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PREFACE

This nonpoint source pollution control plan was produced in accordance with the “Report and Recommendations” (1993) of the County Executive’s Citizens Committee on Nonpoint Source Pollution in Long Island Sound. The document is divided into two sections. The first contains the recommended action plan for the Watershed Advisory Committee 3 (WAC 3) study area of the Long Island Sound watershed. The second assesses specific water quality protection techniques recommended in the first section.

The principles of this plan have been endorsed by all of the municipalities that comprise the WAC 3 study area. Resolutions endorsing the plan were adopted by the Town/Village of Harrison Town Board on March 4, 1998, Village of Mamaroneck Board of Trustees on March 23, 1998, Village of Port Chester Board of Trustees on March 2, 1998, Village of Rye Brook Board of Trustees on March 4, 1998, and City of Rye City Council on April 1, 1998 (copies of resolutions in Appendix).

Section I of the plan provides a broad understanding of watershed planning for the Long Island Sound watershed. It outlines Westchester County’s nonpoint source pollution control program and makes specific recommendations for controlling nonpoint source pollution in the WAC 3 study area. This section describes characteristics of the study area, such as land use and demographics, and includes the results of watershed analyses and recommendations to reduce the volume of nonpoint source pollution entering Long Island Sound. The first section is specific to the WAC 3 study area and is an “action-oriented” document.

Section II of the plan highlights threats to water resources, identifies pollutants impacting water quality, and discusses management strategies and practices to protect, preserve and restore natural features that are essential to ensuring good water quality in a watershed. This section is intended to be an education tool to introduce the public and municipal officials to watershed planning, nonpoint source pollution control, and the various ways to reduce the threat of nonpoint source pollution.

The two sections complement each other and provide all the necessary components of a comprehensive watershed plan. These documents are intended to assist the restoration of one of the region’s most valuable natural resources - Long Island Sound.

EXECUTIVE SUMMARY

BACKGROUND

Long Island Sound is an estuary, a place where salt water from the ocean mixes with freshwater from inland streams and rivers. Bounded by Connecticut and Westchester County to the north and Long Island to the south, it is approximately 110 miles long and up to 21 miles across at its widest point.

The Long Island Sound Study, a cooperative effort of the states of New York and Connecticut and the U.S. Environmental Protection Agency resulting in a management plan in 1994, found numerous threats to the future productivity and recreational viability of the Sound. The Long Island Sound Study has focused its efforts and resources on the most pressing problem, the low oxygen levels affecting substantial areas of western Long Island Sound in late summer. It has identified overenrichment of nitrogen as the primary cause. Nitrogen management has been proceeding in phases. In 1990, the U.S. EPA and states of New York and Connecticut agreed to cap nitrogen loadings as Phase 1. The 1994 LISS's Comprehensive Conservation Management Plan contained commitments to begin to reduce the load of nitrogen to the Sound as Phase II. The EPA and states of New York and Connecticut also committed to develop nitrogen reduction targets for Long Island Sound to guide Phase III implementation. On February 7, 1997, the EPA and states of New York and Connecticut released a proposal for Phase III Actions for Hypoxia Management, including nitrogen reduction targets.

In response to the significant concerns raised by the Long Island Sound Study, in 1992 former Westchester County Executive Andrew P. O'Rourke created the Citizen's Committee on Nonpoint Source Pollution in Long Island Sound, consisting of elected officials and staff of municipalities, representatives of the construction industry and building trades, members of the environmental community and Westchester County staff. The Citizen's Committee produced detailed findings and a plan in its "Report and Recommendations" in 1993 to reduce pollution and improve water quality in Long Island Sound. This report, accepted and approved by the County Executive, addressed point source nitrogen pollution, biological/structural nonpoint source controls, institutional and land use controls, education and financing. It was decided that, if implemented, these recommendations would result in improved water quality in Westchester's streams, rivers, ponds, lakes, groundwater, and ultimately, Long Island Sound.

To ensure implementation of the Citizen Committee's recommendations, the County Executive created the Committee on Nonpoint Source Pollution in Long Island Sound. In 1993, the Westchester County Department of Planning, in conjunction with this committee, began the process of implementing the 33 recommendations made by the Citizen's Committee.

The committee and Planning Department embraced a cooperative municipal-County venture to develop and implement cost-effective local programs emphasizing legislative, regulatory, planning, education and outreach components. Many programs and policies have been, or are in the process of being, developed to enhance or improve the Sound's water quality. There are County programs which target technical upgrades for County water treatment facilities, and education and outreach programs, such as storm drain stenciling and information guides, which promote water quality education. The County has also coordinated efforts with the New York State Department of Environmental Conservation to provide funding guidance to private marina owners for construction of pump-out facilities. Many of the Citizen Committee's simpler directives have been accomplished and the County is continuing to focus on other opportunities and innovations, such as watershed planning, to reduce nonpoint source pollution.

WATERSHED PLANNING

The Long Island Sound watershed in Westchester County comprises approximately 68,000 acres and supports approximately one-half of the county's population. Nineteen Westchester County municipalities within 10 subwatersheds contribute drainage to the Sound. To effectively plan for and manage the Long Island Sound watershed, the 68,000-acre basin was divided into 6 subwatersheds (see Map 1) as listed below in Table 1. A nonpoint source pollution control plan will be developed for each of these subwatershed areas.

Table 1. Subwatersheds of Long Island Sound.

WAC #	Subwatersheds	Municipalities
1	Silvermine, Mill and Mianus Rivers	Bedford, Lewisboro, North Castle, Pound Ridge
2	Byram River	Bedford, New Castle, North Castle, Port Chester
3	Blind, Beaver Swamp, and Brentwood Brooks, and Milton and Port Chester Harbors	Harrison, Mamaroneck (Village), Port Chester, Rye Brook, Rye (City)
4	Mamaroneck and Sheldrake Rivers, and Mamaroneck Harbor	Harrison, Mamaroneck (Town and Village), New Rochelle, Scarsdale, White Plains
5	Pine, Stephenson, and Burling Brooks, and Larchmont Harbor	Mamaroneck (Town and Village), Larchmont, New Rochelle, Pelham, Pelham Manor
6	Hutchinson River	Eastchester, Mount Vernon, New Rochelle, Pelham, Pelham Manor, Scarsdale

WATERSHED ADVISORY COMMITTEES

Six intermunicipal Watershed Advisory Committees (WACs) were formed, each representing one of the subwatershed study areas above, and each being essential to Westchester County's watershed planning approach. The WACs were created to foster a cooperative relationship between all municipalities in each of the subwatersheds and to recognize the importance of developing locally acceptable nonpoint source pollution control plans. Targeted land use measures, local ordinances, structural and vegetative best management practices, and education are most effective when implemented at the local level.

The Watershed Advisory Committee 3 (WAC 3) study area comprises the Blind Brook, Beaver Swamp Brook, Beaver Swamp Brook (Brentwood Brook), Coastal Long Island Sound, Port Chester Harbor, and Milton Harbor subwatersheds. These subwatersheds occupy portions of the Town/Village of Harrison, the City of Rye, and the villages of Mamaroneck, Port Chester and Rye Brook in New York and the Town of Greenburgh in Connecticut. For purposes of this profile, figures apply only to Westchester County; they do not, at this time, incorporate Connecticut.

The size of each subwatershed is as follows:

Subwatershed	**Total Area** (Acres)
Blind Brook	6,477*
Beaver Swamp Brook	1,962
Beaver Swamp West (Brentwood Brook)	1,129
Coastal Long Island Sound	1,067
Port Chester Harbor	848
Milton Harbor	272
TOTAL	11,755

* that portion of the subwatershed in Westchester County

WATERSHEDS AND WATER QUALITY

The types of pollutants in urban runoff depend on the type of land uses in the watershed. In general, highways, commercial areas, and high density residential areas are the largest sources of sediment, lead and zinc on a per acre basis. Medium density residential areas are less important sources of sediment and lead, but are significant sources of pesticides, bacteria, and household or automotive maintenance products. Low density residential areas, particularly along the shores of inland and tidal water bodies, also are contributors of nonpoint source pollutants, especially where the improper use and disposal of pesticides, fertilizers and automotive maintenance products occur. Most runoff in an urban area is discharged to a wetland, stream or other water body through a stormwater conveyance system.

In addition to nutrients and toxicants that are generated from existing residential and commercial land use, there are numerous other nonpoint pollution sources which need additional attention, including construction site erosion and runoff from waste disposal sites and resource extraction industries, such as sand and gravel operations. These sources cumulatively have a tremendous effect on the water quality of streams, freshwater water bodies, wetlands and, ultimately, Long Island Sound. The major urban nonpoint sources of pollution in the Long Island Sound watershed are sediment, excess nutrients, bacteria, hydrocarbons (petroleum), trace metals, chemicals, chlorides, and thermal impacts.

RECOMMENDATIONS

A series of general nonpoint source pollution control strategies, including stormwater management, wetland and stream buffers, wetland restoration and creation, storm restoration, and municipal regulatory and non-regulatory controls are analyzed in Section II of this plan. When applied to the WAC 3 study area, specific recommendations were drawn from those strategies and are noted in detail in Section I. Recommendations in Sections I and II are briefly summarized in this Executive Summary. While the list is organized by municipality in this summary, the watershed planning process is premised on the watershed boundary as the planning unit and implementation of the recommended strategies is required by all of the municipalities in the study area to maximize water quality improvements to Long Island Sound.

Strategies related to outreach and education, and to identification of funding opportunities are noted only once below, but are applicable to all the municipalities in the Long Island Sound watershed.

Watershed-wide Strategies

Municipal Comprehensive Plans and Ordinances

- Increase awareness and enforcement of all laws and regulations related to water quality to increase their effectiveness. For example, measures related to erosion and sediment control are only effective if they are implemented according to approved plans and maintained properly during the life of the project.

- Designate an individual or group within each municipality to serve as a facilitator in furthering the goals of the WAC3 Plan and as a liaison to WAC3, the Westchester County Planning Department, the County Committee on Nonpoint Source Pollution in Long Island Sound and other entities that may provide technical and administrative support.

Outreach and Education

- Utilize local media (newspapers, radio and cable television), newsletters and public gatherings to disseminate information about nonpoint source pollution control activities.

- Identify and work with target corporations, businesses, utility companies, golf course and landscape/lawn care industry leaders to promote and co-sponsor nonpoint source pollution control educational activities.

- Host workshops for planning, conservation and other boards as well as municipal staff involved in land use planning and decision-making.

- Work with garden clubs and the landscaping/lawn care industry to develop a targeted campaign for better lawn care and landscaping practices.

- Initiate an awards program that recognizes implementation of a nonpoint source pollution control program.

- Develop a handbook for municipal boards and commissions describing how to incorporate nonpoint pollution control strategies into local land use guidelines, policies and laws.

- Work with and encourage groups and organizations which work beyond your municipal boundaries to provide programs, publications, speakers, formal presentation and other information related to nonpoint source pollution control and to keep you advised of any activities they are planning which your community could benefit from.

Stormwater Management

- A comprehensive watershed protection strategy, which uses non-structural and structural best management practices (BMPs), will reduce the long-term costs of both controlling floods and protecting water quality. In the WAC 3 study area, the emphasis of stormwater management is on the construction of stormwater detention and retention basins. However, more needs to be done to comprehensively address stormwater management. Comprehensiveness ranges from better implementation, monitoring and enforcement of erosion and sediment control practices to the development and implementation of more diverse and better designed non-structural and structural stormwater management practices.

Wetland Protection and Restoration

- Adequate regulatory protection and the restoration of degraded wetlands were of primary concern to WAC 3.

Stream Buffers and Restoration

- Adequate buffers from new development and redevelopment, such as buildings, parking lots, roads and managed lawns, should be provided throughout the WAC 3 study area; buffers filter stormwater runoff before it enters streams and wetlands.

- Eroding stream and shore banks have a detrimental impact on water quality because of the sediment that is discharged from the eroded banks and because eroded banks usually do not have any or enough stabilizing vegetation that also will act to filter out nutrients and contaminants and keep the stream cool by shading it from excessive sunlight. Although structural and non-structural methods can be used to stabilize eroding stream banks and shores, from a water quality protection standpoint the best solutions are often those that focus on non-structural methods.

Funding

- Grants - Pursue federal and state grant programs related to implementation f nonpoint source management programs under Section 319 of the Clean Water Act.

- State Revolving Funds (SRF) - Utilize SRFs, which are particularly suitable for funding structural best management practices such as extended detention and retention basins.

- New York State Clean Water/Clean Air Bond Act - Proposed projects for funding through the 1996 Clean Water/Clean Air Bond Act. Eligible projects include nonpoint source control, habitat restoration and flood control.

- Special Fees and Taxes - Review the examples provided in the plan explaining user fee/tax programs and determine if such examples are appropriate for Long Island Sound communities.
-

County of Westchester

- The County of Westchester should notify the municipality in which any capital project it proposes to undertake will be located prior to project design and construction, especially if the project has potential environmental impacts. This will allow municipal environmental concerns to be considered during the project's design and construction.

Town/Village of Harrison

Municipal Comprehensive Plans and Ordinances

- Amend the Erosion and Sediment Control Ordinance to be consistent with the County Soil and Water Conservation District's Model Ordinance for Erosion and Sediment Control and consider incorporation of Chapter 133 of the Town's laws, entitled "Providing for Regulation and Licensing of the Excavation or Regrading of Land" into the amended ordinance.

- Adopt a Stormwater Ordinance to bring the stormwater management activities, currently regulated to varying degrees under the Subdivision, Flood Prevention, Water Pollution and Erosion and Sediment Control ordinances, into a separate ordinance that will provide controls for stormwater runoff quality and quantity.

- Adopt a new Freshwater Wetlands Ordinance to provide protection for local wetlands and watercourses that are not protected under the current ordinance and to strengthen the existing ordinance to better protect freshwater wetlands and provide more efficient administration and enforcement of the ordinance.

- Consider adoption of a Steep Slopes Ordinance to protect the areas that exhibit slopes of 15 to 25 percent.

- Amend the Zoning Ordinance to include lot coverage limits and establish criteria for establishing buffer/setback distances for streams and water bodies. Coordinate these amendments with the proposed new Freshwater Wetlands Ordinance.

- Adopt an Animal Waste Ordinance to minimize feces contamination or waterways.

- See watershed-wide strategies noted above.

Outreach and Education

- See watershed-wide strategies noted above.

Funding

- See watershed-wide strategies noted above.

Stormwater Management

- Twenty-one surface and subsurface stormwater management basins have been identified in the WAC 3 study area portion of Harrison. Another was under construction at the time of this report and was not evaluated. Many of the basins can be improved from a water quality standpoint by relatively simple changes in design to their outlets, in-basin drainage channels and/or height of basin embankments, or by establishing aquatic, semi-aquatic and upland vegetation within and adjacent to the basins. The establishment of vegetation within some basins may require modifications to basin designs.

- See watershed-wide strategies noted above.

Wetland Restoration

- Restore state-designated, freshwater wetland No. J-3, between Taylor Avenue in Harrison and Coolidge Avenue in Rye City.

- Provide long-term protection for state-designated, freshwater wetland No. G-9, which has been encompassed by the Hickory Pine at Purchase Golf Club.

- Study other freshwater wetlands in Harrison to find smaller wetlands that are suitable for restoration, such as the small headwaters wetlands near Polly Park Road.

Stream Restoration

- Approximately 19 stream miles of Blind Brook, Beaver Swamp Brook, and Beaver Swamp Brook West (Brentwood Brook) flow through Harrison. The Streamwalk identified 16 impaired sites in the city. No Priority Water Bodies List sites were identified by NYSDEC in Harrison, although Blind Brook and Beaver Swamp Brook have PWL sites in Rye City.

- Blind Brook, Beaver Swamp Brook and Brentwood Brook - Improve water quality in these streams by modifying urban housekeeping practices, enhancing the stream buffers and banks, managing nutrients, controlling erosion and sediment, restoring the natural channels, stabilizing stream banks, maintaining septic systems, retrofitting storm drains, improving streamside mowing practices, and removing sediment from the stream channels.

Mamaroneck Village

Municipal Comprehensive Plans and Ordinances

- Update the Master Plan and Local Waterfront Revitalization Program to include specific recommendations and policies for protecting and improving the quality of tributaries and embayments of Long Island Sound.

- Amend the Freshwater Wetlands Ordinance to include a specific description of how wetlands are to be identified, mitigation sequencing requirements and more specific criteria for issuing a permit.

- Adopt a Tidal Wetlands Ordinance to protect the significant amount of tidal wetlands along the Long Island Sound shore.

- Adopt a Stormwater Management Ordinance which incorporates NYSDEC guidelines and the provisions of the County's stormwater runoff control manual.

- Amend the Flood Damage Prevention; Erosion and Sediment Control Ordinance to include a few additional standards to make the ordinance complete.

- Amend Zoning Ordinance to include lot coverage limits and provide for exclusion of sensitive areas (e.g., wetlands, steep slopes) from allowable coverage calculations.

- See watershed-wide strategies noted above.

Outreach and Education

- See watershed-wide strategies noted above.

Funding

- See watershed-wide strategies noted above.

Stormwater Management

- See watershed-wide strategies noted above.

Wetland Restoration

- Restore and provide better long-term protection of state-designated, freshwater wetland No. J-2 at the head of Otter Creek (surrounding Mead Pond).

- Provide long-term protection of the existing tidal wetlands along Guion Creek and Otter Creek.

Stream Restoration

- Approximately 1.8 stream miles of Beaver Swamp Brook, Guion Creek and Otter Creek flow through Mamaroneck Village. The Streamwalk identified two impaired sites in the village. No Priority Water Bodies List sites have been identified by NYSDEC, although Beaver Swamp Brook has a PWL site in Rye City (of course, Long Island Sound also is on the PWL).

- Beaver Swamp Brook, Guion Creek and Otter Creek - Improve water quality in these streams by modifying urban housekeeping practices, enhancing the stream buffers and banks, managing nutrients, controlling erosion and sediment, restoring the natural channels, stabilizing stream banks, maintaining septic systems, retrofitting storm drains, improving streamside mowing practices, and removing sediment from the stream channels.

Rye City

Municipal Comprehensive Plans and Ordinances

- Amend the Surface Water, Erosion and Sediment Control Ordinance to include specific standards and requirements to ensure that the provisions to protect against stormwater, erosion and sediment impacts are consistently applied.

- Amend the City's already strong Wetlands and Watercourses Ordinance to include a ratio standard in the section on wetland mitigation.

- Amend the Zoning Ordinance, which includes innovative zoning districts that protect specific natural resources, to include maximum lot coverage limits.

- Adopt an Animal Waste Ordinance to minimize feces contamination or waterways.

- See watershed-wide strategies noted above.

Outreach and Education

- See watershed-wide strategies noted above.

Funding

- See watershed-wide strategies noted above.

Stormwater Management

- Thirteen surface stormwater management basins have been identified in Rye City. Several others were under construction at the time of this report and were not evaluated. Many of the basins can be improved from a water quality standpoint by relatively simple changes in design to their outlets, in-basin drainage channels and/or height of basin embankments, or by establishing aquatic, semi-aquatic and upland vegetation within and adjacent to the basins. The establishment of vegetation within some basins may require modifications to basin designs.

- See watershed-wide strategies noted above.

Wetland Restoration

- Provide long-term protection of state-designated, freshwater wetland No. J-1, immediately north of the Boston Post Road and adjacent to Rye Neck High School.

- Restore state-designated, freshwater wetland No. J-3, between Taylor Avenue in Harrison and Coolidge Avenue in Rye City.

- Prevent further degradation of state-designated, freshwater wetland No. J-4, immediately east of Frederick Court.

- Restore tidal wetlands on municipally-owned Rye Country Club lands at the mouth of Blind Brook/head of Miltor Harbor.

- Monitor and conduct an assessment of tidal wetlands at Marshlands Conservancy, as well as an analysis of the surrounding watershed, to determine the reason for the decline in size of these wetlands and find solutions to arrest this decline.

- Restore and provide long-term protection for tidal wetlands on Manursing Island.

- Restore and provide long-term protection for tidal wetlands immediately southwest of Playland Parkway along Blind Brook.

Stream Restoration

- Approximately 10 stream miles of Blind Brook and Beaver Swamp Brook flow through Rye City. The Streamwalk identified 12 impaired sites in the city. Three Priority Water Bodies List sites also have been identified by NYSDEC: Blind Brook, Beaver Swamp Brook, and Milton Harbor (of course, Long Island Sound also is on the PWL).

- Blind Brook and Beaver Swamp Brook - Improve water quality in these streams by modifying urban housekeeping practices, enhancing the stream buffers and banks, managing nutrients, controlling erosion and sediment, restoring the natural channels, stabilizing stream banks, maintaining septic systems, retrofitting storm drains, improving streamside mowing practices, and removing sediment from the stream channels.

Port Chester

Municipal Comprehensive Plans and Ordinances

- Revise the Village's LWRP to reflect a more balanced approach between increased public access and the development of water-dependent uses and the protection and preservation of natural resources, which are essential to improving water quality in Long Island Sound and its tributaries.

- Adoption of an Erosion and Sediment Control Ordinance to apply to land disturbing activities within the watershed.

- Amend Zoning Code to provide lot coverage limits and buffer zones for all districts to ensure the preservation of natural features near wetlands and water bodies.

- See watershed-wide strategies noted above.

Outreach and Education

- See watershed-wide strategies noted above.

Funding

- See watershed-wide strategies noted above.

