disturbed, calcareous habitats.

Small white aster (*Aster vimineus*) is ranked S2 by NHP. In the last several years, it has been found at several localities in Orange County and a few others in Ulster, Dutchess, and Putnam. The habitat affinities are similar to those of small-flowered agrimony, but small white aster seems more rare.

Watermeal (*Wolffia braziliensis*). This species of watermeal is ranked S2 by NHP, and there is only one published record (Suffolk County) (New York Flora Association 1990). We have, however, collected *W. braziliensis* at several other Hudson Valley sites, principally east of the Hudson, in the last few years. This species may be expanding northward into New England and New York (Steve Young, pers. comm.). It may be less rare than overlooked due to its small size and similarity to *W. columbiana* and *W. borealis*. We think it should be considered rare until more field work is done in the region. *W. braziliensis* seems to occur in waters that are at least somewhat calcareous.

Winged monkeyflower (*Mimulus alatus*) is ranked S2 by NHP. There are perhaps a dozen localities known from late 1980s - early 1990s field work in the Hudson Valley. This species is associated with light to moderate shade and wet, calcareous soils along streams and the Hudson River (Sharma 1993). Winged monkeyflower is rare on the Wallkill although larger populations have been reported elsewhere in the region. There is some evidence that numbers may fluctuate from year to year.

6.2 Regionally-rare Plants

We found each of the species discussed below at one or more locations along the Wallkill. We consider these species regionally-rare on the basis of our experience and the New York Flora Association (1990) draft atlas. Some may prove to be under-collected and more common than we think, but we prefer to regard them as rare until proven otherwise.

Asa Gray's sedge (*C. grayi*) and **squarrose sedge** (*C. squarrosa*). There is no published Orange County record for Asa Gray's sedge (New York Flora Association 1990), although we have seen it at several locations east of the Hudson (at streams, wetlands, and the estuary itself). Squarrose sedge is known from the Hudson Valley, the New York City area, and the Finger Lakes region (New York Flora Association 1990). We have found squarrose sedge especially on clayey soils at several sites east and west of the Hudson River. Both species are associated with wet, calcareous soils.

Torrey's Rush (*Juncus torreyi*) There are no published records for Torrey's rush in Orange County (New York Flora Association 1990), although it is widespread elsewhere in the state. This is a rush primarily of of shallow water habitats and sandy shores (Clemants 1990). We have also found it in wet clay meadows. In this study we found it in an open floodplain forest.

Clammy cuphea (*Cuphea viscosissima*). There are old records for clammy cuphea from most Hudson Valley counties, the New York City area, and the Southern Tier (New York Flora Association 1990), but we know of no recent documentation except at the U.S. Military Academy property at West Point in 1992. We found clammy cuphea at one wet meadow location on the Wallkill.

We found **green dragon** (*Arisaema dracontium*) at two locations on the Orange County portion of the Wallkill. This species is rare in the Hudson Valley, where it is associated with wet, calcareous soils along streams and at least one station on the Hudson River.

Ground-cherries (*Physalis heterophylla, P. subglabrata*). *P. heterophylla* is a new record for Orange County although there are widespread old records elsewhere in New York (the only recent record is in western New York) (New York Flora Association 1990). *P. subglabrata* has no recent records in New York but there

are old records in Putnam and Ulster counties (none in Orange) (New York Flora Association 1990). The latter species, particularly, may be regionally-rare but we know little of these species.

Ninebark (*Physocarpus opulifolius*). This shrub is common along the shoreline of the fresh-tidal Hudson River (e.g. in northern Dutchess County) but we have not previously seen it away from the Hudson in eastern New York.

Swamp loosestrife (*Decodon verticillatus*). This species is at least scarce, possibly regionally-rare, in the Hudson Valley. It is associated with perennially wet, often organic soils. We found swamp loosestrife at four Wallkill locations.

Tumbleweed (*Amaranthus blitoides*) and **Water-hemp** (*A. tuberculatus*). We have seen neither amaranth previously in the Hudson Valley. Tumbleweed is known from old Ulster and Putnam county records, and water-hemp from old Greene County and Staten Island records (New York Flora Association 1990).

Some of the other plants we collected along the Wallkill appear to be Orange County records according to the New York Flora Association (1990) atlas, although these are not necessarily regionally-rare species. Among these were the lovegrasses *Eragrostis hypnoides* and *E. pectinacea*, and toad-rush (*Juncus bufonius*). At several locations along the Shawangunk Kill in Ulster County Hudsonia found in 1993 the first New York record of the grass *Diarrhena americana*. Because the Wallkill River also flows south to north, is near the Shawangunk Kill, and supports many of the same rare plant species, there is some chance that diarrhena also occurs here.

6.3 Introduced Flora and Floodplain Habitats

We found it striking that the floodplain meadows of the Wallkill had vegetation in which many introduced plant species were prominent. Among these species are purple loosestrife, Japanese hops, purslane, moneywort, garlic-mustard, and in somewhat drier floodplain areas multiflora rose, Bell's honeysuckle, and common buckthorn. Some of these plants (e.g. purslane, Japanese hops) are absent from, or scarce in, floodplain meadows of other Hudson River tributaries.

Well-established introduced species are often more tolerant of water pollution, soil disturbance, or other habitat modification than are many native species. Some of the introduced plants (e.g. purple loosestrife) associated with waterways and wetlands tend to be particularly aggressive invaders of native vegetation. Where certain introduced plant species are common or abundant, they may be indicators of environmental degradation; the abundance is a result of these more degradation-tolerant species outcompeting the more sensitive natives. Likewise, where a plant community contains a large number of introduced species, environmental degradation is often a factor.

The Wallkill is a large stream and as such its habitats are naturally subject to higher nutrient levels and greater flood energies than are habitats in smaller streams (other things equal). Therefore, we must ask to what extent the prominence of introduced species in the floodplain meadows is a result of (and indicator of) human-caused environmental stress, and to what extent a result of natural processes along a large river. We believe both natural processes and human impacts are important in shaping the floodplain vegetation of the Wallkill. Human activities in the Wallkill basin have increased nutrient levels and flood forces in the river. The floodplain meadows directly adjoin the river channel where they have no protection from flood scouring or water quality. Although natural river ecology certainly influences the floodplain habitats, our observations on the intensive historic alterations of the river (channelization, wetland drainage, dams), the low-quality macroinvertebrate community, and poor water quality fit well with the picture of introduced species invasions and displacements in the floodplain flora.

Despite the prominence of introduced plants in the floodplain meadows, these habitats have ecological and environmental values worth conserving. Non-wooded (herb-dominated) habitats that are not actively managed (e.g. mowed, cultivated, grazed) are of limited extent in southeastern New York. An exception is purple loosestrife meadows, which are extensive in our region, but many of the floodplain meadows along the Wallkill are not dominated by purple loosestrife. We have not studied the functions and values of the Wallkill meadows directly, but

these meadows are likely to be good foraging habitats for a variety of songbirds, and could be foraging and nesting habitat for ducks, foraging habitat for the wood turtle and various frogs, and spring-summer habitat for a variety of native butterflies and other native insects. Presumably the meadows also play a role in removing nutrients from the river water (at least seasonally), collecting sediments, and producing detritus (dead leaves, etc.) food for aquatic insects.

7 Significant Habitats

7.1 Riparian Habitats

In this discussion the term "riparian zone" includes both the areas where the water table is irregularly elevated due to proximity to an intermittent or perennial stream, and the areas adjacent to a stream but above the floodplain (i.e., where banks are steep) which drain directly into the stream. The extent of the riparian zone must be defined locally on the basis of slopes, artificial barriers, and land uses. The importance of the riparian zone to terrestrial and stream ecosystems cannot be overstated. There is continuous interaction between aquatic, riparian, and upland ecosystems through exchanges of energy, nutrients, and species (McCormick 1978), and most fish and wildlife are dependent upon riparian habitats for their survival (Hubbard 1977).

Riparian ecosystems often have high species diversity and densities, high biological productivity, a high degree of endemism, and large numbers of rare species (Hubbard 1977, McCormick 1978, Rawinski 1988). Natural and seminatural soil and vegetation in riparian meadows, shrublands, and forests provide an ecological buffer zone for the river. This buffer serves a multitude of crucial functions including: removal of nutrients, silt and other pollutants from surface runoff and shallow groundwater entering the river channel and from the river water itself during floods; stabilization of streambank and floodplain soils; maintenance of stream flows during drought periods; contribution of leaves and wood to the aquatic habitat and food web; filtering of noise, visual disturbance, and intrusion of human activities from the habitats of sensitive biota; and providing habitats for species that depend on riparian areas or that are more successful there than in other habitats. The buffer zone not only protects the river from humans but also protects human activities from river flooding.

Soil texture, flooding regime, and types of vegetation cover all determine the influence of the riparian zone on stream quality, but for the reasons mentioned above we consider all riparian areas to be significant or potentially significant habitats. Nationwide, 70-90% of pre-colonial riparian habitats have been destroyed or severely degraded (McCormick 1978). The restoration of degraded riparian habitats, and the protection of functioning riparian ecosystems are essential to rehabilitation and maintenance of the physical and biological integrity of streams.

7.2 Riparian Forests.

In studies of streams in forested landscapes in the Northeast, Likens et al. (1970) and Bormann et al. (1968, 1969) found that over 99% of the energy in aquatic food webs originated in adjacent forest ecosystems. Floodplain forests absorb more flood energy (i.e. protect downstream areas from flooding more) than do meadows. Forests are probably more effective at removing dissolved nutrients from the river water, and produce better-quality detritus for aquatic food chains (aquatic insects and fish). Numerous studies have found that riparian forests are important nitrogen sinks, and that they significantly reduce acidity of groundwater and precipitation (e.g., Peterjohn and Correll 1986, Schnabel 1986).

In a basin with extensive agricultural and residential land uses, forests that are older or that cover larger areas are especially important habitat for many kinds of birds and other animals, as well as plants. A few of the important habitat functions of riparian forests are: rest areas for northward-migrating birds in spring; breeding and roosting areas for birds, small mammals, amphibians, reptiles, and invertebrates that use cavities in large or flood-damaged trees, and the cavities in and spaces under large fallen branches and trucks; foraging and nesting habitat for wood turtle (that also use the stream

channel); habitat for other animals that require forests near water or wet soils; habitat for species associated with tree species that occur mainly or only in riparian areas (e.g. the rare sycamore ball bug *Belonochilus numenius*), and sources of snags (trunks and large branches) that provide critical habitat features for many fishes, invertebrates, water birds, and reptiles in the river channel. (The last function may be especially important along the Wallkill due to the shortage of snags in the channel.) Woody roots on streambanks provide overhangs that are valuable escape and cover habitats for fish, invertebrates and mammals. Forested streambanks and floodplains also provide shade that helps maintain cool stream water temperatures essential to many aquatic organisms, and are more effective than herbaceous cover at preventing erosion of streambank and floodplain soils.

Removal of a forested canopy from stream edges results in significant increases in stream water temperatures (Burton and Likens 1973, Rishel and Lynch 1980). Subsequent erosion of stream banks creates a wider, shallower stream which is warmer still. Water temperature is a major controlling factor for stream organisms, and is an important determinant of community structure, behavior, growth, reproductive activity, and temporal succession (Hynes 1970, Ward and Stanford 1979). Even a single row of trees along a stream bank is better than none at all, but forest width determines the capacity of riparian forests to carry out a variety of water quality and biological functions. The broader the forested zone along a stream, the higher the abundance of amphibians, reptiles and some mammals (Dickson 1989 and Reay et al. 1991 cited in Keller et al. 1993), other factors equal. Keller et al. (1993) recommended riparian forests at least 100 m wide to provide nesting habitat for area-sensitive bird species; they felt that wider forests are preferable. Riparian forests of any age and size along the Wallkill River and its tributaries deserve protection for their present and potential habitat value and for their contribution to the physical and biological integrity of the stream.

According to a sketch map prepared by John P. Tramontano (Orange County Community College) in 1993 and provided to Hudsonia by Martin Borko, the best riparian forests are concentrated along the Wallkill channel from just above Pellets Island Road to just above Montgomery, with gaps at the landfills, Route 17, below the Goshen Turnpike, and near the 416/Interstate 84 intersection. The map also shows important areas for some distance below (downstream of) the New Jersey line and just above (upstream of) the Ulster County line. Tramontano considered the location and extent of riparian wooded habitat and the size of trees in his determinations of habitat quality. He regarded the best riparian forests to be also the best birding areas on the Orange County portion of the Wallkill. Hudsonia did not attempt to corroborate the map.

7.3 Riparian Forest near Stony Ford Road

The floodplain area upstream of Stony Ford Road had silver maple forest, red ash-shagbark hickory forest, tall wet meadow, shrubby oldfields and agricultural fields (mowed and unmowed at survey time). One maple grove had 12-15 trees 70-100 cm dbh. Other large trees were a double stemmed 210 cm sycamore, a 100 cm sycamore and a 120 cm silver maple. The regionally rare lizard's-tail was among the forest herbs. Unmowed meadows had small-flowered agrimony (S2S3) and the regionally rare squarrose sedge. West of those areas was a selectively-logged floodplain forest with diverse shrubs and herbs (see flora list in Section 12), including the regionally rare ninebark and Torrey's sedge, small white aster (S2), red-root sedge (S2) and three-seeded mercury (NYNHP watch list). South of the streamside forest were hayfields, oldfields and hedgerows with diverse shrubs and herbs, including small-flowered agrimony, small white aster, and clammy cuphea (regionally rare). Small white aster was also abundant and widespread in the meadow just west of Stony Ford Road. This entire area, though somewhat disturbed, is well worth protecting. It is extensive (over 40 ha) and relatively free of serious damage, with diverse wildlife habitats and a large number of rare plant species. The various habitats could support many bird species, and some rare reptiles such as wood turtle (Special Concern) and box turtle. Tramontano considered the riparian habitats above and below Stony Ford Road to be the best on the Orange County reach of the Wallkill.

7.4 Floodplain Habitats East of Route 211 Bridge

Southeast of the Rt 211 bridge (south of the Canning Road intersection) was an extensive area of stream and floodplain habitats including vegetated stream-washed sand bank, floodplain forest, tall meadow, shrub swamp, calcareous seeps and old oxbows with pools and flood channels. The wild habitat area extended well beyond the 8 ha or so that we investigated. The floodplain meadow bordering Rt 211 had mostly reed canary grass and purple loosestrife, with scattered small box elders and silky dogwoods, vines such as wild cucumber and Japanese hops, and broad-leaved herbs such as smartweeds, clearweed and garlic mustard. A 2 x 10 m section of sandy riverbank had dense short herbs, high in species diversity but including no rare plants. Two plants found here, marsh watercress and giant chickweed, are at least uncommon in this region. High floodplain meadows had a few plants of small white aster and small-flowered agrimony. A calcareous spring flowed from a gravelly clay layer at the base of a low wooded slope east of the meadows. The spring fed a shrub-herb marsh with buttonbush, silky dogwood, lizard's-tail, rice cut-grass, three-way sedge and other herbs. An area of high floodplain north of the seep was atypical in having beech, sugar maple, basswood, pignut hickory and hop-hornbeam. This mesophytic assemblage may reflect the better drainage of the coarser soils here. Oxbows among patches of high floodplain had small pools with vegetated margins; one flood channel had winged monkeyflower. The beauty, seclusion, diversity of natural features and communities, and rare plants make this an area worth protecting in its entirety. We do not know its full extent, and it may harbor other rare species or special habitats.

7.5 Rutgers Creek

Barbour examined a wooded portion of Rutgers Creek north of (upstream of) the southern Lower Road bridge. This reach of the creek was mostly cobble-bottomed, and had a remarkably large crayfish population; Barbour observed densities of 10-20 crayfish per square meter of stream bed in places. there were also extensive beds of lizard's-tail (regionally rare), some with climbing hempweed (scarce). In a floodplain channel west of the creek there were about 15 winged monkeyflower (S2) plants under beech trees, and in a nearby patch of sedge meadow he found the rare cattail sedge (S1). South of the Lower Road bridge where the creek corridor had only narrow wooded margins along plowed fields, Barbour found climbing hempweed and two individuals of winged monkeyflower. The wooded corridor north of the bridge should be protected because of the relative lack of disturbance and the unusual stream habitats and rare plants.

A permit application for placement of a natural gas pipeline across Rutgers Creek was accepted by NYSDEC in August 1994. We do not know the location of the proposed crossing. We recommend that the Lower Road area be avoided, and that any construction work in Rutgers Creek be conducted with great care to avoid siltation or other disturbance of downstream habitats.

It may be useful to mention two rare species that probably do *not* occur along the Wallkill in Orange County. Historically there were a number of sites for the endangered bog turtle in the Wallkill basin in Orange County, but only one of those has been recently verified. A 1992 Hudsonia survey for the New York State Department of Environmental Conservation failed to find this species in Orange County, and we saw much evidence of damage to wetlands in areas where bog turtles were found historically. There may yet be a local bog turtle population but if so it is likely to be away from the river rather than in the riparian habitats *per se* because of the bog turtle's affinities for low-nutrient, groundwater seepage fens with low sparse vegetation. The threatened Blanding's turtle, although present in Dutchess County, has never been confirmed in the western portion of the Hudson River basin.

8 Restoration Opportunities

Streams are dynamic ecosystems with a remarkable capacity for self-renewal if the causes of ecological stress are eliminated. The Wallkill River presents many opportunities for restoration, most of which may be conducted on a small-scale, piecemeal basis. Many of the restoration projects we describe below can be conducted by private landowners at little expense or inconvenience. Other projects

will require some technical or financial assistance, and others will need the cooperation and assistance of county, state, and federal agencies in design, permitting, and execution.

8.1 Buffer Zones

Buffer zones of substantially undisturbed soils and vegetation serve many critical functions for streams including protecting the water quality of surface runoff and groundwater entering the stream, maintaining cool stream temperatures, controlling erosion and sedimentation, and contributing organic debris that is important to stream organisms. The buffer zone can itself be valuable habitat for birds, mammals, amphibians, reptiles, and invertebrates that depend on riparian habitats. The buffer zone can also mitigate flood impacts on cultural resources, and help maintain water quality during flood events.

The optimum width for buffer zones depends on the purposes to be served, the potential impacts to the buffer zone and stream, and the local environmental conditions (e.g., soil texture, soil chemistry, vegetation cover). Hilditch et al. (1992) reviewed the literature on the values of buffer zones, and recommended widths for various purposes. We recommend establishment and maintenance of buffer zones wherever possible along the entire length of the Wallkill River and its tributaries.

8.2 Fencing

Streambanks that are trodden and grazed by livestock are sources of sediments, and of nutrient and pathogen pollutants. Grazing and trampling destroys plant cover and soil stability, leading to erosion of banks, destruction of stream bank habitats (e.g., undercut banks) widening of stream channels, and siltation of stream beds. Livestock feces contain high levels of nitrogen, coliform bacteria, and sometimes other pathogens. For improving stream bank stability, a fenced buffer zone of any width between grazed areas and streams is better than none at all. For nutrient removal from pasture runoff, Magette et al. (1989) recommended buffer zones greater than 4.6 m wide. According to Draper et al. (1978) a 10 m buffer can remove 90% of the nutrients in runoff from livestock pastures. Buffer zones to serve other functions, such as riparian wildlife habitat, should be broader. All pasture areas adjacent to streams should be fenced to prevent cattle from grazing, trampling, and defecating in or near the stream. If there is no other drinking source for livestock, a narrow, hardened, fenced ramp would permit access to the stream without undermining soil stability.

8.3 Snags

Sands and fine gravels, the predominant substrate in the Wallkill in Orange County, are of little value as habitat for benthic macroinvertebrates (Keup 1988). In many sand streams, the highest densities of aquatic invertebrates are found on snags and in debris dams that snags create (e.g., Smock et al. 1992). Along with channelization, state and federal agencies have long had a tendency to "de-snag" rivers and streams at regular intervals. Snags, of course, slow down the current and may redirect flows, both undesirable effects if the point of channelization was to move water quickly. De-snagging, however, drastically reduces the fish food productivity of sandy streams. The fish community in the Wallkill in Orange County might be significantly improved by the introduction and maintenance of snags along the length of the river. With more cover and food, the fish population would probably increase, and relative abundance would probably shift more toward fishes that feed on the benthos; thus the dominance of spotfin shiners would probably be lessened. Installation of snags could be conducted on an experimental basis at first on one or several stretches of the stream. With careful documentation of fish and invertebrates before and for several years after snag placement, the effects of snags on the stream could be determined.

8.4 Planting of Woody Plants

Woody vegetation is most effective at holding stream bank soils in place. Woody root systems create overhangs which are important habitats for fishes, mammals, reptiles, and amphibians. The shade provided by woody vegetation, especially trees, helps maintain the cool stream temperatures which are essential to many

stream organisms. The Wallkill would be incrementally improved by planting of trees and shrubs on non-wooded banks wherever possible; only species native to the Wallkill watershed should be used.

8.5 Restoration and Protection of Wetlands

It is safe to say that all wetlands in the entire watershed contribute to the water quality of the Wallkill and its tributaries. Wetlands are important sites for nutrient processing, sediment retention, and other means of water quality maintenance and renovation. Whigham et al. (1988) concluded that wetlands in the upper parts of a drainage system have the greatest impact on water quality, and that riparian wetlands subject to flooding are especially important. Riparian wetlands apppear to be more effective than non-wetlands at denitrification, and may be important catchment areas for phosphorus escaping cultivated fields (Whigham et al. 1988, Gilliam et al. 1986). The State of New York regulates only wetlands 5 ha or larger in most cases. Although activities in any wetland may be regulated by the U.S. Army Corps of Engineers (COE), the federal government cannot be relied upon to detect unpermitted activities or permit violations. Local public and private wetland protection initiatives may be the most effective. A program to monitor, restore, and maintain the functional values of wetlands throughout the watershed could be coordinated by citizen volunteers under the supervision of a wetland ecologist.

8.6 Sewage Treatment

The sewage treatment plant at Walden is clearly degrading the Wallkill water quality. The plant's operation should be assessed and remediated, including upgrading to tertiary treatment if appropriate.

8.7 Floodplain Meadows

An effort to eradicate the many introduced plant species that dominate the floodplain meadows of the Wallkill would probably be futile until other aspects of the Wallkill ecosystem are rehabilitated. Propagules of alien plants are legion in a large stream draining a developed landscape, and the high nutrient levels and turbidity in the Wallkill, together with flood forces augmented by channelization, may combine to produce prime conditions for the invasion of introduced plants on floodplain meadows. Experimental removal (by handpulling or other low-impact mechanical means) of small patches of, e.g., Japanese hops, could provide some baseline information for larger scale restoration projects in the future. The U.S. Fish and Wildlife Service is releasing biological control agents for purple loosestrife, and the U.S. Department of Agriculture for multiflora rose; it is possible that these two pest plants will eventually be reduced in density throughout their North American ranges. Attempts at large-scale control of these species along the Wallkill should be postponed until the results of biocontrol are known. The rare plants along the Wallkill and their habitats (Sect. 6) deserve further study and conservation action. There may be local situations where small-scale control of purple loosestrife, multiflora rose, or other aggressive, pollution-tolerant introduced or native plants would benefit rare species, but this requires further observation to determine.

Charles Keene (Museum of the Hudson Highlands, *fide* David Church and others) has suggested that low floodplain areas along portions of the Wallkill could be "restored" and adapted to more effectively remove pollutants from the river water. This is a timely consideration; a similar experiment is being conducted on the Olentangy River in Columbus, Ohio, by William Mitsch and others at the University of Ohio. Because the available floodplain habitats on the Wallkill are elevated 1-3+ m above summer water level, the floodplain now serves a treatment function mainly at flood stages. Excavating some areas to within 0.3-0.5 m of the average stream water elevation would expose the areas to more frequent flooding. Any such excavation would presumably fill in over time unless artificially maintained. We do not have a specific recommendation or a good sense of the ecological tradeoffs that might be involved in altering the floodplain to attempt to improve its capacity to absorb nutrients and silt. The results of the Olentangy experiment (or results of any similar projects on other rivers) might provide some guidance. The Olentangy River at Columbus is roughly the size of the Wallkill in Orange County.

8.8 Inactive Dams

Dams are harmful to stream ecosystems in several ways. Dams alter downstream flows, block upstream fish migration, and trap organic debris. The reduction of stream flows caused by dams can be critical during drought periods when low flows can lead to elevation of stream temperatures, reduction of dissolved oxygen, reduction of spawning habitats, reduction of fish food invertebrate habitat, and concentration of pollutants. Removal of dams that are no longer in use, if done carefully, would do much to improve the Wallkill for aquatic organisms. Sediments impounded upstream of the dam should be dredged prior to dam removal to prevent downstream siltation. The dam should then be dismantled slowly to avoid the sudden release of a large volume of water. All phases of dredging and dam removal should be carried out at appropriate times of year and under the supervision of qualified stream engineers and biologists. State and federal permits would be required for any such project.

8.9 Removal of Riprap

The presence of riprap in a stream channel creates a uniform, unvegetated stream edge and bottom which is of little value to stream biota. Many macroinvertebrate and fish species require irregular substrates and diverse microhabitats for feeding, cover, and reproduction. Riprapped channel reaches thus tend to be biologically spare, inhabited by a few generalist species which contribute little to stream biological diversity. Riprap also increases stream velocity, and thus tends to increase the stream's downstream erosive power and flood impacts. Removal of riprap in the channelized reaches of the Wallkill would permit the establishment of stream bank vegetation and the diverse microhabitats that inevitably develop on an unreinforced bank. A vegetated stream bank would also be more accessible to amphibians and mammals moving in and out of the stream. Stream bank soils have some capacity to process water pollutants, and stream bank vegetation encourages the deposition of suspended solids. Riprap removal should be done in a piecemeal fashion with as little disturbance to the stream as possible. Great care should be taken to prevent erosion of the newly exposed stream bank soils. The use of fiber technology (Stevens 1994) and biological engineering (e.g., using live and dead plant material) including immediate planting of woody vegetation may be advisable. All work should be carried out in appropriate seasons under the supervision of qualified stream engineers and biologists.

8.10 Restoration of Original Channel

The two major channelized reaches of the Wallkill River - the Cheechunk Canal and the diversion around the landfills - represent the poorest stream habitats for aquatic organisms and stream-dependent wildlife, and almost certainly augment bank erosion and flood impacts downstream. The importance of the Cheechunk Canal to the Black Dirt agricultural region is obvious, but perhaps there are alternative means of maintaining adequate drainage of that area while permitting the Wallkill to resume its original path. Restoration of the Wallkill to its original meandering channel (Black Walnut Channel) would greatly enhance the stream quality there and downstream. Establishment of a substantial buffer zone along this reach would further improve stream habitats and would enlarge the pollution processing capacity of the stream corridor. Diverting water in cropland drainage ditches into created wetland detention areas prior to discharge into the Wallkill would reduce pollution and siltation stress, which may be extreme in this area. If channel restoration is deemed infeasible in the near term, establishment of buffer zones along the existing channel and construction of detention areas for cropland drainage should nonetheless be pursued.

9 Summary

The Wallkill River appeared to be severely degraded by non-point source and point-source pollutants. Siltation and phosphorus pollution were much worse than in other Hudson Valley streams for which we have recent, reliable data. Chloride concentrations were also high. The station immediately downstream from the landfills had among the highest TSS and by far the highest nitrate and phosphate-phosphorus concentrations. Sulfate levels were moderate to high in the upstream stations, but extraordinarily low downstream of station 5. Nitrate

concentrations were exceptionally low for a stream in an agricultural watershed. Laboratory or reporting errors are a possible explanation for the low nitrate and sulfate values given here.