Stormwater Management

- See watershed-wide strategies noted above.

Wetland Restoration

- Prevent further degradation of and restore the freshwater wetland at the end of Alto Avenue.

Rye Brook

Municipal Comprehensive Plans and Ordinances

- Amend the Erosion and Sediment Control Ordinance to apply to all substantial land-disturbing activities and be consistent with the County's Best Management Practices Manual for Erosion and Sediment Control and the NYSDEC's Guidelines for New Development.

- Adopt a Stormwater Management Ordinance that contains provisions for the treatment of stormwater for both water quality as well as quantity.

- Amend Site Plan and Subdivision Regulations to include Steep Slope Provisions to safeguard the remaining undeveloped areas of the Village which contain steep slopes.

- Amend the Village's existing strong and protective Wetlands and Watercourses Ordinance to include a section on mitigation plan requirements.

- Amend the Zoning Ordinance to include lot coverage limits for all zoning districts and provide for the area closest to the Rye Ridge Complex to be kept open to provide a buffer and recreational resource to village residents as recommended in the Village's Rye Brook South Study.

- See watershed-wide strategies noted above.

Outreach and Education

- See watershed-wide strategies noted above.

Funding

- See watershed-wide strategies noted above.

Stormwater Management

- Eleven surface stormwater management basins have been identified in the WAC 3 study area portion of Rye Brook. Many of the basins can be improved from a water quality standpoint by relatively simple changes in design to their outlets, in-basin drainage channels and/or height of basin embankments, or by establishing aquatic, semi-aquatic and upland vegetation within and adjacent to the basins. The establishment of vegetation within some basins may require modifications to basin designs.

- See watershed-wide strategies noted above.

Wetland Restoration

- Provide the long-term protection and preservation of state-designated wetland No. G-3, which straddles the Rye Brook and Harrison municipal boundary.

Stream Restoration

- Approximately nine stream miles of Blind Brook (two branches) flow through Rye Brook. The Streamwalk identified six impaired sites in the village. No Priority Water Bodies List sites have been identified by NYSDEC, although Blind Brook has a PWL site in Rye City.

- Blind Brook - Improve water quality in this stream by modifying urban housekeeping practices, enhancing the stream buffer and banks, managing nutrients, controlling erosion and sediment, restoring the natural channel, stabilizing stream banks, maintaining septic systems, retrofitting storm drains, improving streamside mowing practices, and removing sediment from the stream channel.

LONG ISLAND SOUND WATERSHED PLANNING PROCESS

A. The Importance of Long Island Sound

Long Island Sound is an estuary, a place where salt water from the ocean mixes with fresh water from inland streams and rivers. Bounded by Connecticut and Westchester County to the north and Long Island to the south, it is approximately 110 miles long and up to 21 miles across at its widest point.

Like other estuaries, Long Island Sound abounds with fish, shellfish and waterfowl. It provides feeding, breeding, nesting and nursery areas for diverse plant and animal life. Unlike other estuaries, though, Long Island Sound does not have only one connection to the sea; it has two. Rather than having a major source of freshwater at its head and having a wide mouth that empties into the ocean, Long Island Sound is open at both ends, through "The Race" at the eastern tip of Long Island and at the confluence of the East River and New York Harbor. Most of its freshwater comes from north-to-south flowing rivers, such as the Connecticut and Housatonic rivers in Connecticut, and a series of much smaller streams and rivers that, cumulatively, contribute substantial amounts of freshwater to the Sound. These smaller watercourses include Stephenson, Pine, Blind and Beaver Swamp brooks, and Mamaroneck, Hutchinson, Mianus and Mill rivers in Westchester County.

The Sound is unique in the degree to which it provides recreational and commercial value to the region. It is in the midst of one of the most densely populated regions of the United States. More than eight million people live in the Long Island Sound watershed and millions more flock yearly to the Sound for recreation. Research commissioned by the joint state and federal Long Island Sound Study estimated that about $5 billion is generated annually in the regional economy from boating, commercial and sport fishing, swimming and beach-going. The ability of the Sound to support these uses is dependent on the quality of its waters, living resources and habitats. Westchester's economy also benefits from many other valuable uses of the Sound, such as cargo shipping and boat excursions. With the uses it serves and the recreational opportunities it provides, Long Island Sound is among the most important estuaries in the nation.

While Long Island Sound is a demonstrable economic resource, there are other values that are less quantifiable. Natural habitats and good water quality contribute to residential property values. On another level, the Sound has attributes, aesthetic and otherwise, that can inspire a special bond between people and the water.

The current value and quality of the Sound are partly the result of investments in water pollution control programs over the past 25 years since the passage of the Clean Water Act. These programs have led to measurable improvements in pollution control and water quality, despite ever-increasing numbers of people and activities on the Sound and within its watershed.

B. The Problem

Large areas of Long Island Sound are or have been impaired as habitat for fish, shellfish and other animals partly because of low dissolved oxygen levels called hypoxia. The productivity of many freshwater and tidal wetlands, intertidal areas, and other habitats has been diminished by development and pollution. Streams that empty into the Sound often carry high amounts of nutrients and pollutants because of inland and coastal development. The degradation of habitat has had direct and indirect impacts on the regional economy and quality of life. Health advisories warn against eating too much Long Island Sound fish and shellfish, and the size of commercial and recreational fish catches has diminished over the past several years as a result of a need for better fisheries management, pollution and loss of habitat. Beaches suffer periodic closures due to pathogen contamination and other pollutants.

Since 1985, New York and Connecticut governmental agencies, in conjunction with the U.S. Environmental Protection Agency and several non-profit organizations, have been cooperating to restore the Sound's health. The Long Island Sound Study (LISS) is a result of this cooperative effort and identified numerous threats to the future productivity and recreational viability of the Sound. The study noted that a primary inhibitor to the Sound's health is excessive nitrogen, a nutrient. Nitrogen fuels the growth of algae. When the algae die and decompose, they use up dissolved oxygen in the water, which is needed by fish and other aquatic life. This results in hypoxic, or low oxygen conditions.

The LISS is implementing a phased approach to reducing nitrogen loadings to the Sound. Phase I, announced in December 1990, called for a freeze on point and nonpoint sources of nitrogen loadings to the Sound in critical areas at 1990 levels. Phase II, approved in 1994, committed to low cost actions to begin to reduce the load of nitrogen below the 1990 freeze base line. Phases I and II were based on LIS 2.0, a two-dimensional water quality model, while work was completed on LIS 3.0, a more advanced model. LIS 3.0, a three-dimensional water quality model that better defines the area and duration of low dissolved oxygen conditions, has been used to guide the next phase of hypoxia management. Phase III will set nitrogen reduction targets for each of 11 watershed management zones established around the Sound. Westchester County is in management zone 7.

As new regulations call for improved treatment of sewage effluent to curb point sources of nitrogen pollution, many communities, including Westchester County, are finding that treatment improvements can be difficult and costly. Due to these difficulties, alternative ways of reducing nitrogen levels must be sought. A more cost effective means of protecting water quality may be achieved through a combined pollution control strategy. A combined pollution control strategy addresses both "point" and "nonpoint" sources of nitrogen and other contaminants that threaten water quality. This type of approach addresses as many pollution sources as possible and will help protect the long-term health and recreational value of Long Island Sound.

C. Westchester County's Nonpoint Source Pollution Control Program

In response to the significant concerns raised by the Long Island Sound Study, in 1992 Westchester County Executive Andrew P. O'Rourke created the Citizen's Committee on Nonpoint Source Pollution in Long Island Sound. The Citizen's Committee consisted of elected officials and staffs of municipalities, representatives of the construction industry and building trades, members of the environmental community and Westchester County staff. The Citizen's Committee was charged with making recommendations and proposing a combined pollution control strategy to reduce Westchester County's contribution of nonpoint source pollutants to the 16,000 square mile Long Island Sound watershed. The Citizen's Committee produced detailed findings and a plan in its "Report and Recommendations" in 1993 to reduce pollution and improve water quality in Long Island Sound. This report addresses point source nitrogen pollution, biological/structural nonpoint source controls, institutional and land use controls, education and financing. Overall, the Citizen's Committee made 33 recommendations to address point and nonpoint source pollution, which were accepted and approved by the County Executive and Board of Legislators with the understanding that if implemented these recommendations would result in improved water quality in Westchester's streams, river, ponds, lakes, groundwater, and ultimately, Long Island Sound.

To ensure implementation of the Citizen's Committee's recommendations, the County Executive created the Committee on Nonpoint Source Pollution in Long Island Sound. In 1993, the Westchester County Department of Planning, in conjunction with this committee, began the process of implementing the 33 Citizen' Committee recommendations.

The Committee and Panning Department embraced a cooperative municipal-County venture to develop and implement cost-effective local programs emphasizing the following categories: legislative, regulatory, planning, and education and outreach.

Many of the recommended programs and policies have been, or are in the process of being, developed to enhance or improve the Sound's water quality. There are County programs which target technical upgrades for County water treatment facilities, and education and outreach programs, such as storm drain stenciling and the publication of information guides, which promote water quality education. The County also has coordinated efforts with the New York State Department of Environmental Conservation to provide funding guidance to private marina owners for construction of pump-out facilities. Many of the Citizen's Committee's simpler directives have been accomplished and the County is continuing to focus on other opportunities and innovations, such as watershed planning, to reduce nonpoint source pollution.

D. Watershed Planning

Westchester County recognized the need to identify threats to Long Island Sound, address these threats and implement strategies to ensure nonpoint source pollution reduction. A watershed planning approach was identified by the Nonpoint Source Committee as the best means to accomplish these goals. Watershed planning is a comprehensive planning process which addresses the balance between resource protection and economic development. This requires examination of development patterns or other land use changes which have direct influence over water quality and other natural features. Throughout Westchester County, local actions govern land use changes and development patterns. However, the nature of water quality problems does not follow municipal boundaries. Pollutants enter streams and rivers and then travel these systems to a water body, such as Long Island Sound. Along the way, the pollutants may flow through several towns, villages and cities. Therefore, it is important to establish geographic boundaries based on hydrology, rather than the traditional municipal bounds. A hydrologic boundary requires cooperation and coordination among local governments, especially since municipalities may have different land use goals and strategies, to govern land use changes and development patterns within the entire watershed area.

The Watershed Management Approach

The watershed management process includes a series of steps: assessment, planning, implementation, and evaluation. Assessing a watershed helps quantify and document the current conditions of the watershed and helps identify some general goals of the watershed planning process. Watershed assessment involves careful analysis of water resources and potential stresses, such as land development. The planning phase of watershed management focuses on managing objectives as well as deciding what needs to be accomplished through the watershed planning process. This phase is largely dedicated to selecting actions so that the most critical and feasible goals can be tackled first. The planning phase also identifies which types of management strategies will be effective in protecting, preventing or restoring the health of the watershed. When the planning phase is complete, a list of critical resources and management techniques will result. Implementation of these management techniques provides an opportunity to change land use and development patterns, as well as environmental protection efforts and determine whether or not the implemented strategies are working. Specific management practices can be implemented to correct pollution problems and specific regulatory controls can be introduced or revised to ensure pollution reduction. Watershed planning provides a solid framework to reduce both point and nonpoint sources of pollution and ensure the long-term health and recreational viability of a watershed.

The Nature of Westchester's Long Island Sound Watershed

The Long Island Sound watershed in Westchester County comprises approximately 68,000 acres and supports approximately one-half of the county's population. Between the northern and southern portions of Westchester County, there are drastic demographic and land use differences. The northern section of the county is less developed and less populated, as compared to the urbanized, highly populated character of the south county. This dichotomy can be seen through the nature of the Long Island Sound watershed. Table 1 provides a comparative analysis of the land use difference between the northern portion of the Long Island Sound watershed and the southern section of the Long Island Sound watershed. In summary, the largest difference is in the amount of undeveloped land (6,889 acres in the north and 847 acres in the south) and in the total amount of commercial, retail, office and mixed use land coverage (412 acres in the north and 3,002 acres in the south).

Table 1. Long Island Sound Watershed Land Use Summary

Land Use Type	**Northern Watershed Area (Ac.)**	**Southern Watershed Area (Ac.)**	**Total Watershed Area (Ac.)**
Undeveloped Land	6,889	847	7,736
Open Space (Public and Private)	2,893	7,502	10,395
Commercial/Retail/Office/ Mixed Use	412	3,002	3,414
Residential	14,890	23,628	38,518

Nineteen Westchester County municipalities in 10 subwatersheds of the larger Long Island Sound watershed contribute drainage to the Sound. To effectively plan for and manage the 68,000-acre watershed, the Long Island Sound drainage basin in Westchester County was divided into six subwatershed study areas as listed below in Table 2. A nonpoint source pollution control plan will be developed for each of these study areas that aims to: 1) prevent the increase of nitrogen and related nonpoint source pollution; and 2) implement strategies to maximize reduction of existing pollution within the Long Island Sound watershed.

Table 2. Subwatersheds of Long Island Sound.

WAC #	**Subwatersheds**	**Municipalities**
1	Silvermine, Mill and Mianus Rivers	Bedford, Lewisboro, North Castle, Pound Ridge
2	Byram River	Bedford, New Castle, North Castle, Port Chester
3	Blind, Beaver Swamp, and Brentwood Brooks, and Milton and Port Chester Harbors	Harrison, Mamaroneck (Village), Port Chester, Rye Brook, Rye City
4	Mamaroneck and Sheldrake Rivers, and Mamaroneck Harbor	Harrison, Mamaroneck (Town and Village), New Rochelle, Scarsdale, White Plains
5	Pine, Stephenson, and Burling Brooks, and Larchmont Harbor	Mamaroneck (Town and Village), Larchmont, New Rochelle, Pelham, Pelham Manor
6	Hutchinson River	Eastchester, Mount Vernon, New Rochelle, Pelham, Pelham Manor, Scarsdale

E. Watershed Advisory Committees

Because local government involvement is needed in any watershed planning process, it is necessary to work with all of the communities within the watershed's boundaries. Six intermunicipal Watershed Advisory Committees (WACs) were formed, each representing a study area within Westchester's Long Island Sound watershed. Municipalities in these study areas were asked to designate a qualified representative or representatives to their respective WAC(s). These representatives, with administrative and technical support from the County Department of Planning, are working together to develop local implementation programs that will reduce nonpoint source of pollution.

Watershed Advisory Committees are essential to Westchester County's watershed planning approach. The WACs were created to foster a cooperative relationship between all municipalities in each of the study areas within the Long Island Sound watershed and to recognize the importance of developing locally acceptable nonpoint source pollution control plans. Targeted land use measures, local ordinances, structural and vegetative best management practices, and education are most effective when implemented at the local level.

Elements of the Long Island Sound Watershed Process

The first phase of developing this plan - to control nonpoint source pollution in Long Island Sound - consisted of a natural resource and land use inventory of the study area. This inventory included mapping and identifying zoning and land use; open space; wetlands and hydrography; proposed flood plain, wetland and watercourse buffers; existing stormwater facilities; and golf courses. This process also included identifying large undeveloped land areas with the potential to be developed in the future, to identify resource protection, buffer and/or best management practice opportunities. These inventories are the base line for developing each nonpoint source pollution plan.

The second phase consisted of an assessment of both the natural features and existing water pollution controls in the Long Island Sound watershed and an assessment of the existing local ordinances related to water quality protection. The natural features assessment focused primarily on wetlands and watercourses to identify restoration and protection opportunities. Stormwater management practices, such as detention basins, were assessed and prioritized for water quality retrofit purposes. Surveying local ordinances provided a comparison of water quality protection measures with minimum standards to ensure consistency throughout the watershed study area. Particular attention was paid to wetland, stormwater, and erosion and sediment control ordinances. Recommendations pertaining to new and/or amended regulations for each municipality were then drafted.

The final phase of the Long Island Sound watershed planning process was to make recommendations and prioritize restoration opportunities, preservation opportunities and, where applicable, local ordinance revisions. Nonpoint source pollution reduction recommendations include a list of potential funding opportunities to assist municipalities implementing projects and programs which benefit water quality.

As part of Westchester County's Nonpoint Source Pollution Program, the County and Manhattan College have begun a water quality monitoring study, funded by a federal grant administered through the New York State Department of Environmental Conservation. The monitoring will determine nutrient loads (nitrogen and suspended solids) delivered to Long Island Sound from two watersheds in Westchester County via the Mamaroneck River and Blind Brook. This monitoring will be extrapolated to the entire Long Island Sound drainage area to determine base line conditions for nonpoint sources of pollution entering Long Island Sound from Westchester County.

It is important to recognize that continuous outreach and education plays a large part in controlling nonpoint source pollution. Public outreach and education should happen throughout the various stages of any watershed plan and long after its recommendations have been set forth and implemented. Planning and assessing a watershed can only be effective if the people who work, live and play in the watershed understand water quality issues, problems and their related causes.

STUDY AREA PROFILE

A. Land Area and Use

The Watershed Advisory Committee 3 (WAC 3) study area comprises the Blind Brook, Beaver Swamp Brook, Beaver Swamp Brook West (Brentwood Brook), Coastal Long Island Sound, Port Chester Harbor, and Milton Harbor subwatersheds. These subwatersheds occupy portions of the Town/Village of Harrison, the City of Rye, and the villages of Mamaroneck, Port Chester and Rye Brook in New York and the Town of Greenwich in Connecticut. For purposes of this profile, figures apply only to Westchester County; they do not, at this time, incorporate Connecticut.

The size of each subwatershed is as follows:

Subwatershed	**Total Area** (Acres)
Blind Brook	6,477*
Beaver Swamp Brook	1,962
Beaver Swamp Brook West	1,129
Coastal Long Island Sound	1,067
Port Chester Harbor	848
Milton Harbor	272
TOTAL	11,755

*that portion of the subwatershed in Westchester County.

Land uses within the study area include residential areas (3,132 acres), golf courses (1,430 acres), institutional/public assembly uses (1,250 acres), open space (717 acres), undeveloped land (419 acres), commercial/retain uses (252 acres), and manufacturing/industrial/warehousing uses (48 acres). Other land uses include transportation/communication/utility, office and mixed uses, which total 4,319 acres. The balance, 188 acres, consists of surface water (excluding streams). Ninety-four percent (94 percent) of the roads (189,531 linear feet of roadway), and the properties thereon, in the study area are connected to public sewers; the balance is served by septic systems.

Urban Areas

Watercourses and water bodies flow through and drain Harrison, Mamaroneck Village, Port Chester, Rye Brook and Rye City. These areas are generally urban and suburban in character. Therefore, the watershed itself is generally characterized as an "urban" watershed. The delivery of pollutants to streams from this watershed depends on the types of land uses, stormwater conveyance systems, and urban pollution prevention practices, including but not limited to street sweeping, yard waste collection and waste oil recycling programs. Table B summarizes the type and extent of urban land uses for each subwatershed in the WAC 3 study area. Urban land uses and their estimated pollutant generation rates are shown in table C. Highways, commercial areas, and high density residential areas (over 16 residential units per acre) are the largest sources of sediment, lead and zinc on a per acre basis. Medium density residential areas (6 to 16 dwelling units per acre) are less significant sources of sediment and lead, but are significant sources of pesticides, bacteria and household or automotive maintenance products which are sometimes dumped into ditches and storm sewers. Low density residential areas (2 to 6 dwelling units per acre) and very low density residential areas (less than 2 dwelling units per acre) are important where the improper use and disposal of pesticides, fertilizers and automotive maintenance products occur.

Table 3. Urban Land Uses in the WAC 3 Study Area

	Land Use in Acres									
	Residential				Non-Residential					
Subwatershed	Very Low	Low	Medium	High	Com	Ind	Transp	Inst	Open Space	Total
Blind Brook	2,496	594	225	28	594	3	8	942	1,022	5,912
Beaver Swamp Brook	590	240	55	0	152	0	52	176	644	1,909
Brentwood Brook	629	114	183	0	19	4	33	46	94	1,122
Port Chester Harbor	170	26	168	33	148	48	130	61	46	830
Milton Harbor	100	6	0	0	0	0	0	0	232	338

Table 4. Estimated Pollutant Generation Rates from Urban Land Uses

Land Use	Unit Area Load (pounds/acre/year)				
	Sediment	Phosphorus	Lead	Zinc	Other Concerns
Highways	880	0.9	5.5	2.1	Volatile organics
Industrial	1,000	1.5	2.4	2.1	Volatile organics
Commercial	1,000	1.5	2.7	2.1	Volatile organics
Shopping Centers	440	0.5	1.1	0.6	Volatile organics
High Density Residential	420	1.0	0.8	0.7	Pesticides
Medium Density Residential	190	0.5	0.2	0.2	Pesticides
Low Density Residential	10	0.04	0.01	0.04	Pesticides
Parks	3	0.03	0.005	*	Pesticides
Construction Sites	60,000	*	*	*	None

*pollutant loads were not estimated
Source: State of Wisconsin Department of Natural Resources

The pollutants in urban runoff depend on the configuration of "source areas." Source areas, characterized by streets, parking lots, rooftops and lawn areas (impervious surfaces as compared to pervious surfaces), are present in different proportions depending on the land use pattern throughout each subwatershed area. For example, residential areas contain more lawn area than commercial areas, while commercial areas have more rooftop, street and parking lot surfaces. Lawns can be important sources of fertilizers and pesticides. Rooftop areas are important sources of zinc and deposited atmospheric pollutants. Their connection to the storm drainage system may be direct or indirect depending on the use of downspouts, grassed areas, drain tiles, etc. Streets are sources of significant amounts of lead, cadmium, sediment, and other pollutants, depending on their condition and the amount of traffic.