Apart from the obvious degradation in the Village of Walden from the sewage treatment plant, the fish community provides some clues about how the Wallkill ecosystem is structured and how stream quality could be improved. We observed a diverse but apparently low-density fish community in the Orange County portion of the Wallkill; the dominant species was a surface and drift-feeding minnow, a habitat generalist well suited to an unpredictably fluctuating environment. The sandy and fine-gravelly substrates that predominate in the Wallkill provide poor habitat for benthic invertebrates and thus produce a low abundance of fish food. The removal of snags and debris dams from the stream channel has further reduced fish food productivity.

In general, the macroinvertebrate communities indicated a degraded river that worsened further downstream. This degradation began in New Jersey and persisted throughout the Orange County section of the Wallkill. Our samples consisted almost entirely of taxa highly tolerant of pollution according to tolerance values assigned by Winget (1985), Bode et al. (1991), and Kurtenbach (1990).

At two sites our data indicated localized pollution problems that should be investigated further. The station downstream of the Orange County landfill indicated worse conditions than other stations located either upstream or downstream. The sewage treatment plant in Walden is clearly degrading water quality.

Our riparian surveys were by no means comprehensive, but nonetheless we found 7 species of state-listed rare plants and at least 10 species of regionally rare plants in the areas we examined along the Wallkill corridor. Other rare species may well be present. The combined influence of calcareous soils and large stream dynamics may produce riparian conditions along the Wallkill that are unique in the Hudson Valley.

The riparian habitats (including islands and the lower reaches of some tributaries), despite degradation, have especially important functions and values. These areas provide an ecological buffer zone for the river and important habitat for many native plants and animals. For these reasons, a continuous corridor of riparian lands along the Wallkill should be protected (and in some areas restored). Such a corridor could also potentially be used for a walking or canoeing trail. Corridor conservation could be accomplished by means of conservation easements, land owner agreements, and other protective mechanisms administered by a land trust or another private or public agency. Consideration should be given to the privacy of human residents of the riparian zone as well as to sensitivities of certain rare plants and animals. A compilation of existing data on the use of the Wallkill River corridor by birds, and possibly additional bird surveys, would be useful in designing and fine-tuning a riparian conservation plan.

Likens and Bormann (1974) declared that "management 'solutions' that consider rivers or lakes as entities in isolation from their watersheds and airsheds are sheer folly." For all streams, but especially for streams with large drainage areas such as the Wallkill, evaluation of multiple and cumulative impacts of activities throughoutt the drainage is an essential component of stream management. Such evaluations should encompass not only the large projects that receive regulatory review, but also the small unregulated projects. Even though small unrelated actions may be largely nonjurisdictional, they should nonetheless be considered in the calculation of total impacts. Small habitat modifications are routinely overlooked by planners and regulators, but, depending on their nature, timing, and location, may have significant impacts on a stream. Such activities as small-scale excavation or filling in the riparian zone, tree cutting along stream banks, addition of stormwater discharge, runoff from construction sites, runoff from salted and sanded highways, minor oil spills, new buildings, and new pavement all have the potential to harm stream water quality or stream habitats. Habitat modification can alter fish behavior, growth, reproduction, organ function, and gene function (Heath 1987). Extremely low concentrations of toxins can have significant effects on fish populations; the effects are sometimes sublethal, but may alter growth, reproduction, and immune responses (Burn 1991). Siltation of streams can destroy spawning beds, smother fish eggs, and destroy macroinvertebrate habitat.

Although in keeping with political realities, isolating a section of a river for study, such as the Wallkill in Orange County, limits our understanding of the river system and our capabilities to conserve and manage river resources. River resources (wild biota, water, cultivable floodplain soils, recreation opportunities, waste assimilation capacity) are proportional to the integrity of the entire river system. There are cogent reasons to study the Wallkill in its entirety, including the Ulster County and the New Jersey reaches. The U.S. Fish and Wildlife Service created the Wallkill River National Wildlife Refuge in 1990, a 3000+ ha parcel of land along a 14.5 km stretch of the Wallkill in New Jersey. The water quality of the Wallkill entering New York from New Jersey is apparently poor, but is quickly masked by non-point sources in Orange County. There may be opportunities for integrating conservation of the Wallkill corridor in Orange County with the New Jersey refuge.

There are many opportunities for "restoration," or at least ecological improvement of habitats along the Wallkill. Maintenance of buffer zones wherever possible along the Wallkill is recommended. Areas where riparian habitats have been damaged, altered, and subjected to land uses incompatible with buffer functions could benefit from re-establishment of seminatural riparian habitats. For example, where the golf course below the Al Turi landfill closely approaches the river channel, establishment of a wider buffer zone of native forest tress and shrubs would benefit the river and its biota. Wherever pastures directly border the river, fences should be erected to prevent trampling of the riverside zone, and manure contamination of the river. Restoration of woody vegetation in such areas would prevent further erosion of floodplain pastures. It may also be possible to restore some of the channelized reaches to a more natural (non-channelized) condition.

Ultimately, much of the ecological "health" or integrity of the river will depend on reduction of the pollutants (nutrients, chloride, silt, etc.) entering from agricultural lands, sewage treatment plants, storm drains, landfills, construction sites, highways, lawns, and other sources in the corridor and elsewhere in the basin. It is not our intention to single out particular land uses or pollution sources for blame. People of the Wallkill basin, as everywhere in the Hudson Valley region, need to come to grips with the degradative effects of necessary and ordinary activities on common property resources especially including streams and wetlands. Nutrient enrichment, chloride pollution, and siltation are very widespread in the Hudson Valley. In a study of three Hudson River tributaries (Moodna, Quassaic, and Fishkill creeks), we found that modest levels of chloride, phosphate, and sulfate were associated with major losses of the integrity of the macroinvertebrates, implying that widespread extant and ordinary-seeming pollution is having a serious impact on streams. Because river pollution is cumulative, this should be of concern to everyone who uses (or might in the future use) river resources including water supply, fisheries, recreational resources, and the capacity of the river to assimilate sewage and agricultural runoff.

In previous studies of the Shawangunk Kill, a major tributary of the Wallkill, we found that it supported an unusual number of rare animals and plants (fishes, invertebrates, and plants) for a stream in the mid-Hudson basin (Barbour and Stevens 1994, Schmidt and Kiviat 1989, Kiviat 1991). The lower Shawangunk Kill is essentially free-flowing and has not experienced intensive hydrological alteration or pollution. There was a proposal to withdraw large quantities of Shawangunk Kill water for public supply, because (in our interpretation) of the high quality of the Shawangunk Kill water and the low quality of the Wallkill River water. It is not in the long-term interests of our society or of nature to degrade a river, thus forcing ourselves to degrade another river in order to obtain the environmental services that should be available from the first river. The Wallkill River is the hydrologic centerpiece of Orange County, and we believe that the Wallkill could become a much more prominent cultural and natural amenity to residents and tourists in Orange County with investments in stewardship that are financially minor compared to, for example, the maintenance of major public infrastructure components such as highways, water supply, and sewage treatment.

10 Recommendations

Further Studies

1. Monitor the leachate and surface runoff entering the Wallkill from the Orange County landfill. Install leachate barriers and collection systems if appropriate.

2. Conduct surveys along the Wallkill corridor for butterflies, dragonflies and damselflies, amphibians and reptiles, breeding birds and wintering birds of prey to help identify the most biologically valuable riparian habitats.

3. Conduct stream corridor surveys of the Ulster County and New Jersey segments of the Wallkill.

Wallkill Restoration

1. Establish and maintain buffer zones of substantially undisturbed soils and vegetation wherever possible along the entire length of the mainstem and tributaries of the Wallkill River in Orange County. Buffer zones are most important in areas of intensive development, and in areas such as cropland and golf courses where runoff is contaminated with fertilizers and pesticides.

2. Fence pastures so that livestock cannot trample and graze the banks of the Wallkill and its tributaries. Farmers could be offered a financial incentive to fence their pastures, if feasible.

3. Divert cropland, pasture, and golf course drainage to created wetland detention areas wherever possible so that sediments can be intercepted and nutrient and toxic pollutants can be processed somewhat before entering the Wallkill.

4. Plant native species of trees and shrubs on non-wooded banks wherever possible.

5. Add snags to the mainstem channel to improve habitat for invertebrates and fish.

6. Assess and remediate the Walden sewage treatment plant operations. Upgrade sewage treatment if appropriate.

7. Insist on implementation of Best Management Practices for management of stormwater runoff from roads, parking lots, and residential and urban districts.

Other Projects

1. A canoeing "trail" with a printed guide to the Wallkill would encourage recreational and educational use of the river with minimal impact on biota and land owners. We think this would be a good way to promote interest in, and stewardship of, the resources of the river. The guide would describe available landings on public property, hazards, natural and cultural landmarks, and the "canoeability" of different river segments at different seasons. If there are conflicts with, e.g. sensitive breeding birds, the guide could urge that boaters stay off certain river segments during the breeding season. The guide should also steer boaters away from habitats that are sensitive for other reasons such as the occurrence of rare plants that may be vulnerable to trampling or picking. We urge that snags *not* be removed from the river unless these are directly threatening bridges or other structures. At survey time there were few snags in the Wallkill channel. Snags are very important for fish and other biota, and canoeists can accept the occasional need to haul over a snag as part of the river experience.

2. Establish a "riverwatch" program to a) monitor land use activities in the Wallkill watershed and direct or indirect impacts to the river, 2) alert local, state, and federal regulatory agencies to unauthorized activities and permit violations, and 3) to identify restoration opportunities and areas needing further study.

3. Encourage riparian land uses that are compatible with streams, such as buffer zones, open space, and low-intensity recreation.

11 References Cited

Barbour, S. and G. Stevens. 1994. Rare plants survey of the Shawangunk Kill Corridor. Report to the Shawangunk Valley Conservancy. Hudsonia, Ltd. Annandale, NY. 10 p.

Bode, R.W., M.A. Novak, and L.E. Abele. 1991. Quality assurance work plan for biological stream monitoring in New York State. Unpublished report, Stream Biomonitoring Unit, New York State Department of Environmental Conservation, Albany.

Bormann, F.H., G.E. Likens, and J.S. Eaton, 1969. Biotic regulation of particulate and solution losses from a forest ecosystem. Bioscience 19(7):600-610.

Bormann, F.H., G.E. Likens, D.W. Fisher, and R.S. Pierce. 1968. Nutrient loss accelerated by clear-cutting of a forest ecosystem. Science 159:882-884.

Burton, T.M. and G.E. Likens. 1973. Effect of strip-cutting on stream temperatures in the Hubbard Brook Experimental Forest, New Hampshire. BioScience 23(7):433-35.

Cadwell et al. 1986. Surficial geologic map of New York; Lower Hudson sheet. New York State Museum - Geological Survey, Map and Chart Series 40, 1:250,000, 100 ft contour.

Clemants, S.E. 1990. Juncaceae (Rush Family) of New York State. Bulletin No. 475, New York State Museum, Albany. 67 p.

Clesceri, L.S., A.E. Greenberg and R.R. Trussell. 1989. Standard methods for the examination of water and wastewater. American Public Health Association, Washington DC.

Connally, G.G. 1967. The Pleistocene geology of the Wallkill Valley. P. A1-A16 in Waines, R.H. (ed.) 1967, Guide Book to Field Trips, New York State Geological Association 39th annual meeting. State University of New York, New Paltz.

Cooper, A.L. and G.N. Neuderfer. 1973. A macroinvertebrate study of the Wallkill River. Unpublished report, Avon Pollution Investigations, New York State Department of Environmental Conservation. 37 p.

Draper, D.W., J.B. Robinson and D.R. Coote. 1978. Estimation and management of the contribution by manure from livestock in the Great Lakes Basin to the phosphorus loading of the Great Lakes. In Proceedings of Best Management Practices for Agriculture and Silviculture, Cornell Conference, Rochester, New York.

Edelstein, M.R. and W. Makofske. 1985. The Karst topography of Southern Orange County: An analysis of the relationship between soluble bedrock land use and land use policy. New York Land Report 5(10):10113-10125.

Fisher, Donald W., Y. W. Isachsen and L. V. Rickard. 1971. Geological map of New York 1970. New York State Museum and Science Service, Map and Chart Series 15, 7 sheets, 1:250,000, 100 ft contour.

Gale, W.F. and C.A. Gale. 1977. Spawning habits of spotfin shiner (*Notropis spilopterus*) - A fractional, crevice spawner. Transactions of the American Fisheries Society 106(2): 170-177.

Gibbs, R.H., Jr. 1957. Cyprinid fishes of the subgenus Cyprinella of *Notropis*. II. Distribution and variation of *Notropis spilopterus*, with a description of a new subspecies. Lloydia 20(3): 186-211.

Gilliam, J.W., L.A. Schipper, P.N. Beets and M. McConchie. 1992. Riparian buffers in New Zealand forestry. New Zealand Forestry (August 1992):21-25.

Hankinson, T. 1930. Breeding behavior of the silverfin minnow, *Notropis whipplii spilopterus* (Cope). Copeia 1930(3): 73-74.

Hilditch, T.W. 1992. Buffers for the protection of wetland ecological integrity. Presented at INTECOL's IVth International Wetlands Conference, Columbus, OH. 21 p.

Hubbard, J.P. 1977. Importance of riparian ecosystems: Biotic considerations. In R.R. Johnson and D.A. Jones (eds.), Importance, preservation, and management of riparian habitat: A symposium. U.S.D.A. Forest Service General Technical Report RM-43. (original not seen; cited in McCormick 1978)

Hynes, H.B.N. 1970. The ecology of running waters. University of Toronto Press, Canada. 555 p.

Keup, L.E. 1988. Invertebrate fish food resources of lotic environments. U.S. Dept. of the Interior, Fish and Wildlife Service Biological Rept. 88(13). 96 p.

Kiviat, E. 1991. Shawangunk Kill biodiversity and impacts of the proposed Orange County water diversion. Report to Shawangunk Valley Conservancy. Hudsonia, Ltd. Annandale, NY. 29 p.

Kurtenbach, J. 1990. Stream bioassessment, Wallkill River, New Jersey. Unpublished report. U.S. Environmental Protection Agency, Region, Region II. 25 p.

Kurtenbach, J. 1991. Methods for evaluating biological integrity of streams using fish communities. Draft Report., U.S. Environmental Protection Agency, Region II.

Lee, D.S., C.R. Gilbert, C.H. Hocutt, R.E. Jenkins, D.E. McAllister, and J.R. Stauffer, Jr. 1980. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, 854 p.

Likens, G.A., F.H. Bormann, N.M. Johnson, D.W. Fisher, and R.S. Pierce. 1970. Effects of forest cutting and hericide treatment on nutrient budgets in the Hubbard Brook Watershed-Ecosystem. Ecological Monographs 40:23-47.

Livingstone, D. A. 1963. Alaska, Yukon (Ed.), Northwest Territories, and Greenland. P. 559-574 in D. G. Frey, (Ed.). Limnology in North America. University of Wisconsin Press, Madison.

Magette, W.L., R.B. Brinsfield, R.E. Palmer, and J.D. Wood. 1989. Nutrient and sediment removal by vegetated filter strips. In Transactions of the American Society of Agricultural Engineers (ASAE). 32(2). (original not seen; cited in Hilditch 1992).

McCormick, J.F. 1978. An initiative for preservation and management of a wetland habitat. A position paper to the Office of Biological Services, U.S. Fish and Wildlife Service, Washington, D.C. 24 p.

Mendelson, J. 1975. Feeding relationships among species of *Notropis* (Pisces: Cyprinidae) in a Wisconsin stream. Ecological Monographs 45: 199-230.

Miller, D.L., R.A. Daniels, and D.B. Halliwell. In press. Modification of an index of biotic integrity based on fish communities for streams of the northeastern United States. North American Journal of Fisheries Management.

Mitchell, R.S. 1986. A checklist of New York State plants. New York State Museum Bulletin 458, 272 p.

New York Flora Association. 1990. Preliminary vouchered atlas of New York State flora. NYFA of the New York State Museum Institute, Albany. 496 p.

New York Natural Heritage Program. 1992a. Active inventory list for animals and others. Unpublished. New York Natural Heritage Program, Latham. 9 p.

New York Natural Heritage Program. 1992b. Community status list. Unpublished. New York Natural Heritage Program, Latham. 3 p.

Office of Migratory Bird Management. 1987. Migratory Nongame Birds of Management Concern in the United States: the 1987 list. U.S. Fish and Wildlife Service, OMBM, Washington, DC. 27 p. + appendices.

Offield, T.W. 1967. Bedrock geology of the Goshen-Greenwood Lake area, New York, Map and Chart Series #9, New York State Museum and Science Service, 1967. (Original not seen, cited in Edelstein and Makofske 1985.)

Parsons, T. and G. Lovett. 1993. Effects of land use on the chemistry of Hudson River tributaries. In J.R. Waldman and E.A. Blair (eds.), Final Reports of the Tibor T. Polgar Fellowship Program, 1991. Hudson River Foundation, NY.

Peterjohn, W.T. and D.L. Correll. 1986. The effects of riparian forest on the volume and chemical compositions of baseflow in an agricultural watershed. p. 244-262 in David L. Correll (ed.) Watershed research perspectives. Smithsonian Institution Press, Washinton, D.C. 421 p.

Pflieger, W. 1965. Reproductive behavior of the minnows, Notropis spilopterus and Notropis whipplii. Copeia 1965(1): 1-8.

Pierce, R. 1978. Wallkill River fisheries survey, August 15-18, 1977, Orange and Ulster Counties. Unpublished Rept., NYS DEC Region 3, 12 pp.

Rawinski, T.J. 1988. Notes on riverside vegetation. Nature Conservancy Magazine 38(5):25.

Rishel, G.B. and J.A. Lynch. 1980. Changes in stream temperatures and potential impacts on aquatic organisms caused by forest cover removal. P. 21-22 in 36th Annual Northeast Fish and Wildlife Conference, Ellenville, New York.

Schmidt, R.E. 1991. Saw Kill fishes. P. 34-36. in E. Kiviat (Ed.). Montgomery Place Environmental Studies, Town of Red Hook, Dutchess County, New York. Final Report to Historic Hudson Valley and Hudson & Pacific Designs. Hudsonia Ltd., Annandale, NY.

Schmidt, R.E. and E. Kiviat. 1988. Communities of larval and juvenile fish associated with water-chestnut, watermilfoil and water-celery in the Tivoli Bays of the Hudson River. Report to the Hudson River Foundation. Hudsonia, Ltd., Annandale, NY. 35 p.

Schmidt, R.E. and E. Kiviat. 1989. Shawangunk Kill biology and the proposed water withdrawal, Ulster and Orange Counties, New York. Report to the Shawangunk Valley Conservancy. Hudsonia, Ltd. Annandale, NY. 24 p.

Schnabel, R.R. 1986. Nitrate concentrations in a small stream as affected by chemical and hydrologic interactions in the riparian zone. p. 263-282 in David L. Correll (ed.), Watershed research perspectives. Smithsonian Institution Press, Washington, D.C. 421 p.

Sharma, V. 1993. Habitats of the monkeyflowers *Mimulus alatus* and *Mimulus ringens* on the Hudson River. M.S. thesis, Bard College.

Sheldon, A.L. 1988. Conservation of stream fishes: Patterns of diversity, rarity, and risk. Conserv. Biol. 2(2): 149-156.

Smith, C.L. 1985. The inland fishes of New York State. New York State Department of Environmental Conservation. 522 p.

Smith, S. J. [ca 1974] [List of native vascular plant records by Department of Environmental Conservation Regions.] New York State Museum. Photocopy, 48 p.

Smock, L.A., J.E. Gladden, J.L. Riekenberg, L.C. Smith, and C.R. Black. 1992. Lotic macroinvertebrate production in three dimensions: Channel surface, hyporheic, and floodplain environments. Ecology 73(3): 876-886.

Stevens, G. 1994. Streambank restoration at the Saw Kill in Annandale: a demonstration project. Report to the J.M. Kaplan Fund. Hudsonia Ltd., Annandale, NY. 6 p. + appendices.

Stevens, G., R.E. Schmidt, D.R. Roeder, J.S. Tashiro, and E. Kiviat. 1994. Baseline assessment of tributaries to the Hudson (BATH): Water quality, fishes, macroinvertebrates, and diatoms in Fishkill Creek, Quassaic Creek, and Moodna Creek. Report to the Hudson River Improvement Fund of the Hudson River Foundation. Hudsonia, Ltd. Annandale, NY. 97 p. + appendices.

Stone, U. 1940. Studies on the biology of the satinfin minnows *Notropis analostanus* and *Notropis spilopterus*. Unpublished Ph.D. Thesis, Cornell Univ., 98 p.

Tate, James, Jr. 1986. The Blue List for 1986. American Birds 40(2):227-236.

Thiesing, M.A. 1989. Comparative ecology of a guild of minnows (Pisces: Cyprinidae) in a southeastern New York stream: Habitat separation, spatial distribution, and feeding ecology. Unpublished Ph.D. Thesis, Fordham Univ., 280 p.

Vadas, R.L., Jr. 1990. The importance of omnivory and predator regulation of prey in freshwater fish assemblages of North America. Env. Biol. Fishes 27: 285-302.

Vadas, R.L., Jr. 1992. Seasonal habitat use, species associations, and assemblage structure of forage fishes in Goose Creek, Northern Virginia. II. Mesohabitat patterns. Journal of Freshwater Ecology 7(2): 149-164.

Ward, J.V. and J.A. Stanford. 1979. Ecological factors controlling stream zoobenthos with emphasis on thermal modification of regulated streams. p. 34-55 in James V. Ward and Jack A. Stanford (eds.), The ecology of regulated streams. Plenum Press, New York.

Wetzel, R.G. 1983. Limnology. Saunders Publishing, Philadelphia. 752 p. + appendices.

Wetzel, R.G. and G.E. Likens. 1991. Limnological Analysis. Second Edition. Springer-Verlag, New York. 391 p.

Whigham, D.F., C. Chitterling, and B. Palmer. 1988. Impacts of freshwater wetlands on water quality: A landscape perspective. Environmental Management 12(5):663-671.

White, S.T. and D.C. Wallace. 1973. Diel changes in the feeding activity and food habits of the spotfin shiner, *Notropis spilopterus* (Cope). American Midland Naturalist 90(1): 200-205.

Wille, Chris. 1990. Mystery of the missing migrants. Audubon 92(3):81-85.

Winget, R.N. 1985. Methods for determining successful reclamation of stream ecosystems. P. 165-192. in J.A. Gore (Ed.). The Restoration of Rivers and Streams. Butterworth, Stoneham, MA.

Young, S.M. 1992. New York Natural Heritage Program New York rare plant status list. New York Natural Heritage Program, Latham. 80 p.

Plant species found during the 1991–1992 Wallkill River study. Stations 1–10 are biological and water quality sampling stations. Areas A–E are other observation areas along the Wallkill and selected tributaries (see Fig. 1). Scientific names and most common names follow Mitchell (1986). A question mark (?) indicates an uncertain identification at that location.

COMMON NAME	SCIENTIFIC NAME	STATIONS										OTHER AREAS					
		1	3	4	5	6	7	8	9	10		A	B	C	D	E	F
Agrimony	Agrimonia			x					x								
Agrimony	Agrimonia gryposepala				x											x	
Agrimony, small–flowered	Agrimonia parviflora				x		x	x				x					
Alder	Alnus															x	
Amaranth	Amaranthus						x										
Angelica, purple–stem	Angelica atropurpurea						x			x							x
Arrowhead, broadleaf	Sagittaria latifolia						x										
Arrowwood, northern	Viburnum recognitum						x		x	x							
Arum, arrow	Peltandra virginica				x	x		x	x						x	x	
Ash	Fraxinus									x				x			
Ash, red	Fraxinus pensylvanica	x		x	x	x	x	x	x	x		x				x	x
Ash, white	Fraxinus americana			x		x	x					x		x			x
Aspen, quaking	Populus tremuloides												x	x			
Aster	Aster		x	x	x	x	x		x								
Aster, calico	Aster lateriflorus									x					x		
Aster, heath	Aster pilosus						x										x
Aster, New England	Aster novae–angliae						x										
Aster, rice–button	Aster dumosus													x			
Aster, small white	Aster vimineus						x	x									x
Aster, tall white	Aster lanceolatus						x							x		?	x
Aster, white wood	Aster divaricatus														x		
Aster, white wreath	Aster ericoides													x			
Avens	Geum			x		x	x		x	x							x
Avens, white	Geum canadense			x		x	x	x	x	x		x		x	x	?	
Barberry, European	Berberis vulgaris					x											
Barberry, Japanese	Berberis thunbergii			x	x		x			x						x	
Basswood	Tilia americana							x									
Beard–tongue	Penstemon digitalis						?	x									
Bedstraw	Galium				x												
Bedstraw, marsh	Galium palustre							x									
Bedstraw, stiff marsh	Galium tinctorium						x										
Bedstraw, white	Galium mollugo				x							x					x
Beech, American	Fagus grandifolia							x							x		
Beggar–ticks	Bidens	x	x							x					x		
Beggar–ticks	Bidens tripartita						x								x	x	x
Bentgrass, autumn	Agrostis perennans									x							
Bentgrass, colonial	Agrostis capillaris									x							
Bentgrass, creeping	Agrostis stolonifera s.l.				x												
Bindweed	Convolvulus			x													
Bindweed, black	Polygonum convolvulus				?												
Bindweeed, fringed	Polygonum cilinode								?								
Birch, river	Betula nigra	x				x	x	x		x					?	x	x
Bitternut	Carya cordiformis						x			x							x
Blackberry, northern	Rubus allegheniensis						x							x			
Black–haw	Viburnum prunifolium							?									
Bladdernut	Staphylea trifolia					x	x		x						x		
Bluegrass	Poa			x		?		?									
Boneset, white	Eupatorium perfoliatum						x										
Bottlebrush	Elymus hystrix var. hystrix														x		
Bouncing–bet	Saponaria officinalis				x												
Boxelder	Acer negundo					x	x	x	x								x
Brachyeletrum	Brachyeletrum erectrum													x			x
Bramble	Rubus												x				
Brooklime	Veronica beccabunga						?										
Buckthorn, common	Rhamnus cathartica		x	x	x		x					x		x			
Bull–thistle	Cirsium vulgare				x		x										
Bulrush	Scirpus atrovirens							x		x							
Bulrush, pendulous	Scirpus pendulus						x										
Burdock	Arctium			x													
Burdock	Arctium vulgare				x												

(continued)

(List of Flora, continued)