Stormwater is one of the highest impediments to good water quality in urban areas. Stormwater is most commonly conveyed to streams through a combination of storm sewers, roadside ditches, grassed swales, and ponds. Storm sewers transport runoff rapidly without pretreatment or filtering before the runoff enters streams. Properly designed grassed swales generally reduce runoff volume because of infiltration, while grasses remove some pollutants from runoff before it flows into streams and storm sewer systems. The types and amounts of pollutants transported by runoff depend on the way that pollutant-bearing surfaces are connected to the storm drainage system. For example, commercial parking areas and arterial streets deliver the highest concentrations of lead, asbestos, cadmium, and street sediment because they normally drain via storm sewers that discharge directly into streams or water bodies.

B. Population

According to the 1990 Census, 46,634 people occupy 16,972 dwelling units in the study area, yielding a population density of 3.94 persons per acre. Most of the population (30,133, or 64 percent) is age 18 to 64, while 9,664 (21 percent) are age 17 and under; 6,837 (15 percent) are age 65 and older. Most of the dwelling units (10,252) are owner-occupied; the balance is rental units (6,082) or vacant (638). More than half of the dwelling units (approximately 53 percent) are single-family homes; the balance is multi-family home.

C. Natural Features

Wetlands

Approximately 921 acres of freshwater wetlands and 94 acres of tidal wetlands exist within the study area, yielding a total estimated acreage of 1,015. This estimate may be low. It is based only on areas of hydric soil (somewhat poorly drained, poorly drained, very poorly drained and flood plain) identified by the USDA-Natural Resources Conservation Service's *Soil Survey for Putnam and Westchester Counties* (1994). This survey is generally accurate to plus or minus two acres; therefore, hydric soil inclusions (wetlands) smaller than two acres are not counted in this estimate.

Five State-designated freshwater wetlands exist within the study area: NYS DEC Nos. G-3 and G-9 in the Blind Brook Subwatershed in the Town/Village of Harrison and NYS DEC Nos. J-1, J-3 and J-4 in the Beaver Swamp Brook Subwatershed in the City of Rye. State-designated tidal wetlands also occur along the coasts of Rye and the villages of Mamaroneck and Port Chester. The City of Rye co-regulates tidal wetlands with the State of New York.

Watercourses and Water Bodies

Approximately 188 acres (1.6 percent) of the 11,825-acre study area study area are covered by surface water (excluding streams) and approximately 1,497 acres (12.7 percent) are located within the 100-year flood plain. The following watercourses and water bodies in the study area are listed on the New York State Department of Environmental Conservation’s Priority Water Bodies List (1996):

Watercourse/Water Body	Primary Pollutant/Primary Pollution Sources
Beaver Swamp Brook	nutrients/urban stormwater runoff
Blind Brook	nutrients/urban stormwater runoff
Guion Creek	pathogens/urban stormwater runoff
Long Island Sound	pathogens/municipal infrastructure
Milton Harbor	sediment/construction-related activities

The land adjacent to Beaver Swamp Brook and, in particular, Blind Brook is substantially developed between the Long Island Sound shoreline and Interstate 95. Development adjacent to Blind Brook also is prevalent immediately north of Interstate 95 and the vicinity of Interstate 287. The density of development ranges in intensity from athletic fields to office building complexes to single-family homes on lots of less than 5,000 square feet. Beaver Swamp Brook and Blind Brook also have had significant flooding during this century. Some of the largest events occurred in July 1938, September 1944, October 1955, March 1962, June 1972 and September 1975. These storms caused extensive damage to houses, yards, streets and public buildings along these streams. The June 1972 storm produced the largest flow ever recorded at the Blind Brook gauge, while the September 1975 storm produced a record flow at the Beaver Swamp Brook gauge. Flooding along Blind Brook is caused by narrow channel width, obstructions, inadequate bridge openings, and, in the lower reaches, by tidal backwater. Flooding along Beaver Swamp Brook is primarily the result of low-lying adjacent land.

The Westchester County Generalized Drainage Basin Map divides the WAC 3 study area into six subwatershed areas. These subwatershed areas consist of the Blind Brook, the Beaver Swamp Brook, the Brentwood Brook (Beaver Swamp Brook West), Port Chester Harbor, Milton Harbor and Mamaroneck Harbor subwatersheds. There is an area located to the east of the Blind Brook and Milton Harbor watersheds which is not delineated as part of the above listed subwatershed areas. Within these subwatersheds, there is approximately 27 miles of stream. Within the study area, approximately 19 stream miles exist in Harrison, 9 stream miles in Rye Brook, 10 stream miles Rye City and 1 stream mile in Mamaroneck Village. Where streams flow along municipal borders, the stream will be counted separately in discussions regarding both municipalities. For example, Blind Brook forms portions of the municipal border between the Town/Village of Harrison and the Village of Rye Brook. The length of stream shared between these two municipalities is included in the total stream length for both Harrison and Rye Brook. General watershed characteristics and further discussion of the relationship between pollutant loadings and land use throughout each of the subwatershed areas are found in Table A.

General Stream Classifications

Subwatershed Name	**Subwatershed Area (ac.)**	**NYSDEC Classification**
Blind Brook	6,477	C
Beaver Swamp Brook	1,962	C /I (Tidal Areas)
Beaver Swamp Brook West	1,129	C
Port Chester Harbor	849	SB
Milton Harbor	272	SB
Unidentified Drainage Area	1,066	Overland Flow

Urban runoff carries a variety of pollutants to surface water. Pollutants found in urban runoff include heavy metals (lead, copper, zinc, cadmium and chromium) and a large number of toxic organic chemicals (polychlorinated biphenol, polycyclic aromatic hydrocarbons, pesticides and many others). Other substances in urban runoff include sediment, nutrients, bacteria, and protozoans. Urban runoff can have a detrimental affect on stream characteristics. For example, as pavement and rooftops prevent rainwater and snowmelt from soaking into the ground, water runs off the surface at a much higher rate. Streams crest at much higher levels than pre-development conditions. In effect, urban runoff produces “flashy” streams with temperatures and chemical characteristics that limit animal life and recreational uses. Stream bank erosion may increase as flow extremes occur. Flooding of adjacent property also may occur.

Steep Slopes

The southern and northern portions of the study area contain considerably fewer steep slopes (gradient of 15 percent or more) than the central portion between the Hutchinson River Parkway and Interstate 95. Steep slopes are most prevalent in the Blind Brook corridor.

D. Water Quality Infrastructure

Approximately 18 dry (detention) basins and 27 wet (retention) basins treat part of the stormwater drainage in the study area. The majority of dwelling units and businesses are connected to one of three county sewage treatment plants, two of which are located in the study area (one in Rye, the other in Port Chester). The study area is divided into three sewer districts: the Port Chester, Blind Brook and Mamaroneck districts. Ninety-four percent (94 percent) of the roads (189,531 linear feet of roadway), and the properties thereon, are connected to public sewers; the balance is served by on-site septic systems.

LOCAL COMPREHENSIVE
PLANS AND ORDINANCES

A. Existing Municipal Comprehensive Plans and Ordinances

Overview

An essential tool to maintaining a healthy watershed is local regulation. While federal and state laws address many of the general issues, they frequently target larger resources or larger developments. Therefore, local ordinances tailored to each municipality are critical in affecting the small incremental changes which bring about the problems facing the Long Island Sound watershed today.

A review of local comprehensive plans and ordinances of each WAC 3 municipality was undertaken to determine the extent of existing regulations that protect wetland and other aquatic systems and water quality. Specific ordinances pertaining to wetlands, stormwater management, erosion and sediment control, steep slopes, and animal waste were reviewed. Zoning and other ordinances, such as site plan and subdivision laws, were also looked at to determine if there are water quality protection features within these ordinances.

Town/Village of Harrison

The most recent comprehensive plan is the Master Plan Update adopted by the Harrison Planning Board in January 1988. In addition to assessing the municipality as a whole, the plan focuses on three sections of particular interest: downtown Harrison, the Silver Lake area and Purchase. The Silver Lake area and the Purchase area west of Purchase Street are within the Mamaroneck River watershed and will be discussed in greater detail under the work program of Watershed Advisory Committee 4. The remainder of the Purchase area (east of Purchase Street) drains to Blind Brook and downtown Harrison borders Beaver Swamp Brook; both of these areas are a part of the WAC 3 study area.

Several recommendations featured in the Master Plan Update are supportive of current water quality protection goals. Of particular note are the recommendations for the properties adjacent to Beaver Swamp Brook. The plan calls for preserving the land to the southeast of Grant Avenue as a natural area with possibly a walking trail from Osborn Road to Park Avenue. A report by the Beaver Swamp Brook Inter-Municipal Working Group, entitled “Beaver Swamp Brook: Plan for Restoration and Permanent Protection,”(dated April 1997) furthers this concept by describing in detail many of the current problems and the steps necessary to rectify them in order to truly restore the brook and its adjoining wetlands. The suggestions made in this report, which include restoration and preservation up to Oakland Avenue, are consistent with the goals of the WAC program and are, therefore, recommended herein.

The Master Plan Update recommends that the Purchase area remain low-density residential in nature and suggests the use of mandatory clustering to protect steep slopes, wetlands, and other features that preserve the environment or neighborhood character. The Master Plan Update also recommended the subtraction of wetlands, steep slopes and other natural features from the calculation of density in new subdivisions. These recommendations have been incorporated into the Village’s land use regulations and are consistent with the goals of the WAC program.

A stormwater management plan for the Beaver Swamp Book was prepared in October 1985 with support from the Westchester County Soil and Water Conservation District. While not necessarily inconsistent with nonpoint source pollution efforts, the plan concentrated primarily on the control of flooding rather than water quality.

The Town/Village of Harrison has an erosion and sediment control law, a water pollution ordinance, and a wetlands and watercourses ordinance. It also has building coverage limits and some buffer setbacks in its zoning ordinance.

Village of Mamaroneck

Mamaroneck Village's Master Plan of Development, adopted in 1986, acknowledges the environmental sensitivity associated with the Village's low-lying coastal location, much of which is within 100-year flood plains. The Master Plan discusses the indirect and direct adverse environmental impacts extensive development can have on flooding along the tidal tributaries and embayments and Mamaroneck River within and adjacent to the Village, but it does not directly address the issue of nonpoint source pollution and the impact development can have on the water quality of Long Island Sound.

The Village adopted a Local Waterfront Revitalization Program (LWRP) in 1984 and this program addresses to a modest extent nonpoint source pollution. It also puts forth policies concerning point source pollution and harbor sedimentation that can interfere with navigation. The program largely discusses stormwater runoff from industrial and commercial facilities and advises that stormwater runoff from all development be controlled largely for water volume, not quality, considerations. The LWRP further advises that structural flood control projects be implemented to "increase the carrying capacity of rivers." Such a recommendation, without careful consideration, can have a detrimental impact on the quality of downstream water resources. The program does suggest, however, that "best management practices will be utilized to minimize the nonpoint discharge of excess nutrients, organics and eroded soils into coastal waters."

The Village of Mamaroneck has a freshwater wetland ordinance, an erosion and sediment control ordinance, building coverage limits in its zoning ordinance, and an animal waste ordinance.

Village of Port Chester

The Village of Port Chester lies in three watersheds: the majority lies in the Byram River watershed; the southern portion of the Village drains to Port Chester Harbor; and small portions located on the west and north sides of the Village drain into Blind Brook. While the Byram River watershed is not part of this study, notable features found within this watershed are being considered with respect to the review of Port Chester's ordinances, which generally apply to the whole Village and not just to the watersheds covered under WAC 3.

Since the development of a comprehensive Master Plan in 1968, the Village of Port Chester has concentrated on revisions to its Zoning Code and a Local Waterfront Revitalization Program, adopted in 1992, to provide guidance on development in the Village. The Zoning Code employs the use of special districts to promote more efficient use of the land and protection of natural features. However, these are limited to larger parcels and do not affect smaller vacant parcels or increased development within developed properties. Additionally, given the urban status of much of the southern part of Port Chester, much of the focus has been on urban renewal. Urban renewal plans have also been incorporated by way of amendments to the Zoning Code and urban renewal districts were formed for the Village Center area and the marina area in 1977 and 1982, respectively. The latest Urban Renewal Plan amendment was adopted in 1991, which created a Marina Redevelopment Project Urban Renewal District that consisted of portions of the Village Center Urban Renewal Plan Area and the Marina Redevelopment Urban Plan Area. This plan, which was based on a proposal submitted by the Robert Martin Company, was never implemented. Nevertheless, it should be noted that while the Marina Redevelopment Project Urban Renewal Plan provides for elimination of substandard, blighted and deteriorating conditions in the subject areas, its redevelopment provisions do not include any natural restoration.

The Village's Local Waterfront Revitalization Program (LWRP) affects the areas adjacent to the Byram River and Port Chester Harbor. In general, it covers the area up to U.S. Route 1 and Interstate 95. Although the LWRP advocates policies of the State's Coastal Management Program, it focuses primarily on promoting public access and water-dependent/water-enhanced uses for the waterfront and less on protecting natural resources.

The LWRP notes that much of the Port Chester waterfront has been altered by pavement, bulkheads, and other development. Of the two areas identified as having "natural" shorelines, the LWRP marginally calls for the protection of one (Greyrock neighborhood) by prohibiting structures only within the area of mean high water. The other area (north cove of the proposed Columbus Park Marina), however, could be significantly impacted by the proposed marina, which the LWRP acknowledges would require bulkheading and piers and other structural shoreline modifications. Both of these areas are located in the Port Chester Harbor watershed. Furthermore, the proposed marina will be within an existing tidal wetland identified on the New York State Tidal Wetlands Map. The destruction of tidal wetlands, regardless of their size, runs counter to Policy 44 of the LWRP, which recommends the preservation and protection of these wetlands. Furthermore, the LWRP states that mitigation of development impacts to these wetlands "will be considered." Any development impacts should be avoided to the fullest practicable extent. Any unavoidable impacts should be fully minimized. And, in accordance with state and federal requirements, impacts must be fully mitigated.

The LWRP further states that because no "significant" fish and wildlife habitats, "natural protective features" or wetlands exist in Port Chester, dredging will have "no negative impacts." This assessment should be reconsidered. It does not consider the close proximity of Port Chester Harbor to Manursing Island, which is a New York Department of State-designated Significant Coastal Fish and Wildlife Habitat. It also does not consider the extensive tidal marshes in neighboring Greenwich. Additionally, the 1.7 acres of tidal wetlands along the Byram River should not be discounted as being insignificant. The LWRP, however, provides for limits on fuel tank storage within the LWRP area, calls for use of best management practices, and provides coverage and setback requirements.

The Village of Port Chester has an animal waste ordinance and some zoning provisions to provide for open space and conservation of sensitive features.

Village of Rye Brook

Subsequent to the incorporation of the Village of Rye Brook in 1982, the Village conducted two studies entitled "Rye Brook South Study" and "Rye Brook North." The South Study covered the older, medium density residential areas and local commercial districts in the southern part of Rye Brook, located around Ridge Street. The North study was a Generic Environmental Impact Statement concentrating on the potential development of large tracts of land located in the northern end of the Village that was prompted by three major development proposals in that area. In general, the northern communities are characterized by low-density residential areas and uses with considerable open space, such as institutions, office parks, and estates.

The South Study, which was completed in 1986, spoke of several vacant or anticipated redevelopment parcels located along Blind Brook. In many cases, it advocated protection of the sections of Blind Brook running through these parcels by allowing for cluster development and the preservation of open space abutting the water. Since that time, most of these properties have been developed, but with only partial implementation of the water quality objectives. Development of the former Lundell property into townhouses known as Brook Ridge provided for an approximately 60-foot buffer from the Blind Brook. Its maintenance as a manicured park, however, limits its overall water quality benefits. The subdivision of the property formerly owned by the Rye Town Hilton, known as Hidden Falls, presents both good and bad examples of water quality protection measures. True to its name, a substantial natural buffer obscures the stream, which can be heard cascading over rocks underneath the bridge. Above the dam, however, the homes and a clubhouse with an outdoor pool are built right to the banks of the pond. Furthermore, the majority of this development was built on steep slopes. There is only one remaining substantial vacant parcel along Blind Brook in the southern part of Rye Brook. This property is located on the south side of Bowman Avenue and belongs to the City of Rye. The Study suggests office development as the most appropriate use. The City of Rye, which acquired the property for flood control purposes, currently has no plans to develop the site.

The North Study evaluated the potential development of five large parcels of land totaling 427 acres in size located on the west side of King Street, south of the Westchester County Airport. It recommended amendments to the Planned Unit Development (PUD) provisions in the Zoning ordinance that would allow mixed use development on four of the five parcels. These amendments were adopted in 1993. While one of the purposes of the PUD overlay zoning was to conserve natural resources, the regulations do not expressly provide for this in its standards or requirements. Its buffer requirements apply solely to property lines and its open space requirements target recreational use.

The Village of Rye Brook has an Erosion and Sediment Control ordinance, a Wetlands and Watercourses ordinance, and animal waste regulations.

City of Rye

The City of Rye is currently guided by its 1985 Development Plan and a Local Waterfront Revitalization Program, which was adopted in 1991. Overall, both plans promote policies which support water quality protection. As early as 1946, the City has recognized the natural beauty of the Blind Brook and in its first master plan suggested the creation of a trailway along the Blind Brook. In its 1963 Development Plan, the City recognized the importance of preventing development within flood plains and recommended acquisition of such sites along both the Beaver Swamp Brook and Blind Brook in order to preserve them as natural conservation areas.

The current Development Plan supports maintaining open spaces and natural features, discourages development within flood plains and wetlands, suggests various techniques to offer alternatives to subdivisions and suburban sprawl, including the use of clustering and the possible conversion of large estate homes into condominiums to preserve common grounds. It also advocates vegetative buffers between environmentally sensitive areas and development. Instead of developing remaining natural areas to fulfill the City’s waterfront recreational desires, the plan recommends awaiting opportunities for acquisition of existing waterfront clubs or requiring public access if they are developed for non-water dependent uses. The 1985 plan proposes preservation by public means of the Hummocks, Hen Island and the marshes on Manursing Island, should preservation under private ownership fail and continues to advocate the acquisition of floodprone parcels along Blind Brook and Beaver Swamp Brook.

Its Local Waterfront Revitalization Program contains many similar policies that protect water quality, particularly with respect to the coastal area. It prompted the creation of three new zoning districts--Membership Club District, Waterfront Recreation District and Conservation District--along Milton Harbor and the Long Island Sound shoreline, with added special provisions, such as lot coverage limits, to preserve natural features. It also recommended additional standards for subdivisions in the coastal zone, including the preservation of wetlands and flood plains and the limitation of development within 100 feet of mean sea level for those properties bordering the waterfront. Most of the projects proposed in the LWRP to further public enjoyment of the waterfront will not significantly impact water resources as they are small in scope and utilize existing developed facilities. However, with respect to the proposed launch facility at Playland Park, its placement will need to be carefully considered in light of the prospects for restoring wetlands in this location. With respect to the proposed walkway along Blind Brook, it is recommended that improvements be limited to truly protect the natural habitat. While creating a walkway along Blind Brook is beneficial for a variety of reasons, including providing pedestrian access from Rye Nature Center to Disbrow Park and Oakland Beach Avenue, the walkway should be no more than a nature trail and not be altered by man-made landscaping.

The City of Rye has an erosion and sediment control ordinance, stormwater management ordinance, wetlands and watercourses ordinance, and water quality protection provisions in its zoning ordinance.

B. Recommendations

Watershed-wide Strategies

Increase Awareness and Enforcement - Awareness and enforcement of all laws and regulations related to water quality are critical. For example, erosion and sediment control measures are frequently not implemented according to approved plans or are not properly maintained during the life of the project. Therefore, they do not perform their intended function. As another example, three of the five municipalities in the WAC 3 study area have an existing animal waste ordinance intended to reduce the amount of such wastes that enter water resources. One way to advise dog owners that they are required to pick up after their pets is to give them informational literature when they license their dogs or to include such literature in mailings.

Designate Individual or Group Within Each Municipality to Further the WAC 3 Plan - This plan will be successful only if it is endorsed, at least in principle, by most or all of the municipalities in the study area. Once the plan has been endorsed, it must be transformed from recommendations on paper to actions that will improve the health of the area's water resources and Long Island Sound. Each municipality should designate a municipal staff member, such as a municipal planner or engineer, and/or a group or organization, such as a municipal conservation advisory council or board, to further the recommendations of this plan. The designee should act as a coordinator and facilitator in advancing the plan's recommendations and act as a liaison to WAC 3, Westchester County Planning Department, Westchester County Committee on Nonpoint Source Pollution in Long Island Sound, and any other entity that may provide technical, administrative or other support.

County of Westchester

WAC 3 recommends that whenever the County of Westchester undertakes a capital project on County-owned or -controlled land that it notify the municipality(ies) in which the project is located before project design and construction, especially if the project has potential environmental impacts. The purpose of such notification is to allow municipal environmental concerns, especially those regarding water quality, to be considered during a project's design and construction. Such notification should be for all projects in the WAC 3 study area, regardless of their status under the New York State Environmental Quality Review Act (SEQRA).