COMMON NAME	SCIENTIFIC NAME	STATIONS									OTHER AREAS					
		1	3	4	5	6	7	8	9	10	A	B	C	D	E	F
Bur–reed	Sparganium	x												x		
Butternut	Juglans cinerea				x		x							x		
Buttonbush	Cephalanthus occidentalis							x							x	
Canary–grass, reed	Phalaris arundinacea	x		?	x	x	x	x		x						
Cardinal–flower	Lobelia cardinalis													x	x	
Catalpa	Catalpa									x						
Cat–nip	Nepeta cataria			x				x					x			
Cattail	Typha							x								
Cattail, broadleaf	Typha latifolia						x								x	
Celandine, greater	Chelidonium majus			x												
Charlock	Sinapis arvensis												x			
Cherry, black	Prunus serotina			?	x					x			x			
Chickweed, giant	Myosoton aquaticum							x	x							
Chicory	Cichorium intybus				x											x
Cinquefoil, sulfer	Potentilla recta						x									
Clearweed	Pilea pumila			x	x	x	x	x	x	x	x		x	x	?	x
Clover, alsike	Trifolium hybridum						x									
Clover, red	Trifolium pratense												x			
Clover, white	Trifolium repens												x			
Cocklebur, common	Xanthium strumarium	x	x				?								x	
Coontail	Ceratophyllum													?		
Coontail	Ceratophyllum demersum	x														
Cottonwood, eastern	Populus deltoides		x	x	x	x				x			x			
Cow–parsnip	Heracleum lanatum														x	
Creeper, Virginia	Parthenocissus			x	x			x		x		x	x			
Creeper, Virginia	Parthenocissus quinquefolia			x	x	x		x	x	x						
Cress	Rorippa						?									
Crowfoot, buttercup	Ranunculus						x									
Cucumber, bur	Sicyos angulatus								?							
Cucumber, prickly	Echinocystis lobata			x			x	x					x			
Cuphea, clammy	Cuphea viscosissima						x									
Currant	Ribes			x			x									
Currant, wild black	Ribes americanum					x										
Cutgrass	Leersia							x					x	x	x	
Cyperus	Cyperus erythrorhizos						x									
Dames–rocket	Hesperis matronalis			x			x			x						x
Dandelion, common	Taraxacum officinale													x		
Day–lily, orange	Hemerocallis fulva			x												
Dewberry, American	Rubus flagellaris						x	x								
Ditch–stonecrop	Penthorum sedoides						x							x		
Dock, bitter	Rumex obtusifolius							x								
Dodder	Cuscuta gronovii													x	x	
Dogwood, gray	Cornus foemina ssp. racemosa				x		x	x			x				x	
Dogwood, silky	Cornus amomum	x		x	x		x	x	x	x					?	x
Dragon, green	Arisaema dracontium			x				x								
Duckweed, common	Lemna minor	x		x	x	x	x	x					x		x	
Duckweed, great	Spirodela polyrhiza	x				x	x	x				x			x	
Elderberry, common	Sambucus canadensis							x		x						
Elecampane	Inula helenium							x								
Elm	Ulmus		x	x	x		x	x	x							
Elm, American	Ulmus americana				x	x				x			x			x
Elm, slippery	Ulmus rubra						x	x			x				?	x
Evening–primrose, common	Oenothera biennis				x					x						
Eyebane	Chamaesyce maculata						x									
False–buckwheat, climb'g	Polygonum scandens										x	x	x			x
False–nettle	Boehmeria cylindrica			x		x	x	x		x	x		x	x	x	
False–pimpernel	Lindernia dubia							x	x							
Felon–herb	Artemisia vulgaris			x												
Fern, crested	Dryopteris cristata						x									
Fern, marsh	Thelypteris palustris						x	x							x	
Fern, royal	Osmunda regalis							x								
Fern, sensitive	Onoclea sensibilis						x	x		x	x					
Fern, spinulose wood	Dryopteris carthusiana												x		x	

(continued)

(List of Flora, continued)

COMMON NAME	SCIENTIFIC NAME	STATIONS									OTHER AREAS					
		1	3	4	5	6	7	8	9	10	A	B	C	D	E	F
Field–thistle	Cirsium discolor						x									
Figwort	Scrophularia							x					x			
Fireweed	Erechtites hieracifolia		x				x					x				
Fleabane	Erigeron						x									
Fleabane, daisy	Erigeron annuus												x			
Fleabane, daisy	Erigeron strigosus			x												
Galingale	Cyperus strigosus	?					x	x	x							
Garlic–mustard	Alliaria petiolata			x	x	x	x	x	x	x		x				x
Geranium, wild	Geranium maculatum													x		
Germander, wild	Teucrium canadense			x				x			x					
Ginger, wild	Asarum canadense					x										
Goldenrod	Solidago			x	x			x								
Goldenrod, bush	Euthamia graminifolia						x									
Goldenrod, Canada	Solidago canadensis						x	x					x			x
Goldenrod, late	Solidago gigantea						x									x
Goldenrod, tall	Solidago canadensis var. scabra										x					x
Goldenrod, tall hairy	Solidago rugosa				x		x			x	x	x	x		x	
Grape	Vitis			x	x			x	x	x			x			
Grape, frost	Vitis riparia							x								
Grass(es)	Poaceae						x	x								
Grass, barnyard	Echinochloa crus–galli						x		x		?					
Grass, cockspur	Echinochloa muricata								?							
Grass, orchard	Dactylis glomerata				x		x									
Greenbrier	Smilax rotundifolia													x		
Ground–cherry	Physalis														x	
Ground–cherry	Physalis subglabrata									x						
Ground–cherry, clammy	Physalis heterophylla							?								
Groundnut	Apios americana							x		x						
Hare–figwort	Scrophularia lanceolata							x								
Hawthorn	Crataegus						x	x	x							
Hedge–bindweed	Calystegia sepium											x				
Hedge–mustard	Sisymbrium							x								
Hedge–mustard	Sisymbrium officinale											x				
Hedge–nettle, creeping	Stachys tenuifolia						x									
Hemlock	Tsuga canadensis														x	
Hempweed, climbing	Mikania scandens													x		
Hemp, Indian	Apocynum cannabinum						x						x			
Hickory, pignut	Carya glabra							x								
Hickory, shagbark	Carya ovata						x								x	x
Hog–peanut	Amphicarpea bracteata			x			x			x						
Honewort	Cryptotaenia canadensis					x				x						
Honey–locust	Gleditsia triacanthos				x											
Honeysuckle	Lonicera									x						
Honeysuckle, Bell's	Lonicera x bella			x	x	x									?	
Honeysuckle, Japanese	Lonicera japonica			x												
Honeysuckle, Morrow	Lonicera morrowi			?												
Honeysuckle, Tartarian	Lonicera tatarica						?									
Hop–hornbeam	Ostrya virginiana							x								
Hops, Japanese	Humulus japonicus						x	x	x		x					
Hornbeam	Carpinus caroliniana						x									
Horse–nettle	Solanum carolinense			x	x		x	x	x				x			x
Horseradish	Armoracia rusticana												x			
Horsetail, field	Equisetum arvense				x	x										
Horseweed	Conyza canadensis															x
Indian–tobacco	Lobelia inflata						x							x		
Iris, yellow	Iris pseudacorus								x							
Ironweed	Vernonia noveboracensis	x					x		x							
Jack–in–the–pulpit	Arisaema triphyllum			x									x			
Jewelweed	Impatiens									x						
Jewelweed, pale	Impatiens pallida			x												
Jewelweed, spotted	Impatiens capensis		x	x	x	x	x	x	x		x	x	x		x	x
Joe–pye–weed	Eupatorium fistulosum							x								
Joe–Pye–weed	Eupatorium													x		

(continued)

(List of Flora, continued)

COMMON NAME	SCIENTIFIC NAME	STATIONS									OTHER AREAS					
		1	3	4	5	6	7	8	9	10	A	B	C	D	E	F
Joe–Pye–weed, spotted	Eupatorium maculatum						?			x				x	x	
Jumpseed	Polygonum virginianum						x	x	x					x		
Knapweed, bushy	Centaurea maculosa												x			
Knot–rush	Juncus nodosus						x									
Knotweed	Polygonum aviculare						x									
Lady's–sorrel	Oxalis stricta			x	x	x	x	x	x							
Ladys–thumb	Polygonum persicaria												x			
Live–forever	Sedum telephium													x		
Lizards–tail	Saururus cernuus	x					x	x		x				x		x
Lobelia, great	Lobelia siphilitica													x		
Loosestrife, fringed	Lysimachia ciliata						x	x		x						
Loosestrife, purple	Lythrum salicaria	x	x	x	x	x	x	x	x	x	x			x	x	x
Loosestrife, swamp	Decodon verticillatus							x							x	
Lovegrass	Eragrostis hypnoides	x			x			x	x							
Lovegrass	Eragrostis pectinacea								x							
Mannagrass, fowl	Glyceria striata							x								
Maple, Norway	Acer platanoides									x						
Maple, red	Acer rubrum			x	x	x	x	x							x	
Maple, silver	Acer saccharinum	x	x	x	x	x	x	x	x	x	x		x			x
Maple, sugar	Acer saccharum			x				x		x					x	
Meadow–rue, tall	Thalictrum pubescens						x			x						
Milkweed, common	Asclepias syriaca						x	x					x			x
Milkweed, swamp	Asclepias incarnata						x	x								
Mint, field	Mentha arvensis						x	?								
Mint, red	Mentha x gentilis					?										
Moneywort	Lysimachia nummularia			x	x	x	x	x	x		x			x	x	x
Monkeyflower, common	Mimulus ringens	x					x		x				x			
Monkeyflower, winged	Mimulus alatus							x						x		
Moonseed	Menispermum canadense			x									x			
Moss	Hypnum													x		
Moss	Mnium						x			x						
Motherwort	Leonurus cardiaca			x			x	x								
Mountain–mint	Pycnanthemum virginianum						x									
Mulberry, white	Morus alba					x		x		x						
Mullein	Verbascum thapsus												x			
Nettle, stinging	Urtica dioica	x				x	x	x	x	x		x	x			x
Nightshade, black'	Solanum nigrum						x					x				
Nightshade, climbing	Solanum dulcamara					x		x								
Nightshade, enchanters	Circaea lutetiana ssp. canadensis			x		x		x	x	x		x				
Ninebark	Physocarpus opulifolius						x									
Nut–grass, yellow	Cyperus esculentus				x											
Oak, northern red	Quercus rubra														x	
Oak, pin	Quercus palustris						x	x		x				x	x	
Oak, swamp white	Quercus bicolor						x	x						x		x
Oak, white	Quercus alba								x					x		
Osier, green	Cornus alternifolia			x												
Ox–eye daisy	Leucanthemum vulgare												x			
Parsnip, wild	Pastinaca sativa					?										
Pear	Pyrus communis							x								
Pea, Everlasting	Lathyrus sylvestris				x											
Pennywort	Hydrocotyle americana						x		x	x						
Pickerelweed	Pontederia cordata												x			
Pinkweed	Polygonum pensylvanicum				x		x	x								x
Plantain, buck–horn	Plantago lanceolata				x											
Plantain, common	Plantago major				x			x								
Poison–ivy	Toxicodendron radicans			x	x	x	x	x	x	x			x		x	
Poke	Phytolacca americana				x		x					x				x
Pond–lily, yellow	Nuphar luteum	x														
Pondweed	Potamogeton natans	x														
Pondweed	Potamogeton nodosus					x										
Pondweed, curly	Potamogeton crispus					x										

(continued)

(List of Flora, continued)

COMMON NAME	SCIENTIFIC NAME	STATIONS									OTHER AREAS					
		1	3	4	5	6	7	8	9	10	A	B	C	D	E	F
Pondweed, sago	Potamogeton pectinatus					x										
Prickly–ash, American	Zanthoxylum americanum														x	
Privet	Ligustrum														x	
Purple–leaf willow–herb	Epilobium coloratum						x			x					x	
Purslane	Portulaca oleracea				x		x									
Purslane, water	Ludwigia palustris	x					x	x	x							
Pussy–willow	Salix discolor						x									x
Queen–Annes–lace	Daucus carota				x		x									
Quickweed	Galinsoga						x									
Ragged–robin	Lychnis flos–cuculi									x						
Ragweed, common	Ambrosia artemisiifolia			x			x					x				x
Ragweed, giant	Ambrosia trifida						x		x				x			x
Raspberry, black	Rubus occidentalis			x	x			x								
Raspberry, red	Rubus idaeus						x									
Reed, common	Phragmites australis					x			x	x			x			
Rose, multiflora	Rosa multiflora			x	x	x	x	x	x	x					x	
Rose, swamp	Rosa palustris						x									
Rush, soft	Juncus effusus						x	x								
Rush, Torrey's	Juncus torreyi						x									
Sedge	Carex gynandra						x	x								
Sedge	Carex typhina													x		
Sedge(s)	Carex							x								
Sedge, Asa Gray's	Carex grayi				x		x	x	x							
Sedge, blunt broom	Carex tribuloides			?				x		?						
Sedge, crested	Carex cristatella						x									
Sedge, fox	Carex vulpinoidea						x	?		x						
Sedge, hop	Carex lupulina						x	?								
Sedge, pointed broom	Carex scoparia						x									
Sedge, shallow	Carex lurida						x	x								
Sedge, squarrose	Carex squarrosa						x	x								
Sedge, three–way	Dulichium arundinaceum						x	x								
Self–heal	Prunella vulgaris				x		x							x		x
Shepherds–purse	Capsella bursa–pastoris						x									
Skullcap, common	Scutellaria galericulata				x		x	x								
Skullcap, mad–dog	Scutellaria lateriflora				x											
Skunk–cabbage	Symplocarpus foetidus									x					x	
Smartweed	Polygonum	x	x				x									
Smartweed	Polygonum cespitosum			x	x	x				x						
Smartweed, dotted	Polygonum punctatum							x	x	?						x
Smartweed, large water	Polygonum robustius														x	
Snakeroot, black	Sanicula marilandica			x												
Sneezeweed	Helenium autumnale							x						x		
Solomons–seal, false	Smilacina racemosa								x							
Speargrass	Poa annua			x	x	x	x			x						
Speedwell, water	Veronica anagallis–aquatica				x	x										
Spicebush	Lindera benzoin					x	x	x		x				x		
Spikerush	Eleocharis	x				x	x	x								
Spikerush	Eleocharis obtusa var. obtusa							?								
Star–grass, water	Heteranthera dubia	x				x		x								
Stickseed	Hackelia virginiana			x									x			
Stick–tights	Bidens cernua						x							x		
Strawberry, wild	Fragaria virginiana						x	x								
St. Johns–wort	Hypericum perforatum						x									
St. Johns–wort, dwarf	Hypericum mutilum						x									
Sumac, poison	Toxicodendron vernix					x										
Sumac, staghorn	Rhus typhina											x	x			
Sundrops	Oenothera perennis											x				x
Sweet–clover, white	Melilotus alba				x											
Sweetflag	Acorus							x								x
Sycamore, American	Platanus occidentalis		x	x	x	x	x				x		x	x	x	x
Tearthumb, arrow–leaf	Polygonum sagittatum						x	x			x				x	x
Tearthumb, halberd–leaf	Polygonum arifolium						x	x								
Teasel, common	Dipsacus fullonum							x					x			x

(continued)

(List of Flora, continued)

COMMON NAME	SCIENTIFIC NAME	STATIONS									OTHER AREAS					
		1	3	4	5	6	7	8	9	10	A	B	C	D	E	F
Thistle, Canada	Cirsium arvense				x		x	x					x			
Three-seeded-mercury	Acalypha virginica						x								x	
Tickseed-sunflower	Bidens coronata							x						x		
Toad-rush	Juncus bufonius				x											
Tree-of-heaven	Ailanthus altissima			x	x								x			
Trefoil, birds-foot	Lotus corniculata												x			
Tumbleweed	Amaranthus blitoides						x									
Turtlehead	Chelone glabra									x					x	
Umbrella-wort, heartleaf	Mirabilis nyctaginea												x			
Vervain, blue	Verbena hastata	x					x	x								
Vervain, white	Verbena urticifolia			x	x	x	x	x		x			x			
Violet	Viola			x		x	x		x	x			x			x
Violet, common	Viola sororia							x								
Virgins-bower	Clematis virginiana						x					x				
Walnut, black	Juglans nigra			x			x				x					
Watercress, marsh	Rorippa palustris							x								
Water-hemlock	Cicuta maculata			x	x	x		x								
Water-hemlock, bulb-b.	Cicuta bulbifera							x								
Water-hemp	Amaranthus tuberculatus				x				x							
Water-horehound	Lycopus						x									
Water-horehound	Lycopus americanus				x		x	x								
Water-horehound	Lycopus virginicus						x	x								
Watermeal	Wolffia			x												
Watermeal	Wolffia borealis														x	
Watermeal	Wolffia braziliensis				x											
Watermilfoil, Eurasian	Myriophyllum spicatum					x		x								
Water-millet	Echinochloa walteri															x
Water-parsnip	Sium suave						x	x								
Water-pepper	Polygonum hydropiper						x	x			x					x
Water-plantain	Alisma plantago-aquatica						x		x							
Water-starwort	Callitriche						x	x								
Waterweed	Elodea							x		x						
Whitegrass	Leersia virginica			x	x			x	x							
Wild-millet	Echinochloa	x					x									
Wild-rye(s)	Elymus					x		x					x			x
Wild-rye, Virginia	Elymus virginicus			x	x			x	x	x					x	
Willow-weed	Polygonum lapathifolium						x									
Willow(s)	Salix	x	x		x	x				x			x			
Willow, crack	Salix fragilis				?		x	x								
Willow, white	Salix alba					x	x	?			x	x	x			
Wineberry	Rubus phoenicolasius				x											
Winterberry	Ilex verticillata						x					x				
Withe-rod	Viburnum cassinoides									x						
Wolf's-milk	Euphorbia esula												x			
Wood-nettle	Laportea canadensis			x			x	x	x				x			x
Wood-reed, stout	Cinna arundinacea			x						x						
Woolgrass	Scirpus cyperinus							x								
Wormseed-mustard	Erysimum cheiranthoides					x	x		x							
Woundwort	Stachys palustris								x							
Yam, wild	Dioscorea villosa						x	x	x			x		x	x	
Yard-rush	Juncus tenuis						x	x								
Yarrow, common	Achillea millefolium				x		x									
Yellow-cress, creeping	Rorippa sylvestris						x	x	x							

13 Criteria of Rarity

Rare native species are important because their disappearance or decline often warns us of environmental deterioration (e.g., water or air pollution). All native species play a role in the structure and function of ecological systems. Furthermore, any species of plant or animal is potentially useful to human society; for example, for studying human disease and other phenomena in the laboratory, as a source of pharmaceutical chemicals, as a "gene bank" for crop and domestic animal improvement, for food, fiber, etc., and as an object of study and enjoyment.

Although in any region, most rare species are those species at their geographical range margins and are more common somewhere else, biological conservation must begin at a species' range margins where much genetic variability occurs and where the species is most likely vulnerable to natural or human-caused stress. In some cases, even fairly common species can be vulnerable, and severe decline or extirpation can occur rapidly if habitats are destroyed or other conditions change.

Table 5. Summary of rare species lists. A = all groups of animals; B = birds only; P = plants; listing categories are in parentheses. * indicates non-governmental lists. See text for explanation.

List	*Taxa*	*Rankings*
Federal Endangered Species	AP	Endangered, Threatened
American Birds Blue List (AB)*	B	Blue List, Special Concern
Migratory Nongame Birds of Management Concern	B	Management Concern
Migrants in Jeopardy*	B	In Jeopardy
New York Endangered Species (DEC)	A	Endangered, Threatened, Special Concern
New York Natural Heritage Program	AP	various (see below)
New York Protected Native Plant List	P	Endangered, Threatened, Rare, Exploitably Vulnerable
Regionally-rare*	AP	Regionally-rare (see text)

The concepts of rarity and vulnerability can be more-or-less objectively and consistently defined and applied. We have used, as much as possible, lists and evaluations of rare species at the national and state geographic levels, because these lists integrate information from many sources and provide a perspective that is not available on a regional or local level (see Table 5). Generally speaking, we do not consider of conservation significance those species (particularly of birds) that are highly mobile and occasionally show up in our area as "accidentals" but do not use the Hudson Valley on a regular and manageable basis; examples are the sandhill crane and the western meadowlark.

The New York State Department of Environmental Conservation (DEC) prepared a list of Endangered, Threatened, and Special Concern animals that became part of the State Environmental Conservation Law in 1983. Endangered Species are those that are imminently in danger of disappearing from New York State. Threatened Species have declined significantly and may become endangered if conditions in their environment continue to worsen and successful management actions are not undertaken. Special Concern Species are believed to be declining or vulnerable and may become Threatened or Endangered in the future, but often not enough is known about population levels and the ecology of these species to reach conclusions about their actual status and vulnerability.

The "Rare Animal Status List" and "Rare Plant Status List" of the New York Natural Heritage Program (NHP) (New York Natural Heritage Program 1992a, Young 1992) include many animals listed as Endangered, Threatened and Special Concern by the DEC, but also include many other species considered rare or vulnerable in the state. Each Heritage-listed species has been assigned a global rarity ranking and a state rarity ranking by the Heritage program and these rankings are updated every year or so (see below). A standardized letter of inquiry to the DEC Significant Habitat Unit requesting a summary of available file data on occurrences of rare animals, rare plants, rare plant communities, and other special habitat occurrences is appropriate as part of any environmental planning for land use change. This inquiry results in a search of files originating in three DEC offices: Significant Habitat Unit, Endangered Species Unit, and Natural Heritage Program. Available data, of course, do not necessarily include all significant occurrences at a site.

Some species are rare statewide and appear to meet NHP criteria but have not been listed by NHP, because of delays in evaluating data. A few species listed by NHP are actually more common than published data indicate, and in our opinion should not be on the Heritage lists; examples are the red-breasted sunfish and mummichog. We note these species and explain the basis for our conclusions. Many groups of invertebrate animals and non-vascular plants have not been reviewed at all by NHP and thus many rare species are not on the Heritage lists. Examples of non-reviewed groups are the fingernail clams, true flies, and fungi. Hudsonia considers species in groups not reviewed by NHP only when there is salient evidence of rarity.

The New York State list of protected plants lists species as Endangered, Threatened, Rare, or Exploitably Vulnerable. These categories are defined below. Protected plants may still be picked, collected, or bulldozed with the landowner's permission.

The Blue List is published every few years by American Birds (Tate 1986) and includes those species of birds in the U.S. which are thought to be undergoing long-term declines in numbers. The Blue List is referred to as an "early warning list" for species not in serious enough trouble to have been Federally listed as Endangered. It is based on reports filed by many active birdwatchers throughout the country with reference to their observations in the previous years. The 1986 Blue List has two categories: Blue-listed, and Special Concern (the latter indicates lesser declines, often restricted to certain regions).

The U.S. Fish and Wildlife Service Office of Migratory Bird Management (1987) published a list of 30 migratory, nongame bird species evincing population decline or instability throughout a significant portion of their ranges. These birds are deemed "Migratory Nongame Birds of Management Concern". Nine of the listed species breed (or have bred) in the Hudson Valley.

Neotropical "Migrants in Jeopardy" are 57 North American breeding birds, mostly insect eaters, that winter in tropical forests of Latin America. These species are "considered by many ornithologists to be at grave risk because of rapidly accelerating deforestation in Central and South America." The list, extracted from *The Birder's Handbook*, is based on the work of John Terborgh and David Wilcove (Wille 1990). Although conserving breeding habitat for these species may not address the root problem, this action reduces an additional source of stress to populations.

"Regionally-rare" species are native plants and animals which are rare in the mid-Hudson region and in the county under consideration. These judgments are based on the extensive field experience of biologists associated with Hudsonia and other biologists. Usually, a species we call regionally-rare has been found by us at fewer than 10 localities in the county during the 1970s and 1980s. Although we are not aware of all of the extant populations of all rare species in the region, the regionally-rare ranking serves at least as a measure of relative rarity in our region. For vascular plants, we also refer to the *Preliminary Vouchered Atlas of New York State Flora* (New York Flora Association 1990) and an unpublished list compiled ca 1974 by the late Stanley J. Smith (New York State Museum) which indicates the number of occurrences of each species in each DEC Region of New York; this list was based on specimens in the State Museum and other herbaria as well as Smith's own field observations but the time depth of occurrences is not known and may go back many decades. DEC Region 3 includes

Dutchess, Orange, Putnam, Rockland, Sullivan, Ulster, and Westchester counties. Most plants with 10 or fewer occurrences for Region 3 in the Smith list can safely be considered regionally-rare, and some species with 11-20 occurrences may now be regionally-rare and must be judged in part by our recent field knowledge. The Smith list is more useful for comparing species within groups (e.g., sedges or ferns) because different groups receive different amounts of attention from collectors (Jerry C. Jenkins, pers. comm.). The definition and listing of regionally-rare species in the mid-Hudson is just beginning, and should serve as a useful but not dogmatic guide for conservation. There is no official or legal list of regionally-rare species. Most regionally-rare species depend upon habitat types which themselves are rare and vulnerable.

Plants and animals tend to be more sensitive to environmental changes at their range margins, where the species are subsisting close to the limits of their environmental tolerances. Many endangered and threatened species started out as species that were rare statewide or regionally rare and were subjected to deteriorating ecological conditions of various kinds causing eventual contraction of the geographic ranges and/or declines in population numbers. (Examples from New York and neighboring states include the peregrine falcon, the red-shouldered hawk, the timber rattlesnake, and goldenclub [an aquatic plant], and in other states many freshwater mussels and small fishes.) Furthermore, the bulk of the genetic variation in a species often occurs at its geographic range margins. Many subspecies and species have not yet been described by biologists, thus we are not even aware of all of the major variants. It is of considerable recreational, educational, scientific, and commercial interest that the diversity of species naturally present in a region, and the conservation of representative natural communities and habitats, be maintained in the long term so these resources are available to society. These are among the reasons for concern about the conservation of regionally-rare and statewide rare (Heritage) species.

Generally speaking, Federally-listed Endangered and Threatened species are most important, followed by State-listed Endangered and Threatened species. Next in importance are State Natural Heritage Program listed species, State Special Concern species and (for birds) Management Concern and Blue-listed species. Finally, regionally-rare species are of concern in our region, though not necessarily on a statewide basis.

Explanation of Heritage Ranking System

This key is reprinted from the New York Natural Heritage Program New York Rare Plant Status List, August 1992.

Each element has a global and state rank. The global rank reflects the rarity of the element throughout the world and the state rank reflects the rarity within N.Y.S. Infraspecific taxa are also assigned a taxon rank to reflect the infraspecific taxon's rank throughout the world.

Global Rank

G1 = Critically imperiled throughout its range due to extreme rarity (5 or fewer sites or very few remaining individuals) or extremely vulnerable to extinction due to biological factors.

G2 = Imperiled throughout its range due to rarity (6 - 20 sites or few remaining individuals) or highly vulnerable to extinction due to biological factors.

G3 = Either very rare and local throughout its range (21 - 100 sites), with a restricted range (but possibly locally abundant), or vulnerable to extinction due to biological factors.

G4 = Apparently secure throughout its range (but possibly rare in parts).

G5 = Demonstrably secure throughout its range (however it may be rare in certain areas).

GH = No extant sites known but it may be rediscovered.

GX = Species believed extinct.

GU & G? = Status unknown.

State Rank

S1 = Critically imperiled in New York State because of extreme rarity (5 or fewer sites or very few remaining individuals) or extremely vulnerable to extirpation from New York State due to biological factors.

S2 = Imperiled in New York State because of rarity (6 - 20 sites or few remaining individuals) or highly vulnersble to extirpation from New York State due to biological factors.

S3 = Rare in N.Y.S. (usually 21 - 100 extant sites).

S4 = Apparently secure in N.Y.S.

S5 = Demonstrably secure in N.Y.S.

SH = No extant sites known in N.Y.S. but it may be rediscovered.

SX = Apparently extirpated from N.Y.S.

SE = Exotic, not native to N.Y.S.

SR = Reported from the state, but existence has not been documented.

SU = Status uncertain because of the cryptic nature of the plant.

Taxon Rank (T-rank)

The T-ranks are defined the same way the Global ranks are but the T-rank only refers to the rarity of the subspecific taxon not the rarity of the species as a whole.

A "Q" indicates a question exists whether or not the taxon is a good taxonomic entity.

A "?" indicates that an identification question exists about known occurrences. It also indicates the rank presumably corresponds to actual occurrences even though the information has not been documented in heritage files or historical records. It serves to flag species that need more field studies or specimen identification.

DOUBLE RANKS (i.e. S1S2, S2S3)

The first rank indicates rarity based upon current documentation. The second rank indicates the probable rarity after all historical records and likely habitat have been checked. Double ranks denote species that need additional field surveys.

New York State Plant Legal Status

The following catagories are defined in regulation 6NYCRR part 193.3 and apply to New York State Environmental Conservation Law section 9-1503.

E = Endangered Species: listed species are those with
1) 5 or fewer extant sites, or
2) fewer than 1,000 individuals, or
3) restricted to fewer than 4 USGS 7.5 minute topographical maps, or
4) species listed as endangered by the U.S. Department of the Interior, as enumerated in the Code of Federal Regulations 50 CFR 17.11.

T = Threatened: listed species are those with
1) 6 to fewer than 20 extant sites, or
2) 1,000 to fewer than 3,000 individuals, or
3) restricted to not less than 4 or more than 7 USGS 7.5 minute topographical maps, or
4) listed as threatened by the U.S. Department of the Interior, as enumerated in the Code of Federal Regulations 50 CFR 17.11.

R = Rare: listed species have
1) 20 to 35 extant sites, or
2) 3,000 to 5,000 individuals statewide.

V = Expoitably vulnerable: listed species are likely to become threatened in the near future throughout all or a significant portion of their range within the state if causal factors continue unchecked.

U = Unprotected

Federal Status

The categories of federal status are defined by the United States Department of the Interior as part of the 1974 Endangered Species Act (see Code of Federal Regulations 50 CFR 17). Recent changes in federal status were published in the Federal Register on February 21, 1990 (Vol. 55(35): 6184-6229). A summary of federally listed plants is in the U.S. Fish and Wildlife Service Publication "Endangered & Threatened Wildlife and Plants" (July 15, 1991).

(blank) = No Status

LE = The taxon is formally listed as endangered.

LT = The taxon is formally listed as threatened.

PE = The taxon is formally proposed as endangered but a final ruling has not been made.

PT = The taxon is formally proposed as threatened but a final ruling has not been made.

C1 = Candidate, category 1--The taxon with sufficient information to list as endangered or threatened.

C2 = Candidate, category 2-- The taxon may be appropriate for listing but for which more data are needed.

3A = The taxon is considered extinct by the U. S. Fish and Wildlife Service.

3B = The Taxon is no longer considered taxonomically distinct by the U. S. Fish and Wildife Service and thus not appropriate for listing.

3C = The taxon has been shown to be more abundant, widespread, or better protected than previously thought and therefore not in need of official listing.

* = The taxon is possibly extinct.

NHP LIST

Y = Yes, a taxon on the New York Natural Heritage Program rare plant status list.

W = Watch list, a taxon that may be rare or declining in New York, more data is needed before including it on the rare plant status list.

14 Project Staff

Table 6. Project personnel. Experience is in years (minimum).

Worker	Degree	Experience	Role in Wallkill study
Barbour, Spider	B.S.	21	Flora, habitat surveys
Jenkins, Jerry C.	B.A.	25	Identified or verified plant specimens
Kiviat, Erik	Ph.D.	23	Habitat, flora, fauna; administration
Schmidt, Robert E.	Ph.D.	23	Fish, invertebrate surveys
Stevens, Gretchen	B.S.	12	Flora survey & identification; water quality

APPENDIX C

ORANGE COUNTY SOIL & WATER CONSERVATION DISTRICT
225 Dolson Avenue, Suite 103
Middletown, NY 10940
845-343-1873 Fax: 845-344-1341
www.ocsoil.org

ULSTER COUNTY SOIL & WATER CONSERVATION DISTRICT
Times Square Office Park
652 Route 299, Suite 103
Highland, NY 12528
845-883-7162 Ext. 5 Fax: 845-883-7184

STEERING COMMITTEE

WALLKILL RIVER WATERSHED MANAGEMENT PLAN

Dear Residents of the Wallkill River Watershed,

The Wallkill River Watershed Management Plan Steering Committee would like your help. We are drafting a plan to assist communities in the watershed with planning for the future of their water resources. The Committee wants to be sure we are addressing your concerns as we develop recommendations to include in the Plan. Environmental, economic, and quality of life concerns differ depending on where you live in the watershed and the enclosed, short survey will help us in identifying citizens' interests and concerns in the watershed. Please take a few minutes to look it over and fill it out. We appreciate and value your response!

Some background on the Project: The Wallkill River is an important resource in both Orange and Ulster Counties. A north flowing river, the Wallkill begins from its source, Lake Mohawk in New Jersey, then enters Orange County where it flows for approximately 40 miles, draining 386 square miles or nearly half the County, before entering Ulster County. Once there it continues for another 34 miles, draining approximately 190 square miles, then emptying into the Rondout Creek which empties into the Hudson River, making the Wallkill a part of the Hudson River Estuary. The Wallkill River watershed, with a watershed being all the land that water flows across or under on its way to a river, stream, or lake, is 806 square miles in size.

Growth in the watershed has resulted in concerns about water quality and quantity, pollution and loss of habitat. Given the size of the watershed, the diversity of land uses, the number of political subdivisions and the constantly changing social and economic patterns of the landscape, this Plan will identify critical issues impacting the future of the watershed.

This is a cooperative project between Orange and Ulster County with a goal to provide assistance to communities in the watershed with planning for the future of their water resources. Approximately 40 individuals representing various organizations, municipalities and agencies in Orange and Ulster Counties and New Jersey initially met in September 2004 to provide input about the important issues facing the watershed. Meetings continue as more information is obtained to include in the Management Plan. At one of the meetings it was suggested that a survey be sent out to watershed residents to see what interests and concerns they have for today and the future of the Wallkill River Watershed. The information gathered will be part of the Watershed Management Plan so we would request that you take a few minutes to complete the survey. The more information gathered the more comprehensive the Plan.

We appreciate your interest in this project and want to thank you for taking time to fill out the survey. Please feel free to contact the Soil and Water District office in your County if you would like more information or have questions.

WALLKILL RIVER WATERSHED MAP IS ON THE BACK OF THIS PAGE

CITIZEN'S SURVEY - WALLKILL RIVER WATERSHED MANAGEMENT PLAN

Please indicate your town/village/city: _____

Are you a: _____ Homeowner _____ Farmer _____ Landowner _____ Business _____ Municipal Official

How long have your lived, worked or represented residents within the Wallkill River Watershed?

_____ 1 - 5 years _____ 6 - 10 years _____ 11 – 20 years _____ 20+ years

Which of the following definitions best fits your definition of what a watershed is?

_____ Low area that retains water

_____ Reservoir that serves a municipal water source

_____ Area that drains into a specific river or lake

_____ Don't know

In your opinion conditions on the Wallkill River are generally:

_____ Excellent, need no change in management

_____ Good, but could use some improved management

_____ Fair, need much more management

_____ Poor, need urgent management

How concerned are you with pollution and environmental quality?

_____ Very concerned

_____ Somewhat concerned

_____ Not very concerned

_____ Not at all concerned

_____ Do not know

I enjoy the Wallkill River and/or its tributaries (streams) for the following activities: (Check all that apply)

_____ Swimming

_____ Fishing

_____ Walking along the River

_____ Watching birds and other wildlife

_____ Hunting

_____ Camping along river banks

_____ Horseback riding

_____ Boating

_____ Other (please specify) _____

Which tributary(ies) have you used for recreation? _____

I use the land and water in the following ways: (Check all that apply)

_____ Household water supply

_____ Lawn or garden water supply

_____ Area for disposal of leaf and yard waste

_____ Source of gravel or sand material

_____ Irrigation

_____ Other (please specify) _____

Please rank your top five concerns about the Wallkill River Watershed. ***1 = most important*** ***5 = least important***

_____ Stream bank erosion

_____ Land development

_____ Recreational opportunities

_____ Flooding of property

_____ Litter and debris dumping

_____ Construction of roads

_____ Water running off roofs & streets into storm drains

_____ Construction of new businesses and industry

_____ Golf course, playing fields, & other high maintenance green spaces

_____ Public Awareness and Education

_____ Nuisance wildlife (e.g. mosquitoes)

_____ Riverside wildlife habitat enhancement

_____ Extent of impervious (paved) surfaces

_____ Wastewater treatment facilities

_____ Farm operations

_____ Fertilizers & lawn chemicals that people use on their lawns and garden

_____ Construction of homes

_____ Other (please specify) _____

Below are some concerns about environmental quality and land use in your region. How much of a problem do you think each is where you live? (Circle your answer)

	Not a problem	Slight problem	Moderate problem	Serious problem	Don't know
Water quality of streams and the River	NP	SLP	MP	SP	DK
Groundwater quality	NP	SLP	MP	SP	DK
Frequency and extent of flooding	NP	SLP	MP	SP	DK
Loss of wetlands	NP	SLP	MP	SP	DK
Soil erosion	NP	SLP	MP	SP	DK
Quality of fish habitat	NP	SLP	MP	SP	DK
Quality of wildlife habitat	NP	SLP	MP	SP	DK
Woodlands and other natural communities occurring only as small scattered areas	NP	SLP	MP	SP	DK
Expansion of housing development into rural areas	NP	SLP	MP	SP	DK
Job opportunities	NP	SLP	MP	SP	DK
Way in which public lands are managed	NP	SLP	MP	SP	DK
Availability of incentives for private landowners to adopt practices that benefit the environment	NP	SLP	MP	SP	DK
Coordination among public programs to provide assistance to private landowners for land management activities	NP	SLP	MP	SP	DK
Loss of small family farms	NP	SLP	MP	SP	DK
River and streams with eroding banks	NP	SLP	MP	SP	DK

I personally have been affected by flooding: (Check all that apply to you)

____ Never ____ Once ____ A number of times

_____ Damage to my home

_____ Washout of road access

_____ Washout of bridge access

_____ Erosion of stream banks

*This section concerns **FUTURE ENVIRONMENTAL CONDITIONS**. Please indicate whether you would like to see less, more, or about the same of each in your area. (Circle one answer for each statement)*

Areas of natural cover, including forests, woodlands and wetlands	Less	Same	More	DK
Area of new residential development	Less	Same	More	DK
Area devoted to the protection of plant and animal species	Less	Same	More	DK
Area of new light industrial development	Less	Same	More	DK
Area of public land managed using techniques that attempt to imitate nature	Less	Same	More	DK
Area of wetlands that have been restored or conserved	Less	Same	More	DK
Number of recreation areas devoted to non-motorized outdoor recreation	Less	Same	More	DK
Area of River flood plains that have been maintained or restored to their natural state, free of structure	Less	Same	More	DK
Areas in towns and cities planted to trees and shrubs	Less	Same	More	DK

Additional comments: _____

_____

_____

(Optional) Name: _____ Email _____

Address: _____

Please mail or fax your completed survey to the Soil and Water District Office in your County. Their addresses are on the cover sheet.

THANK YOU for your participation in this survey.

CITIZENS SURVEY SUMMARY
ORANGE AND ULSTER COUNTIES
WALLKILL RIVER WATERSHED MANAGEMENT PLAN

Total responders: **230** (**93** from Orange Co. and **137** from Ulster Co.)
The survey was distributed by hand at various venues, gatherings, etc. in both Counties)

Are you a: **191** Homeowner **20** Farmer **17** Landowner **8** Business **9** Municipal Official

How long have your lived, worked or represented residents within the Wallkill River Watershed?

39 1 - 5 years **89** 6 - 10 years **65** 11 – 20 years **74** 20+ years

Which of the following definitions best fits your definition of what a watershed is?

27 Low area that retains water

135 Area that drains into a specific river or lake

29 Reservoir that serves a municipal water source

28 Don't know

In your opinion conditions on the Wallkill River are generally:

5 Excellent, need no change in management

100 Good, but could use some improved management

89 Fair, need much more management

32 Poor, need urgent management

How concerned are you with pollution and environmental quality?

145 Very concerned

62 Somewhat concerned

10 Not very concerned

3 Not at all concerned

4 Do not know

I enjoy the Wallkill River and/or its tributaries (streams) for the following activities: (Check all that apply)

22 Swimming

84 Fishing

103 Walking along the River

107 Watching birds and other wildlife

17 Hunting

23 Camping along river banks

15 Horseback riding

54 Boating

26 Other (please specify):

Photography-3/Farming/ Drainage/Driving past/Sitting by water/Running by/Aesthetics/Picnic pavilion/Trail bicycling/Gorgeous stream in my property

Which tributary(ies) have you used for recreation?

Wawayanda Creek-**1**/Rutgers Creek-**4**/Pochuk-**4**/Tin Brook-**5**/Papakating Creek-**3**/Beaver Run-**2**/Little Shawangunk Kill-**1**/Dwaar Kill-**2**/Shawangunk-**7**/Muddie Kill-**2**/Pleasure Ground Park-**1**/ Rondout Creek-**5**/Esopus Creek-**4**/New Paltz-**1**/Many areas from Minisink, NY to Hamburg, NJ-**1**/Wallkill-**19**/Split Rock- **1**

I use the land and water in the following ways: (Check all that apply)

97 Household water supply

78 Lawn or garden water supply

25 Area for disposal of leaf and yard waste

6 Source of gravel or sand material

11 Irrigation

3 Other (please specify) Recreation, local food source/Nice view/Emergency water for hikes along the "A" trail

Please rank your top five concerns about the Wallkill River Watershed. ***1 = most important*** ***5 = least important***

	1	2	3	4	5	X's
_____ Stream bank erosion	**22**	**11**	**22**	**13**	**5**	**6**
_____ Land development	**73**	**19**	**9**	**11**	**6**	**13**
_____ Recreational opportunities	**19**	**15**	**4**	**7**	**11**	**5**
_____ Flooding of property	**33**	**10**	**14**	**10**	**12**	**1**
_____ Litter and debris dumping	**48**	**21**	**16**	**10**	**11**	**14**
_____ Construction of roads	**10**	**6**	**6**	**3**	**9**	**2**
_____ Water running off roofs & streets into storm drains	**14**	**8**	**15**	**6**	**5**	**8**
_____ Construction of new businesses and industry	**24**	**21**	**15**	**7**	**13**	**3**
_____ Golf course, playing fields, & other high maintenance green spaces	**13**	**5**	**7**	**8**	**18**	**3**
_____ Public Awareness and Education	**22**	**11**	**7**	**12**	**13**	**4**
_____ Nuisance wildlife (e.g. mosquitoes)	**9**	**10**	**10**	**4**	**11**	**2**
_____ Riverside wildlife habitat enhancement	**15**	**13**	**11**	**11**	**9**	**3**
_____ Extent of impervious (paved) surfaces	**7**	**11**	**10**	**9**	**9**	**4**
_____ Wastewater treatment facilities	**34**	**10**	**8**	**12**	**12**	**9**
_____ Farm operations	**12**	**10**	**9**	**8**	**2**	**4**
_____ Fertilizers & lawn chemicals that people use on their lawns and garden	**26**	**8**	**15**	**12**	**9**	**4**
_____ Construction of homes	**19**	**14**	**3**	**18**	**18**	**6**

_____ Other (please specify) Maintaining high water quality/more horse trails-multiuse/public access/ and invasive species

Below are some concerns about environmental quality and land use in your region. How much of a problem do you think each is where you live? (Circle your answer)

	Not a problem	Slight problem	Moderate problem	Serious problem	Don't know
Water quality of streams and the River	**11**	**36**	**70**	**64**	**18**
Groundwater quality	**18**	**41**	**59**	**52**	**27**
Frequency and extent of flooding	**34**	**61**	**48**	**37**	**17**
Loss of wetlands	**26**	**37**	**46**	**61**	**24**
Soil erosion	**26**	**40**	**61**	**41**	**29**
Quality of fish habitat	**17**	**35**	**42**	**71**	**33**
Quality of wildlife habitat	**20**	**34**	**46**	**69**	**25**
Woodlands and other natural communities occurring only as small scattered areas	**18**	**39**	**50**	**76**	**18**
Expansion of housing development into rural areas	**10**	**20**	**44**	**112**	**15**
Job opportunities	**29**	**32**	**41**	**50**	**32**
Way in which public lands are managed	**8**	**41**	**64**	**47**	**31**
Availability of incentives for private landowners to adopt practices that benefit the environment	**15**	**28**	**56**	**58**	**40**
Coordination among public programs to provide assistance to private landowners for land management activities	**13**	**25**	**52**	**41**	**59**
Loss of small family farms	**11**	**21**	**34**	**107**	**20**
River and streams with eroding banks	**11**	**37**	**58**	**57**	**20**

I personally have been affected by flooding: (Check all that apply to you)

150 Never **20** Once **48** A number of times

23 Damage to my home

39 Washout of road access

20 Washout of bridge access

29 Erosion of stream banks

1 Other: Crop damage

*This section concerns **FUTURE ENVIRONMENTAL CONDITIONS**. Please indicate whether you would like to see less, more, or about the same of each in your area. (Circle one answer for each statement)*

	Less	Same	More	Don't know
Areas of natural cover, including forests, woodlands and wetlands	**1**	**58**	**138**	**9**
Area of new residential development	**160**	**28**	**13**	**10**
Area devoted to the protection of plant and animal species	**5**	**39**	**146**	**12**
Area of new light industrial development	**84**	**64**	**34**	**19**
Area of public land managed using techniques that attempt to imitate nature	**30**	**50**	**101**	**25**
Area of wetlands that have been restored or conserved	**9**	**52**	**134**	**12**
Number of recreation areas devoted to non-motorized outdoor recreation	**5**	**53**	**137**	**14**
Area of River flood plains that have been maintained or restored to their natural state, free of structure	**7**	**53**	**105**	**17**
Areas in towns and cities planted to trees and shrubs	**5**	**27**	**165**	**8**

Additional comments: _____**ORANGE COUNTY'S ATTACHED**_____

_____

_____

(Optional) Name: _____ Email _____

Address: _____

Please mail or fax your completed survey to the Soil and Water District Office in your County. Their addresses are on the cover sheet.

THANK YOU for your participation in this survey.

SUMMARY
CITIZEN SURVEY RESPONSES

- Total of **230** responses (**87** from Orange County, **6** from New Jersey and **137** from Ulster County)

- **83%** of the responders were homeowners.

- **38.7%** had lived in the watershed 6-10 years; **32.2%** for 20+ years; **28.3%** for 11-20 years; and 17% for 1-5 years.

- **43.5%** feel conditions on the Wallkill River were good.

- **63%** are very concerned with pollution and environmental quality.

- **The top 3 activities people participate in are:**
  - Watching birds and other wildlife **46.5%**
  - Walking along the River **44.8%**
  - Fishing **36.5%**

- **42.2%** use the land and water for household water supply.

- **The top 5 concerns (listed as #1) were:**
  - Land development
  - Litter & debris dumping
  - Wastewater treatment facilities
  - Flooding
  - Fertilizers & lawn chemical

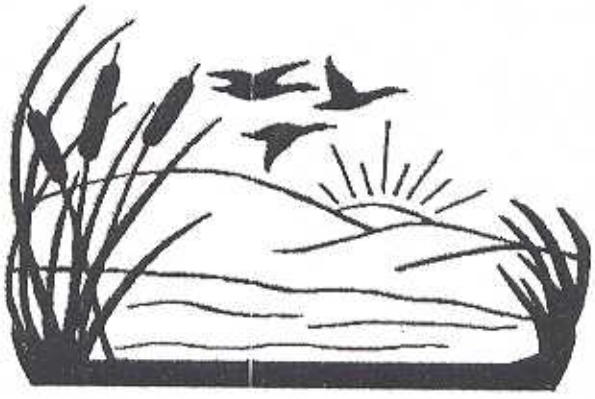
- While the 4th major concern listed was flooding, **65.2%** of the responders never experienced any kind of flooding.

- **The top 2 serious problems listed were:**
  - Expansion of housing development into rural areas **48.7%**
  - Loss of small family farms **46.5%**

- **The top 3 Future environmental concerns listed were:**
  - More areas in towns & cities planted to trees **71.7%**
  - Less areas of residential development **69.6%**
  - More areas devoted to the protection of plant & animal species **63.5%**

Wallkill River Streambank Reconnaissance
June 4, 2002

Oil City Road to Rte. 1, Pine Island

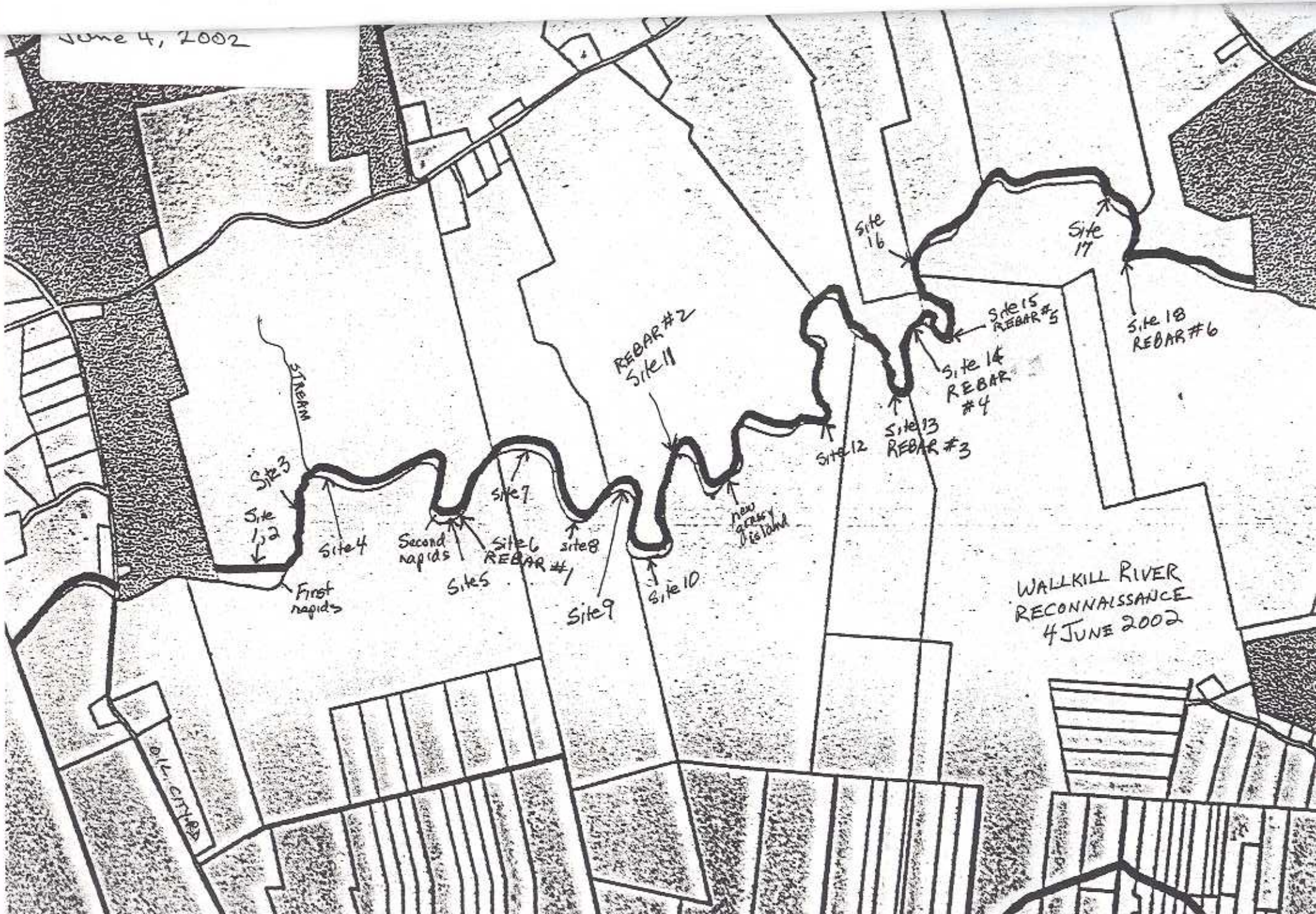


John Gebhards, rebar installation
Diana Krautter, general support
Kelly Dobbins, digital photography
Kevin Sumner, rebar installation
Richard Botshon, photography
Ann Botshon, data recording

Wallkill River Streambank Reconnaissance June 4, 2002

SITE # & DESCRIPTION	GPS	RB PHOTO #	KD PHOTO #	JOHN's 2001 equiv. photo	COMMENTS
1,2. Just below Oil City Bridge, upstream of farm shed		—		1,2	Tree in water no longer evident; banks well vegetated. Lily pads.
3. Curve past first riprap		—			
4: 30' below stream coming in from the left	41° 17' 40" N 74° 31' 49" W	1,3	1,2		More ailanthus than last year on e. bank. Downed tree
5. After second rapids	New riprap at 41° 17' 44" N 74° 31' 33" W	4,5,6	RB 5 = KD 3 RB6 = KD 5	#5	#4, looking N at downed tree rocky slab #5, looking at e bank just below second rapids: bank loss #6 farmer's new riprap 80-90' long just the other side of downed tree
6. REBAR INSERT #1 E. BANK	41° 17' 46" N 74° 31' 32" W	7	6		Yellow portion protrudes 10"; 32" above waterline
7. Leaning tree		8	7		Tree at 30° angle on east bank
8. Riprap		9	8,9	#6	Riprap over wide arc
9. Eroded banks		10,11	#12 10		Eroded banks, grass and trees, looking SE
10. Riprap		12		Probably #14	Extensive riprap
11. REBAR INSERT #2	41° 18' 03" N 74° 31' 14" W	13	13,14		Probably corresponds to Kevin's site 8 just above riffle. Rod protrudes 12.5"; approx. 4 ft above waterline.
12.Eroded bank.		14		17	Eroded bank (treed) on w. side of river, riprap in distance on E. side. (Note: we passed Kevin's Site 1 and did not note any special problem)

13. REBAR INSERT #3	41° 18' 22" N 74° 30' 55" W	15	19		Rebar Yellow portion protrudes 9"; XX" above waterline. (Not clear where this is on river!)
14. REBAR INSERT #4 equiv. to Kevins Site 3	41° 18' 28" N 74° 30' 57" W	16	20		Eroded bank. Rebar Yellow portion protrudes 12"; XX" above waterline
15. REBAR INSERT #5 equiv to Kevin's Site 4	41° 18' 29" N 74° 30' 52" W	18	21,22	25	Rebar Yellow portion protrudes 10"; 4.5 ft above waterline. Short distance downstream of iron bridge.
16. River birch as last year		--	24,25		
17. Tree down		19	26,27		Tree down, bank pulled down; new bad bank spot
18. REBAR INSERT #6 equiv to Kevin's Site 5	41° 18' 45" N 74° 30' 39" W	20	28,29, 30		4 big trees ready to fall. Rebar Yellow portion protrudes 9"; 4.0 ft above waterline
19. REBAR INSERT #7 equiv to Kevin's Site 6	41° 18' 49" N 74° 29' 51" W	21	31,32		Gentle curve of river. Bar on e. bank. Old riprap. Rebar Yellow portion protrudes 9"; 4.0 ft above waterline
20. REBAR INSERT #8 (not a Kevin site)		24	33,34 35	48	Rebar Yellow portion protrudes XX"; 67" above waterline


June 4, 2002
STREAM
Site 3
Site 1,2
First rapids
Site 4
Second rapids
Site 5
Site 6 REBAR #1
Site 7
site 8
Site 9
Site 10
REBAR #2 Site 11
new grassy island
Site 12
Site 13 REBAR #3
Site 14 REBAR #4
Site 15 REBAR #5
Site 16
Site 17
Site 18 REBAR #6
WALLKILL RIVER RECONNAISSANCE 4 JUNE 2002


Site 19
REBAR
#7
site 20
REBAR #8

Site 1,2. Just below Oil City Bridge, upstream of farm shed	Tree in water no longer evident; banks well vegetated. Lily pads. John's photo #2 2001 No photo for 2002