Town/Village of Harrison

Formally Designate The "Environmental Advisory Committee of Harrison" As Conservation Advisory Council or Conservation Board - Harrison currently has an informal committee that is functioning in an informal and unofficial capacity as the municipality's environmental steward. WAC 3 recommends that the Town/Village of Harrison formally designate this group of residents as the municipality's official Conservation Advisory Council or Conservation Board per New York State's enabling legislation.

Amend Erosion and Sediment Control Ordinance - The Town currently has two ordinances which apply to land-disturbing activities (apart from developments): Chapter 133, entitled "Providing for Regulation and Licensing of the Excavation or Regrading of Land," adopted in 1970, and Chapter 130, "Erosion and Sediment Control," adopted in 1982. The Excavation and Regrading ordinance involves a separate administrative permit process and applies to any regrading activities or commercial excavation. The Erosion and Sediment Control ordinance applies to any action requiring a municipal permit. A separate permit is not issued, however. Instead, conditions are placed on any other appropriate municipal permit (s). The Town should consider combining these ordinances, which overlap to some extent. Furthermore, a combined ordinance should limit the authority of the town/village building inspector who, under Chapter 133, is now given authority to grant or deny applications for any regrading project regardless of its size and scope. A new, combined ordinance might give the building inspector authority to grant or deny applications for regrading one acre or less of any site and require that applications for any project or projects over one acre be reviewed and acted on by the Planning Board or other appropriate board or commission.

While the Erosion and Sediment Control ordinance references the County best management practices manual, the Town also will benefit by incorporating specific guidelines and standards as described in the County Soil and Water Conservation District's *Model Ordinance for Erosion and Sediment Control,* NYSDEC's "Erosion and Sediment Control Guidelines" (Technical and Operations Guidance Series 5.1.10), and Westchester County *Best Management Practices Manual for Erosion and Sediment Control* to ensure consistent and full compliance with best management practices. Finally, enforcement of erosion and sediment control guidelines, practices and plans is critical in controlling sediments and other nonpoint source pollutants. Erosion and sediment control plans and practices should be periodically monitored to ensure that they are properly implemented, installed and maintained. Field observations in Harrison have indicated a lack of erosion and sediment control practices at several active construction sites, pointing to the need for better enforcement of erosion and sediment control guidelines and plans.

Adopt a Stormwater Management Ordinance - The Town should adopt a separate stormwater management ordinance. Stormwater is currently regulated to varying degrees under several separate ordinances: Subdivision, Flood Prevention (Chapter 146), Water Pollution (Chapter 230), and Erosion and Sediment Control (Chapter 130). These ordinances either speak to regulating the volume of stormwater runoff or provide protection to water quality in very limited circumstances. The Water

Pollution ordinance, which speaks primarily to water quality, applies only to the construction or operation of a facility having 20,000 square feet or more of impervious surface within 500 feet of any tributary to a drinking water resource, namely the Kensico watershed. In addition, it does not provide detailed guidelines or standards to provide such protection. The Town should refer to current New York State DEC guidelines, including *Reducing the Impacts of Stormwater Runoff* (1992) and “Stormwater Management Guidelines for New Development” (Technical and Operations Guidance Series 5.1.8), in addition to the County’s *Best Management Practices for Stormwater Management*, in preparing an ordinance that controls stormwater runoff quality and quantity in all of its watersheds. In addition, the New York City Department of Environmental Protection’s “Rules and Regulations for the Protection from Contamination, Degradation and Pollution of the New York City Water Supply and Its Sources” should be consulted for further guidance on water quality protection.

<u>Adopt a New Freshwater Wetlands Ordinance</u> - The current Freshwater Wetlands ordinance is based on the New York State’s Freshwater Wetlands Act and promulgating regulations, which is highly generalized. Since the State Freshwater Wetlands Map includes only significant wetlands of substantial size (12.4 acres), it does not recognize the many local wetlands that need protection. The Town should rewrite this ordinance in accordance with the County Soil and Water Conservation District’s *Model Ordinance for Wetland Protection* (May 1997). This would provide for a more functional definition of wetlands, a more defined set of standards, and incorporate wetlands mitigation considerations. In addition, it will allow for the inclusion of watercourse protection. Although civil and criminal sanctions are included, the lack of enforcement has undermined the effectiveness of this ordinance. The Town will need to consider ways to bolster its enforcement actions if it is to truly succeed in protecting wetlands.

<u>Consider an Ordinance on Steep Slopes</u> - There are a few scattered sites within the Blind Brook and Beaver Swamp Brook watersheds that exhibit slopes of 15 percent to 25 percent. Slopes of 25 percent or greater exist in the Mamaroneck River watershed. This area will be analyzed under Watershed Advisory Committee 4 and a recommendation will be made at that time. However, the Town may wish to begin to consider a Steep Slopes ordinance in light of the presence of significant steep slopes within its borders and the potential for development proposals to arise prior to completion of the WAC 4 plan.

<u>Amend Zoning Ordinance</u> - While a purpose of the zoning regulations is to protect and preserve the natural environment and its ecological systems, there are few provisions that actually provide for such protection. Harrison’s zoning ordinance contains building coverage limits (which it terms “lot coverage”) for residential and some non-residential districts. Only two districts, Special Business (SB-35) and General Commercial (GCD) contain floor area ratio requirements. The districts with no building coverage or FAR requirements involve professional, neighborhood and central business zones, which are located in essentially fully developed areas. Since paved areas and other impervious surfaces contribute to stormwater runoff and water quality impacts, true lot coverage limits - which apply to all types of impervious surfaces and not just buildings and structures - should be added to most, if not all, zoning districts.

Existing buffer strip provisions relate to vegetative screening of developments from roadways only in the Purchase area and from roadways, residences, and between businesses in the special business districts. Provisions for fifty-foot setbacks from streams and other bodies of water are included (Section 235-31), but they do not apply to the “R-75,” “B,” and “MF” residential districts and the “PB,” “NB,” “CBD,” and “MFR” commercial districts. In these districts, any actions requiring a building permit on properties adjoining or containing a stream are reviewed by the Town Engineer and then his recommendation must be approved by the Town Board by resolution. While these districts are located in the downtown, highly developed portion of Harrison, there should be some criteria for establishing buffer/setback distances and physical composition to assist the Town Engineer in making his recommendation. Furthermore, the existing 50-foot-wide regulated setback from streams and water bodies for all other districts should be expanded to include wetlands and be increased to 100 feet, at least where the wider regulated setback can be accommodated in the less developed portions of northern Harrison. Such zoning code amendments should be coordinated with the proposed recommendation to revise the Town's Freshwater Wetlands ordinance.

Harrison also should consider zoning and master plan revisions to strengthen its ability to preserve open space in conjunction with water quality protection. For example, conservation easements over streams and wetlands as well as the regulated setbacks thereto should be made a condition of approval for new subdivisions, golf courses and commercial and agricultural development, especially along the major Long Island Sound tributaries and their headwaters.

<u>Adopt Animal Waste Ordinance</u> - To minimize feces contamination of waterways, the Town should adopt regulations requiring owners to pick up after their pets. The ordinance should include fines sufficient to deter violations and must be followed up by public education and enforcement. Harrison also should require a minimum 100-foot-wide buffer between certain agricultural components, such as manure stockpiles and riding rings and paddocks, and streams and wetlands. Livestock wastes contain a significant amount of nitrogen and other nutrients as well as bacteria. These can adversely impact water resources.

Village of Mamaroneck

<u>Update Master Plan and LWRP (Address WAC 3 Recommendations In Harbor Management Plan)</u> - Although the Village's LWRP cites the best management practices guidelines of Westchester County, it also should recommend adherence to the New York State Department of Environmental Conservation's *Reducing the Impacts of Stormwater Runoff* (1992).

Although the LWRP and Master Plan discuss coastal natural resources and offer some protective recommendations and policies, they also should include more specific recommendations and policies for improving the quality of tributaries and embayments of Long Island Sound. These recommendations should encompass the reduction of nonpoint source pollutants from residential, municipal, commercial and industrial facilities. WAC 3 also urges the Village to address the recommendations made in this report in the Village's draft Harbor Management Plan, which is currently being reviewed by Village officials and the public. WAC 3 also supports the designation of Mamaroneck Harbor as a "no-discharge zone" for boaters.

<u>Amend Freshwater Wetlands Ordinance</u> - The Village's Freshwater Wetlands Ordinance (Chapter 192) is based on the State's Freshwater Wetlands Act (Article 24), but is somewhat more inclusive; it calls for the identification of wetlands based on the Article 24 definition but has no minimum size threshold. However, the ordinance lacks a specific description of how wetlands are to be identified and allows for an ambiguous determination by the Planning Board. It also lacks mitigation sequencing requirements and could benefit from more specific criteria in its standards for issuing a permit. Amendment of the existing ordinance to include these items as well as a few others as found in the Soil and Water Conservation District's *Model Ordinance for Wetland Protection* is recommended.

<u>Adopt Tidal Wetlands Ordinance</u> - The Village contains a significant amount of tidal wetlands along the Long Island Sound shore. As such, the Village would benefit by adopting a local tidal wetlands ordinance that would supplement the State's tidal wetlands permit program. The State's regulations are limited to the seaward side of bulkheads or seawalls that are greater than 100 feet long. Much of the Village's shoreline has seawalls. While the landward side of seawalls typically is no longer wetland, these are adjacent areas where certain smaller-scale activities can cumulatively impact the health of adjoining

wetlands. Through a local tidal wetlands ordinance, the municipality has an opportunity to regulate activities in adjacent areas.

Adopt a Stormwater Management Ordinance - The Village has worked with neighboring municipalities to develop an intermunicipal stormwater management plan for the Beaver Swamp/Brentwood Brook subwatershed. This plan provides for detention capable of handling a 100-year frequency storm, but applies only to the Beaver Swamp/Brentwood Brook subwatershed, which is in WAC 3 and affects only a small portion of the Village of Mamaroneck. Other references to stormwater management are found in various ordinances, including the Village's Housing Standards Ordinance (Section 226-16) and its joint Flood Damage Prevention; Erosion and Sediment Control Ordinance (Section 186-9). Section 226-16 simply requires proper drainage away from buildings, sidewalks, and the like. Section 186-9 references the County's *Best Management Practices Manual for Stormwater Management*, but primarily in relation to controlling off-site erosion. The Village would benefit from adopting a stormwater management ordinance which consolidates all requirements into one section and incorporates the new NYSDEC guidelines in addition to the provisions of the County's stormwater runoff control manual.

Amend Flood Damage Prevention; Erosion and Sediment Control Ordinance - The Village's regulations on Erosion and Sediment Control (Article II of Chapter 186) incorporate most of the currently recommended standards. Only a few standards need to be added to complete the ordinance. They include the following: design of erosion controls to handle impacts of up to a 10-year frequency storm, diversion of clean surface water runoff around construction areas, stabilization of all pipe outlets, and requiring that controls be functional before any land is disturbed. It should be noted that the Coastal Zone Management Commission, which has land use regulatory authority in the village, requires best management practices for new construction, including practices related to erosion and sediment control (see Chapter 146, Coastal Management ordinance).

Amend Zoning Ordinance - The Village provides building coverage limits as well as FAR standards in its zoning regulations. It does not, however, include lot coverage limits. The addition of lot coverage limits is recommended to ensure that impervious surfaces, not just those of buildings, are regulated. In addition, sensitive areas (e.g., wetlands, steep slopes) should be excluded in whole or in part in FAR and allowable coverage calculations.

Village of Port Chester

Revise LWRP - The LWRP should be revised to reflect a more balanced approach between increased public access and the development of water-dependent uses and the protection and preservation of natural resources, which are essential to improving water quality in Long Island Sound and its tributaries. Some projects proposed by the Village's LWRP, such as the Columbus Park Marina, promote public access and water-dependent uses. However, impacts from these projects could, if not properly mitigated, cause an overall loss of tidal wetlands and increase boating activity without providing adequate pump-out facilities. The marina, for example, also could result in a parking lot adjacent to the water's edge. These impacts run counter to many of the tenets of the NYS Coastal Management Program, the Long Island Sound Study, and the County's intermunicipal nonpoint source pollution control initiative. At minimum, the LWRP should discourage the elimination of the village's remaining wetlands. It also should mandate the creation of new wetlands in the same watershed to replace existing wetlands destroyed by unavoidable impacts. The LWRP should take a pro-active position, not only calling for the preservation of remaining wetlands but also the restoration and/or creation of wetlands in the Village, particularly on public property. The Village should incorporate such standards into any urban renewal plans affecting the waterfront. Furthermore, setbacks to the mean high water line should be increased to allow for a greater buffer area. Finally, LWRP references to the old County best management practices (BMP) manual should be updated to refer to the County's latest erosion and sediment control manual.

Adopt an Erosion and Sediment Control Ordinance - The Village of Port Chester is highly developed, with very few parcels of vacant land remaining. While the Village's site plan regulations (Section 345-23) ordinance calls for the inclusion of erosion and sediment control measures "with reference to Westchester County's Best Practices Manual," it only applies to projects subject to site plan approval. The Village should review the Westchester County Soil and Water Conservation District's *Model Ordinance for Erosion and Sediment Control* (August 1986), and adopt a similar ordinance. Proper erosion and sediment control of all land-disturbing activity, except for routine maintenance and emergency activities, will help reduce deposition into the Byram River and Port Chester Harbor and ultimately reduce the need for dredging.

Amend Site Plan and Subdivision Review Procedures - As previously mentioned, since the Village of Port Chester has few vacant parcels remaining and none of significant size, a separate stormwater management ordinance may not be necessary. The Village's Flood Damage Prevention ordinance (Chapter 39), which is modeled after the Federal Emergency Management Agency model ordinance, focuses on preventing increases in flooding and flood damage to property . The Village's Site Plan Review regulations require adequate drainage facilities to minimize flooding and property damage. Neither set of regulations provide for water quality protection. Stormwater management provisions that address water quality issues should, therefore, be incorporated into the Village's existing Site Plan and Subdivision review regulations to ensure that water quality protection is considered whenever possible [refer to NYS DEC guidelines (Reducing the Impacts of Stormwater Runoff (1992)]. Similarly, since the Village contains only a few areas with steep slopes, provisions to protect steep slopes should be included in the Site Plan and Subdivision regulations as well. The Zoning Code only mentions steep slopes provisions for R2F zoning districts, whereas the LWRP identifies steep slopes in the R7, DW and M1 districts within the LWRP boundary.

Amend Zoning Code

The Village of Port Chester's Zoning Code employs some of the techniques of controlling development in favor of water quality preservation. However, they are scattered throughout the regulations applying only in selective cases. Only in some special districts and in the site plan review provisions, which do not apply to one- or two-family residences, is the preservation of natural features endorsed. Similarly, only one special district, the Planned Residential Development District, provides for a limit on lot coverage. The maximum floor area ratios that are provided apply to structures and do not limit other types of impervious surfaces, such as pavement. For many of the residential districts , there are minimum requirements for "usable open spaces." However, this is defined as areas "designed for outdoor recreational use" and "household activities normally carried on outdoors," and does not necessarily guarantee preservation of natural features. The Zoning Code should be amended to provide lot coverage limits and buffer zones for all districts to ensure the preservation of natural features near wetlands and water bodies.

Village of Rye Brook

Amend Erosion and Sediment Control Ordinance - The ordinance should be amended to capture land-disturbing activities not covered by permits, because municipal approval is not required for all substantial land-disturbing activities. While the ordinance refers to the Westchester County best management practices manual as a source of guidance in preparing erosion and sediment control plans, specific requirements for a proper erosion and sediment control plan should be incorporated into the ordinance to ensure that suitable plans are prepared for review and to assist in the installation, phasing and inspection of erosion and sediment control measures, which are often overlooked. Should the ordinance be revised, it should reference the current Westchester County *Best Management Practices Manual for Erosion and Sediment Control* (1991) and/or the New York State *Guidelines for Urban Erosion and Sediment Control* (1997). In addition, the fines should be increased with minimum, rather than maximum, fines established to more effectively deter violations. Also, the ordinance states that permit applications involving the "excavation of five thousand (5,000) cubic yards, shall be referred by the Building Inspector to the Westchester County Soil and Water Conservation District for review and comment...." Although the District is capable of providing technical assistance in the review of erosion and sediment control plans, the Village has not requested this type of assistance in at least five years. The Village should use the District's services, as is required by its erosion and sediment control ordinance.

Adopt a Stormwater Management Ordinance - Although most of properties in the Village have been developed to some extent, there is room for greater development, particularly in the northern section of the Village, which is comprised of large parcels that contain substantial amounts of open space. These areas are part of an overlay zone for Planned Unit Developments (PUDs), which allow for a mixture of single-family residences, townhouses, apartments and limited commercial, retail and institutional uses, in addition to office/research uses in the OB-1 district. Provisions for the treatment of stormwater for both water quality and quantity need to be provided. The Village should refer to the NYSDEC's *Reducing the Impacts of Stormwater Runoff from New Development* and the County's *Best Management Practices Manual for Stormwater Management* in developing an effective stormwater management ordinance. At the very least, the Village should include such provisions in its existing review/approval procedures.

Amend Site Plan and Subdivision Regulations to include Steep Slope Provisions - The Village contains several areas with slopes in excess of 15 percent, namely along Ridge Street, at the Rye Town Hilton, along the west branch of the Blind Brook from I-287 to the Hutchinson River Parkway, and in the northern section of Rye Brook. Many of these areas already have been developed, so provisions to protect steep slopes are better added to existing site plan and subdivision review regulations to safeguard the remaining undeveloped areas.

Amend Wetlands and Watercourses Ordinance - Overall, the Village has adopted a very strong and protective Wetlands and Watercourses ordinance. The only recommendations offered by WAC 3 involves the section on mitigation plan requirements. A wetland replacement ratio of 1.5:1 or better should be indicated in section 245-9A(1) with respect to the replacement of wetlands. The ordinance is not clear as to how watercourses are to be replaced at a ratio of 1:1 if altered by development. Similarly, it is unclear how wetland/watercourse buffers or wetlands are to be enhanced or restored at a ratio of 2:1 if disturbed by proposed activities. The Westchester County Soil and Water Conservation District's rewritten *Model Ordinance For Wetland Protection*, dated January 1998, provides recommended language concerning mitigation. In regard to buffer mitiation, typically, this involves improving the density and diversity of native woody plant species to offset the loss of buffer area or implementing preventive measures to protect the natural condition and functions of the wetland/watercourse which the buffer was intended to protect.

Amend Zoning Ordinance - Except for zone OB-1-Campus/Office Building District, no other zoning district incorporates true lot coverage limits (lot coverage includes buildings and all paved/impervious surfaces). Section 250-37, entitled "lot area coverage," pertains to residential structures only, such as buildings and decks, and not to all impervious surfaces. Since impervious surfaces in any area can contribute to stormwater runoff within a watershed, the Zoning Ordinance should be amended to include lot coverage limits, or "maximum gross land coverage" (as called in the regulations for the OB-1 District), for all zoning districts. Consideration also should be given to subtracting from the base lot area all or a portion of the area covered by more sensitive natural resources or topography, such such as steep slopes and wetlands. The area just south of Bowman Avenue should be rezoned from R-10 to a lower density and/or be allowed to cluster its development to permit greater collective setbacks from the adjacent Blind Brook "pond." As recommended by the Village's Rye Brook South Study, the area closest to the Rye Ridge complex, which is currently zoned C1-P-Planned Neighborhood Retail District but is mostly covered by water, "should be kept open to provide a buffer and recreational resource to village residents."

City of Rye

Amend Surface Water, Erosion and Sediment Control Ordinance - While this ordinance provides the fundamental provisions to protect against stormwater, erosion and sediment impacts, greater identification of the standards and requirements should be included in the ordinance to ensure that they are consistently applied. Reference to the best management practices manuals of the County are made (the latest erosion control manual is now entitled *Best Management Practices Manual for Erosion and Sediment Control*, dated 1991). However, other references, particularly the NYSDEC's Technical and Operations Guidance Series documents and *Reducing the Impacts of Stormwater Runoff*, offer additional guidance that should be considered. Among the standards worth articulating is the schedule for inspections to ensure that the erosion control measures are maintained. In addition, fines should be increased and minimum amounts set that should begin much earlier than the 30-day grace period currently given. With respect to surface water control, only control of stormwater runoff quantities appear to be considered. Provisions to provide for first-flush and other water quality treatment need to be added to the ordinance.

Amend Wetlands and Watercourses Ordinance - Overall, the City has a strong ordinance for protecting wetlands and watercourses. It uses the *1989 Federal Manual for Identifying and Delineating Jurisdictional Wetlands* and regulates activities in and within 100-feet of a wetland or watercourse. To further strengthen this ordinance, the City should include under the section on wetland mitigation a replacement ratio standard of at least 1.5 to 1, or in the case of disturbance to buffers, to provide for enhancement of the remaining adjacent area.

Amend Zoning Ordinance - The City also is to be commended for incorporation of water quality protection measures in its Zoning ordinance. Innovative zoning districts, such as Residential Flood plain and Wetland Preservation District and Conservation District, reflect regulations specifically aimed at protecting wetlands, flood plains and other natural resources. For all areas not covered by such districts, it is recommended that maximum lot coverage limits be provided. The success of these measures, however, is directly related to the willingness of municipal land use boards and commissions to use and enforce them.

Adopt Animal Waste Ordinance - To minimize feces contamination of waterways, the City of Rye should adopt regulations requiring owners to pick up after their pets. The ordinance should include fines sufficient to deter violations and must be followed up by public education and enforcement.