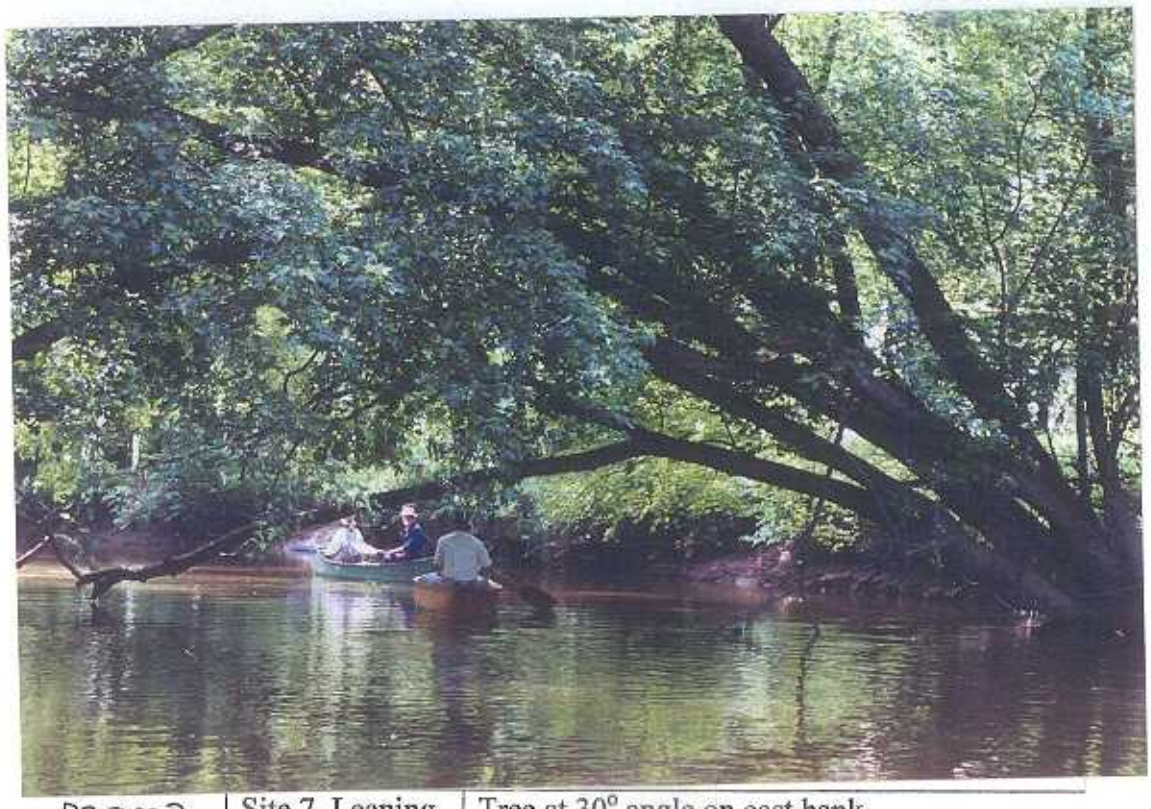
Site 4: 30' below stream coming in from the left	More ailanthus than last year on e. bank. Downed tree RB #13 2002

RB photos 4,5 2002	Site 5. After rapids	#4, looking N at downed tree rocky slab #5, looking at e bank just below second rapids: bank loss #6 farmer's new riprap 80-90' long just the other side of downed tree

Site 5, cont. After rapids	#6 farmer's new riprap 80-90' long, just the other side of downed tree. East bank of river. RB photo # 6 new riprap 2002 JF photo #5 erosion 2001

RB 2002 #7	Site 6. REBAR INSERT #1 E. BANK	Yellow portion protrudes 10"; 32" above waterline

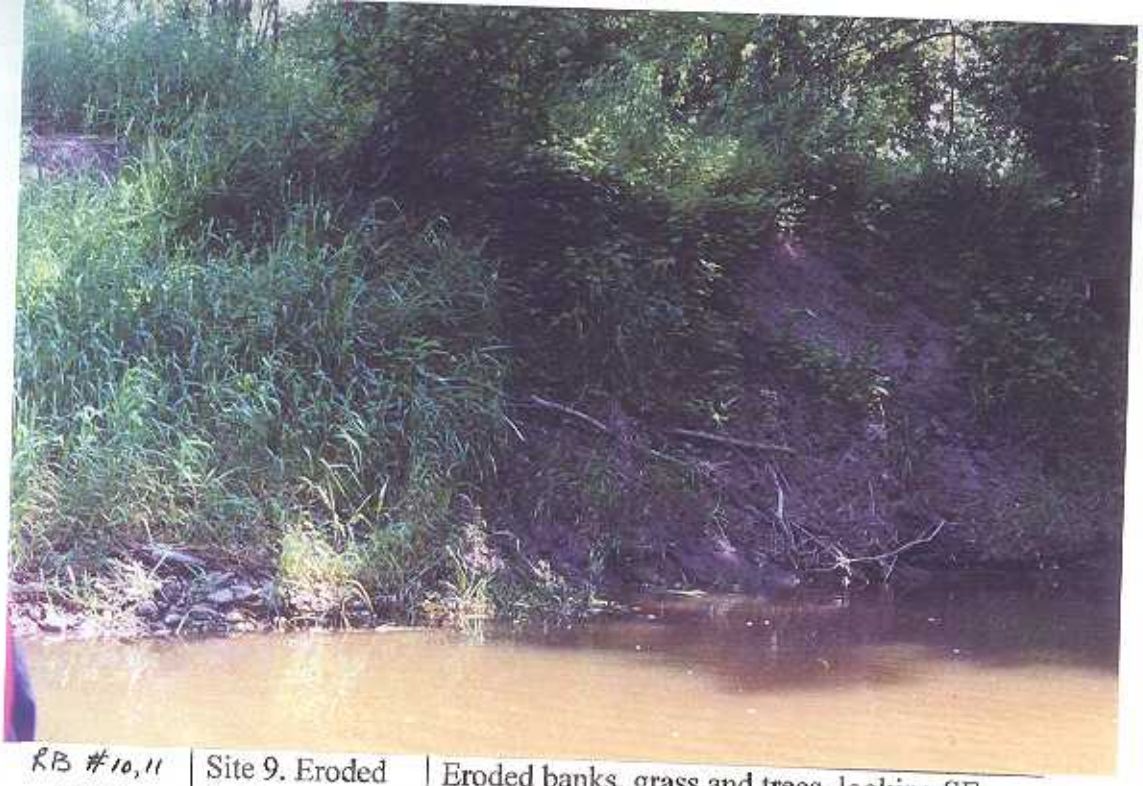
KD 2002 #6	REBAR #1, view from a distance



RB 2002 #8	Site 7. Leaning tree	Tree at 30° angle on east bank

RB #9 2002	Site 8.	Riprap over wide arc

Site 8 John Gebhard s photo April 2001 #6



RB #10,11 2002	Site 9. Eroded banks	Eroded banks, grass and trees, looking SE

Site 10. Riprap	RB photo # 12 2002 JG photo #14 2001

RB # 13
2002

Site 11. REBAR INSERT #2	Probably corresponds to Kevin's site 8 just above riffle

RB #14, 2002 JG #17, 2001	Site 12.Eroded bank.	Eroded bank (treed) on w. side of river, riprap in distance on E. side. (Note: we passed Kevin's Site 1 and did not note any special problem)

#15
02
Site
REF
INS

Site for REBAR #
Site 13

← KD# 17

Looking to the ri
of REBAR #3 sit
for reference

KD #18

↓

#15 002	Site 13. REBAR INSERT #3	Rebar Yellow portion protrudes 9"; XX" above waterline

RB #16 2002	Site 14. REBAR INSERT #4 equiv. to Kevin's Site 3	Eroded bank. Rebar Yellow portion protrudes 12"; XX" above waterline

~~KB 2002 Site 15 REBAR #5~~

RB #18 2002	Site 15. REBAR INSERT #5 equiv to Kevin's Site 4	Rebar Yellow portion protrudes 10"; 4.5 ft above waterline

KD #21
2002

Site 15. REBAR #5 (distant view)

KD #24
2002
River birch

J6 #30
2001

Site 16. River birch as last year

KD #26
2002

Distant view of fallen tree Site 17.

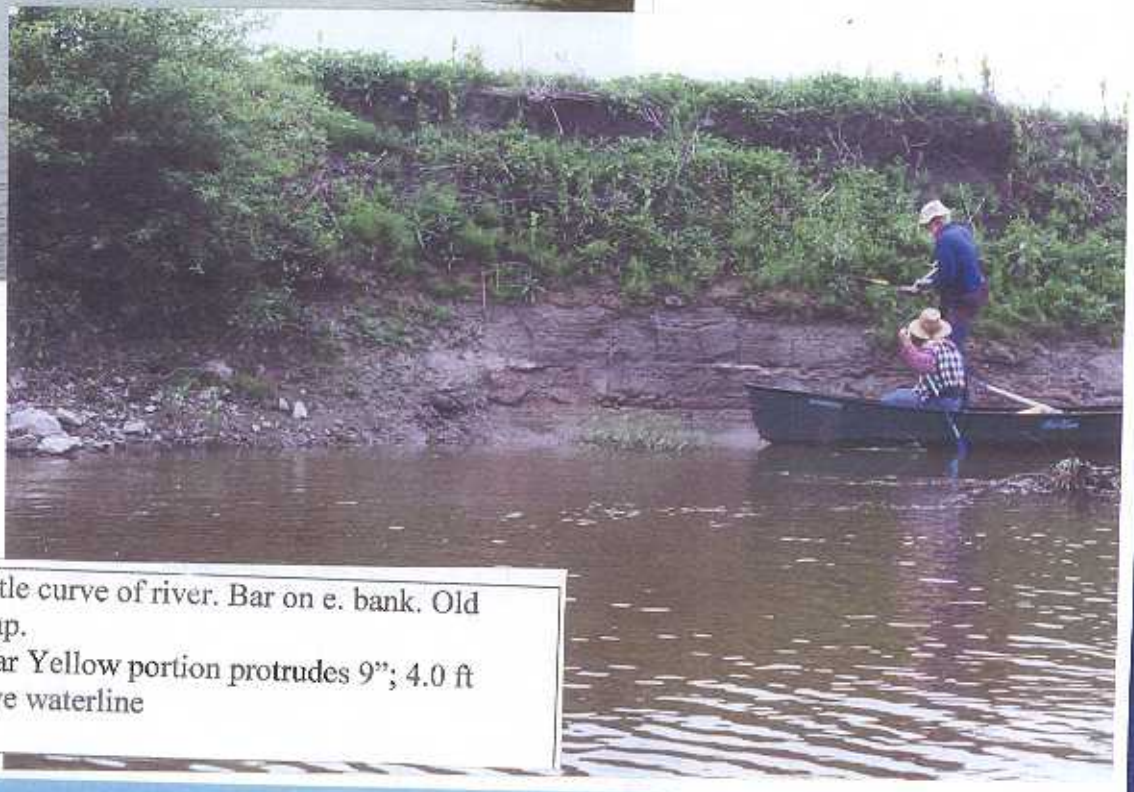
RB #19 2002	Site 17. Tree down	Tree down, bank pulled down; new bad bank spot

RB #20 2002	Site 18. REBAR INSERT #6 equiv to Kevin's Site 5	4 big trees ready to fall. Rebar Yellow portion protrudes 9"; 4.0 ft above waterline. East bank of river.

KD#30 Site 18. Rebar #6 (circled)
2002

KD #31 2002

← Looking downstream to Site 19, site for REBAR #7.



ite 19. EBAR NSERT #7 quiv to evin's Site 6	Gentle curve of river. Bar on e. bank. Old riprap. Rebar Yellow portion protrudes 9"; 4.0 ft above waterline

JG #47 Site 19 Site in 2001

KD #35 2002
Site 20, RB
Looking back (
at REBAR #
(circled)

RB #23 →
2002

Site 20. REBAR INSERT #8 (not a Kevin site)	Rebar Yellow portion protrudes X above waterline. West bank of riv RB photo # 23 2002 JG photo #48 2001

JG #48, 200(

Erosion Study on the Wallkill River
Between Oil City Road and County Route 1
Town of Warwick, New York
March 2005

Introduction:

Landowners along the Wallkill River in the Black Dirt region of Orange County have been concerned about stream bank erosion on segments of the river for a number of years. While it is recognized that some erosion and subsequent deposition of sediment is a natural process in many rivers, the process is often exacerbated by human activities. Increased runoff from impervious surfaces and lost of wetlands may increase stream flow and velocity, increasing the severity of erosion. A report by the Natural Resources Conservation Service and the Orange County Soil and Water Conservation District from 1987, estimated bank erosion in the Black Dirt to be 91 T/Bank Mile/Yr. (1)

Site of significant bank erosion.

According to the Priority Water List (PWL), (2) silt/sediment is the major pollutant impacting the river from the New Jersey state line to Middletown. It is documented that sediment has impaired both aquatic life and aesthetics of the river.

Due to flooding concerns over the years, the Army Corp of Engineers was called upon to assess the situation in the early 1980s. While the emphasis of the study was on flood protection, the report did mention streambank erosion control projects. However, based on cost-benefit analysis, further "improvements combining flood control and allied purposes…" (3) were not warranted. An agreement was reached between the New York State Department of Environmental Conservation, Orange County and the towns of Goshen, Minisink and Warwick, to inspect the river twice a year and provide maintenance of the river by removing obstructions to stream flow.

As erosion remained a problem in this stretch of the river, in 1991, the Soil and Water Conservation District sent a letter to the Orange County Commissioner of Public Work identifying eight locations on the Wallkill River and Pochuck Creek where erosion seemed excessive and where riprap might be used to stabilize the banks. (4) Unfortunately, while removal of trees was considered maintenance under the agreement, riprap to prevent undermining was deemed to be a capital expenditure, therefore, excluded.

With little being done to resolve the erosion issue, the Wallkill River Task Force in conjunction with the Orange County Soil and Water Conservation District and black dirt landowners undertook a study in 2002 to document the amount of erosion at various points along the river.

Procedure

On June 4, 2002, members of the Task Force and the Orange County Soil and Water Conservation District, canoed the river from Oil City Road to County Rt. 1, a distance of approximately six miles, to establish a baseline for further study. Photographs of the riverbanks were taken and notes on plant and water conditions were made. At eight points along the river, 4-foot lengths of ½ steel rebar were pounded horizontally into the riverbank leaving a small portion sticking out of the bank. The exposed portion was painted yellow for easier identification and the exposed length and the height above the water level was measured and recorded. An estimate was made on the length of eroded bank and the bank height at each site. An attempt was made to accurately locate each site using GPS. Not all banks segments that seemed to be eroding were monitored.

Rebar being hammered into bank.

On November 10, 2003, several members of the group returned to the same stretch of the river. Each rebar previously inserted was identified. The exposed portion of the rebar was measured and recorded. The height above water level was noted. GPS was again used, but some of the readings were inconsistent with those from 2002.

On November 7, 2004, the trip was repeated and the measurements taken. This trip had been postponed from two previous dates due to high water levels and the number of fallen trees blocking the channel. The exposed portion of each rebar was again measured. Once measured, several of the rebars were hammered further into the bank. The portion sticking out was measured and recorded. Six new rebars were inserted into the bank at various locations and notes were made on each.

Table 1.

rebar	Erosion inches '02 to '03	Erosion inches '03 to '04	Total In inches	Inches/ year	Estimated cubic yds soil lost in 2 years
1	14	3	17	8.5	31
2	0	0.5	0	0	0
3	13	10	23	11.5	15
4	7	7	14	7	78
5	2	7	9	4.5	42
6	5	6	11	5.5	10
7	0	20	20	10	19
8	31	27	58	29	186

Results and Discussion:

The results from 2002 to 2004 are listed in Table 1. As can be seen from the results, erosion is variable along the stretch of river under study, ranging from nearly none to almost 2

½ feet per year. Several of these points were those locations identified as concerns in 1991. This includes rebar #2, #4, #5, #6, and #7.

While it is difficult to directly compare this to the 1987 estimate of 91 tons/bank mile/ per year, these numbers appear to be within the range. The following assumptions were used in order to compare these two estimates.

- ? ? All of the soil eroding from the banks is organic
- ? ? A cubic yard of organic soil weights 270 pounds
- ? ? The average height of the bank is 8 feet

Therefore, converting the 91 tons per bank mile to inches lost per year equals about 5 inches per year. Averaging the eight points under study, the erosion was 9.5 inches per year. Since this only represents a portion of the entire bank throughout this section of the river, the rate of 5 inches per year may be reasonable.

Various sand layers are visible below organic soil layer at site of rebar #8.

The relatively stability of a couple of sites was surprising given the fact that all sites initially selected appeared to be actively eroding in 2002. Considering the severity of storms in the fall of 2004 and the extent of flooding along the river, it was anticipated that more erosion would be found on many of the sites. This was not the case at all locations.

Clearly, erosion is a dynamic process and erosion and deposition causes changes in channel flow that alters erosion along the banks. The difference in soil texture and structure also appears to be a factor in the extent of the erosion. While the black dirt region appears uniform from the surface, the banks of the river tell a different story. On different banks along the river, various layers of organic and mineral material can be seen. The most erosive site is one of the most interesting, with several layers of sands crossed bedded beneath the organic soil. Other locations show a layer of sand between two layers of organic matter.

While the specific points at which erosion occurred may have changed, erosion appeared to be a problem throughout much of this stretch of the river. As stated in the PWL, sediment is a major pollutant impairing both aquatic life and aesthetics of the river. Given the extent of bank erosion in this portion of the river, it would appear that much of the sediment may be entering the river in this region.

The extent of the stream bank erosion in this portion of the river is supported by information contained in the semi-annual reports on the river prepared by the DEC. For the purposes of these reports, the river between the state line and Pellets Island is divided into 16 map sheets. DEC map sheets 12 through 16 correspond to the segment of the river under discussion. Inspection reports obtained from the DEC for the period May 1993 to April 2004 show that approximately 35 trees been removed from this portion of the river. Undercutting of the banks and roots is the cause of nearly all of these trees being lost. Often when a tree topples into the river, further damage to the bank is done from the root mass pulling large chunks of soil into the river, leaving the bank more susceptible to erosion. Once trees are removed from the river, it appears that little is done stabilize the bank, leaving it susceptible to further erosion.

Damage to bank from undermined tree falling into the river.

Riprap has been used to stabilize the bank in a few sections and appears to have been successful. The picture taken during the November 2004 trip clearly shows where the riprap stops and erosion starts on one bank. It was noted during the June 2000 inspection that a 300-foot section on sheet 15 needed repair. This section correspondence to the segment in which rebar 1 is located. In the October of 2000 inspection report, it was stated that the section should be repaired with riprap. This was still not completed by the May 2002 report, but no mention of it is made after that time.

Arrow indicates end of riprap and beginning of erosion.

Conclusions:

Clearly, bank erosion is a problem on segments of the Wallkill River in the Black Dirt region of Orange County. Whether this erosion is the result of natural processes or exacerbated by changes in land use is not known. Sediment, however, is a known problem in the river and impairs both the aesthetics and aquatic life. It is clear that erosion and undercutting of banks is related to the loss of numerous trees along the river reducing the riparian forest.

Recommendations:

Given the extent of bank erosion and its obvious relationship to sediment in the river, various options which may include riprap along with vegetative buffers should be considered for streambank stabilization.

Works Cited:

(1) Upper Wallkill River Water Management Plan Orange County, NY 1987. Prepared by the USDA Soil Conservation Service and the Orange County Soil & Water Conservation District Staff.
(2) The 1999 Lower Hudson River Basin Waterbody Inventory and Priority Waterbodies Lists. June 2000. New York State Department of Environmental Conservation.
(3) Review of Report for Flood Control. Wallkill River Basin New York and New Jersey. July 1982. US Army Corps of Engineers New York District.
(4) Letter from Kevin Sumner to Louis J. Cascino, Commissioner Orange County DPW. Nov. 25, 1991.

APPENDIX E

ORANGE COUNTY/ULSTER COUNTY HORSE FARM SURVEY

DATA SUMMARY

The survey was distributed through a direct mailing, with assistance from Nutrena and using their database and through personal contacts.

Total Number of Responders: 102 (Orange Co.-86 Ulster Co.-16)

Number of animals: 2018

Acres owned or rented: 6843.7 Acres fenced: 2649.5

Grow your own hay? Yes 26 No 75 How many acres? 1763

Do you have any land management issues for which you would like assistance, if it were available? If yes, check all that apply:

- **41 Muddy conditions, drainage, runoff concerns around stables**
- **58 Pasture management (stocking, fertility, wetness, reseeding, yield, forage quality)**
- **17 Hayland management (fertility, wetness, reseeding, yield, forage quality)**
- **4 Other: See attached sheet**
- **5 No answer**

How do you manage manure?

- **25 Spread on grazed pasture How many acres? 446.5**
- **20 Spread on hayland How many acres? 478.5**
- **13 Another farmer uses it on his/her land**
- **18 Pay a hauler to take it away**
- **45 Compost (explain)- See attached sheet**
- **27 Other means of manure use/disposal: See attached sheet**

Would you be interested in a regional horse manure management project if one were available? (For example, a regional composting facility)

64 Yes (4 are maybe's)

34 No (1 not sure)

APPENDIX F

This section on the ecological impacts of stream barriers and barrier removal was written by Jesse S. Sayles and Erony Whyte from the NYS DEC Hudson River Estuary Program. The Hudson River Estuary Action Plan of 2001 strives to promote local community stewardship of estuary tributaries and stream barriers impede the full function and flow of these tributaries. There are two types of dams: run-of-the-river and impounding (Poff and Hart, 2002). Run-of-the-river dams store little or no water with short residence times (period of time water is stored) and little or no control over water release rate. Impounding or storage dams are taller, with a larger storage volume, long residence times and controlled release rates. Other stream barriers include culverts and buried streams. Culverts are enclosed pipes through which stream flow is directed. Buried streams are those that have been paved or developed over, but stream interactions with soils may still exist.

Stream barriers cause a lot of negative effects on the ecology of the river and floodplain system. I will explain these effects in general and then in terms of location: upstream of the dam, within the impoundment, downstream of the dam and in the floodplain. In general, the movement of anadromous fish, riparian species and plant seeds is restricted. Nutrients often do not get downstream of the dam nor into the floodplain which results in a decrease in biodiversity and invasive or non-native species may take over. In addition, the natural meandering of streams is also eliminated. Upstream of the dam, the flow rate of the stream decreases. Within the impoundment, the water is either slow or still which causes sediment to smother habitat and a stratification in temperature (warm on top, cool below) and dissolved oxygen (high on top, low below). Detritus, or decaying organic matter, is also trapped behind the dam which prevents nutrients and habitat for detritivores, a vital part of the food web, from reaching beyond the dam.

Downstream of the dam, the flow rate varies depending on the type of dam and the rate at which the water is released through the dam. The temperature of the water also varies according to where the water is released from the dam: flowing over the top or through a pipe in the bottom of the dam. As a result of the decreased or variable flow rate and the changes in temperature, the wildlife and plants downstream cannot adapt very well and many cannot survive which leads to a decrease in biodiversity. There is increased erosion of the stream bottom (benthos) and banks which causes loss of habitat. With a lack of detritus that provides nutrients, it is difficult for the typical stream species to survive. Finally, there is a reduction in flooding which is beneficial for human settlement, but prevents species in the floodplain from receiving the moisture levels and nutrients needed to thrive. Culverts and buried streams, depending on their length, exhibit varying degrees of these impacts. In addition, there are no floodplain interactions, limited or no sunlight and limited or no oxygen and nutrient exchange.

The decision to remove a stream barrier must take into account the short and long term ecological effects. The short-term impacts are generally negative while the long-term impacts are positive overall. For example, sediment that has been stored behind the dam will scour out habitats below the dam and it may be contaminated with toxic materials. If the sediment is contaminated, it must be dredged and moved properly. Economic, legal, safety, recreational, historic and aesthetic concerns must also be taken into account for barrier removal. Sometimes, addressing other watershed concerns first, such as pollution, will create more benefits than barrier removal. It is important to look at the barrier as a site-specific project, its context within the watershed and the cumulative

effects of several dams in the river. Some successful dam removals include the Edwards Dam on the Kennebec River in Maine and a dam on the Baraboo River in Wisconsin. Some unsuccessful dam removals include the Fort Edwards Dam on the Hudson River in New York which discharged PCB laden sediments downstream, and a dam on the Kettle River in Minnesota which killed mussels downstream, but restored fish access upstream. Monitoring and research must occur before and after removal occurs for success.

	Resource Protection		
Municipality	**Erosion & Sediment Control Stormwater Management**	**Flood Plains**	**Open Space Plan**
T/Chester	Subdivision of Land 83-25 Sediment basins/debris basins installed/maintained to remove sediment from runoff waters on lands undergoing development. Design standards/specs must follow New York Guidelines for Urban Erosion and Sediment Control.	ZONING >Floodplain and ponding area environmental sub-district.	
T/Crawford			
T/Goshen (Available online @ http://www.townofgoshen.org)	97-42 EROSION AND SEDIMENT CONTROL: >developer must submit a plan that demonstrates compliance with stated control practices COMPREHENSIVE PLAN: > Drainage Controls(p.32) Zero Runoff, currently only required for black dirt areas, should be expanded to other areas of the town. >Erosion and Sediment Control : The town should encourage designs which will avoid potential difficulties and preserve natural drainage to the greatest extent possible.	>Flood Plain and Ponding Area Overlay District	Open Space Plan Priorities: 1)Water - Maintain quality and Quantity 2)Farmland - preserve businesses and rural character of the town 3)Scenic - Preserve scenic, historic and cultural resources 4)Recreation - opportunities for outdoor rec. 5)Forest Land - protection and enhancement of water and air 6)Biodiversity - preserve healthy ecosystems
T/Greenville	>SUBDIVISION OF LAND : 181-29 - F. Sediment control - Subdivider shall provide an effective sediment control measures for planning and construction of subdivisions. G. All primary drainage channels which are located within or immediately adjacent to an improvement or subdivision shall be protected by the developer.		
T/Hamptonburgh (Available Online @ http://www.generalcode.com)	SUB 120-69 - Subdividers must provide adequate storm water drainage facilities.	>Floodplain overlay district - regulation regarding area within the 100 year plain	
T/Minisink		SUBD: No residences allowed within land subject to periodic or occasional flooding	
T/Montgomery	SUB Section 6 B. Drainage structure to Accommodate Development Upstream - A culvert or other drainage facility shall be large enough to accommodate potential runoff from its entire upstream drainage area. Section 8 G.Drainage Channels - all primary drainage channels located within or adjacent to subdivision shall be protected by the developer >SUB Section 8 F. Sediment Control - the subdivider shall provide effective sediment control measures	ZONING floodplain subdistrict	

	Resource Protection		
Municipality	**Erosion & Sediment Control Stormwater Management**	**Flood Plains**	**Open Space Plan**
T/Mount Hope		>Flood Plain Overlay Zone	>COMP PLAN Open Space Plan (P.38) defines two special elective or voluntary environmental districts that are contractual: 1.) agricultural tax reduction, 2.) forest mgmt tax reduction
T/New Windsor (Available Online @ http://www.generalcode.com)		SUB 257-20 :Lands in the floodplain shall be preserved as undeveloped open space.	
T/Newburgh (Available Online @ http://www.generalcode.com)		ZONING 185-22 : special regulations and procedures for floodplain development.	
T/Wallkill (Available Online @ http://www.generalcode.com)	SUB 6: Developer shall provide a culvert or other drainage facility shall be large enough to accommodate potential runoff from sites entire upstream drainage area, and will be responsible for any additional downstream drainage caused by the site. SUB 8-F: The subdivider shall provide effective sediment control measure for planning and construction of subdivisions using specified technical principals.	ZONING >Floodplain and Ponding Area Environmental Subdistrict.	
T/Warwick (Available Online @ http://www.generalcode.com)	SUBDIVISION: >Developer shall provide effective sediment control measures. >all primary drainage channels which are located within or immediately adjacent an improvement or a subdivision shall be protected by the developer. ZONING 164-43: All building site development activities within the Town of Warwick shall have erosion and sediment control measures that meet the most current version of the New York Guidelines for Erosion and Sediment Control.		GOALS: >Preserve open space in Warwick to maintain the Town's rural character and quality of life. >Plan for sufficient recreational land and facilities. >Cooperate with Villages to plan for open space protection.