OUTREACH AND EDUCATION

Even the best planned watershed management and nonpoint source pollution control programs cannot succeed without community participation and cooperation. Strong public information and education programs are invaluable tools to be planned for and nurtured. The following is a recommended strategy for fostering a long-term public information and education program for WAC 3.

A. Existing Programs

A number of avenues have already been explored and efforts made to begin the education process in the WAC 3 study area. For example, a storm drain stenciling program is in place in all or parts of Rye City, Rye Brook, Harrison, Mamaroneck Village and Port Chester. A grant has been obtained and municipal monies set aside which will continue the effort begun and implemented two years ago. This program is not complicated to implement, and has an immediate effect due to its high visibility. It is of interest to young people as well as adults and is relatively inexpensive to implement provided the volunteer base is adequate. This program may be carried out with the help of volunteers, including those from civic organizations such as fraternal organizations, garden clubs and environmental groups, and youth groups, such as school clubs, science classes or scouts.

Three nature centers exist in the WAC 3 study area. All are in Rye City. The City-owned Rye Nature Center on Boston Post Road offers environmental education programs to children and adults. It encompasses a section of Blind Brook, which potentially can serve as an outdoor classroom for nonpoint source pollution control and stream management education. Two County-owned nature centers also exist in Rye, at Marshlands Conservancy on Boston Post Road and at Edith Read Fish and Wildlife Sanctuary near Playland Park. Both of these facilities are situated on the Long Island Sound coast and offer education programs for children and adults.

The State University of New York at Purchase (Harrison) offers environmental degree programs, and some of its students have become involved in water sampling projects along the Blind and Beaver Swamp brooks. The university's environmental program students also are initiating a newsletter, which could provide an avenue for nonpoint source pollution education. Also in Harrison, middle school students have been sampling the waters of Beaver Swamp Brook West (Brentwood Brook). Water sampling also is being conducted in other parts of the WAC 3 study area, including the American Yacht Club on Milton Point in Rye City.

B. Recommended Strategies

To best carry out the objectives of the public awareness program in the WAC 3 study area, target audiences must be identified and carefully assessed; specific activities to match their interests and individual needs must be designed. It is important to remember that to be successful the content of the message must change to suit the audience, different practices must be promoted, and flexibility must be exercised in implementing particular program policies and ideas.

A potential tool for public outreach and education is environmental partnerships, such as the New Rochelle Environmental Partnership in the WAC 5 study area. The formation of similar environmental partnerships in the WAC 3 study area is recommended. The New Rochelle Environmental Partnership was formed two years ago and is dedicated to educating the public about watershed management and nonpoint source pollution control in New Rochelle, with emphasis on "neighborhood watershed awareness." This alliance includes representatives of local and regional civic organizations (e.g., Save the Sound Inc.), the city's public school system, and colleges, as well as government agencies of the City of New Rochelle and County of Westchester. This partnership is a strong foundation for public education activities and source of potential volunteers.

The Watershed Education Program Guide published by the Westchester Land Trust and currently being implemented in at least two Westchester County middle schools should be a teaching guide for many other schools in the county. The Guide is a series of lesson plans which may be used as hands-on science projects to teach students about the watershed they live in; to field test the rivers or streams within it; to learn about the effects of human lifestyles on water quality; and to evaluate and disseminate student findings. Science teachers in the WAC 3 study area should use the Guide whenever feasible as part of their science curriculum. For example, students at Rye City and Rye Neck middle and high schools have easy access to Blind Brook and Beaver Swamp Brook, respectively. These streams run adjacent to school property. Here, they can implement water quality monitoring and learn about stream ecology and restoration in their own back yard. A section of Blind Brook also traverses the Rye Nature Center property, providing a good medium for watershed and stream management education.

The Guide can be augmented by materials available through the Westchester County Planning Department and the U.S. Environmental Protection Agency, Region 2, in New York City, such as maps, aerials, fact sheets, brochures, and other informational literature.

Media

- Approach local newspapers (weekly and daily) about a regular column (weekly, bi-weekly, or monthly) to feature nonpoint source pollution control activities (municipal and County activities). If applicable to the Plan, these columns could also feature other municipal, County, state and federal activities as well as those by private business and industry. Other techniques include press releases and photographs with captions.

- Approach local radio stations about short regular features (public service announcements) or guest speakers on regular talk shows.

- Approach local cable/news stations with ideas described in this section of the Plan. Suggestions include a 60-second commercial or update to focus on nonpoint source pollution control efforts in the community.

- Submit articles to newsletters such as those for governmental and civic associations, chambers of commerce, or corporations, or initiate a new newsletter for inclusion with other municipal mailings that focuses on nonpoint source pollution and ways residents can assist in its control.

- In conjunction with municipal and County parks and recreation departments, implement a campaign that focuses on minimizing chemical use and other adverse landscaping practices.

- Use public gatherings, club meetings, special conferences, and workshops to explain the nonpoint source pollution control program, customizing the message to the audience. A speakers bureau of municipal and County officials also should be formed; face-to-face communication to a specialized audience provides a powerful opportunity to deliver a message, answer questions, and clarify ambiguities.

Corporations/Businesses

- Identify target corporations/businesses in the WAC 3 study area and approach them about co-sponsoring nonpoint source pollution educational activities from printing/layout of publications to best management practices implementation on their properties (chemical use minimization, buffer establishment, stormwater management basins, etc.).

- Draft sample inserts for bills (water, electric, tax, etc.) that describe the nonpoint source pollution control program and various components (fertilizer and pesticide use minimization, soil erosion and sedimentation control, buffer corridor protection, septic maintenance, etc.).

- Approach private golf courses about nonpoint source pollution control issues, landscaping practices, and implementing best management practices.

- Approach and meet with golf course and landscape/lawn care industry leaders and organizations about the nonpoint source pollution control issues, landscaping practices, and implementing best management practices.

- Approach small businesses, possibly through the Chamber of Commerce, about their role in controlling nonpoint source pollution. Businesses should strive to implement some prevention measures for which they can receive positive public relations. Encourage mention of the prevention measures that have been implemented in its newsletter and press releases.

Targeted Education

- Coordination with middle and high schools is crucial in furthering the education of this generation on nonpoint source pollution control. If school districts understand the value of making this part of a science curriculum, future generations will not need the intensity of effort that is now necessary to educate most citizens of Harrison, Rye City, Rye Brook, Mamaroneck Village and Port Chester. Each WAC 3 liaison, or designated representative, should meet with the superintendent of schools or other school official for each of the school districts to put forth the idea and initiate efforts to begin incorporating nonpoint source pollution program ideas in the curriculum. Water quality monitoring has been a successful method in some of the county's schools already, including Isaac Young Middle School and New Rochelle High School in New Rochelle, but other tools and approaches also are possible.

- Host workshops targeting municipal planning, conservation and other boards as well as staff involved in land use planning and decision-making on the topics of environmental protection ordinances and the need for enforcement and consistent implementation, planning for economic growth while protecting environmental health, best management practices, such as erosion and sediment control and stormwater quantity and quality control, and ecological and water quality principles, such as vegetation buffers and stream management.

- Approach garden clubs and the landscaping/lawn care industry about developing an educational program targeting residents on the topics of lawn care/landscaping practices and approach Cornell Cooperative Extension about applying "Sound Gardening" as a pilot program in a few subwatersheds of the Long Island Sound watershed.

- Initiate an annual certificate award program for corporations, schools, municipalities, etc., that implement a nonpoint source pollution control program. Initiation of such a program will broaden the program's visibility, recognize good work, and gain a variety of advocates for the program through these conservation awards for young people, public service awards, and participation and sponsorship awards. Possible award name ideas: Champions of the Environment Award, Environmental Achievement Award, Clean Water Award, and/or Environmental Partner Award.

- Develop a handbook for municipal boards and commissions describing how to incorporate nonpoint source pollution control strategies into local land use guidelines, policies and laws.

- Develop a circular and public awareness about the need/importance of natural buffers and stormwater management basins, emphasizing scientific support.

Environmental Organizations and Citizen Groups

- Encourage municipal staff and volunteers to attend educational conferences and seminars on water quality related topics. For example, the Soil and Water Conservation District conducts periodic seminars, which traditionally draw a large audience to hear subjects of a technical nature. Request that the District focus a future seminar on implementing best management practices to avoid nonpoint source pollution. Other groups which host annual or bi-annual conferences, particularly those dealing with water-related issues, such as the Savewater Symposium or the WaterWise Council, should be asked to include the topics of nonpoint source pollution control and watershed management in future conferences. These groups reach a diverse audience.

- Request that the Westchester County Environmental Management Council and Soil and Water Conservation District focus future programs on nonpoint source pollution control. With grant money and other funding that can be obtained, the EMC and SWCD could conduct seminars on water quality; and the EMC's quarterly meetings also could become an educational forum for speakers and issues related to the subject. Other efforts should include a traveling exhibit to bring to the various forums or conferences attended by SWCD and EMC members, as well as distribution of fact sheets on nonpoint source pollution and articles in the quarterly *Environmental Bulletin*. The EMC-sponsored "roundtables" should also be used as a forum whereby the coastal communities could come together and plan the most effective ways in which to broaden the visibility of the nonpoint source pollution control program.

- Encourage the SWCD and EMC to coordinate with the Westchester Municipal Planning Federation (WMPF) so that the issues of nonpoint source pollution control and land use planning become part of the agenda for the next series of the WMPF-sponsored "short courses." This is an effective way to continue disseminating information to municipal officials, local government staff, planning and zoning boards, and others who generally attend the WMPF courses.

- Coordination with the Long Island Sound Study's public outreach efforts should be an integral part of the WAC 3 outreach program. Representatives should meet with U.S. Environmental Protection Agency staff to try to dovetail the Long Island Sound and WAC 3 outreach efforts to avoid duplication and maximize the products of these programs.

- The WAC 3 municipalities which do not have Conservation Advisory Councils (CACs), or a similar municipal board or commission which can be used as a vehicle for environmental education, should form such a group. Other boards or commissions which could fulfill this role include a Coastal Zone Management Commission. It would be the best liaison between the Long Island Sound Study and WAC 3, and can best coordinate public information and participation activities. The CACs, in turn, should closely communicate with their municipal boards and commissions to share information and elicit support for nonpoint source pollution control programs.

- Work with citizen groups in the community. Environmentally conscious citizens have made great contributions to local programs nationwide. Groups such as the Chesapeake Bay Watch, Save the Sound, Inc., and the Streamwalk Committee in Seattle, Washington, have become integral parts of the water quality programs. Citizen groups can collect valuable information on basic parameters - they can monitor and identify problems, collect surface water samples, and measure turbidity.

Outreach and Volunteerism

- It is important to identify, collect, and, if necessary, generate materials which can be used for a "traveling road show" or exhibit. A moveable exhibit could be taken to festivals and other events as well as workshops or seminars where diverse groups can view the exhibit and take home pamphlets, brochures or other material for further education.

- Outdoor billboards and other signs advertising the importance of citizen participation in watershed management and nonpoint source pollution control have been successfully used in some communities. For example, the City of Springfield, Illinois was the first city to use billboards paid for by federal Clean Water Act grants. The first billboard message, "We All Live Downstream, Protect Your Watershed," was displayed in the spring of 1995 at 14 locations throughout Springfield. A second billboard message, "A River Runs Through It, Protect Your Watershed," was displayed at a new set of 14 locations in the summer of 1995. During the summer and fall of 1996, new messages have been displayed at the same 28 locations. In some states, it is common to see watershed signs on highways which advise motorists that they have entered the watershed area of a specific river or water body. Similar signs should be installed throughout the Long Island Sound watershed as another way of raising people's consciousness.

- The importance of volunteers in watershed education cannot be stressed enough. Activities that can be carried out by volunteers include the EarthTeam's Streamwalk (see stream restoration chapter), storm drain stenciling, certain components of wetland restoration and stream bank stabilization projects, distribution of informational literature, water sampling and quality monitoring, and ecological assessments. Volunteers not only provide the labor necessary to undertake these projects but also act as ambassadors to other groups and advocates of watershed protection. As a result of their volunteerism, they not only become educated themselves but also educate others.

Watershed Advisory Committee - Ongoing Efforts

- Members of WAC 3, or another intermunicipal committee, should have regularly scheduled meetings with County Planning Department staff and the Committee on Nonpoint Source Pollution in Long Island Sound to discuss the action plan for implementing this public information and education program. It is important to begin with the small steps which lead to accomplishing a visible goal, otherwise volunteers may lose interest and drop out. Realistic goals need to be set which take into account the time each person is willing and able to commit to projects relative to the time it takes to successfully fulfill a particular objective. Even small gains show tangible results, so that participants remain encouraged and are more willing to tackle the bigger tasks.

- Instill a sense of proprietorship for the watershed in the people who live and work in it. Without community support by citizens who understand their individual responsibilities regarding the community's needs, remediation efforts will progress only slowly and sporadically.

STORMWATER MANAGEMENT

A comprehensive watershed protection strategy, which uses nonstructural and structural best management practices (BMPs), will reduce the long-term costs of both controlling floods and protecting water quality. In the WAC 3 study area, the emphasis of stormwater management is on the construction of stormwater detention and retention basins. However, more needs to be done to comprehensively address stormwater management. Comprehensiveness ranges from better implementation, monitoring and enforcement of erosion and sediment control practices to the development and implementation of more diverse and better designed structural and non-structural stormwater management practices.

Forty-four stormwater management basins were identified in the WAC 3 study area. Of these, 20 are in Harrison, as well as 11 in Rye Brook and 13 in Rye City. In Harrison, 16 basins are retention basins and four are detention or extended detention basins. In Rye Brook, seven are retention basins and four are detention or extended detention basins. In Rye City, four are retention basins and nine are detention or extended detention basins. New development is adding to the inventory of stormwater management basins in the study area. For example, a residential subdivision at the former Sloan-Kettering site in Rye City, currently under construction, is slated to include two extended detention basins and an underground detention basin. No basins were identified in the portion of the study area in Port Chester and Mamaroneck Village.

In developing a regional watershed management plan, the identification and preservation of naturally-vegetated buffers and other natural systems are key. These areas serve as nonstructural controls, filtering out many pollutants in urban runoff that might reach the water bodies. However, in developed areas, such as WAC 3, they have often been altered. When nonstructural controls are impossible or impractical because of existing development, a community may turn to structural practices - constructing new runoff treatment structures or retrofitting existing runoff management systems. The 50 existing stormwater management basins and undetermined amount of new or planned basins demonstrate the reliance on structural methods in the WAC 3 study area.

Unfortunately, some of these basins have not been sited, designed and/or constructed so as to maximize their abilities to improve and protect water quality. However, these can be retrofitted to enhance their water quality improvement and protection functions. Retrofitting requires modifying runoff control structures or conveyance systems, originally designed to control flooding, to also control water quality. Modifications might include enlarging structures, changing the inflow and outflow patterns, and increasing detention times. Retrofitting costs are a major hindrance in improving water quality in developed areas. Therefore, communities may need to identify the most insidious pollutants and then select the most cost-efficient and effective solutions to deal with them, thus improving water quality in urban runoff.

Further discussion of the WAC 3 study area basins will follow. Below, however, is a synopsis of urban best management practices that can be implemented in the study area.

Urban Best Management Practices

Best management practices (BMPs) should be selected as part of an erosion and sediment control plan during the site development process, with long-term runoff management part of the objective. The best system of practices to control nonpoint source pollution after construction is completed may be a modification of the practices used during the construction process.

Selecting the proper BMP system is critical in achieving the ultimate goal - reducing the pollutants in urban runoff. In selecting the most appropriate BMPs for a specific site, consider the following:

- the site's physical condition and development status;
- runoff control benefits provided by each BMP option;
- the pollutant removal capability of each BMP option under several design scenarios;
- the environmental and human advantages of each BMP option; and
- the long-term maintenance cost of the BMP.

Urban BMPs are generally grouped into four categories based on the operating principle or physical mechanism used to reduce the amount of runoff pollutants: detention, extended detention or retention basins; infiltration devices; vegetative controls; and pollution prevention (source controls).

- **Stormwater Management Basins -** Stormwater management basins are most popular and effective in reducing suspended solids and particles by temporarily holding the runoff and allowing the sediment to settle.

In addition to reducing the pollution in runoff, basins also delay the amount of runoff released into receiving waters, thus reducing flooding and stream bank erosion and lessening the stress on the physical habitat. The slow release also dilutes the runoff, thereby reducing the concentration of pollutants entering the stream.

With proven success in controlling runoff, properly designed, constructed and maintained basins can reduce suspended solid concentrations by 50 to 95 percent. These basins can be used for large drainage areas, be incorporated into new development site plans, and enhance the value of the surrounding property.

Often, however, finding suitable land for a basin is difficult and constructing basins in developed areas may not be possible. One solution may be to convert detention basins previously installed for flow control into extended detention or retention basins; they usually can be economically retrofitted to extended detention or retention basins. Routine maintenance is required for basins. Solids should be removed regularly, because removing accumulated solids after a decade or two can be expensive.

Stormwater management basins are generally of three types:

> *Detention Basins* - Used for flood and erosion control, detention basins, or dry ponds, remain dry and available to catch water following large storms. While intended to control water quantity, they can be retrofitted to improve water quality.
>
> *Extended Detention Basins* - These basins catch stormwater and retain it for 24 to 48 hours, remaining dry at other times. They remove pollutants by trapping sediment particles and allowing them to settle, along with nutrients and pollutants that have adsorbed to the particles.
>
> *Retention Basins* - Designed to hold water permanently, retention basins, or wet ponds, can be highly efficient in removing sediment and in reducing nutrients through biological activity such as algal growth if properly constructed; therefore, dissolved nutrients, in addition to those adsorbed to sediment particles, may be removed from the water column.

- **Infiltration Devices -** Infiltration devices allow runoff to percolate into the ground, reducing the amount of pollutants released into surface receiving waters. Filtration and adsorption mechanisms trap many pollutants - particularly suspended solids, bacteria, heavy metals, and phosphorus - in the upper soil layers and prevent these nutrients and pollutants from reaching the groundwater.

Infiltration devices can remove up to nearly all of runoff pollutants, depending on the percolation rate and area, soil type, pollutants present, and available storage volume. Success also depends on the volume and rate of rainfall. Not only do infiltration devices have high pollution removal rates, but they can also be built in developed areas and effectively reduce the volume of runoff.

However, poor site conditions such as impermeable soils, a high water table, and bedrock can lessen the effectiveness or cause failure of retention/infiltration devices. These devices must also be installed carefully to prevent soil compaction from heavy machinery, and they require such pretreatment devices as grass filter strips to remove coarse sediment from the infiltration surface. Operation and maintenance are also critical. Many infiltration BMPs have failed from lack of maintenance. Devices must be designed for ease of access, maintenance, and operation.

Infiltration devices fall into the following categories:

> *Infiltration Basins* - An infiltration basin is a natural or excavated large open depression. It temporarily stores runoff until the water percolates through the bottom or sides. Excess runoff can overflow through elevated outlets to maximize the storage volume. Because runoff usually percolates in a day or two, these basins can be dry.
>
> *Infiltration Trenches and Dry Wells* - Similar in design, infiltration trenches and dry wells are excavated holes filled with coarse stones and then covered. Dry wells are used primarily for roof drainage; trenches are used on larger areas such as streets and commercial parking lots. In both designs, runoff infiltrates the surrounding soil or is collected by perforated underdrain pipes and routed to an outflow. Infiltration trenches preserve the natural hydrology of an area and can fit on small sites. However, they require considerable maintenance and can contaminate groundwater under certain conditions.
>
> *Sand Filters (see description under Port Chester)* - Sand filters may be placed underneath parking lots, alleys or driveways, taking up no usable space on the surface. This is an advantage in the ultra-urban environment. To use sand filters, drainage areas must be stabilized against erosion. Designed mainly to enhance water quality, sand filters also can be used to control first-flush water quantity in smaller drainage areas.
>
> *Porous Pavement* - Most practical for parking lots and low volume roads and driveways, porous pavement increases infiltration of water into the soil, maintaining the water balance at nearly the same level as before the land was paved. Runoff rapidly permeates the pores of several layers of different permeable materials and filters the pollutants into the underlying subsoil or perforated drain pipes. The rate of pollutant removal depends on the amount of filtered runoff and underlying soil type.
>
> A study by the Metropolitan Washington Council of Governments found that porous pavement removes as much or more suspended sediment and other pollutants - phosphorus, nitrogen, bacteria, lead, and zinc - as detention/retention basins. However, the success of porous pavement is dependent on proper design and maintenance. They do eventually clog and should be routinely vacuumed. Certain types of porous pavement perform better in milder climates than that of Westchester County, so the selection of pavement also is important. Porous pavement can moderate runoff rate and volume so that drainage patterns and surrounding vegetation remain

normal, improving erosion control and enhancing water quality. Operation and maintenance must be considered in the use of porous pavements, however.

Oil/Grit Separators - Also known as water quality inlets, oil/grit separators are designed to remove sediment and hydrocarbons from runoff before it is released to the storm drain network or infiltration system. Runoff passes through long, rectangular concrete chambers - modified to remove sediment, grit, and oil - before exiting through a storm drain pipe.

Oil/grit separators have a limited ability to remove pollutants because of short detention times and the possibility that pollutants removed during one storm could reenter runoff from later storms. The functional benefit of oil/grit separators is dependent on faithful periodic maintenance. However, oil/grit separators can remove coarse-grained sediments from urban runoff and treat runoff before it enters underground filtration systems. They are unobtrusive, compatible with storm drain networks, and easily accessed for maintenance.

- **Vegetative Controls -** Vegetative BMPs decrease the velocity of stormwater runoff, promoting infiltration and settling of suspended solids and preventing erosion. For maximum effectiveness, vegetative controls must be used in combination with other BMPs as a first line of defense in removing suspended solids before more intensive treatments take over. Vegetative BMPs also remove organic material, nutrients, and trace metals.

Less costly than other control practices, vegetative controls enhance the attractiveness and value of sites. Using vegetative controls to pre-treat runoff improving the operation and maintenance of other BMPs.

The ultimate performance and practicality of vegetative controls depend on the site’s physical features. Plant material must be selected carefully and regularly maintained. Because they have limited ability to control runoff, and effectiveness varies according to the season, vegetative controls should not be a site’s only control practice.

Several types of vegetative controls are as follows:

Basin Landscaping - Landscaping can improve a stormwater basin’s effectiveness in removing pollutants. Landscaping around a basin reduces the amount of impervious surface area, provides an attractive, green buffer along stream banks, and protects and enhances the use of existing wetlands. Proper landscaping can route stormwater runoff through green areas and away from erosion-prone steep slopes and other areas.

Grassed Swales - Grassed swales are depressions, such as gullies, that infiltrate and transport runoff water. They are often used in residential developments and on highway medians as an alternative to curb and gutter drainage systems.

Swales control peak discharges by reducing runoff velocity. The swale allows some runoff to infiltrate the soil, thus diminishing the volume of water passing downstream. Swales are easy to construct, attractive, and a potential habitat for wildlife. However, effectiveness varies considerably from site to site; swales may encourage mosquitoes, ragweed, dumping, and erosion.

Filter Strips - While similar to grass swales, filter strips are more shallow and distribute runoff across a wider area. Their efficiency depends on strip length, slope, and size; soil porosity; normal runoff velocity; and vegetation type. Grassy strips supplemented with shrubs and small trees increase the ability to absorb and retain nutrients.

Riparian Reforestation - Trees planted near stream banks can stabilize soil, thereby decreasing the release of sediment from stream banks and into streams; cool water; and benefit many forms of aquatic life.

- **Pollution prevention**. Local governments should establish ongoing programs to reduce the generation and exposure of pollutants that accumulate on streets and other surfaces, and eventually wash into lakes and streams. These source reducing programs are usually called pollution prevention programs.

In most cases, pollution prevention is more cost effective than structural BMPs in reducing pollutant loadings. However, a combination of source reduction efforts and structural BMPs is generally needed to fully control the effects of urbanization.

Pollution prevention controls - also known as nonstructural controls - include land use planning and zoning strategies, as well as public education efforts. Storm drain stenciling, recycling, and household hazardous waste collection offer high value for the initial investment. Incentives to use public transportation or otherwise lower emissions that generate pollutants are also considered source controls.

Pollution prevention controls can generate a sense of community; in addition, they have aesthetic or economic benefits. To be effective, source reduction practices require a combination of education, regulation, and guidance. The chapter on outreach and education more fully discusses the issues related to citizen involvement and education.

Listed below are common pollution prevention controls communities can consider. Local governments can:

- collect and recycle crankcase oil;
- establish a program for seasonally cleaning out and maintaining catch basins;
- redesign road salting programs to minimize the salt quantity and, where feasible, use an alternative deicer;
- educate the public about the hazards of fertilizers and pesticides used in commercial lawn care and grounds maintenance operations and the alternative organic treatments;
- start remedial erosion control programs;
- educate the public on how to reduce litter and properly dispose of pet wastes and household pollutants;
- remove illegal and improper industrial and commercial connections to storm drains that discharge directly into receiving waters without prior treatment; and
- plug or seal abandoned wells and cisterns that are conduits for nonpoint source groundwater pollution.

Other administrative strategies may include hazardous waste restrictions or contingency plans. Source prohibitions - barring storage or use of dangerous materials in a defined area - are common ways to protect health and the environment. Many jurisdictions, for example, now prohibit handling or storing toxic chemicals where a spill could threaten groundwater supplies. Jurisdictions also offer hazardous waste amnesty days, which provide residents the opportunity to properly dispose of hazardous waste.

Many commercial and industrial users produce hazardous wastes that can, without careful mitigation, threaten water quality. They include dry cleaners, auto service stations, industrial plants, trucking and railroad facilities, and airports. Other activities - such as agriculture, junk yards, machine shops, landfills, and septic systems - also use hazardous materials.

Water Quality Retrofit Potential in WAC 3 Study Area

With all stormwater management basins, the potential for and success of complete retrofits, minor design improvements and periodic maintenance is dependent on the cooperation of landowners. Publicly-owned basins are more likely to be retrofitted, improved and maintained due to the willingness of most municipal, county, state and federal governmental agencies to keep the basins in good working order from water quality and quality control standpoints. However, the ability of these agencies to maintain the basins is limited by funding and staff availability. Basin maintenance on privately-owned lands is dependent on the willingness of individual landowners to maintain the basins, or on maintenance requirements imposed by governmental agencies. For residential and commercial development where basins have been constructed to control stormwater, maintenance may be the responsibility of the landowner, neighborhood association, local public works department, or other private or public entity. Maintenance responsibilities and enforcement should be specified as part of subdivision, site plan or other municipal development approvals.

HARRISON

Twenty surface and subsurface stormwater management basins have been identified in the WAC 3 study area portion of Harrison. Sixteen of these are retention basins and four are detention basins. The basins are on privately-owned lands, except for a retention basin in Harrison at the Westchester County Airport (see description under Rye Brook). Most of the basins are associated with golf courses and residential subdivisions. The balance is associated with office buildings.

Most of the basins are retention basins (wet ponds). Therefore, structural modifications only need to be made to detention basins (dry ponds) to increase their water storage time by transforming them into extended detention basins or retention basins. A good candidate for this type of retrofit is a detention/infiltration basin adjacent to Kenilworth Road and Ironwood Lane. This basin currently consists of a shallow depression lined with a mowed lawn; it is probable that this basin stores water only for very short periods of time during significant storms. Design modifications will allow this basin to be transformed to an extended detention or retention basin. Another retrofit candidate is a basin which is part of a larger stormwater management system at Purchase Corporate Park. A small watercourse traverses one end of this basin but the close proximity of the inlet and outlet does not allow for sufficient storage time and does not allow for sufficient interaction between the incoming water and the rest of the basin. Relocation of the basin outlet, as well as a modest increase in the outlet height, will transform the basin into an extended detention or retention basin, thereby increasing its usefulness for water quality protection.

Two subsurface detention basins, at Purchase Park on Westchester Avenue and Puritan Woods on Puritan Road, cannot be readily transformed into another form of stormwater management basin; therefore, no retrofit opportunity is available for the two basins. These underground basins will function best if they are properly maintained on a regular basis and are supplemented by some type of pretreatment system to remove excessive sediments which could result in their premature failure.

Pollutant removal effectiveness is very limited for any type of dry detention basins (which collect and store stormwater runoff in a temporary pool of water for less than 24 hours) when compared to extended detention (which collect and store stormwater runoff in a temporary pool for more than 24 hours) and retention (which retain stormwater in a permanent pool of water from two to 14 days) basins. Pollutant removal is even more limited if they are not properly maintained, especially for underground detention basins. In general, the longer the detention time, the greater the pollutant removal. Typical removal rates for pollutants after detention times of 48 hours or more are: 90 to 95 percent for sediment; 45 to 50 percent for total phosphorus; 35 to 40 percent for nitrogen; 45 to 50 percent for organic matter; and 90 to

95 percent for lead (Source: Metropolitan Washington Council of Governments, 1987). A significant reduction in removal rates occurs for detention times of less than 24 hours (e.g., after 12 hours detention time, sediment drops to 60 to 65 percent removal, nitrogen drops to 20 to 25 percent removal, and lead drops to 70 to 75 percent removal.

Although structural modifications are not needed for nearly all of the evaluated retention basins in Harrison, most only needed better landscaping to improve their water quality enhancement capabilities. Most of the retention basins in Harrison lack a shallow aquatic bench along the perimeter of their permanent pool of water. Benches should be installed and then planted with aquatic vegetation. This vegetation may include duck potato (<u>Sagittaria latifolia</u>), common three square (<u>Scirpus pungens</u>), softstem bulrush (<u>Scirpus validus</u>), sweet flag (<u>Acorus calamus</u>), button bush (<u>Cephalanthus ocidentalis</u>), rose mallow (<u>Hibiscus moscheutos</u>), rice cutgrass (<u>Leerisa oryzoides</u>), spatterdock (<u>Nuphar luteum</u>), arrow-arum (<u>Peltandra virginica</u>), pickerel weed (<u>Pondederia cordata</u>), and lizards tail (<u>Saururus cemuus</u>). The fringe immediately above the aquatic bench may be planted with tall fescue (<u>Festuca elatior</u>), river birch (<u>Betula nigra</u>), black willow (<u>Salix nigra</u>), arrowwood (<u>Viburnum</u> sp.), silky dogwod (<u>Cornus amomum</u>), and possumhaw (<u>Ilex decidua</u>).

Establishing aquatic vegetation at the perimeter of retention basins enhances the basins' pollutant removal capabilities. It also has several other benefits. Emergent plants can provide an attractive fringe habitat, providing food and cover for wildlife and waterfowl. The marsh fringe also protects the shoreline from erosion, and if situated near the inlet to the basin, can trap incoming sediment. While most emergent plants withdraw nutrients from the sediments rather than the water column, associated algae which are attached to the plants or grow nearby on the shallow sediments, are capable of soluble nutrient removal. Shallow, organic-rich waters in the marsh fringe provide an ideal environment for bacteria and other microorganisms that reduce organic matter and nutrients. Similarly, the marsh fringe provides a habitat for predacious insects that can serve as a natural population control for mosquitoes and other nuisance insects. From an aesthetic standpoint, the fringe of aquatic vegetation conceals trash and floatable debris and disguises and stabilizes the pond shoreline, which is sometimes barren due to fluctuating water levels.

Retention basins in the WAC 3 study areas portion of Harrison needing an aquatic bench to enhance their water quality improvement capabilities include several basins at Hickory Pine at Purchase Golf Club near Cottage Avenue, The Crossing at Blind Brook near Purchase Street, Starr Farm Subdivision near Meadow Lane, and Keio Academy, as well as a basin at each of two residential subdivisions on Purchase Street. The landscaping of these basins also could be improved by reducing the mowing frequency in the 15- to 20-foot-wide upland strip around the basins (including their side slopes and embankments) to once or twice a year; these strips are currently being mowed on a frequent basis and are being managed as closely cropped, intensively maintained lawn.

A good example of a properly landscaped retention basin is found behind the Hitachi Metals offices on Westchester Avenue. Although the basin embankments should be raised to prevent overtopping by pond water, the perimeter of the basin contains a bench on which is growing a variety of emergent plants, the dominant species being cattail. Most of the basin is surrounded by woodland. The side facing the office building is flanked by meadow which is infrequently mowed. Other good examples of landscaping are the retention basins at the Somerset Subdivision on Harrows Lane near Anderson Hill Road and the Spring Hill Subdivision on Anderson Hill Road and Purchase Street.

ROUTINE MAINTENANCE

<u>Mowing</u>

The upper stage, side-slopes, embankment and emergency spillway of basins should be mowed once or twice a year to discourage excessive woody growth. Soggy conditions can make mowing costly and difficult within the pond unless a two-stage design is used. The use of native or introduced grasses which are water-tolerant, hardy and slow-growing are recommended, such as tall fescue, crown vetch, and switchgrass.

Inspections

Basins should be inspected on an annual basis to ensure that the structure operates in the originally intended manner. Inspections can be conducted by municipal personnel or contractors/consultants hired by neighborhood associations or other entities, depending on ownership and other conditions (e.g., an extended detention basin at a corporate park could be inspected by a professional hired by the landowner with inspection reports forwarded to the municipal engineering, building or public works depeartment, as appropriate).

When possible, inspections should be conducted during wet weather to determine if the pond is meeting the targeted detention times. In particular, the control device should be regularly inspected for evidence of clogging, or conversely, for too rapid a release. Outlets should be checked for erosion problems. Other problems which should be checked include: subsidence, erosion, cracking or tree growth on the embankment; the condition of the emergency spillway; the accumulation of sediment around the rise; the adequacy of upstream/downstream channel erosion control measures; erosion on the basin's bed and banks; and modifications to the basin or its contributing watershed that may influence basin performance.

Debris and Litter Removal

Debris and litter may accumulate near the control device and should be removed during periodic mowing operations. Particular attention should be paid to floatable debris that can eventually clog the control device or riser.

Erosion Control

The basin side slopes, emergency spillway and embankment all may periodically suffer from slumping and erosion, although this should not occur often if the soils are properly compacted during construction. Regrading and revegetation may be required to correct any problems.

Nuisance Control

Standing water or soggy conditions within the lower stage of extended detention basins can create nuisance conditions for nearby residents. Odors, mosquitoes, weeds and litter are all occasionally perceived to be problems in extended detention basins. Most of these problems are generally a sign that regular inspections and maintenance are not being performed (e.g., mowing, debris removal, clearing the extended detention control device).

NON-ROUTINE MAINTENANCE

Structural Repairs and Replacement

Eventually, the various inlet/outlet and riser works in a basin will deteriorate and must be replaced. Some local public works experts have estimated that corrugated metal pipe (CMP) has a useful life of about 25 years, whereas reinforced concrete barrels and risers may last from 50 to 75 years. No stormwater management basins have been in the ground for more than 25 years in the WAC 3 study area; as a result, there is not much local experience in this area. However, since the various water works constitute about 25 percent of the initial construction cost, their replacement will be a significant future expense.

Sediment Removal

When properly designed, stormwater management basins will accumulate significant quantities of sediment over time. Sediment accumulation is a serious maintenance concern for several reasons. First, the sediment gradually reduces available stormwater management storage capacity within the basin. The best available estimate is that approximately one percent of the storage volume capacity associated with the two-year design storm can be lost annually. Thus, as much as 20 percent of the basin’s total storage capacity can be lost within 20 years. Even more storage capacity can be lost if the basin receives large sediment input during the construction phase. Second, unlike retention basins (which have a permanent pool to conceal deposited sediments), sediment accumulation can make detention and extended detention basins very unsightly. Third, and perhaps most importantly, sediment tends to accumulate around basin control devices. Sediment deposition increases the risk that either the orifice or the filter medium will become clogged, and also gradually reduces storage capacity reserved for pollutant removal.

For these reasons, accumulated sediment may need to be removed by those responsible for its maintenance about every five to 10 years for extended detention basins and about every 10 to 20 years for retention basins. More frequent spot clean-outs may be needed around the control device for some designs. Sediment removal operations are relatively simple if access for heavy equipment is provided. Front-end loaders or backhoes can be used to scrape off the bulk of the accumulated sediment, followed by manual removal of sediment deposited around the control device. The disturbed area should be immediately stabilized with vegetation after removal operations are completed to prevent the control device from clogging again. If an on-site disposal area is not available, then transport and landfill tipping fees may double or even triple the total cost of sediment removal operations.

PORT CHESTER

Most of the City of Port Chester is densely developed. Future development will largely consist of infill construction and the redevelopment of previously developed building lots. The use of conventional structural BMPs, such as surface detention and retention basins, is largely impractical in this environment. No existing surface stormwater management structures have been identified in Port Chester.

Despite the difficulty of installing stormwater management structures in urban areas such as Port Chester, various state and federal environmental programs, for good reason, still require the use of on-site structural BMPs to control the quality of stormwater discharges from infill construction and redevelopment. Space constraints, extremely high property values, soil conditions, and the proximity of other building foundations will preclude the use of most conventional stormwater BMPs in Port Chester, where pollutant loads are presumed to be high. Therefore, WAC 3 recommends that the City of Port Chester develop and adopt stormwater management regulations as part of its existing land use regulations. It also should adopt guidelines that identify appropriate stormwater management structures for its urban character; these can be conventional or non-conventional BMPs designed to reduce high pollutant loads.

According to Warren Bell, engineer for the City of Alexandria, Virginia, that city has adopted and published design criteria for a number of innovative (non-conventional) BMPs, many of which employ intermittent sand filter technology.

Intermittent sand filters use an 18-inch- to 24-inch-thick layer of sand, underlain by a collector pipe system in a bed of 2-inch-diameter gravel, which acts as the filter media. A layer of geotechnical filter fabric and approximately 3 inches of "pea" gravel are placed between the sand and coarser gravel to prevent washout of the filter sand. Pretreated runoff floods the filter and percolates through the filter media to the coarse gravel layer, from which it flows into the underdrain pipes. A clearwell chamber is often provided to collect water from the underdrains and direct it to the storm sewer. Underground vault sand filters have been widely used in Washington, D.C., and are appropriate for this region as well.

Peat-sand filters, which are adapted from the general sand filter concept and design, are applicable in situations where high pollutant removal is required and more rigorous maintenance can be provided. In addition, this type of basin, used more extensively in warmer areas, cannot normally operate during the most severe winter months when the peat freeze, rendering them less effective from early December through early March. More information on non-conventional BMPs can be obtained from the Westchester County Soil and Water Conservation District.

MAMARONECK VILLAGE

No existing stormwater management basins have been identified in the WAC 3 study area portion of Mamaroneck Village. Because of its similarity to Port Chester in terms of development density, the above narrative and recommendations for Port Chester are applicable to Mamaroneck Village (it should be noted that although Mamaroneck Village is densely developed, sufficient space is available in some areas for surface stormwater management basins; existing basins are located in the study areas for WAC 4 and WAC 5).

RYE BROOK

Eleven surface stormwater management basins exist in the WAC 3 study area portion of Rye Brook. Seven of these are retention basins and four are detention basins. With the exception of one basin at the Westchester County Airport and the basin at Rich Manor Park on Acker Drive, the basins are on privately-owned lands.

Many of the issues raised for the Harrison basins (see above) are applicable to those in Rye Brook. For example, the water quality improvement function of the large retention basin at the General Foods office building on Westchester Avenue can be enhanced by constructing an aquatic bench planted with emergent vegetation along the basin's perimeter, as well as establishing much denser vegetation (such as various species of grass) on the basin's side slopes than currently exists. Although shallow bedrock is evident on some of the side slopes, thereby negating the effectiveness of vegetation, other areas have bare soils which should be stabilized with vegetation, which also will act to filter sediment, nutrients and other pollutants from any overland flow of stormwater runoff (see recommendations for aquatic benches and side slopes/embankments above under Harrison). The lack of aquatic benches and/or properly managed (from a water quality standpoint) vegetation on basin side slopes and embankments also is evident at several of the retention basins that make up the stormwater management system at Arrowwood Golf Course, part of the Doral Arrowwood complex on Anderson Hill Road.

The retention basin in municipally-owned Rich Manor Park on Acker Drive also could be enhanced through better landscaping. This basin was formed in the channel of the east branch of Blind Brook. The east side of the basin can easily be stabilized and improved from a water quality protection standpoint by planting aquatic and semi-aquatic vegetation. Aquatic vegetation should be planted on the unvegetated aquatic bench that exists along the basin's eastern shore and wetland (hydrophytic) herbaceous and woody vegetation should be planted along the basin's eastern embankment and adjoining flood plain, which is currently maintained as closely-cropped lawn.

Other retention basins that are well managed and do not require a great deal of improvement are Price's Pond (formed by a dam across Blind Brook) in the Hidden Falls Development and the Royal Executive Park on King Street. Although steep slopes adjoin parts of these basins and aquatic benches are largely absent, much of the basins are bounded by woodland, which does much to shade the basins and filter excessive nutrients and pollutants from stormwater flows. However, a few small sections are not well vegetated. Allowing these sections to revert to more natural conditions would enhance the water quality improvement function of the basins.

A stormwater management basin at the Westchester County Airport, known as Basin A, is a good example of a properly-functioning retention basin (actually just over the municipal boundary line in Harrison). A diverse community of wetland vegetation exists through much of the basin and encircles standing water in the basin's center. A small subbasin at the outlet further treats stormwater before it leaves the basin. The basin's embankments are vegetated by a dense community of grasses, which are mowed no more than once or twice a year. Another basin, however, known as Basin B (just over the municipal boundary line in Rye Brook), could be improved from a water quality protection standpoint. Incoming stormwater enters the northeast corner of the basin. It then travels through the basin in a relatively straight watercourse to the outlet in the basin's southeast corner. Some standing water is evident at the outlet, but the western two-thirds of the basin is dry and has no interaction with the incoming stormwater. It is recommended that the inlet or outlet be relocated and changes made to the basin's interior topography to require the watercourse to meander through the basin rather than traveling quickly through it in a straight line. This will increase the interaction of stormwater with soil and vegetation, thus increasing storage time, infiltration and pollutant removal. It is anticipated that these recommendations will be incorporated into the planned expansion of the basin.

Two detention basins should be converted from detention to extended detention or retention structures. This type of conversion would enhance their water quality improvement benefits and could be performed with relative ease. One of the basins is at The Atrium office building on Arbor Drive. The other is part of a multi-family residential complex on Arbor Drive. Both basins were dry at the time of inspection and were filled with a dense population of common reeds (Phragmites sp.). The basin embankments were covered by closely-cropped lawn. Relatively simple design changes should be made to the basins to increase their storage time, thus converting them from detention basins to extended detention or retention basins in accordance with the design guidelines of the New York State Department of Environmental Conservation's *Reducing the Impacts of Stormwater Runoff* (1992). Design changes could include adjusting the height of the basins' outlets. Whatever changes are made, the increased storage time (duration of inundation) should weaken or eliminate the Phragmites population; the wildlife habitat value of the basins would be improved as long as appropriate growing conditions are provided for other, more beneficial, plants.