	Resource Protection		
Municipality	**Erosion & Sediment Control Stormwater Management**	**Flood Plains**	**Open Space Plan**
T/Wawayanda	SUB 162-24 Drainage easements may be required. COMPREHENSIVE PLAN : >approval of erosion control plans by the TPB or Building Inspector, submitted by the potential developers along with their application for subdivision or site plan approval. >Encouragement of designs that will avoid potential difficulties rather than devising and maintaining expensive engineering solutions.	SUB The following areas shall be preserved as open space: ... 3)lands in the floodplain … ZONING >Flood hazard zoning district: no development shall be permitted that does not comply with the Town of Wawayanda Flood damage Prevention Law of 1987	
V/Florida	SUB: where a watercourse separates a proposed street, provisions shall be made for stormwater by means of culvert or other structure approved b the municipal engineer. >proper drainage facilities shall be constructed to provided for the area to be developed as well as future development upstream.	SUB: site must have a flood hazard rating of no more than "slight" (as defined by a soil scientist assigned to the Orange County soil and Water Conservation District)	
V/Goshen			
V/Montgomery	ZONING: 122-16 During site plan review, the planning board shall consider the impact of the proposed use on soil erosion and measures which may be taken to minimize soil erosion.	ZONING: 122-16 During site plan review, the planning board shall consider the danger of flood damage to the site or adjacent properties. >Floodplain subdistrict	
V/Otisville (Available Online @ http://villageofotisville.com)			
V/Unionville			
V/Walden	ZONING: 148-56 During site plan review, the planning board shall consider on-site stormwater detention/retention facilities, depicting that the anticipated stormwater runoff from the site after development will not exceed the peak runoff from the site in an unimproved condition. ZONING: 148-56 During site plan review, the planning board shall consider the impact of the proposed use on soil erosion and measures which may be taken to minimize soil erosion.	ZONING: 148-56 During site plan review, the planning board shall consider the danger of flood damage to the site or adjacent properties.	
V/Warwick	SUB section 4-6 : Drainage structure to accommodate Potential development upstream, as well as responsibility from drainage upstream	SUB section 4-6 : land subject to flooding shall not be platted for residential occupancy	
C/Middletown			

	Resource Protection		
Municipality	**Steep Slopes**	**Tree Preservation**	**Wetlands**
T/Chester	ZONING 98-25: Cluster developments shall preserve steep slopes as open space.	SUB: 83-24: In no case shall a tree with a diameter of 8 inches or more be removed without the approval of the planning board.	>all federal wetland shall be provided with a minimum 25 ft buffer. >no building shall be erected within a 100 ft of the high water mark of a stream or within 50 ft of an intermittent stream. >septic systems shall be no closer than 100 ft to a wetland.
T/Crawford			
T/Goshen (Available online @ http:/www.townofgoshen.org)	>Alteration of steep slope areas poses potential risks of erosion, sedimentation landslides, and the degradation of scenic views. >Requirements imposed for the development of areas with a slope that is in excess of 25%		ZONING 97-45 Planning board may require establishment of buffers/other measure to protect any wetland from adverse effects of development in the surrounding area. Stream corridor and Reservoir watershed Overlay District
T/Greenville	ZONING 205-29 The natural topography of land is public asset which should be preserved/safeguarded; permit NOT required - road building, property improvement where improvement shall not cover an area more than 3 times foundation size, landscaping in which topsoil is moved from on part of the property to another part of same property; permit IS required - property improvement where improvement shall cover an area more than 3 times foundation size, commercial purposes		
T/Hamptonburgh (Available Online @ http://www.generalcode.com)	SUB 120-55 Subdivision design shall preserve, insofar as possible, the natural terrain and natural watercourses, improvements, drainage areas		

	Resource Protection		
Municipality	**Steep Slopes**	**Tree Preservation**	**Wetlands**
T/Minisink		ZONING: Planning Board has right to require that all trees over 8" in diameter be mapped by applicant when land is under site plan or subdivision review. SUBD: Planning Board approval needed for removal of trees over 8". Conscious effort to preserve all "worth-while trees and shrubs."	
T/Montgomery	SUB 7 F 1 Subdivision design shall preserve natural terrain	>SUB the board shall establish the preservation of natural features, such as large trees or groves, water courses and falls, beaches, historic spots , vistas and similar irreplaceable assets.	
T/ Mount Hope	SUB Article IX 52 Subdivision design shall preserve, insofar as possible, the natural terrain and natural watercourses, improvements, drainage areas	SUB : A conscious effort shall be made to preserve all worthwhile trees and shrubs which exist on the site. No tree with a diameter of eight inches or more as measured three feet above the base of the trunk shall be removed without the prior approval of the Planning Board.	
T/New Windsor (Available Online @ http://www.generalcode.com)	SUB 257-20 : Steep slopes in excess of 20% as measured over a ten-foot interval, unless appropriate engineering measures concerning slope stability, erosion and resident safety are taken shall be preserved as undeveloped open space	SUB 257-20 : Significant trees or stands of trees, large trees approaching the diameter of the known largest trees or species or clumps of trees that are rare to the area or of particular horticultural or landscape value shall be preserved as undeveloped open space	SUB 257-20 : Unique and/or fragile areas, including wetlands shall be preserved as undeveloped open space.
T/Newburgh (Available Online @ http://www.generalcode.com)	ZONING 300-16 Steep slopes (applicable prior to development) (1) Not more than 50% of land area of that portion of each lot that is proposed to be disturbed may be counted as part of any lot area if subject to the following: a. For residentially zoned properties, slopes over 30%. b. For nonresidentially zoned properties, slopes over 20%. (2) No construction shall be permitted on that portion of a lot with a slope in excess of 40%. (3) No portion of land area of that portion of a lot with a slope in excess of 50% may be counted as part of the minimum lot area of a parcel	>SUB Establishment of all natural features such as large trees or groves, watercourses and waterfalls, beaches, historic spots, stone walls, vistas and similar irreplaceable assets.	ZONING 185-22 : additional regulation for wetlands and other critical environmental areas including the Chadwick Lake Critical Area of Environmental Concern.
T/Wallkill (Available Online @ http://www.generalcode.com)	ZONING 249-80 Conservation subdivisions - Conservation resources, areas, and requirement: Applicant shall develop a tract resource map/conduct conservation analysis according to site's resources/unique features. The conservation analysis will assist in the design evaluation process for the site layout of the development area and will help identify the site's conservation areas, including steep slopes.	SUB 6-I: In no case shall a tree with a diameter of 8 inches as measured 3 feet above the base of the trunk be removed without the approval of the planning board.	

	Resource Protection		
Municipality	**Steep Slopes**	**Tree Preservation**	**Wetlands**
T/Warwick (Available Online @ http://www.generalcode.com)	SUB 137-23 Subdivision design shall preserve, insofar as possible, the natural terrain and natural watercourses, improvements, drainage areas		ZONING 164-47.6 Town Board has determined it is appropriate to make adjustments to permissible density/area requirements for specific purpose of preserving open space (i.e. greenway corridors, water resources, environmentally sensitive areas, important ecological resources); 164-47.7 Town may acquire for conservation easement an area significant because of its value as a watercourse/water body/freshwater wetland/aquifer recharge area.
T/Wawayanda	COMPREHENSIVE PLAN: >Steep slopes areas should be regulated in order to prevent erosion and drainage problems as well as protect the scenic vistas associated with these areas. >controlling development through complete prohibition or a program of regulation that bases the amount of development on the degree of the slope, construction techniques soils data and vegetative cover runoff.		COMPREHENSIVE PLAN: >Wetland and stream buffer can be considered to preserve these streams in their natural state and a means of protecting water quality. >Conservation easements may be used for this purpose.
V/Florida	SUB: site must have an average slope of less than 15%		
V/Goshen			
V/Montgomery		ZONING: 122-61 During site plan review, the planning board shall consider a tree saving plan to ensure that land stripping techniques are not being used when developing the site.	
V/Otisville (Available Online @ http://villageofotisville.com)			
V/Unionville			
V/Walden		ZONING: 148-56 During site plan review, the planning board shall consider a tree saving plan to ensure that land stripping techniques are not being used when developing the site.	ZONING: 148-56 During site plan review, the planning board shall consider the impact of the proposed use on federal, state and locally protected wetlands.
V/Warwick		>SUB no tree with a diameter of 8" or more shall be removed without the approval of the planning board	
C/Middletown			

	Site Plan		
Municipality	**Review Criteria**	**Required Information**	**SEQRA Coordination**
T/Chester	ZONING 98-30 Reduce conflict between existing and proposed uses or natural conditions, minimize adverse effects on health, safety, overall resident welfare, comfort and convenience	ZONING 98-30 Area map including floodplains, easements, all existing natural features such as aquifers, watercourses, wetlands, large trees w/diameter =/> 8 in, 3 ft off ground; 25 ft minimum buffer around federal wetlands; general landscaping plan w/buffers; grading/erosion control plans; location/design for stormwater management facilities; drainage report w/design data and capacities computations; adequacy of water supply; adequacy of floodproofing	
T/Crawford		ZONING 137-29 Location/width of all easements/rights-of-way; key map scaled one in = 2,000 ft showing relationship of site to marshes, wetlands, rivers, lakes, other natural features; existing topography of site/adjacent property, proposed regrading; location of existing on-site watercourses, marshes, wetlands, areas subject to ponding/flooding, wooded areas, rock outcrops, isolated trees w/diameter =/> 12 in, 4 ft off ground; location, dimensions, grades, and flow of all existing/proposed stormwater drainage facilities, sewer lines, water lines	ZONING 137-29 Where required/appropriate pursuant to SEQRA additional information concerning environmental impact may be required as part of the site plan application
T/Goshen (Available online @ http://www.townofgoshen.org)	ZONING 97-75 Integrated, compatible layout/design, in keeping with small-town architectural character of Goshen, trademarked architecture prohibited; landscaping that enhances appearances of development, minimizes impact on adjoining uses of dust, litter, noise, glare, runoff, outdoor storage, loading, parking areas; Peak rate of surface water flowing off site shall not increase above predevelopment conditions/adversely affect drainage on adjacent properties or public roads	ZONING 97-75 Map scaled 1 in = 2,000 ft showing relation of proposal to easements within 500 ft; existing features map w/topography, natural land features, rock outcrops, single trees =/>8 in, forest cover, soils, ponds, lakes, wetlands, watercourses, aquifers, floodplains, drainage retention areas; erosion/sedimentation control plan; existing/proposed topography at 2 ft contour intervals; long-form environmental assessment or EIS	ZONING 97-76 Upon application materials it deems complete, Planning Board shall initiate SEQRA process
T/Greenville	ZONING 205-67 Public health, safety, general welfare, comfort and convenience, Fire/Police protection/accessibility, harmony (will not be detrimental to orderly, efficient, economical, healthful development of adjacent properties/town as a whole)	ZONING 205-65 Map showing parcel in relation to adjacent parcels, streams, all drainage and watercourses; map at convenient scale, including streams; location of existing/proposed usable open spaces/recreational areas/their landscaping; location of existing water lines, sewer lines, storm drainage system; location of existing watercourses, wooded areas, rock outcrop/single trees w/diameter =/> 12 in, 4 ft from ground	

	Site Plan		
Municipality	**Review Criteria**	**Required Information**	**SEQRA Coordination**
T/Hamptonburgh (Available Online @ http://www.generalcode.com)	ZONING 150-16 Public health, safety, welfare; comfort and convenience of general public; community and aesthetic character of the surrounding neighborhood	ZONING 150-16 Natural features (including existing topographic contours at intervals =/< 2 ft, flooding or stormwater overflows boundaries, location of existing watercourses, marshes or swamps, wooded areas, rock outcrops, isolated trees, wetlands, and soil types); existing water/sewer utilities; erosion control/stormwater management plan; drainage according to TR-55 method/other equivalent model; erosion control measures according to New York Guidelines for Urban Erosion and Sediment Control or Orange County Soil and Water Conservation District	ZONING 150-16 Planning Board shall comply with the provisions of SEQRA and its implementing regulations
T/Minisink	ZONING 9.2 Traffic access; circulation/parking; landscape plan; landscaping/screening	ZONING 9.2 Location of existing/proposed easements/rights-of-way; location map w/streams; existing contours w/intervals =/< 2 ft; indication of 100-yr flood elevations/boundaries, freshwater wetlands boundary, 100 ft buffer zone/elevation of stormwater overflows; location existing watercourses, marshes, trees w/diameter =/> 8 in, 3 ft above base of trunk; location/dimensions/grades/flow directions of existing sewers,culverts,water lines,septic systems, wells, under/above-ground utilities; proposed grading/screening/landscaping; location/details of installation of all proposed water lines, valves, hydrants, sewer lines, stormwater drainage/disposal system	
T/Montgomery	ZONING 122-61 Relationship of accessory buildings to proposed location; location/design underground utilities; height, bulk, setback of buildings; provision of buffer areas, vegetative screening/earth berms; tree-saving plan to ensure land-stripping techniques are not used when developing the site; provision for water supply/sewage disposal, stormwater drainage systems; impact of proposed soil erosion; danger of flood damage	ZONING 122-61 Location of existing/proposed easements/rights-of-way; key map scaled 1 in = 2,000 ft w/marshes, wetlands, rivers, lakes, other natural features; existing topography in 5 ft intervals where >10% and 1 ft intervals where =/<10%; location of existing watercourses, marshes, regulated wetlands, areas subject to ponding or flooding, wooded areas, rock outcrops, trees w/diameter =/> 8 in, 3 ft off ground; landscaping plan	ZONING 122-61 Where required/appropriate pursuant to SEQRA additional information concerning environmental impact may be required as part of the site plan application
T/Mount Hope	ZONING 9.3 Public health, safety, general welfare; comfort/convenience; Fire/Police protection accessible; harmony w/surrounding development, will not be detrimental to orderly development of adjacent properties; traffic flow (both pedestrian and vehicular); circulation/parking; landscaping/screening; character/appearance	ZONING 9.2 Existing/proposed storm drainage facilities; location buffer strips/screening; all easements; all farm operations in accordance w/NYS Ag and Markets Law w/in 500 ft of property; existing/proposed wells/septic systems	ZONING 9.2 Submitted applications shall include a SEQRA Short or Long Environmental Assessment Form.

	Site Plan		
Municipality	**Review Criteria**	**Required Information**	**SEQRA Coordination**
T/New Windsor (Available Online @ http://www.generalcode.com)	ZONING 300-86 Public health, safety, welfare; comfort and convenience; landscaping character in keeping with the neighborhood; existing trees diameter > 8 in, 3 ft above ground, shall be retained to the maximum extent possible; restrictive covenants/easements, including conservation easements; stormwater detention basins, retention basins, and water quality ponds; basin design criteria incorporated into all basins/ponds (landscaping required where buffers/screening necessary; basins shall include stone channels between inlet/outlet locations; max side slopes shall be 1:3, vertical: horizontal; basin/outlet control facilities shall be designed/sized to result in zero net increase in runoff from the site; all facilities shall be evaluated/designed based on five-year, ten-year, and twenty-five-year storm frequency, unless the site is greater than 320 acres. Sites greater than 320 acres shall be based on the aforementioned criteria, plus the fifty-year storm frequency)	ZONING 300-86 Location, width, purpose of all existing/proposed easements, setbacks; area location map, scaled 1in = 1,000 ft, showing adjoining major watercourses; natural features (existing contours w/intervals =/< 2 ft; approximate boundaries of any areas subject to flooding/stormwater overflows; location of existing watercourses, marshes, wooded areas, rock outcrops, isolated trees (w/diameter =/> 8 in inches, 3 ft above ground); locations, dimensions, grades, flow direction of existing sewers, culverts and waterlines, underground/aboveground utilities within/adjacent to the property; location and size of water and sewer lines; location of all proposed waterlines, valves and hydrants, and of all sewer lines or alternate means of water supply and sewage disposal and treatment	
T/Newburgh (Available Online @ http://www.generalcode.com)	ZONING 185-56 Harmonious relationship w/existing/permitted use of contiguous land/adjacent neighborhoods; Health, safety, welfare, comfort, convenience of public	ZONING 185-57 Sketch plan review w/overall drainage system, including existing water bodies/provision for sewers, water supply, any areas w/in 200 ft Chadwick Lake, any areas w/in 100 ft of any drainageway tributary to Chadwick Lake, any areas w/slopes 15-20%, 20-25%, and >25%, any area w/in 100 ft of any protected wetland, any area w/in any 100 yr floodplain, outline of all soil types, any environmentally sensitive features; Final site plan review scaled 1 in=2,000 ft, locations of existing/proposed easements, typical cross sections of proposed final grading, approx boundary wetland/100 yr floodplain/any other area subject to flooding/stormwater overflow, trees >8 in diameter, four ft above ground, utilities	ZONING 300-57 The Planning Board shall comply with the provisions of the New York State Environmental Quality Review Act under Article 8 of the Environmental Conservation Law and its implementing regulations
T/Wallkill (Available Online @ http://www.generalcode.com)	ZONING 249.40 Public health, safety, welfare; convenience/comfort; traffic access; circulation/parking; landscaping/screening	ZONING 249.40 Location/width all easements/rights-of-way; existing contours w/intervals of 5 ft based on United States Geological Survey datum, and on all projects which Board deems large in scope/importance contour interval 2 ft based on United States Geological Survey datum; boundaries of any areas subject to flooding/ponding; location existing watercourses, marshes, wooded areas, isolated trees w/diameter=/>12 in, 3 ft above ground; location/size/type/gradient/flow direction of all existing culverts, sewers, waterlines; location of proposed waterlines, valves and hydrants, wells	

	Site Plan		
Municipality	**Review Criteria**	**Required Information**	**SEQRA Coordination**
T/Warwick (Available Online @ http://www.generalcode.com)	ZONING 164-46 Development/use individual parcels do not have adverse effect on adjacent lands/character of community; protect community from traffic congestion/conflicts, noise, odor/other forms of pollution, inappropriate design, flooding, excessive soil erosion; harmony w/appropriate/orderly development of district; that impacts can be mitigated by compliance w/reasonable conditions	ZONING 164-46 Vicinity map scaled 2,000 ft=1 in shows relationship of proposal to existing community facilities that will serve/influence the layout; site plan scaled 1 in=40 ft showing grading/drainage plan w/existing/proposed contours w/intervals of 2 ft extending 50 ft beyond the tract (w/in 100 yr floodplain as determined by FEMA base flood elevations given; natural land features (i.e. isolated trees =/>12 in diameter/all trees over 24 in diameter, existing vegetative/forest cover, soil types/boundaries, steep slopes >15%, water sources such as ponds, lakes, wetlands/watercourses, aquifers, aquifer recharge areas, floodplains, drainage retention/detention areas); landscape plan showing all proposed changes to existing natural land features w/landscape schedule, landscape maintenance plan; location, design, construction materials of all existing/proposed utility systems	ZONING 164-46 The Planning Board shall review the resources and public facilities available to the subdivision, including transportation, water supply, waste disposal and fire protection, during the mandatory SEQR review, to ensure the additional density being proposed will not create significant environmentally damaging consequences.
T/Wawayanda		ZONING 195-58 Location existing watercourses or any other significant natural features; location/design buffer areas, location public/private utilities	ZONING 195-58 A completed SEQRA environmental assessment must be submitted to Board.
V/Florida	ZONING 119-33 Traffic access; circulation/parking; landscaping/screening; construction hours of operation; restricted clearing/grading; fire lanes/proper turning radii; proposed noise decibel levels	ZONING 119-33 Location of all existing/proposed water lines, valves, hydrants, culverts, swales, drains; existing/proposed sewer lines w/pipe sizes, grades, direction of flow or alternative means of water supply/sewage disposal and treatment; proposed stormwater drainage system; location existing water mains, culverts, drains w/pipe sizes, grades, direction of flow; location existing watercourses, marshes	
V/Goshen	ZONING 10.1 Traffic access; landscaping/screening; stormwater/erosion/sedimentation control; environmental considerations	ZONING 10.1 Location/width/purpose of all existing/proposed easements, setbacks, reservations, areas dedicated to public use; existing contours w/intervals =/< 2 ft; boundaries areas subject to flooding/stormwater overflows; location existing watercourses, wetlands; locations/dimensions/grades/flow direction of existing under/aboveground utilities; proposals for soil erosion/sedimentation control	ZONING 10.1 All projects shall be reviewed by the environmental review board pursuant to the requirements of SEQRA
V/Montgomery	ZONING 122-61 Proposed location of buildings/relationship to one another; location/design of utilities; height/bulk/setback of all buildings; provision buffer areas/vegetative screening/earth berms to preserve harmonious relationship w/adjacent properties; tree-saving plan; water supply/sewage disposal including estimate of effect on any existing communities; stormwater drainage; impact of/measures to minimize proposed soil erosion; flood damage danger	ZONING 122-61 Location/width easements/rights-of-way; key map showing relationship of site to marshes, wetlands, rivers, lakes, other natural features; existing topography/proposed regrading (5 ft contour when slope > 10%, 1 ft contour when slope < 10%), location existing on-site watercourses, marshes, regulated wetlands, areas subject to ponding or flooding; location/dimensions/grades/flow direction of existing/proposed under/aboveground utilities; landscaping plan	ZONING 122-61 Where required/appropriate, pursuant to SEQR, additional information concerning environmental impact may be required.

	Site Plan		
Municipality	**Review Criteria**	**Required Information**	**SEQRA Coordination**
V/Otisville (Available Online @ http://villageofotisville.com)	ZONING 9.2 Public health, safety, welfare; convenience/comfort; traffic access; circulation/parking; landscaping/screening	ZONING 9.2 Location/width/purpose of all existing/proposed easements, set-backs, reservations, areas dedicated to public use; boundaries subject to flooding/storm water overflows; location existing watercourses, marshes; locations/directions/grades/flow direction existing sewers, culverts, water lines, under/above-ground utilities; location proposed water lines, valves/hydrants, sewer lines/disposal/treatment	
V/Unionville	ZONING 9.2 Traffic access; circulation/parking; landscaping/screening	ZONING 9.2 Location/width/purpose of all existing/proposed easements, set-backs, reservations, areas dedicated to public use; existing contours =/< 5 ft; approximate boundaries areas subject to flooding/storm water overflows; location existing watercourses, marshes; locations/directions/grades/flow direction existing sewers, culverts, water lines, under/above-ground utilities; location proposed water lines, valves/hydrants, sewer lines/disposal/treatment	
V/Walden	ZONING 148-56 Proposed location of buildings/relationship to one another; location/size/design underground utilities; provision buffer areas/vegetative screening/earth berms to preserve harmonious relationship w/adjacent properties; tree saving plan; water supply/sewage disposal including estimate of effect on any existing communities; on-site stormwater detention/retention facilities w/anticipated peak stormwater runoff not to exceed unimproved conditions; danger of flood damage; impact of proposed use on soil erosion/measures to minimize erosion; impact of proposed use on federal, state, local wetlands; public health, safety, welfare	ZONING 148-56 Location/width all easements/rights-of-way; key map 2,000 ft=1in, showing marshes, wetlands, rivers, lakes, other natural features; existing topography/proposed grading, 2 ft contour; location existing watercourses, marshes, regulated wetlands, buffer areas, areas subject to ponding/flooding; locations, dimensions, grades of existing/proposed culverts/stormwater drainage facilities/under/above-ground utilities; location/size existing/proposed water mains, sanitary sewer mains, storm sewer lines; erosion control measures/construction schedule; landscaping plan	ZONING 148-56 Board shall comply w/provision of SEQRA
V/Warwick	ZONING 145-91 Traffic access; circulation/parking; landscaping/screening; compatibility (of signs/lights/textures of buildings/asphalted paving for parking); design/layout/operation characteristics will not represent significant impact on environment/waste of land/other natural resources; development plan elements will not adversely affect potential of adjacent properties/property under review from highest/best use	ZONING 145-92 Certificate of Occupancy/Certificate of Use, where required; Procedures for Site Plan approval provide detailed specifications as to application materials	

	Site Plan		
Municipality	**Review Criteria**	**Required Information**	**SEQRA Coordination**
C/Middletown	ZONING 123-43 Public health, safety, welfare; comfort/convenience; fire/police protection accessible; harmony w/adjacent properties; traffic access; circulation/parking; landscaping/screening; character/appearance	ZONING 123-43 Location/width/purpose all existing/proposed easements, setbacks, reservations, areas dedicated to public use; approximate boundaries areas subject to flooding/storm water overflows; location existing watercourses, marshes; existing structures/utilities; locations/ dimensions/grades/flow directions of existing sewers, culverts, water lines, under/aboveground utilities; location proposed water lines, valves, hydrants	ZONING 123-43 Board shall comply with provisions of SEQRA

	Subdivision				
Municipality	**Sep. from Zoning?**	**Application Requirements**	**Cluster Development/ Conservation Subdivision**	**Parks, Open Space & Natural Features**	**Special Considerations**
T/Chester	yes		ZONING:98-25 - Planning board may approve a cluster development in any of the residential districts. Cluster development may be required by the planning board if they feel it is necessary. >shall preserve at least 50% of the sites buildable lot area.	>lands comprising approximately 10% of the total area to be subdivided shall be reserved for the creation of parks, playgrounds, or recreational purposes.	
T/Crawford	yes		ZONING 121-7.5: Cluster Development not mandatory. >A cluster subdivision shall include substantial open space areas (no specific minimum %)		ZONING 137-11:In density calculations of PUD's total gross acreage shall exclude 25% slopes, lands subject to flooding or ponding, public utility easements, wetlands, lands proposed for educational, cultural, religious or commercial uses. At least 30% must be preserved as open space, permitting recreational uses.
T/Goshen (Available online @ http://www.townofgoshen.org)	yes		ZONING 97-18: development in the RU is restricted to small-scale, open space and conservation density (avg. lot >20 acres) development. >Environmental Control formula used to calculate min. permitted lot size. >"constrained land" must be excluded from density calc. for open space developments ZONING 97-15: At least 50% of the total area Zoned HM and HR must be protected as undeveloped open space, implementing the concept of Traditional Neighborhood Development	83-2: 4. Preservation of existing features which are important to the natural, scenic, and historic character of the town or add value to the residential development, such as large trees, watercourses, scenic views, historic places, and similar irreplaceable assets. topsoil shall not be removed without the approval of the Planning Board.	ZONING 97-14 CO Districts = larger-scale/other non-residential uses permitted. Impervious surfaces are limted to 40% total project area, requiring 60% be maintained as open/undeveloped green space, arranged in a manner adequately buffers buildings/parking areas from public roads/neighborhood properties, while protecting wetlands, watercourses, scenic views. 97-15 HM, HR Districts = Traditional Neighborhood Development. 50% protected as undeveloped open space
T/Greenville	yes		>181-14: Planning board authorization >May be required, not mandatory COMP PLAN OBJ: >Smart Growth & Clustering >conservation density subdivision		

	Subdivision				
Municipality	**Sep. from Zoning?**	**Application Requirements**	**Cluster Development/ Conservation Subdivision**	**Parks, Open Space & Natural Features**	**Special Considerations**
T/Hamptonburgh (Available Online @ http://www.generalcode.com**)**	yes		>Conservation Subdivision not required ZONING 150-21: Density bonus given to subdivision that retain at least 50% of the total land as open space.	SUB 120-51: Board shall not accept an area of less than 3 acres and require not less than 10 acres of recreation space be provided per 100 dwelling units. 120-55: Board shall require preservation of all natural features, such as large tress or groves, watercourses and waterfalls, beaches, historic spots, vistas.	
T/Minisink	yes		> Cluster subdivisions should be encouraged and mandated where appropriate. Major subdivisions should be clustered, subtracting steep slopes and wetlands from the gross acreage to calculate buildable acres, and using a build-out formula based on two acre zoning and individual water or septic systems.		
T/Montgomery	yes		ZONING 75: A cluster development may be required by the planning board. The Planning Board may establish conditions on the ownership, use and ongoing maintenance of preserved open space.	>no less than 3 acres per 100 dwelling units >the board shall establish the preservation of natural features, such ass large trees or groves, water courses and falls, beaches, historic spots , vistas and similar irreplaceable assets.	
T/Mount Hope	yes		COMP PLAN OBJ >Encouragement of clustering and Planned Unit Development	>3 acre minimum Recreation/ parkland for subdivisions, for every 25 dwellings 1 acre or an equivalent monetary compensation will be provided. >Preservation of Natural Terrain, Trees, Soil and Watercourse.	
T/New Windsor (Available Online @ http://www.generalcode.com)	yes		>Required in Cluster Zone.	>Zoning 300-31- PUD's shall provide usable open space, recreational facilities as well as preserve outstanding topographical, geological and water resource features of the site.	SUB 257-20 :The following shall be preserved as undeveloped open space, 1)Habitats of endangered or threatened wildlife or plants, as identified on federal or state lists. 2)Visually prominent landscape features, such as fields, pastures and/or meadows on knolls and hilltops.