RYE CITY

Thirteen surface stormwater management basins have been identified in Rye City. Several more were under construction at the time of this report and were not evaluated. These include surface and subsurface structures at a new residential subdivision at the former Sloan-Kettering site on the Boston Post Road near the Marshlands Conservancy. Six detention basins exist in the city, along with three extended detention basins and four retention basins. All of these basins are on privately-owned lands.

Many of the issues raised for the Harrison and Rye Brook basins (see above) are applicable to those in Rye City. For example, retention basins at the Apawamis County Club golf course, the One Interstate Terrace office building near the corner of Peck and Midland avenues and a residential subdivision near the corner of Bird Lane and Forest Avenue, all could be enhanced from a water quality perspective by improved landscaping. Improvements can include constructing an aquatic bench planted with emergent vegetation along the basins' perimeters, as well as establishing much denser vegetation (such as various species of grass) on the basins' side slopes and/or embankments. Another example is the detention basin at Rye Manor Apartments on Theall Road, which could be converted to an extended detention or retention basin by altering its outlet to increase the storage time from less than 24 hours to greater than 24 hours as an extended detention basin or permanently as a retention basin. The stone-lined side slopes of this basin should be vegetated to the fullest extent possible. Converting the basin from a detention to extended detention or retention basin and properly vegetating its side slopes should, if properly executed, not only improve the basin's water quality improvement value but also its appearance.

Some other basins in Rye City, however, have special retrofit needs.

The extended detention structure at the Melville Corporation office building near Playland Access Road is well maintained but could be improved from a design standpoint simply by diverting or splitting the low flow channel. A diversion or split in the channel would slow the flow of stormwater through the basin and allow for a slightly longer detention time and greater infiltration. This, in turn, would enhance the pollutant removal capabilities of the structure. This type of retrofit could be performed relatively easily and cheaply.

A stormwater management basin has recently been constructed at the Osborn Retirement Community at the corner of Osborn and Theall roads. During a visit to the basin, it was noted that the basin was retaining a small amount of water at the bottom of the basin despite the absence of precipitation during the previous week. The shallow, stagnant water created an unsightly appearance. This basin's design should be reexamined. In its current form, this basin is not functioning properly; it is neither acting as a detention basin nor a retention basin. WAC 3 recommends that the basin be converted to a retention basin, if possible; if not, it should be retrofitted into an extended detention basin.

A diversion or split in the low flow channel of the extended detention basin at the Corporate Center at Rye near Theodore Fremd Avenue would enhance the water quality improvement function of this basin. However, the basin also would benefit from the conversion of a paved inflow channel to a grassed or vegetated swale or channel as noted in the NYS DEC's *Reducing the Impacts of Stormwater Runoff from New Development* (1992) and Westchester County *Best Management Practices Manual for Erosion and Sediment Control* (1991). The same type of retrofit is suggested for a detention basin at the Courtyard at Marriott hotel on Midland Avenue. However, in addition to these retrofit activities, this detention basin also would benefit from a modification of the outlet structure to convert the basin to an extended detention basin.

The outlet of a detention basin at the end of Pondview Road, adjacent to Interstate 95, should be re-designed due to its susceptibility to clogging. An outlet re-design also should consider the basin's conversion from a detention basin to an extended detention or retention basin.

A large pond, called Mead Pond, surrounded by Pondview Road, Sharon and Mead Pond lanes and Marlene Court, functions as a retention basin. The pond was on the NYS DEC's 1993 Priority Water Problem List (now called the Priority Water Bodies List). Although the pond was not on the 1996 list, there is no evidence that the pond's quality has substantially improved. The pond contains excessive amounts of algae, resulting in low dissolved oxygen levels. The 1993 list states, "Mead Pond is impacted from urban runoff contaminated with fertilizers and pesticides. Road de-icing salts and sands also contribute to a chronic water quality problem. Tree service trucks have been observed "filling" their pesticide tanks; however, flushing of tanks and backflow of pesticide residues into the pond is suspected." This retention basin, therefore, is the victim of the nonpoint source pollutants it is intended to treat. A short-term solution may be to install aerators in the pond to improve dissolved oxygen concentrations. The long-term solution may be found after an examination of land use practices around the pond. Reducing fertilizer and pesticide use by homeowners, reducing the amount of sand and de-icing materials applied to surrounding roads, and preventing tree service trucks from discharging pollutants into the pond all may be necessary components of a long-term management plan. So, too, may be planting a 15- to 20-foot-wide vegetative buffer (e.g., herbaceous plants and woody shrubs) wherever closely-cropped lawns meet the pond edge.

Golf Courses and Stormwater Management

Golf Courses in the WAC 3 Study Area

Eight golf courses, with a combined area of approximately 1,430 acres, exist in the WAC 3 study area. These golf course include the Hickory Pine at Purchase Golf Club, Old Oaks Country Club, Westchester Country Club and Willow Ridge Golf Club in Harrison. The size of these properties are 278 acres, 183 acres, 389 acres, and 115 acres, respectively. They also include the 164-acre Blind Brook Country Club and 81-acre Arrowwood Golf Course in Rye Brook, 109-acre Apawamis Country Club in Harrison and Rye City, and 111-acre Rye County Club in Rye City. These golf courses, with the exception of Rye Country Club, are privately owned. Rye Country Club was purchased by the City of Rye for use by city residents.

A major environmental concern of these and all golf courses is the degradation of water quality as a result of the use of high rates of fertilizers, pesticides and fungicides on the managed turf that makes up the courses. The use of these chemicals is often shown to be incompatible with management strategies for both ground and surface waters. Other concerns are the loss of riparian vegetation needed to filter pollutants, stabilize stream banks, shade stream channels, and provide shelter for wildlife which may use streams as migratory corridors.

Some studies have shown that golf courses are not major sources of pollution from nitrates and phosphate. A study at Pennsylvania State University, for example, concluded that managed turf grasses do not display a high potential for movement of pesticides and fertilizers by stormwater runoff or percolation. However, some of these studies compared golf courses to agricultural uses, concluding only that surface runoff, sediment loss and total nitrogen and phosphate movement were significantly lower for golf courses than for agricultural activities, which are traditionally the most significant source of nonpoint source pollution. Other studies confirmed that the application of best management practices, such as the use of slow-release fertilizers, will reduce the level of pollutants and nutrients in ground and surface waters.

Nevertheless, most golf courses require substantial land disturbance during construction and maintenance afterwards. Although many courses in Westchester County, including those operated by the County, have developed programs to minimize the application of chemicals and provide for property management of stormwater, environmental degradation as a result of golf course construction and maintenance is a very real concern. In the WAC 3 study area, golf courses make up approximately 11.5 percent of the area. This is a sizeable portion, especially considering it is for a single, very specific, land use. Therefore, it is important for golf course managers in the area to develop or improve their stormwater management and maintenance programs. Successful programs will result in better water quality not only for the tributaries which flow through or near golf courses, but also for the primary receiving water body - Long Island Sound.

WAC 3 recommends that, because it is publicly-owned, the Rye Country Club serves as a model for water quality protection on golf courses in the WAC 3 study area. State and federal funding, as well as other funding sources, should be sought to develop or improve and then implement environmentally-sound stormwater management and maintenance programs at the golf course. In the meantime, the managers of privately-owned golf courses in the area should be asked to work with the committee, municipalities, County Soil and Water Conservation District, and other appropriate entities to develop and implement programs of their own. Once the Rye County Club programs have been developed and implemented, the managers of privately-owned courses may use its programs for guidance - in effect, Rye Country Club will serve as an outdoor classroom or model for endeavors on privately-owned courses.

Principles For Planning, Siting, Designing, Constructing, and Managing Golf Courses

WAC 3 recommends that turf and stormwater management strategies be re-examined at the study area's eight existing golf courses, as well as any new golf courses in the future. Tees, greens, fairways and roughs should be maintained not only from a golfer's perspective but also from that of a natural resources steward. Golf course managers should anticipate potential impacts to natural resources as a result of golf course construction and maintenance before these impacts degrade water quality and other environmental features. This can best be achieved by first avoiding any impacts, then minimizing impacts that cannot reasonably be avoided, and finally mitigating any unavoidable impacts that have been fully minimized. For example, irrigation should be avoided to the fullest practicable extent to avoid hydrologic impacts to nearby water resources, particularly pollutant filtering wetlands. Because irrigation is needed to keep most golf courses "green" and is, in most cases, unavoidable, irrigation should be minimized by lessening the volume of water used for irrigation. This can be accomplished in a number of ways, such as restricting watering to times of the day and year when the effects of evapotranspiration and evaporation are lowest, planting turf grasses that are tolerant of drought, shrinking the size of managed fairways, and establishing proper drainage and soil conditions for optimum plant growth. Potential impacts may be mitigated by properly sited, designed, and constructed stormwater management systems, such as infiltration basins and trenches, porous pavement and grassed swales.

The following recommendations should be applied to any new golf course construction as well as alterations to existing golf courses in the WAC 3 study area:

Planning and Siting

1. Developers, designers and others involved in golf course development should work closely with local community groups and regulatory/permitting bodies during planning and siting and throughout the development process.

2. Site selection is a critical determinant of the environmental impact of golf courses. A thorough analysis of the site or sites under consideration should be completed to evaluate environmental suitability. Both the designer and a team of qualified golf and environmental professionals should be involved in this process.

3. Based on the site analysis and/or regulatory review process, it may be determined that some sites are of such environmental value or sensitivity that they should be avoided. Other less environmentally sensitive or valuable sites may be more suitable or even improved by the development of a golf course if careful design and construction are used to avoid, minimize and mitigate environmental impacts.

4. There may be opportunities to restore or enhance environmentally sensitive areas through golf course development by establishing buffer zones or by setting unmaintained or low maintenance areas aside within the site.

5. Golf course development can be an excellent means of restoring or rehabilitating previously degraded sites (e.g., landfills, quarries and mines). Golf courses are also excellent treatment systems for effluent water and use of effluent irrigation is encouraged when it is available, economically feasible, and agronomically and environmentally acceptable.

Design

1. When designing a golf course, it is important to identify existing ecosystems. Utilizing what nature has provided is both environmentally and economically wise. A site analysis and feasibility study should be conducted by experienced professionals. The identification of environmentally sensitive areas and other natural resources is important so that a design can be achieved that carefully balances environmental factors, playability, and aesthetics.

2. Cooperative planning and informational sessions with community representatives, environmental groups and regulatory agencies should be part of the initial design phase. Early input from these groups is very important to the development and approval process. This dialogue and exchange of information should continue even after the course is completed.

3. Native and/or naturalized vegetation should be retained or replanted when appropriate in areas that are not in play. In play areas, designers should select grasses that are best adapted to the local environmental conditions to provide the necessary characteristics of playability yet permit the use of environmentally sustainable maintenance techniques.

4. Emphasis should be placed on the design of irrigation, drainage and retention systems that provide for efficient use of water and the protection of water quality. Drainage and stormwater retention systems should, when possible, be incorporated in the design as features of the course to help provide for both the short- and long-term irrigation needs of the maintained turf and unmaintained areas.

5. Water reuse for irrigation should be practiced when economically feasible and environmentally and agronomically acceptable. It is important that recycled water meets applicable health and environmental standards and that special consideration be given to water quality issues and adequate buffer zones. Water reuse may not be feasible on some sites that drain into high quality wetlands or sensitive surface waters. Suitable soils, climatic conditions, groundwater hydrology, vegetative cover, adequate storage for treated effluent and other factors will all influence the feasibility of water reuse.

6. Buffer zones or other protective measures should be maintained and/or created, if appropriate, to protect high quality surface water resources or environmentally sensitive areas. The design and placement of buffer zones will vary based on the water quality classifications of the surface waters being incorporated into the course. Regulatory agencies and environmental groups can assist in the planning of buffer zones.

7. The course should be designed with sustainable maintenance in mind. The design should incorporate integrated plant management and resource conservation strategies that are environmentally responsible, efficient, and cost-effective. Integrated plant management includes Integrated Pest Management (IPM) and emphasizes plant nutrition and overall plant health.

8. The course design should enhance and protect special environmental resource areas and improve or revive previously degraded areas, if any, within the site through the use of plants that are well adapted to the region.

Construction

1. Best management practices for construction include the following:

    a. use only qualified contractors who are experienced in the special requirements of golf course construction.
    b. develop and implement strategies to effectively control sediment, minimize the loss of topsoil, protect water resources, and reduce disruption to wildlife, plant species and designated environmental resource areas.
    c. schedule construction and turf establishment to allow for the most efficient progress of the work while optimizing environmental conservation and resource management.
    d. retain a qualified golf course superintendent/project manager early in the design and construction process(es) to integrate sustainable maintenance practices in the development, maintenance and operation of the course.

Maintenance

1. Plant protection and nutrition include the following:

    a. the principles of Integrated Pest Management (IPM) should be employed. IPM is a system that relies on a combination of common sense practices of preventing and controlling pests (e.g., weeds, diseases, insects) in which monitoring is utilized to identify pests, damage thresholds are considered, all possible management options are evaluated and selected controls) are implemented. IPM involves a series of steps in the decision-making process:

        o Through regular monitoring and record keeping, identify the pest problem, analyze the conditions causing it, and determine the damage threshold level below which the pest can be tolerated.

        o Devise ways to change conditions to prevent or discourage recurrence of the problem. Examples include: utilizing improved (e.g., drought resistant, pest resistant) turfgrass varieties, modifying microclimate conditions, or changing cultural practice management programs.

- If damage thresholds are met, select the combination of control strategies to suppress the pest populations with minimal environmental impact, to avoid surpassing threshold limits. Control measures include biological, cultural, physical, mechanical, and chemical methods. Biological control methods must be environmentally sound and should be properly screened and tested before implementation.

  Non-chemical control measures should focus on practices such as the introduction of natural pest enemies (e.g., parasites and predators). Utilizing syringing techniques, improving air movement, soil verification techniques, and mechanical traps. The selection of chemical control strategies should be utilized only when other strategies are inadequate.

b. When chemical and nutrient products need to be applied, the following practices should be used*:*

- Always read and follow label directions when using any plant protectant products. Strive to treat problems at the proper time and under the proper conditions to maximize effectiveness with minimal environmental impact. Spot treatments may provide early, effective control of problems before damage thresholds are reached.

- Store and handle all pest control and nutrient products in a manner that minimizes worker exposure and/or the potential for point and nonpoint source pollution. Employ proper chemical storage practices and use suitable personal protective equipment and handling techniques.

- Use nutrient products and practices that reduce the potential for contamination of ground and surface water. Strategies include: use of slow-release fertilizers, selected organic products, and/or soluble fertilizers applied during irrigation.

- Test and monitor soil conditions regularly and modify practices accordingly. Choose nutrient products and time applications to meet, not exceed, the needs of the turfgrass.

- All plant protectant products should only be applied by or under supervision of a trained, licensed applicator or as dictated by law.

- Maintain excellence in the continuing education of applicators (including state licensing, professional association training and IPM certification). Training for non-English speaking applicators should be provided in the worker's native language.

- Facilities should inform golfers and guests about golf course chemical applications. Common methods include permanent signs on the first and tenth tees and/or notices posted in golf shops and locker rooms.

c. To minimize water use, the following practices should be used:

- Use native, naturalized or specialized drought-tolerant plant materials wherever possible. For areas in play (greens, tees and fairways), use plant materials that are well-adapted to local environmental conditions and can be efficiently managed, as well as provide the desired playing characteristics.

- Plan irrigation patterns and/or program irrigation control systems to meet the needs of the plant materials in order to minimize overwatering. When feasible, use modern irrigation technologies that provide highly efficient water usage. Inspect systems regularly for leaks and monitor water usage.

- Water at appropriate times (usually during the morning) to minimize evaporation and reduce the potential for disease.

- Consider converting to effluent irrigation systems when available, economically feasible and agronomically and environmentally acceptable.

- Manage water use effectively to prevent unnecessary depletion of local water resources.

d. For waste management, the following practices should be used:

- Leave grass clippings and other organic materials in place whenever agronomically possible. If clippings are removed, compost and, if possible, recycle them.

- Dispose of chemicals in a manner that will not increase the potential for point or nonpoint source pollution. Methods include rinsate recycling or "spraying out" diluted compound in previously untreated areas.

- Dispose of chemical packaging according to label directions (e.g., triple rinsing, recycling or returning to manufacturer).

- Other waste products, such as used motor oil, electric batteries and unused solvents, should be recycled or disposed of according to the law and available community disposal techniques.

- Seek to reduce waste by purchasing products that minimize unnecessary packaging.

e. To manage wildlife, the following practices should be used:

- Habitat for wildlife species (e.g., bats, bluebirds, purple martins, etc.) that help control pestsshould be protected. Additional habitat for these beneficial species should be created whenever feasible and environmentally desirable.

- Manage habitat to maintain healthy populations of wildlife and aquatic species.

- Species, such as skunks, non-migratory Canada geese and deer, that become damaging should be managed through non-harmful means whenever possible. Non-harmful control methods could include dogs, noisemakers, repellents, and trapping and removal.

f. The operation of facilities (golf courses) should include the following practices:

- An environmental assessment to develop and implement an overall environmental policy and/or long-range plan that reflects or expands upon these principles.

- Ongoing records to measure and document progress toward environmental improvement.

- The environmentally responsible practices adopted for golf course maintenance should extend to all other areas of the facility, including those not directly related to golf, such as parking lots, maintenance and storage facilities, and unmanaged natural areas.

- Facilities should adopt practices and technologies that conserve natural resources, including water and energy.

- Facilities should develop and initiate comprehensive programs for reducing waste, including recycling and reusing.

- Facilities should properly store and dispose of solvents, cleaning materials, paints and other potentially hazardous substances.

- Facilities should take active steps to educate golfers, neighbors and the general public about their environmental policies and practices.

WETLAND RESTORATION

While regulatory controls and best management practices are needed to reduce the harmful effects of polluted runoff, the protection, restoration and creation of wetlands are crucial parts of the solution. Once pollutants have entered the ecosystem, wetlands provide the first line of defense against the contamination of streams, lakes and Long Island Sound.

A. Wetland Water Quality Functions

What Makes Wetlands Uniquely Suited To Improving Water Quality?

Wetlands occur in many sizes and forms throughout nature. They may be saltwater or freshwater, and they may be either permanently, seasonally, or irregularly flooded. But these swamps, bogs and marshes all contain the proper balance of physical, chemical and biological conditions needed to break down or neutralize many common contaminants. Filtration of pollutants is a natural function of wetland ecosystems, which improves water quality for the benefit of humans and wildlife.

- Because of their position between water and land, wetlands provide a buffer zone that intercepts polluted runoff before it contaminates lakes, rivers, and coastal waters.
- Dense wetland vegetation improves the clarity of receiving waters by trapping sediment and pollution in its root system.
- The chemical cycling of nutrients is facilitated by the presence of both aerobic (oxygenated) and anaerobic (oxygen free) conditions in wetlands. Without this range of conditions unique to wetland ecosystems, pollutants would begin to accumulate within the water supply.
- Large areas of shallow water lead to significant sediment-water exchange that facilitates the chemical degradation of pollutants.
- A diversity of decomposers exists on root surfaces and in wetland soils. These microbiotic organisms biodegrade organic chemicals like pesticides.
- High primary productivity within most wetland ecosystems leads to high rates of mineral uptake by plants, which remove these substances from the water column.

How Do Wetlands Filter Out These Pollutants?

Wetlands filter pollutants from the water that flows into streams, rivers, lakes and Long Island Sound.

Sediment

Dense wetland vegetation provides more resistance to stormwater runoff than would an impermeable surface such as pavement. As a result, wetlands lower the velocity of runoff. Instead of allowing sediment particles to be swept along with the rushing water, wetlands enable the suspended sediment to settle out of a gentle flow. The roots of wetland vegetation stabilize the stream bank by holding soil and preventing further erosion of sediments.

- The City of Tallahassee, Florida constructed a 2.5-acre marsh for the purpose of filtering pollutants from urban stormwater runoff. The artificial marsh reduced suspended sediment concentrations by between 70 and 76 percent.
- A study of the Minnehahna Creek watershed in Minnesota found that a wetland there filtered 94 percent of the suspended solids entering the wetland. The wetland was found to filter out over 16,000 kg of sediment annually before discharging water into the nearby creek.

Nutrients

Plant roots remove soluble nutrients, such as nitrate from subsurface water flow. Nutrients taken up by the plants are stored in leaf matter and other plant parts. These decompose into the soil. Woody wetland plants provide even longer storage of nitrogen and phosphorus. Nitrogen may be converted to harmless gas by the plants and released into the atmosphere through the process of microbial denitrification. Scientific studies have revealed high rates of nitrogen removal from flooded soils, especially in wetlands that experience periodic flooding and drying (Lowrance et al., 1985).