	Subdivision				
Municipality	**Sep. from Zoning?**	**Application Requirements**	**Cluster Development/ Conservation Subdivision**	**Parks, Open Space & Natural Features**	**Special Considerations**
T/Newburgh (Available Online @ http://www.generalcode.com)	yes		ZONING 185-26: cluster development not required.	>Establishment of all natural features such as large trees or groves, watercourses and waterfalls, beaches, historic spots, stone walls, vistas and similar irreplaceable assets.	ZONING 185-22 All existing land uses/proposed construction, land management activities, land development within any critical environmental area subject to review by Board; no land development activity/accessory use that involves construction of impervious surfaces, sewage treatment, discharge of effluent shall occur w/in 200 ft of shoreline of Chadwick Lake; no septic tank/leaching field shall be located w/in 150 ft of any perennial stream tributary to Chadwick Lake; proposed construction/land management activities w/in Chadwick Lake Critical Area of Environmental Concern required to submit plan for approval by Board indicating total area to be disturbed not to exceed 20% gross site area, soil erosion/storm run-off control measures
T/Wallkill (Available Online @ http://www.generalcode.com)	yes		ZONING : Conservation Sub -RA-min. 40% open space w/ 15% being buildable land. -R2-min. 30% open space w/ 10% being buildable land. -R1 min. 20% open space w/ 5% being buildable land.		ZONING 249-19 Rural Agricultural District's procedure for determining the maximum number of lots permitted = a.) Select soil types found on site, and thereby the soil group, b. Calculate/enter acreage in each soil group, c. Enter environmental factor for each soil group, d. Multiply each environmental factor by acreage in each soil group, e. Total environmental acreage quotas. This is the maximum number of lots permitted

	Subdivision				
Municipality	**Sep. from Zoning?**	**Application Requirements**	**Cluster Development/ Conservation Subdivision**	**Parks, Open Space & Natural Features**	**Special Considerations**
T/Warwick (Available Online @ http://www.generalcode.com)	yes		ZONING 164-41 > Planning board may require cluster subdivision where it finds the following elements present, slopes, water resources, agricultural lands, community water and/or sewer, critical environmental areas, designated open space areas, historic sites or scenic viewsheds >ZONING 164-41.3: Cluster subdivision lot size calculation based on soil type		>Table of Soil Groups - Outline soil group characteristics as well as use and requirements.
T/Wawayanda	yes		ZONING: Cluster Development required on all land designated as significant agricultural resources by the New York State Agricultural and Markets Law, defined as class 4 and higher soils. May be required elsewhere ZONING 195-34 : Cluster Development - no less than 50% of the total land area of the conservation subdivision shall be dedicated to permanent open space and at least 25% of the open space shall be usable for active recreational activities, not including water bodies, wetlands, floodplains, slopes over 15% in grade or other undevelopable areas.	The following areas shall be preserved as open space: 1)unique and/or fragile areas, including wetland and fields 2)significant trees or stands of trees 3)lands in the floodplain 4)steep slope in excess of 20%/10ft 5)habitats of endangered species 6)Historically significant feature or sites. >cont'd>	7)Prime agricultural soils 8) Visually prominent landscapes features 9)Trees and hedges running along road walls, stone walls, streams and property lines.
V/Florida			ZONING: a minimum of 20% of the gross tract area shall be reserved as open space and/or public parks. At least 50% of this area must be derived from buildable land and/or wetland.		
V/Goshen (Available online @ http://www.townofgoshen.org)					
V/Montgomery					
V/Otisville (Available Online @ http://villageofotisville.com)	no				

	Subdivision				
Municipality	**Sep. from Zoning?**	**Application Requirements**	**Cluster Development/ Conservation Subdivision**	**Parks, Open Space & Natural Features**	**Special Considerations**
V/Unionville	no				
V/Walden					
V/Warwick	yes		ZONING: Annexation District - a ,minimum of 25% of the gross tract of land shall be preserved as open space, at least 50% of that area must be derived from the Net Area (Gross area excluding slopes over 25%, wetlands + 100ft buffer, ROW's, streams measure to the mean high water mark, 100 yr flood plain and water bodies) ZONING 145-27 : the natural and significant cultural features of a site shall be preserved within the annexation district, a minimum of 25% of the gross tract area shall be reserved as common open space and/or public parks.	>no less than 10% of the gross area of the subdivision shall be preserved as Parks or Playground. >Planning Board shall establish the preservation of all natural features >no tree with a diameter of 8" or more shall be removed without the approval of the planning board	SUB Section 7 B Two acres = minimum contiguous recreation space which shall be acceptable to Board. In subdivisions 20 acres or less, park/playground areas of lesser size may be approved when Board finds difference between recreation area shown on Plat and 2 acres may be made up in connection with subdivision of adjacent land.
C/Middletown	yes				

	Supplemental Regulation		
Municipality	**Agricultural Land Protection**	**Clearing, Filling & Grading**	**Wetland/Watercourses**
T/Chester	ZONING: 98-25 - planning board approval of cluster subdivision shall be based on, among other things, protecting significant agricultural lands and resources , and the rural appearance of the Town of Chester, including the preservation of natural assets such as streams, ponds, fields, trees, and critical areas.	SUB 83-25 Permit required to grade/shape topography. ZONING: 98-12 Removal/excavation of soil > 100 cubic yards must be authorized by Board. Building permit may also be required under certain circumstances. Proposals must include rehabilitation plan, w/existing/proposed final contours.	>all federal wetland shall be provided with a minimum 25 ft buffer. >no building shall be erected within a 100 ft of the high water mark of a stream or within 50 ft of an intermittent stream. >septic systems shall be no closer than 100 ft to a wetland.
T/Crawford		ZONING 137-19 Excavation of sand, gravel, shale, topsoil, other aggregate allowed to prepare for construction of a building for which a permit has been issued	ZONING 137-20 a building setback will be established in all zoning districts, parallel to and 50ft from the present normal shoreline or bank of every lake or other body of water or everflowing watercourse or stream in the town. No sewage disposal facility shall be located within 100ft of said places.
T/Goshen (Available online @ http://www.townofgoshen.org)	Farmland Protection program for PDR >Farmland Preservation is a top priority of Open Space Plan	97-44 >Excavating that adversely affects natural drainage or structural safety of building or lands, causes erosion or sedimentation, or creates any noxious condition or hazard to public health or safety if prohibited.	ZONING 97-45 Planning board may require establishment of buffers/other measure to protect any wetland from adverse effects of development in the surrounding area. Stream corridor and Reservoir watershed Overlay District
T/Greenville		>ZONING 205-29 Tree removal , topsoil removal, surface grading and excavation : the natural topography of the land is a public asset and it should be preserved and safeguarded….no changes shall be made in such topography , except those that are absolutely necessary in order to permit the proper and appropriate use of the land.	SUB 181-28 Open watercourses shall be recognized as community assets; subdivision design may well be enhanced by featuring streams and brooks; floodplain land, areas bordering on watercourses, drainageways, other lands which cannot be used safely for building purposes without danger to health or peril from flood may be offered to municipality as a gift to be used as public open space or for recreational purposes
T/Hamptonburgh (Available Online @ http://www.generalcode.com)		ZONING: 150-12 - Clearing and grading standards. >minimize soil loss and air and water pollution resulting from soil erosion.	SUB 120-55 Open watercourses shall be recognized as community assets; subdivision design may well be enhanced by featuring streams and brooks; floodplain land, areas bordering on watercourses, drainageways, other lands which cannot be used safely for building purposes without danger to health or peril from flood may be offered to municipality as a gift to be used as public open space or for recreational purposes
T/Minisink		SUBD: No topsoil should be removed from the site during subdivision construction.	

	Supplemental Regulation		
Municipality	**Agricultural Land Protection**	**Clearing, Filling & Grading**	**Wetland/Watercourses**
T/Montgomery	COMPREHENSIVE PLAN: Section 9-4 - create incentives for continued agricultural use of land including an Agricultural District Plan >enlargement of road buffers >consider revising regulation to provide for use of land for equestrian-related uses	SUB Section 5 K 8 Any topsoil removed from natural position in process of grading must be replaced to depth approx = to existing depth except in streets, driveways, foundation areas	SUB 7 F 1 Subdivision design shall preserve natural watercourses, improvements, drainage areas
T/Mount Hope		SUB Article XIII 69 Any topsoil removed from natural position in process of grading subdivision site, such topsoil shall be replaced to depth approx = to that existing prior to such grading, except in streets, driveways, foundation areas	SUB Article IX 52 Open watercourses shall be recognized as community assets; subdivision design may well be enhanced by featuring streams and brooks; floodplain land, areas bordering on watercourses, drainageways, other lands which cannot be used safely for building purposes without danger to health or peril from flood may be offered to municipality as a gift to be used as public open space or for recreational purposes
T/New Windsor (Available Online @ http://www.generalcode.com)	SUB 257-20: Prime agriculture soils shall be preserved as undeveloped open space.	ZONING 300-21 Before approval is granted, plan for rehabilitation, showing current field topography, including location of watercourses/proposed restoration grading plat, indicating general grades/slopes to which the disturbed area will be graded, shall be submitted/approved (all banks shall be left with a slope no greater than 45º, upon completion of operations, land shall be left in safe condition with all grading/drainage such that natural stormwater leaves the property at original, natural drainage points, area drainage to any one such point not increased, site shall be left in condition suitable for use permitted in district); where topsoil removed, sufficient arable soil shall be set aside for respreading over all disturbed areas with a minimum depth of four inches	SUB 257-20 : Unique and/or fragile areas, including wetlands shall be preserved as undeveloped open space.
T/Newburgh (Available Online @ http://www.generalcode.com)		ZONING references Chapter 83-6 in General Legislation - Permit required for following activities: site preparation w/in wetlands or within 100 ft buffer strip of wetland and site preparation w/in one-hundred-year floodplain of any watercourse, excavation, clearing, grading, filling, tree removal	ZONING 185-22 : additional regulation for wetlands and other critical environmental areas including the Chadwick Lake Critical Area of Environmental Concern.
T/Wallkill (Available Online @ http://www.generalcode.com)		SUB 209-20 If any topsoil removed from natural position in process of grading subdivision site, shall be replaced to depth approx = to that existing prior to such grading, except in streets, driveways and foundation areas	SUB 6: Subdivision shall preserve, in so far as possible, the natural terrain and watercourses.

	Supplemental Regulation		
Municipality	**Agricultural Land Protection**	**Clearing, Filling & Grading**	**Wetland/Watercourses**
T/Warwick (Available Online @ http://www.generalcode.com)	ZONING: Use of Agricultural Overlay District and TRD/PDR programs including the establishment of a TRD Bank.	ZONING 164-44 references General Legislation Chapter 150 - Various features of topography (topsoil/other natural materials, shape/contour of the land, plant life/wildlife, water/flow) are of prime concern to welfare of the people/no changes shall be permitted except those absolutely necessary to permit proper/appropriate use of land; health, safety, welfare of citizens must be protected from potentially harmful effects of excavation, mining, exploratory drilling/production drilling; permit NOT required for road building, minor improvement of property, landscaping; permit IS required for major improvement of property, commercial purposes, removal of shade trees SUB 137-24 Permit required to grade/shape topography/subject to same reviews as are special uses. (Preparation of agricultural land fitting to seed crops for harvest is not considered grading.)	ZONING 164-47.6 Town Board has determined it is appropriate to make adjustments to permissible density/area requirements for specific purpose of preserving open space (i.e. greenway corridors, water resources, environmentally sensitive areas, important ecological resources); 164-47.7 Town may acquire for conservation easement an area significant because of its value as a watercourse/water body/freshwater wetland/aquifer recharge area. SUBDIVISION OF LAND 137-23 Open watercourses shall be recognized as community assets, Subdivision design may well be enhanced by featuring streams and brooks. Floodplain land, areas bordering on watercourses, drainageways and other lands which cannot be used safely for building purposes without danger to health or peril from flood may be offered to municipality as a gift to be used as public open space or for recreational purposes
T/Wawayanda	ZONING: 195-33 >B. Cluster development shall be required on all lands that are designated as significant agricultural resources by the New York State Agricultural and Markets Law	SUB 162-21 No topsoil, sand, gravel, other minerals shall be removed from any lots shown on any subdivision plat, except for the purpose of improving lots and for the laying out of streets; topsoil removed shall be restored to depth of at least 6 in/properly seeded/fertilized on areas of such lots not occupied by buildings or structures	COMPREHENSIVE PLAN: >Wetland and stream buffer can be considered to preserve these streams in their natural state and a means of protecting water quality. >Conservation easements may be used for this purpose.
V/Florida		SUB: any topsoil removed shall be replaced to a depth approximately equivalent to that existing prior to grading	SUB 103-19 Where subdivision traversed by watercourse there shall be provided stormwater easement/drainage right-of-way 103-20 Open watercourses shall be recognized as community assets; subdivision design may well be enhanced by featuring streams and brooks; floodplain land, areas bordering on watercourses, drainageways, other lands which cannot be used safely for building purposes without danger to health or peril from flood may be offered to municipality as a gift to be used as public open space or for recreational purposes
V/Goshen			
V/Montgomery			
V/Otisville (Available Online @ http://villageofotisville.com)			
V/Unionville			

	Supplemental Regulation		
Municipality	**Agricultural Land Protection**	**Clearing, Filling & Grading**	**Wetland/Watercourses**
V/Walden			ZONING: 148-56 During site plan review, the planning board shall consider the impact of the proposed use on federal, state and locally protected wetlands.
V/Warwick			SUB Section 7 G Board shall, wherever possible, establish the preservation of all natural features which add value to residential developments and to the community, such as water courses and falls.
C/Middletown			

	Supplemental Regulation		
Municipality	**Excavation & Mining**	**Landfill & Solid Waste**	**Timber Harvest**
T/Chester	ZONING 98-12: regulations regarding the removal of 100 cubic feet of sand, gravel, shale, topsoil, black dirt or similar material.	COMPREHENSIVE PLAN: plan for new sewer treatment plant in Chester.	
T/Crawford	ZONING 137-28 >Special permit required >Rules and regulations concerning adverse affect on soil fertility, drainage, and lateral support of abutting land, erosion		
T/Goshen		ZONING 97-58: A. Solid waste management facilities , as define in Environmental Conservation Law , shall be prohibited in the town of Goshen.	
T/Greenville	ZONING 205-30 : Commercial excavation standards : restrictions concerning drainage, soil erosion and soil fertility.		>ZONING 205-31 : Commercial and noncommercial forest improvement operations : permit required, regulation regarding conservation practices.
T/Hamptonburgh			
T/Minisink			ZONING 5.7: Permit required for tree removal relating to site development or commercial harvesting.
T/Montgomery			
T/ Mount Hope			
T/New Windsor	Zoning 300-21: sandpits, gravel pits, removal of topsoil and landfill and excavation: the proposed operation shall not adversely affect the soil fertility, drainage and lateral support of abutting land, nor shall it contribute to soil erosion by water or wind.		

	Supplemental Regulation		
Municipality	**Excavation & Mining**	**Landfill & Solid Waste**	**Timber Harvest**
T/Newburgh	ZONING 185-36: Quarrying and removal of sand and gravel - setbacks of operations, environmental protection, fencing and screening, and reclamation.		
T/Wallkill			
T/Warwick			Ridgeline Overlay District - Timber Harvesting by permit. No clearcutting of area exceeding 20,000 sq. ft.
T/Wawayanda	ZONING: 195-31> Mining operations shall require special use permit approval in the town's AB, IORB and MI zoning districts. >Special restriction including hours of operation, setbacks, dust control. >shall not adversely affect soil, drainage, erosion. >>cont'd>>	>slope of excavated material shall not exceed the normal angle of repose or 60°, whichever is less.	ZONING: 195-44 >All forestry operation shall require permit approval by the town planning board >Clear-cutting as a method of harvesting forest is prohibited unless clearly justified by the requirements of sound forest management.
V/Florida			
V/Goshen			
V/Montgomery		ZONING: 122-16 During site plan review, the planning board shall consider provisions for water and sewage disposal, including an estimate of the effect on any existing community systems.	
V/Otisville			
V/Unionville			
V/Walden		ZONING: 148-56 During site plan review, the planning board shall consider provisions for water and sewage disposal, including an estimate of the effect on any existing community systems.	
V/Warwick			
C/Middletown			

	Zoning				
Municipality	**# Districts**	**Soil-based?**	**Overlay Zones**	**Advisory Boards** (all municipalities have a Zoning Board of Appeals)	**Enforcement**
T/Chester	12	yes	>Floodplain and ponding area environmental sub-district. >Ridge preservation overlay district. >Planned adult community overlay district.	>Architectural Review Board	building permit issued by the Building Inspector.
T/Crawford	7	yes	>Architectural Overlay District >Scenic Overlay District		It shall be the duty of the Building Inspector appointed by the town to administer and enforce the provisions of this chapter and issue building permits.
T/Goshen (Available online @ http://www.townofgoshen.org)	6	yes	>Flood Plain and Ponding Area Overlay District >Stream corridor and Reservoir watershed Overlay District >Aquifer Protection Overlay District >Soil Mining Overlay District >Scenic Road Corridor Overlay District	>Town of Goshen Environmental Review Board >Town of Goshen Joint Recreation Commission >Farmland and Open Space Committee	The provisions of this chapter shall be enforced by the Building Inspector, who shall issue building permits and zoning permits
T/Greenville	4	yes			permits issued by Building Inspector
T/Hamptonburgh (Available Online @ http://www.generalcode.com)	9	no	>Floodplain overlay district - regulation regarding area within the 100 year plain >Airport Overlay District - protection from airplane hazard >Gateway Road Overlay District - preserve Gateway roads historic resources, stone walls and other natural features.		Permits issued by Building Inspector
T/Minisink	4	no			Building Inspector
T/Montgomery	16	yes	>Floodplain (sub-district) >Airport (sub-district) >Gateway overlay district >water supply overlay district	Conservation Advisory Council	It shall be the duty of the Building Inspector to enforce the provisions of this Local Law.
T/Mount Hope	7	no	>2 of the districts are Resource Preservation Districts; West and East of the Ridge >Flood Plain Overlay Zone		Building Inspector shall enforce the provisions of this chapter and issue permits.
T/New Windsor (Available Online @ http://www.generalcode.com)	13	no	> Cluster Zone (included in 12 districts) >New Windsor Cantonment Historical Corridor. >Knox Headquarters Historical Corridor.		permits issued by Code Enforcement Officer.

	Zoning				
Municipality	**# Districts**	**Soil-based?**	**Overlay Zones**	**Advisory Boards** (all municipalities have a Zoning Board of Appeals)	**Enforcement**
T/Newburgh (Available Online @ http://www.generalcode.com)	8	yes	>Airport overlay district. >Professional office overlay district.		Enforcement shall be the duty of the building and code enforcement officer.
T/Wallkill (Available Online @ http://www.generalcode.com)	9	yes	>Floodplain and Ponding Area Environmental Subdistrict. >Wallkill Performance Overlay Zoning District (POD) - POD Core Overlay Area: 1)100' buffer within the PID and MI districts where they abut a residential zone. 2)50' buffer within all residential districts that abut the PID and MI district. POD Secondary Overlay District : 1) 200' buffer within the PID and MI districts where they border with a residential district.	Conservation Advisory Council	Building Inspector shall administer all the provisions of laws, ordinances and regulations.
T/Warwick (Available Online @ http://www.generalcode.com)	10	yes	>land conservation district >Traditional Neighborhood Overlay >Ridgeline overlay >Agricultural Protection Overlay >Aquifer Protection Overlay	>Conservation Board >Agricultural Advisory Board	
T/Wawayanda	10	no			Building Inspector shall enforce the provisions of this chapter and issue permits.
V/Florida	10	yes			>Building permits shall be required >Building inspector shall enforce the provisions of the zoning code
V/Goshen	12			>Environmental Review Board - 5 members, appointed by mayor w/ village board approval, serve for 3 years	Enforcement shall be the duty of the Building Official.
V/Montgomery	11	no	>Floodplain subdistrict >Airport subdistrict >Antique overlay >Senior Citizen Development overlay		Enforcement shall be the duty of the Building Official.
V/Otisville (Available Online @ http://villageofotisville.com)	6	no			>Building inspector shall enforce the provisions of the zoning code
V/Unionville	4				>building Inspector shall enforce the provisions of the zoning ordinance
V/Walden	15				Enforcement shall be the duty of the Building inspector.
V/Warwick	12	no			>Building inspector shall enforce the provisions of the zoning code

	Zoning				
Municipality	**# Districts**	**Soil-based?**	**Overlay Zones**	**Advisory Boards** (all municipalities have a Zoning Board of Appeals)	**Enforcement**
C/Middletown	16				Enforcement shall be the duty of the Commissioner of Public Works.

(see end of document for explanation of checklist responses)

Name: Scott Cuppet

Email: swcuppet@gw.dec.state.ny.us
Phone: (845) 256-3029
Fax: (845) 255-3649

Agency: NYS DEC
21 South Putt Corners Road
New Paltz, NY 12561

CHECKLIST RESPONSES
7, 9, 10, 12, 13

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Technical:

Funding:

NOTES:

Name: George Profous
Senior Forester
Email : guprofou@gw.dec.state.ny.us
Phone: (845) 256-3082
Fax: (845) 255-4659

Agency: NYS DEC
21 South Putt Corners Road
New Paltz, NY 12561

CHECKLIST RESPONSES
2, 3

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Regulatory: DEC Permits, stream crossing permits, etc.

Funding: Land Acquisition (Bond Act) Division does Bond Act applications. Recent ones include lands near Ellenville, Port Jervis and Pochuck Mountains and Unit Mgmt. plans for these lands, including Wurtsboro Ridge.

NOTES:

DEC Natural Heritage has Biological and Ecological info. Regulatory Affairs has maps. DEC Lands and Forests has info. on 480 forest tax law participants. Best to go to Hudson River Est. Research Reserve. See above for Shawangunk Kill. DEC's other Dept.'s deal with most, of not all of these. Currently, except for forest inventory, I am not involved in these issues (although I was in the past).

Name: Richard Rommel
Senior Forrester
Wallkill River Watershed Coordinator
Email : rmrommel@gw.dec.state.ny.us
Phone: (845) 256-3078
Fax: (845) 255-4659

Agency: NYS DEC
21 South Putt Corners Road
New Paltz, NY 12561

CHECKLIST RESPONSES
2, 3, 5, 6, 13, 16

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Regulatory: 48GA Forest Tax Law

Technical: Several programs. Forestry related.

Funding: Federal - FLEP, FIP

NOTES:

Name: William Rudge
Natural Resources Supervisor
Email: wprudge@gw.dec.state.ny.us
Phone: (845) 256-3092
Fax: (845) 255-4659

Agency: NYS DEC
21 South Putt Corners Road
New Paltz, NY 12561

CHECKLIST RESPONSES

1, 2, 9, 10, 15, 16

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Regulatory:

Technical:

Funding:

NOTES:

Name: Karen Strong

Email : klstrong@gw.dec.state.ny.us
Phone: (845) 256-3061
Fax: (845) 255-3649

Agency: NYS DEC Hudson River Estuary Program
21 South Putt Corners Road
New Paltz, NY 12561

CHECKLIST RESPONSES

2, 3, 13, 14, 16

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Regulatory: NYS DEC issues permits for wetland disturbances; SPDES; Stormwater (Construction and MS4 Permit); Mining; solid waste; hazardous waste; and others.

Technical: NYS DEC Hudson River Estuary Program has a Watershed Program Coordinator (Scott Cuppett), Stormwater Outreach Specialist (Barbara Kendall), Biodiversity Specialist (Karen Strong) on staff. These staff members can provide technical assistance in the fields noted.

Funding: NYS DEC has various grant programs for watershed groups: Hudson River Estuary Program Watershed Grants, Environmental Protection Fund Nonpoint Source Implementation Grants, and other programs as funding allows.

NOTES:

#2- Natural Heritage Program data on rare animals, rare plants, and significant ecosystems. Actual database is proprietary info., but interpreted polygons based on the needs of species and habitats will be available in Orange County very soon and in the next year in Ulster County. These data are available on GIS in vector format. Includes threatened and endangered species as well as species determined to be rare in NY by NY Natural Heritage. Significant ecosystems are habitat types (forests, wetlands, meadows, etc.) that may be rare in NY or are of extremely high quality when compared to other areas of New York.

Name: Robert W. Bode

Email : rwbode@gw.dec.state.ny.us
Phone: (518) 285-5682
Fax: (518) 285-5601

Agency: NYS DEC
425 Jordon Road
Troy, NY 12180

CHECKLIST RESPONSES

2

Activity Involvement - Please list the activities with which you or your agency are involved that relate to

NOTES:

watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Name: Kris Breitenfeld
Education Coordinator
Email: kris.breitenfeld@ocsoil.org
Phone: (845) 343-1873
Fax: (845) 344-1341

Agency: Orange County Soil & Water Conservation District
225 Dolson Avenue
Suite 103
Middletown, NY 10940

CHECKLIST RESPONSES

None

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Technical:

Funding:

NOTES:

Name: Patrick Cassidy

Email: patrick.cassidy@ny.usda.gov
Phone: (845) 677-3952
Fax: (845) 677-8354

Agency: USDA Farm Service Agency
PO Box 138
Millbrook, NY 12545

CHECKLIST RESPONSES

6

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Funding:

NOTES:

Aerial Photos, crop reports

Name: Martha Cheo

Email: mcheo@hvi.net
Phone: (845) 256-9316

Agency: Wallkill River Task Force
115 Springtown Road
New Paltz, NY 12561

CHECKLIST RESPONSES

1, 2, 3, 6, 9, 11-15

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

NOTES:

I have info. on Town and Village of New Paltz present and future water supplies. Town of Gardiner was trying to decide whether to conduct a study of groundwater resources. I can find out if they did and get info. if so. I have results from a biodiversity habitat assessment that Hudsonia conducted of a parcel of land in the Village of New Paltz. Also have results from biodiversity habitat assessment conducted by citizens trained by Hudsonia of the Wallkill and Kleinkill corridors just north of Village of New Paltz. Forests and wetlands are included in the studies described in #2. Town of New Paltz had a consulting firm compile some land use info. as part of their Open Space Inventory. The info. is available on GIS. I know of the location of two sewage treatment plants in New Paltz and

Wallkill. Have some limited, student generated water quality data related to them. I know of one area on the Shawangunk Kill that I suspect has a septic leakage because of smell and another area where I see stormwater runoff enter the Wallkill during significant rainstorms. *See written notes for more info.

Name: Robert A. Daniels

Email : rdaniels@mail.nysed.gov
Phone: (518) 473-8121

Agency: NYS Museum
CEC 3140
Albany, NY 12230

CHECKLIST RESPONSES

2, 13

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Technical: fish

NOTES:

Name: Dennis Doyle

Email : planning@co.ulster.ny.us
Phone: (845) 340-3339
Fax: (845) 340-3429

Agency: Ulster County Planning Board
PO Box 1800
Kingston, NY 12402

CHECKLIST RESPONSES

3, 5, 6, 9, 15, 16

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Regulatory:

Technical:

NOTES:

Name: Erik Kiviat

Email : kiviat@bard.edu
Phone: (845) 758-7273

Agency: Hudsonia Ltd.
PO Box 5000
Annandale, NY 12504

CHECKLIST RESPONSES

None

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

NOTES:

We did a report on the Wallkill River in Orange County, one on the Shawangunk Kill and various reports on sites. Please see: www.hudsonia.org. Attached is a nearly complete list of project reports - let me know what you need.

Name: Larry Larson
District Conservationist
Email: larry.larson@ny.usda.gov
Phone: (845) 343-1873
Fax: (845) 344-1341

Agency: Natural Resources Conservation Service
225 Dolson Avenue
Suite 103
Middletown, NY 10940

CHECKLIST RESPONSES

None

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.

NOTES:

Type of Assistance or Oversight Provided:

Technical:

Funding:

Name: John Mickelson

Email: jmickels@ciesin-org
Phone: 365-8957

Agency: CIESIN
61 Route 9W
Palisades, NY 10964

CHECKLIST RESPONSES

2, 3, 4, 5, 6, 16

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Technical: Data development, distributing

NOTES:

Name: Nick Miller

Email: nmiller@wcs.org
Phone: (914) 925-9175
Fax: (914) 925-9164

Agency: Wildlife Conservation Society
68 Purchase St., 3rd Floor
Rye, NY 10580

CHECKLIST RESPONSES

2, 16

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Technical: Better land use planning to reduce ecological impacts of sprawl.

NOTES:

Name: Neal Needleman
County Executive Officer
Email: neal.needleman@ny.usda.gov
Phone: (845) 343-1872
Fax: (845) 344-1341

Agency: USDA Farm Service Agency
225 Dolson Avenue
Suite 101
Middletown, NY 10940

CHECKLIST RESPONSES

None

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Funding: USDA Ag Conservation

NOTES:

Name: Margaret Phillips

Email: mphillip@usgs.gov
Phone: (518) 285-5602
Fax: (518) 285-5601

Agency: US Geological Survey
425 Jordon Road
Troy, NY 12180

CHECKLIST RESPONSES

1, 3, 15

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

NOTES:

Open File Report 97-241, Bugliosi 1998

Technical:

Geohydrology and WQ, topographic maps avail for purchase from Denver office. See online report: http://ny.water.usgs.gov/pubs/of/of97241/OF97-241.pdf.

Name: Michelle A. Rodden

Email : roddenm@sunyulster.edu
Phone: (845) 687-5000
Fax: (845) 687-5083

Agency: SUNY at Ulster County Community College
PO Box 557
Stone Ridge, NY 12484

CHECKLIST RESPONSES
6, 11, 13

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

NOTES:

Your GIS map contains more than the Wallkill River Watershed - It also includes the Rondout Creek Watershed and Binnewater No. 4 - Is it intended to show this? Why?

Name: Teresa Rusinek

Email : tr28@cornell.edu
Phone: (845) 340-3990

Agency: CCE Ulster County
10 Westbrook Lane

CHECKLIST RESPONSES
11

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Technical: educational, pesticide/ nutrient management

NOTES:

Active farmland, pesticide/fert. apps.

Name: Nathaniel Sajdak
Wallkill River Watershed Coordinator
Email : scmua@nac.net/nsajdak@scmua.org
Phone: (973) 579-6998
Fax: (973) 579-7819

Agency: Wallkill River Watershed Management Group
34 South Route 94
Lafayette, NJ 07848

CHECKLIST RESPONSES
1-16

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Technical:

NOTES:

Name: George Schuler

Email :
Phone:
Fax:

Agency: The Nature Conservancy
PO Box 617

CHECKLIST RESPONSES
None

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

NOTES:

Name:

Agency: Orange County Land Trust
PO Box 2442
Middletown, NY 10940

CHECKLIST RESPONSES

2, 15

Email: oclt@warwick.net
Phone: (845) 343-0840
Fax: (845) 341-0898

Activity Involvement - Please list the activities with which you or your agency are involved that relate to watershed management in the Wallkill.
Type of Assistance or Oversight Provided:

Funding: projects in Orange County along the Wallkill River

NOTES:

CHECKLIST RESPONSES LEGEND

(Respondents checked items for which they had information)

Wallkill Watershed assets and land uses

1. Water resource assests, for example, water supply and aquifers, recreational areas, power generation, use for sewage, use for agriculture.
2. Biological and ecological assets such as significant wildlife habitat, endangered and threatened species.
3. Land resource assets, such as forests, wetlands, and topographic features.
4. Percent impervious surface cover.
5. Trends in land-use cover and impervious surface.
6. Land uses, including agricultural, residential, commercial and other major categories, and how these uses impact the watershed.

Known and suspected water quality and quantity problems (involving, but not limited to, segments on the NYSDEC Priority Waterbodies List):

7. Withdrawals
8. Community wellfields
9. Sewage treatment plants
10. Other SPDES permit discharges
11. Known nonpoint source pollution areas
12. Sites where additional study is recommended.

Biological and ecological concerns

13. Biological and ecological impairments: areas in the watershed, including land areas, under stress.
14. Waterbodies or landscapes where additional study is recommended.

Community Concerns

15. Ongoing river-related activities (local, state, federal) you know about.
16. Ongoing educational and outreach activities you know about.

Wallkill River Watershed Conservation and Management Plan

EXECUTIVE SUMMARY (1/07)

The full Wallkill River Watershed Conservation and Management Plan presents detailed sections on existing watershed conditions, issues and recommendations. The executive summary will focus primarily on the recommendations of the Plan, with a minimum of background information.

The size of this Watershed (nearly 800 square miles) and the wide scope of the recommendations in this Plan argue for a dedicated staff position to coordinate implementation efforts. A ***Watershed Coordinator*** could focus exclusively on watershed conservation and management issues and help to make more efficient the efforts of other involved agencies and individuals.

Additionally, a lesson from other watersheds that have been successful in implementing management programs is the value of a ***Watershed Association*** or similar group for ensuring broad stakeholder participation and support. The Watershed Coordinator would logically work for, or at least receive some direction from, this group.

Therefore, an initial and major recommendation of this Plan is to seek funding for a full time coordinator position. In addition, further study should be made of the optimal structure of said position and of the broad-based group that would provided guidance to the Coordinator and help to ensure that active watershed management efforts maintain continuity. Implementation of the following recommendations will proceed with or without a Watershed Coordinator and Association, but having them would vastly increase the efficiency with which limited resources are brought to bear on the ambitious list.

Black Dirt Region

The 16,000 acre Black Dirt Region plays a major role in the agricultural economy of the Watershed. Its unique geology presents many natural resource management challenges. These include addressing the following :

- wind and water erosion
- flooding
- effective drainage
- subsidence
- streambank erosion

Wind and Water Erosion – Conservation practices have been developed that are adaptable to the specialized agriculture practiced in the Black Dirt Region. These include cover crops, ditch bank seeding, and to a limited extent windbreaks. ***This Plan recommends continued financial support for implementing these practices, and for staff to work with growers on practice adoption, addressing technical issues, and developing new practice approaches.***

Flooding – The Black Dirt is located in a natural floodplain area; therefore complete elimination of flooding is of questionable practicality. Nevertheless, continued flood control measures are warranted to protect these highly valuable agricultural lands. The Army Corps of Engineers and the USDA-Natural Resources Conservation Service have recently been asked to investigate feasibility and options

for improving flood control. ***This Plan recommends vigorous lobbying of both federal agencies to ensure full and quick response to these requests.***

Effective Drainage – While effective drainage is primarily a production practice, strong erosion control and flood management programming will facilitate grower efforts to maintain effective drainage systems.

Subsidence – This process of oxidation of the highly organic Black Dirt soils truly makes them a nonrenewable resource. However, their useful life can be greatly extended by careful management. ***This Plan recommends that the continued financial and staff resources called for under the Wind and Water Erosion Control section be also utilized to continue studying and promoting practical subsidence control practices such as controlled drainage systems and green manure crops like Sudex.***

Streambank Erosion – Extensive reaches of streambank erosion in the Black Dirt Region degrade water quality, exacerbate flooding and consume valuable cropland. ***This Plan recommends continuation of ongoing efforts to identify, monitor and prioritize eroding streambank segments. It also recommends accelerated implementation of streambank stabilization projects using natural but effective practices and materials. Opportunities to improve management of the overall riparian corridor (i.e. expanding streamside buffers) should be explored in concert with bank stabilization planning. All agencies with roles and responsibilities related to these channels, including the ACOE's, NYSDEC, County of Orange, OCSWCD, USDA-NRCS, and the four Black Dirt Region towns, should work together to address this issue.***

Horse Farms

Horse operations are a segment of animal agriculture that cannot be ignored in the Wallkill Watershed. ***This Plan recommends accelerated outreach efforts to horse owners to better assess the extent of this industry, and its natural resource management issues and needs.*** Preliminary study indicates high potential for two projects which will be a focus of initial outreach efforts: 1) ***study and actively pursue regional manure management options for horse owners such as composting facilities****, and 2)* ***conduct assessment and planning on lands operated by horse owners to identify 'habitat enhancement opportunities'***, for example, projects that would meet the criteria of programs such as the Wetland Reserve Program (WRP), Wildlife Habitat Incentive Program (WHIP) or Environmental Quality Incentive Program (EQIP).

AEM

The New York State Agricultural Environmental Management Program (AEM) is New York's answer to the Federal Environmental Protection Agency's (USEPA) mandate that all fifty states must come up with a plan to address agricultural non-point source pollution. This program is carried out by the local County Soil and Water Conservation Districts (SWCD's) on behalf of the State Department of Agriculture and Markets.

The New York State AEM program is already being extensively applied by the SWCD's in both Ulster and Orange Counties. These efforts are also being done in association with other local partners such as the USDA Natural Resources Conservation Service (NRCS) and Cornell Cooperative Extension (CCE).

The AEM Program is used to address water quality issues via five stages: Preliminary Information (Tier I); Assessment (Tier II); Planning (Tier III); Implementation (Tier IV); and Monitoring/Evaluation (Tier V). Both County SWCD's are actively engaged with integrating AEM with several cost share funding opportunities that are available through both the Federal and State government.

Other Agriculture

Similar to the Black Dirt Region, erosion is an ongoing resource concern throughout the Watershed. In addition, animal agriculture beyond horse farms (for example, dairy, dairy replacement, beef and miscellaneous other livestock) maintains a respectable position, and demands attention to associated water quality concerns. ***This Plan recommends maintaining strong levels of staff support from SWCD's, USDA-NRCS and Cornell Cooperative Extension to ensure that all interested farmers receive technical support and access to funding opportunities for erosion control, water quality protection, and related natural resource management projects.***

Education and Training

Education and training are functions that happen continuously and informally, as well as in more formal settings such as classroom presentations and workshops. This Plan mentions the importance of education efforts in numerous contexts, for example in the Stormwater Management and Biological Resources sections. ***Education and training should be considered high priority recommendations of the Plan. This Plan further recommends a strong commitment to youth conservation education*** such as that currently demonstrated by Orange County via their Soil and Water Conservation District and Water Authority (numerous other youth conservation education activities occur in the Watershed, but are not detailed here). ***It also recommends accelerated education opportunities for all ages. This last goal could be much advanced by the development of an interpretive center with a focus on the Wallkill River and its Watershed*** as described in more detail in the full version of the Watershed Plan.

Riparian Corridors/Stream Buffers

The character of riparian corridors (areas alongside streams) heavily influences the water quality and overall health of the waterbody they border. Because both riparian corridor infringement and water quality problems have been well documented in the Watershed, project staff mapped the land cover within the corridors of the Wallkill River and its major tributaries. The resulting information led to the identification of areas within riparian corridors that the Plan recommends studying further to determine if conservation, restoration, or mitigation work is needed to maintain or improve the condition of the stream. This project also identified broader trends for stream corridors in the Wallkill, such as the fact that Orange County's Monhagen Brook has the highest percentage of developed/urbanized riparian land (33%) in the Wallkill Watershed. ***The Plan recommends that all municipalities adopt regulations to protect streams from infringement,*** specifically through the use of overlay zones, the adoption of a local wetland and watercourse protection law (appendix I), and other measures.

Stormwater Management

Given the current pace of development, stormwater management must be considered a high priority in the Watershed. ***This Plan recommends increased erosion control compliance at constructions sites. Achieving this goal will require expanded staffing at some level, for example the soil and water conservation districts and/or the local municipalities. Also recommended is accelerated stormwater retrofit planning with the goal of generating a list of potential water quality protection projects for***

***future funding opportunities*.** Low impact development and better site design are stormwater-related concepts that are discussed in a separate section of this Plan.

Impervious Surfaces Analysis

Research has clearly demonstrated impacts to aquatic systems, particularly streams, when the percentage of the contributory watershed covered by impervious surfaces exceeds 10%. For watersheds in the 5 to 10 square mile range where percent impervious is approaching or exceeds 10%, management programs must address imperviousness to be effective.

Recently developed computer mapping procedures have allowed an analysis to be made of imperviousness in the sub-watersheds of Wallkill Watershed (see Map 6 in the full Watershed Plan). ***This Plan recommends that future, more detailed watershed planning in sub-watersheds of the Wallkill utilize this mapping work to guide the initial direction of planning efforts.***

Biological Resources

The Wallkill Watershed has an impressive diversity of species and habitats due its geology, climate, and past and current land uses. Research has shown that threatened or endangered species are found throughout the Watershed and that biological diversity is under siege due to many factors, both natural and cultural. ***The Plan recommends that the important habitats outlined in the Plan - especially stream-associated wetlands - be protected. The Plan also advocates for the protection of land surrounding or adjacent to water bodies as well as land that serves to maintain connectivity between large natural areas***. Little is known about biodiversity in certain regions of the Watershed because little or no scientific research has occurred there. ***The Plan recommends that, while all subwatersheds could benefit from additional research, the Tin Brook, Dwaar Kill, Masonic Creek, and Monhagen Creek be targeted for future biological research.***

Wetlands Degradation

The importance of properly functioning wetlands to the health of watersheds has received extensive attention. These functions include groundwater recharge, flood attenuation, water quality protection and wildlife habitat. ***This Plan recommends compiling existing information and securing new information as necessary to characterize the quality and health of wetlands in the watershed.*** A related recommendation is to ***identify and prioritize candidate wetlands for improvement projects.*** Numerous government programs provide funding and technical assistance for such projects, but accelerated staffing is necessary to utilize these programs to their full potential.

Targeted Assistance to Municipalities

A recurring theme of the full Wallkill Watershed Management Plan is the crucial role that local governments, of which there are 30 in the Watershed, play in land use planning and related decisions that impact watershed health. ***A major recommendation of this Plan, therefore, is to provide targeted technical support to all receptive municipalities in the Watershed. Said support would focus on adoption of local laws, incentive-based programs, conservation project planning and implementation, or other measures that achieve goals of this Plan. A second related recommendation is to foster an affiliation between existing Conservation Advisory Councils (CAC's), lend some staff support to them, and encourage the creation of CAC's where they do not***

***currently exist*.** This is particularly relevant in Orange County where a small number of CAC's exist with little interaction.

Low Impact Development and Better Site Design

Urban development alters the natural landscape in many ways. Creation of impervious surfaces and fragmentation of wildlife habitat are but two examples. Low Impact Development (LID) and Better Site Design (BSD) describe approaches to site design that attempt to minimize these adverse impacts. 'Stormwater treatment trains' is a related term denoting the routing of urban runoff through multiple stormwater treatment practices to increase pollutant removal and more closely approximate natural hydrology. ***This Plan encourages local municipalities to fully explore opportunities to incorporate principles such as LID, BSD and stormwater treatment trains into the site plan approval process, and supports increasing local agency technical support to municipalities to provide education and assistance on these approaches.*** *The counties and the state can support this approach by funding or producing guidance documents, training workshops and other tools for design professionals, developers, and municipal officials.*

Increase Water-related Recreational Opportunities

When people are able to enjoy a water resource through recreational opportunities such as swimming, boating, or fishing, they are more likely to be concerned about the health and welfare of that resource. There are currently 18 sites in Orange and Ulster Counties where the public can access the Wallkill River, but these opportunities are somewhat concentrated geographically. ***The Plan recommends that public access opportunities be established within all six municipalities that flank the Wallkill River but are without public access to the River. The Plan also recommends that public access be established to the major tributaries that are without such opportunities,*** including Rutgers Creek, Pochuck Creek, Quaker Creek, Monhagen Creek, Masonic Creek, and Platte Kill. ***Additionally, the Plan recommends that those municipalities (only three in the Watershed) without public access to a major tributary, lake, or other water resource work to create some type of water-related recreation opportunity.***

Research and Monitoring

This Plan supports increased investments in water resources monitoring systems, including stream gauges, groundwater level monitors, precipitation measurement, and ambient water quality monitoring in rivers, streams and lakes*.** Initial steps should include establishing a dialogue with NYS DEC and DOH and with USGS regarding technical issues, and Federal and state legislators representing the watershed region regarding funding needs. ***Partnerships with academic institutions, US EPA, NYS DEC and other agencies and organizations should be cultivated to facilitate development of research projects on other priority issues such as biodiversity, land use and environmentally-compatible economic development.

Water Supply

Water supply projects have historically been planned without much consideration of the potential impacts of water withdrawals and diversions on overall watershed hydrology. Permitting of new wells by the State also has not included consideration of cumulative, watershed-scale effects. ***This Plan supports a more integrated approach to water supply planning and permitting that places a priority***

on limiting the need for new supplies through conservation and efficiency, maintaining in-stream flows, protecting wetlands and groundwater recharge areas, and ensuring that water withdrawals are sustainable for meeting both human and ecological needs over time. Specific measures that can be implemented include:

- Water conservation measures in new development projects to reduce demand,
- Water reuse, including treated wastewater and graywater for irrigation, groundwater recharge, and other uses,
- Site design and community planning strategies that support sustainable watershed goals,
- Water supply development decisions that place greater emphasis on protecting in-stream flows, recharging groundwater, and cumulative impacts of water withdrawals,
- Land use planning, development approvals and other activities that can impact water quality and quantity, including agriculture, discharge permits, road maintenance and others, should be implemented in a watershed framework that recognizes the full lifecycle benefits of protecting water resources, and the costs of compromising these resources.

Protecting Streamflow, Groundwater, Wetlands

As discussed on p. [60] and in other sections of this Plan, existing regulations and other programs are not adequate to protect water quality and quantity in streams, groundwater formations, wetlands, and other water bodies. Unless and until stronger regulatory and policy measures are adopted at the state or Federal level, one of the primary opportunities for improving these protections is more widespread use of local laws and other methods by local government. ***This Plan strongly supports providing more resources to facilitate training, technical assistance, model ordinances, and other elements needed by local government to enable implementation of local laws to preserve stream buffers, aquifer recharge areas, wetlands, and steep slopes, and to protect groundwater and surface water from contamination.***

Wastewater Management

Infiltration and inflow (I&I) of rainwater and groundwater to older sewer systems, which causes wet-weather overflows of inadequately treated sewage, is believed to a fairly widespread problem in the Wallkill Watershed, as it is many other areas as well. Other major problems with wastewater management include the lack of any regulations requiring maintenance of existing onsite septic systems and a lack of resources to support adequate implementation of existing regulations and oversight programs regarding septic system siting and installation. Additionally, the State's approach to permitting and financing small community treatment systems, often called "package plants", allows the use of private entities called Transportation Corporations to build, own and maintain systems, and these systems are very often underfunded and poorly maintained. ***This Plan supports coordinated action to request Federal and state funding to upgrade old wastewater collection and treatment systems***. At the same time, ***decentralized approaches to wastewater management that combine individual onsite and small community systems should be the preferred option rather than building or expanding larger centralized systems***, for a myriad of reasons. ***This Plan supports stronger municipal involvement and oversight for all new community systems to ensure that existing and new decentralized systems are constructed and operated properly. It also supports resources to help local municipalities to implement management programs for private septic systems, including inspection and pumpouts.*** The NY State Onsite Training Network and other resources should be utilized and promoted for training of inspectors, designers, installers and maintainers of onsite septic systems. In addition, the county health departments should be given more staff resources for field inspections and other activities needed to ensure that new septic systems are properly sited and installed. There should be better coordination between local government staff (building and code enforcement officials, etc.),

county health departments, and NYS DEC on these issues, including reporting of violations and problems with wastewater systems. Better monitoring and tracking will also be useful, including regular stream biomonitoring to evaluate water quality trends downstream of major discharges, and record keeping and availability of information on existing problems with municipal systems and other permitted discharges.

Local Planning and Regulations

In order to develop an inventory of existing municipal land use goals and regulations, as well as to determine if any generalizations could be made in regards to local environmental regulations within the Watershed, the Planning Departments from Ulster and Orange Counties completed a review of municipal plans and codes of municipalities within the Watershed. The findings led to the recommendation that ***the use of certain zoning techniques, such as overlay zones and incentive zoning, is underutilized in Watershed communities and should be used more frequently to effectively protect natural resources. The Plan recommends that all municipalities adopt the NYS Model Law for Sediment and Erosion and Stormwater and that a responsible party be designated to ensure compliance. The Plan also endorses protection at the local level for wetlands, watercourses, and steep slopes, which are safeguarded in just a handful of municipal codes.***

ACTION ITEM*	RESPONSIBLE PARTIES	PRIORITY
Seek funding for a full time coordinator position.	all Plan partners	H
Black Dirt Region		
Ensure continued financial support for implementing erosion control practices, and for staff to work with growers on practice adoption, addressing technical issues, and developing new practice approaches.	SWCD's, USDA-NRCS	M
Vigorously lobby ACOE and USDA-NRCS to provide full and quick response to recent requests for flood control assistance.	Orange County, WVDIA, Affected Towns	H
Ensure continued financial and staff resources for studying and promoting practical subsidence control practices such as controlled drainage systems and green manure crops like Sudex.	SWCD's, USDA-NRCS	M
Continue ongoing efforts to identify, monitor and prioritize eroding streambank segments. Accelerate implementation of streambank stabilization projects using natural but effective practices and materials.	ACOE's, NYSDEC, County of Orange, OCSWCD, USDA-NRCS, four Black Dirt Region towns	M
Horse Farms		
Accelerate outreach efforts to horse owners to better assess the extent of this industry, and its natural resource management issues and needs.	SWCD's, CCE, USDA-NRCS	M
Study and actively pursue regional manure management options for horse owners such as composting facilities.	SWCD's	H
Conduct assessment and planning on lands operated by horse owners to identify 'habitat enhancement opportunities'.	SWCD's, USDA-NRCS	M
Ulster AEM		
Utilize the tiered AEM approach to identify watershed enhancement and partnership opportunities.	SWCD's, USDA-NRCS	H
Other Agriculture		
Maintain strong levels of staff support from SWCD's, USDA-NRCS and Cornell Cooperative Extension to ensure that all interested farmers receive technical support and access to funding opportunities for erosion control, water quality protection, and related natural resource management projects.	All Plan Partners	M
Education and Training		
Place high priority on all education and training aspects of the Watershed Management Plan.	All Plan Partners	H

* Many of these action items will require new funding.

ACTION ITEM*	RESPONSIBLE PARTIES	PRIORITY
Maintain strong commitment to youth conservation education.	SWCD's, OCWA, OC Planning Dept.	M
Accelerate education opportunities for all ages, for example - development of an interpretive center with a focus on the Wallkill River and its Watershed.	All Plan Partners, Town of Montgomery	H
Stream Buffers/Riparian Corridors		
Protect valuable riparian corridors	municipalities, conservation groups, and all Plan partners	H
Restore degraded riparian corridors	municipalities, conservation groups, and all Plan partners	H
Outreach to municipalities on importance of stream buffers	all Plan partners	H
Stormwater Management		
increase erosion control compliance at constructions sites.	NYSDEC, SWCD's, local municipalities	H
Accelerate stormwater retrofit planning with the goal of generating a list of potential water quality protection projects for future funding opportunities.	SWCD's	H
Impervious Surfaces Analysis		
Conduct more detailed watershed planning in sub-watersheds of the Wallkill utilizing % impervious mapping work from this Plan to guide the initial direction of planning efforts.	TBD	M
Biological Resources		
Protect stream-associated wetlands	municipalities, all Plan partners	H
Promote biological research within the watershed	municipalities, all Plan partners	M
Protect important habitats	municipalities, all Plan partners	H
Create/maintain buffers around water resources	municipalities, all Plan partners	H
Maintain habitat connectivity	municipalities, all Plan partners	M
Educate landowners and land use decision-makers on biological resources conservation	all Plan partners	H
Wetlands Degradation		
Compile existing information and secure new information as necessary to characterized the quality and health of wetlands in the watershed.	SWCD's, County Planning Departments	M
Identify and prioritize candidate wetlands for improvement projects.	SWCD's, NRCS	M

* Many of these action items will require new funding.

ACTION ITEM*	RESPONSIBLE PARTIES	PRIORITY
Targeted Assistance to Municipalities		
Provide targeted technical support to all receptive municipalities in the Watershed. Said support would focus on adoption of local laws, incentive-based programs, conservation project planning and implementation, or other measures that further the goals of this Plan.	SWCD's, County Planning Departments	H
Foster an affiliation between existing Conservation Advisory Councils (CAC's), lend some staff support to them, and encourage the creation of CAC's where they do not currently exist	SWCD's, County Planning Departments	H
Low Impact Development and Better Site Design		
Encourage local municipalities to fully explore opportunities to incorporate principles such as LID, BSD and stormwater treatment trains into the site plan approval process, and support increasing local agency technical support to municipalities to provide education and assistance on these approaches.	SWCD's, County Planning Departments, all Plan partners	H
Increase Water-related Recreational Opportunities		
Increase access to the Wallkill River in those municipalities that are without access	municipalities, all Plan partners	H
Eastablish access to certain major tributaries that are without any public access	municipalities, all Plan partners	M
Establish public opportunities for water-related recreation in areas that are without any	municipalities, all Plan partners	
Research and Monitoring		
Increase investments in water resources monitoring systems, including stream gauges, groundwater level monitors, precipitation measurement, and ambient water quality monitoring in rivers, streams and lakes.	TBD	M
Cultivate partnerships with academic institutions, US EPA, NYS DEC and other agencies and organizations to facilitate development of research projects on other priority issues such as biodiversity, land use and environmentally-compatible economic development	TBD	M

* Many of these action items will require new funding.

ACTION ITEM*	RESPONSIBLE PARTIES	PRIORITY
Water Supply		
Support a more integrated approach to water supply planning and permitting that places a priority on limiting the need for new supplies through conservation and efficiency, maintaining in-stream flows, protecting wetlands and groundwater recharge areas, and ensuring that water withdrawals are sustainable for meeting both human and ecological needs over time. (See full Plan for examples of specific measures)	municipalities, all Plan partners	H
Protecting Streamflow, Groundwater, Wetlands		
Provide more resources to facilitate training, technical assistance, model ordinances, and other elements needed by local government to enable implementation of local laws to preserve stream buffers, aquifer recharge areas, wetlands, and steep slopes, and to protect groundwater and surface water from contamination.	TBD	H
Wastewater Management		
Coordinate actions to request Federal and state funding to upgrade old wastewater collection and treatment systems. Promote decentralized approaches to wastewater management that combine individual onsite and small community systems, and stronger municipal involvement and oversight for all new community systems Seek resources to help local municipalities implement management programs for private septic systems, including inspection and pumpouts.	TBD	M
Local Planning and Regulations		
Increase use of zoning techniques to protect water resources	municipalities	H
Explore feasibility of creating an EMC for Orange County	OC Legislature, Plan partners	M
Adoption by municipalities of NYS Model Law for Sediment Erosion and Stormwater	municipalities	H
Local protection of water resources	municipalities	H
Increased protections for steep slopes	municipalities	H
Subtraction of "nonbuildable" areas from gross area during subdivision application process (written into subdivision regulations)	municipalities	M
SWCD=Soil and Water Conservation District NRCS=Natural Resources Conservation Service TBD=To Be Determined WVDIA=Wallkill Valley Drainage Improvement Association OCWA=Orange County Water Authority ACOE=Army Corps of Engineers		
Responsible parties were listed based on typical roles and responsibilites of those parties. All listed parties have not all necessarily agreed to undertake these action items.		

* Many of these action items will require new funding.