- Forested wetlands along streams and rivers play a crucial role in reducing nutrient loading, particularly in agricultural areas that are polluted with nitrogen and phosphorus. For instance, a riparian forest in the Chesapeake Bay watershed removed about 80 percent of the phosphorus and 89 percent of the nitrogen from agricultural runoff entering a stream (EPA, 1995).
- A pilot operation at Houghton Lake, Michigan used a natural wetland to filter 100,000 gallons per day of secondarily treated wastewater, resulting in significant improvements to water quality. The wetland removed approximately 70 percent of ammonia nitrogen, 99 percent of nitrate nitrogen, and 95 percent of total dissolved phosphorus from the wastewater (Mitsch and Gosselink, 1993).

Other Chemical Contaminants

Chemical pollutants often adhere to sediment particles and settle along the wetland bottom. The high productivity of wetland systems leads to high mineral uptake by plants, while additional contaminants are removed through the processes of chemical precipitation and biodegradation.

- Wetlands have been shown to remove heavy metals from the water column at an efficiency rate as high as 100 percent (Maltby, 1986).
- During the 1980s, more than 140 wetlands were constructed to control water pollution from mine drainage by removing iron and sulfates while rendering the water less acidic (Mitsch and Gosselin, 1993; Wider, 1989).

Bacteria

Dense wetland vegetation decomposes to form a substrate where natural microbes can work to remove bacteria. Artificial wetland systems are now being used for water purification purposes in place of tertiary treatment facilities.

- Microbial action taking place on the wetland bottom may reduce coliform bacteria by 90 percent (Reed and Brown, 1992).
- Prior to the restoration of the Arcata Marsh in California, local oyster harvesters faced lengthy closures and lowered income due to health hazards stemming from polluted runoff. Now that the wetland is being used to help clean wastewater effluent, one-half of California's $5 million annual oyster harvest comes from the surrounding Humboldt Bay (Kier and Associates, 1993).

B. Wetlands In The WAC 3 Study Area

The WAC 3 study area contains both freshwater and tidal wetlands. Between 175 and 225 acres of freshwater wetland exist in the study area, along with 400 to 450 acres of tidal wetland. Less than 60 percent of the former wetland acreage that once existed in the study area exists today; the balance has been filled or drained to accommodate residential, commercial, industrial and agricultural uses.

In general, freshwater wetlands in the study area consist of forested swamps [dominated by red maple trees (Acer rubrum)] and emergent marshes [dominated by common reeds (Phragmites sp.)]. Where they exist, red maple swamps themselves are generally in good condition. Few, however, have substantial undeveloped upland (non-wetland) buffers around them.

Tidal wetlands generally consist of three types of emergent marshes: those that are dominated by smooth cordgrass (Spartina alterniflora) and/or salt marsh hay (Spartina patens); those that are dominated by common reeds; and those that contain areas of cordgrass and salt marsh hay and areas of common reeds. The tidal range of these wetlands can generally be divided into three zones: above mean high water (supratidal); from mean high water to mean low water (intertidal zone) and below mean low water (subtidal zone). The area above mean high water can further be divided into the area above the mean spring high tide and the area between the mean spring high tide and mean high water (spring high tide is the elevation to which the tide rises during the two times of the month when the sun, moon and Earth are in direct line with each other - it has nothing to do with the season of spring). Due to encroachment by development and land filling, tidal wetland areas between the mean spring high tide and mean high water are infrequently found in the WAC 3 study area. If they do exist, these wetlands (high marsh) contain a variety of plant species, such as black needlerush (Juncus roemerianus), marsh elder (Iva frutescens) and salt grass (Distichlis spicata).

Adequate regulatory protection and the restoration of degraded wetlands were of primary concern to WAC 3. In this section, the focus is on restoration. Under each municipality below are identified sites that may be suitable for restoration and those that warrant extraordinary protection or acquisition by a land conservation organization or government. Rye City's large stock of freshwater and, particularly, tidal wetlands include several offering opportunities for restoration. Harrison has a few freshwater wetlands, particularly state-designated wetland No. G-3, which offer opportunities for substantial restoration; however, many of Harrison's wetlands do not lend themselves to large-scale restoration due to their small size and good condition. In Harrison, emphasis should be placed on protection and preservation of the town's/village's existing wetlands. A small number of wetlands also are suitable for restoration in Mamaroneck Village, Rye Brook and Port Chester.

HARRISON

Freshwater Wetlands

State-Designated Wetlands

Three state-designated freshwater wetlands exist in the WAC 3 study area portion of Harrison. They are identified by the NYS DEC as Nos. J-3 (between Coolidge Avenue in Rye City and Taylor Avenue in Harrison), G-9 (at the Hickory Pine at Purchase Golf Club near Cottage Avenue), and G-3 (between the former High Point Hospital and State University of New York at Purchase). Wetland G-3 is described under Rye Brook. All three wetlands are rated Class II by the DEC. Classification is a NYS DEC designation placed upon mapped state-designated wetlands (see descriptions under Harrison and Mamaroneck Village). Class II wetlands may be an emergent marsh in which purple loosestrife (Lythrum salicaria) or common reed constitute less than two-thirds of the vegetation, may have a plant community comprised of at least two species, or may be associated with a tidal wetland, permanent open water or a stream classified C(t) or higher. It also may be traditional migration habitat for endangered or threatened animal species, resident habitat for a plant or animal species "vulnerable" in the state, and/or an animal species "in abundance or diversity unusual for the county in which it is found." This class of wetland also may be valuable from a flood control perspective, hydrologically connected to a ground water supply, acts in a tertiary treatment capacity for a sewage disposal system, and/or is one of the three largest wetlands within a municipality.

State-Designated Wetland J-3

Wetland No. J-3, between Taylor Avenue in Harrison and Coolidge Avenue in Rye City, is partly forested with the balance consisting of marsh dominated by common reed. The wetland is bisected by Beaver Swamp Brook. Therefore, its importance to water quality and wildlife habitat is significant. Unfortunately, this wetland has been substantially degraded by unauthorized and accidental filling, dumping, and petroleum and sewage discharges. The deposition of fill has altered the wetland's hydrology, which may be promoting the proliferation of common reed and adversely impacting the wetland's water quality protection and flood control benefits. Dumped materials include abandoned motor vehicles, parts of motor vehicles, discarded metal, tires and containers, all of which have not only affected the visual appearance of this wetland but also its functional value for water quality protection, flood control and habitat. The accidental discharge of sewage and unauthorized discharge of petroleum directly impact the quality not only of the wetland but also of Beaver Swamp Brook. This degradation has largely occurred along Taylor Avenue in Harrison, where light industrial uses are present. Their encroachment into the wetland is unabated.

Wetland No. J-3 is one of more than 450 degraded sites in New York and Connecticut nomited for restoration under the Long Island Sound Study's Habitat Restoration Program. The wetland flanks Beaver Swamp Brook from Osborn Road to Park Avenue. It is encompassed by the brook's flood plain, which extends beyond Taylor Avenue in Harrison. Its potential importance for water quality protection, flood control and wildlife habitat is significant, but its substantial degradation has profoundly limited its potential.

Restoration of wetland No. J-3 is warranted and recommended. An intermunicipal citizen's committee issued a report in 1997 also recommending protection and restoration of this wetland; the recommedations of this committee, where practicable, should be carried to fruition. However, any restoration initiative should be preceded by appropriate changes in land use along Taylor Avenue in Harrison. This area is (1) near Beaver Swamp Brook, (2) a direct tributary of Long Island Sound, (3) adjacent to one of the largest and, from a water quality perspective, most important wetlands in Rye City and Harrison, and (4) within the brook's flood plain. Therefore, the presence of light industry in this area is inconsistent with the existing and potential functional values of this wetland for water quality protection, flood control and wildlife habitat. The area is zoned for two-family residences; therefore, light industry is a non-conforming use. Light industry should be discouraged from this area; conservation easements and public acquisition of lands encompassing and adjacent to the brook and wetland should be encouraged.

Filling and dumping has occurred along most of the east side of Taylor Lane in Harrison. Restoration should be focused here. Restoration would be a complex task warranting further study before the scope of restoration is determined. In general, though, restoration should consist of physically separating any remaining light industrial uses from the wetland, such as with a sturdy fence; removing fill and debris from the wetland and any adjoining upland; possible minor regrading; repairing, replacing or installing drainage structures in this area to improve the wetland's hydrology; and planting vegetation in some portions of the wetland.

The Town//Village of Harrison has applied for funding under the state Clean Water/Clean Air Bond Act [under the section concerning funds for Environmental Restoration (Brownfields) Investigation Projects] to conduct a Phase 1 and II environmental audit of the site, as well as to study the potential restoration of the wetland and conversion of the site to a passive recreation area. WAC 3 strongly encourages the state to fund this request because of its long-term water quality enhancement and protection benefits.

State-Designated Wetland G-9

State-designated wetland No. G-9, near the headwaters of the west branch of Blind Brook, has been encompassed by the Hickory Pine at Purchase Golf Club. The comprehensive value of this wetland has been diminished by the golf course development (e.g., its value to wildlife has been significantly lessened due to the loss of wetland and adjoining upland forest), but it still provides important water quality enhancement benefits. No restoration opportunities exist at this time for wetland No. G-9. However, the wetland should be monitored by a governmental or other independent (non-golf course) entity to ensure that the wetland's water quality enhancement and biological functions are not further reduced by golf course encroachment and the influx of nonpoint source pollutants, such as sediments, excessive nutrients, and pesticides and herbicides. Any impacts detected as a result of this monitoring should be stopped and mitigated. Further encroachment also should not be allowed through the regulatory process (i.e., no additional permits should be granted that would allow further wetland loss).

Other Wetlands

A substantial number of smaller freshwater wetlands exist in the WAC 3 study area portion of Harrison. These wetlands generally do not provide opportunities for large-scale restoration. Small-scale restoration projects are possible in conjunction with individual residential and commercial development projects. The conversion of vegetated wetlands to open water ponds is not considered restoration and should be strongly discouraged (the conversion of vegetated wetlands to open water ponds and lakes is a growing trend in the United States, with the U.S. Fish and Wildlife Sevice estimating that 621,607 acres of freshwater ponds have been added to the nation's stock between 1985 and 1995, a nearly 14 percent increase).

An example of restoration that could occur in conjunction with development projects is found at the Polly Park Estates subdivision on Polly Park Road, at the headwaters of Beaver Swamp Brook. Small headwaters wetlands have been filled or adversely impacted by sedimentation due to the land disturbance associated with subdivision construction. At the time of the site visit, no erosion and sediment control practices were in place and a small pond and Beaver Swamp Brook were very turbid due to suspended sediment particles. Sediment deposits also were noted in some of the wetlands. Restoration at this and other similar sites should include stabilizing the site and removing fugitive sediment from on- and off-site water resources, provided the removal is practicable and does not cause further degradation. The Polly Park Road example also points to the need for much more diligent administration, monitoring and enforcement of erosion and sediment control practices on the part of developers, residents and municipal officials.

MAMARONECK VILLAGE

Freshwater Wetlands

State-Designated Wetland J-2

The only state-designated freshwater wetland in Mamaroneck Village is at the head of Otter Creek (surrounding Magid Pond) and is identified by the NYS DEC as No. J-2, which is rated Class I by the DEC. Classification is a NYS DEC designation placed upon mapped state-designated wetlands. The classification system establishes four separate classes that rank wetlands "according to their ability to perform wetland functions and provide wetland benefits," according to Title 6, NYCRR, Part 663. Class I is the highest ranking. This class of wetland may support endangered or threatened plant or animal species and/or an animal species "in abundance or diversity unusual for the state or for the major region of the state in which it is found." This class of wetland also may be valuable from a flood control perspective and/or is critical from a water quality protection standpoint.

Otter Creek, a tidal tributary of Mamaroneck Harbor, is the focal point of one of the most extensive and functionally valuable tidal wetland systems in the WAC 3 study area. Much of the wetland is protected not only by the state Tidal Wetlands Act (Article 25) but also by benefit of being owned by The Nature Conservancy as the Otter Creek Preserve. The wetland is dominated largely by smooth cordgrass (Spartina alterniflora) and salt marsh hay (Spartina patens), although common reed (Phragmites sp.) is dominating areas nearer the creek's head (closer to Magid Pond).

This state-designated freshwater wetland consists of a marsh dominated by common reed surrounding freshwater Magid Pond. The pond is adjacent to Taylor Lane and is bounded by residential and commercial development to the north and west along The Parkway, Southview Drive and the Boston Post Road. Otter Creek Preserve is immediately south of the wetland and the former Taylor Lane compost site, which is suspected of containing a significant quantity of hazardous waste, is northeast of the wetland. It is noted in Mamaroneck Village's Local Waterfront Revitalization Program (LWRP) that Magid Pond and the surrounding wetland are "major habitat for resident, overwintering and migratory waterfowl and birds" and has a "concentration of wildlife, including many rare species."

During visits to the wetland, discolored water (reddish orange with a surface sheen) was being discharged on two occasions directly into the wetland and pond from a culvert adjacent to Taylor Lane. The cause of the discoloration is not known, but the former compost site is suspected of playing a role. WAC 3 recommends that the cause of the discoloration be identified and its potential impact on the wetland and pond be determined. Corrective action, such as providing a pre-treatment basin or other structure prior to discharge, is recommended if feasible and it is determined that the discharge contains nutrients or pollutants that are harming the wetland and pond.

Consideration also should be given to restoring the wetland by removing part of the common reed population that encircles the pond. From a habitat enhancement perspective and, to a lesser extent, a water quality improvement standpoint, the common reed should be replaced with woody freshwater wetland plants, such as shrubs and low-growing trees. These will be more beneficial to the birds and mammals that use the wetland and pond on an intermittent, seasonal and permanent basis. Any restoration to diversify the plant species growing in the wetland (by removing the dominant common reed) may require regrading the wetland to a lower elevation. The best restoration site is the area along Taylor Lane, where equipment access is easiest and a pre-treatment basin or other structure for the culvert noted above may be incorporated into restoration design.

The introduction of other plant species into the restored site may be accomplished via natural means, by allowing existing plants in the area to colonize the site, or by artificial means, by first obtaining the plants as seeds, rhizomes or plugs or as bare root, balled and burlapped or container plants from an reputable nursery and then planting the site with this nursery stock. The actual planting may be conducted with assistance from volunteers, including school children. Further study must be conducted to determine the feasibility, scope and design of any restoration project. Support also must be acquired from neighborhood residents and NYS DEC, which has jurisdiction over regulated activities within the wetland and surrounding upland.

No other sizeable freshwater wetlands were identified in the WAC 3 study area portion of Mamaroneck Village.

Tidal Wetlands

The most extensive wetland systems in the WAC 3 study area portion of Mamaroneck Village are adjacent to Guion Creek and Otter Creek, both tidal tributaries of Mamaroneck Harbor. Guion Creek is the tidal portion of Beaver Swamp Brook, a freshwater stream that extends northward into Harrison.

The Guion Creek wetland system is relatively intact along the creek's east bank. Here, the wetland is dominated largely by smooth cordgrass (Spartina alterniflora) and salt marsh hay (Spartina patens), although common reed (Phragmites sp.) is dominating areas nearer the creek's head (closer to the Boston Post Road). Residential development has encroached into the wetland along the creek's west bank. Part of the wetland here has been filled and retaining walls now line the creek's channel. The area immediately north of the Barry Avenue bridge exemplifies the contrast between the east and west banks; the east is bounded by vegetated wetlands consisting of both high and low marshes and the west is bounded by retaining walls, lawns and unvegetated mud flats. Restoration of the Guion Creek wetland system is not feasible on the west bank due to existing residential development and is not warranted on the east bank due to its relatively pristine condition there. The long-term preservation of tidal wetlands along the east bank should be ensured through protective land use practices and regulations, open space acquisition and incentives for conservation easements.

Otter Creek divides one of the most extensive and functionally valuable tidal wetland systems in the WAC 3 study area. The wetland system flanks the creek. Much of it is protected not only by the state Tidal Wetlands Act (Article 25) but also by benefit of being owned by The Nature Conservancy, which maintains it as the Otter Creek Preserve. The wetland system is generally dominated largely by smooth cordgrass (Spartina alterniflora) and salt marsh hay (Spartina patens), but common reed (Phragmites sp.) is encroaching into the creek's head (closer to Magid Pond). The area immediately north of the Barry Avenue bridge exemplifies the relatively pristine character of this wetland system, which protects Otter Creek from upland-borne sediment and other nonpoint source pollutants. Restoration of the Otter Creek wetland system is not warranted.

Other Tidal Wetlands

Other small tidal wetlands exist along Van Arminge Mill Pond and Mamaroneck Harbor. Restoration of these wetlands is not feasible or warranted.

RYE CITY

Freshwater Wetlands

Three state-designated freshwater wetlands exist in Rye City. They are identified by the NYS DEC as Nos. J-1 (near Rye Neck High School), J-3 (between Coolidge Avenue in Rye City and Taylor Avenue in Harrison) and J-4 (immediately east of South Road between the Metro-North Commuter Railroad tracks and Interstate 95). All three wetlands are rated Class II by the DEC. Classification is a NYS DEC designation placed upon mapped state-designated wetlands (see description under Mamaroneck Village). Class II wetlands may be an emergent marsh in which purple loosestrife (Lythrum salicaria) or common reed constitute less than two-thirds of the vegetation, may have a plant community comprised of at least two species, or may be associated with a tidal wetland, permanent open water or a stream classified C(t) or higher. It also may be traditional migration habitat for endangered or threatened animal species, resident habitat for a plant or animal species "vulnerable" in the state, and/or an animal species "in abundance or diversity unusual for the county in which it is found." This class of wetland also may be valuable from a flood control perspective, hydrologically connected to a ground water supply, acts in a tertiary treatment capacity for a sewage disposal system, and/or is one of the three largest wetlands within a municipality.

State-Designated Wetland J-1

Wetland No. J-1, immediately north of the Boston Post Road adjacent to Rye Neck High School, is a forested wetland (red maple swamp) containing a watercourse and pond; this wetland drains to Beaver Swamp Brook, less than 300 feet to the north. The condition of this wetland is relatively good, although residential development has recently been constructed immediately south and east of the wetland. Restoration of this wetland is not warranted, although long-term protection and preservation of the remaining upland buffer adjoining it should be a City priority.

State-Designated Wetland J-3

Wetland No. J-3, between Taylor Avenue in Harrison and Coolidge Avenue in Rye City, is partly forested with the balance consisting of marsh dominated by common reed. The wetland is bisected by Beaver Swamp Brook. Therefore, its importance to water quality and wildlife habitat is significant. Unfortunately, this wetland has been substantially degraded by unauthorized and accidental filling, dumping, and petroleum and sewage discharges. The deposition of fill has altered the wetland's hydrology, which may be promoting the proliferation of common reed and adversely impacting the wetland's water quality protection and flood control benefits. Dumped materials include abandoned motor vehicles, parts of motor vehicles, discarded metal, tires and containers, all of which have not only affected the visual appearance of this wetland but also its functional value for water quality protection, flood control and habitat. The periodic but accidental discharge of sewage and unauthorized discharge of petroleum directly impact the quality not only of the wetland but also of Beaver Swamp Brook. This degradation has largely occurred along Taylor Avenue in Harrison, where light industrial uses are present. Their encroachment into the wetland is unabated.

Wetland No. J-3 is one of more than 450 degraded sites in New York and Connecticut nominated for restoration under the Long Island Sound Study's Habitat Restoration Program. The wetland flanks Beaver Swamp Brook from Osborn Road to Park Avenue. It is encompassed by the brook's flood plain, which extends beyond Taylor Avenue in Harrison. Its potential importance for water quality protection, flood control and wildlife habitat is significant, but its substantial degradation has profoundly limited its potential.

Restoration of wetland No. J-3 is warranted and recommended. An intermunicipal citizen's committee issued a report in 1997 also recommending protection and restoration of this wetland; the recommedations of this committee, where practicable, should be carried to fruition. However, any restoration initiative should be preceded by appropriate changes in land use along Taylor Avenue in Harrison. This area is (1) near Beaver Swamp Brook, (2) a direct tributary of Long Island Sound, (3) adjacent to one of the largest and, from a water quality perspective, most important wetlands in Rye City and Harrison, and (4) within the brook's flood plain. Therefore, the presence of light industry in Harrison is inconsistent with the existing and potential functional values of this wetland for water quality protection, flood control and wildlife habitat. The area is zoned for two-family residences; therefore, light industry is a non-conforming use. Light industry should be discouraged from this area; conservation easements and public acquisition of lands encompassing and adjacent to the brook and wetland should be encouraged.

Filling and dumping has occurred along most of the east side of Taylor Lane in Harrison. Restoration should be focused here. Restoration would be a complex task warranting further study before the scope of restoration is determined. In general, though, restoration should consist of physically separating any remaining light industrial uses from the wetland, such as with a sturdy fence; removing fill and debris from the wetland and any adjoining upland; possible minor regrading; repairing, replacing or installing drainage structures in this area to improve the wetland's hydrology; and planting vegetation in some portions of the wetland.

A small parcel of land owned by Rye City, off Wilson Drive and Coolidge Avenue adjacent to the east side of wetland No. J-3, also is suitable for restoration, not because it is severely degraded but because it could be a model for other restoration efforts along Beaver Swamp Brook. The parcel largely consists of mowed lawn, a fringe of common reed, and the forested portion of wetland No. J-3. Restoration here may consist of removing the common reed by mechanical means, minor regrading, and planting wetland shrubs and trees in their place and in the area of mowed lawn along the forest edge.

State-Designated Wetland J-4

Wetland No. J-4 is a marsh through which Beaver Swamp Brook flows. It is immediately east of Frederick Court, a new residential subdivision upslope of the wetland. It also is between Interstate 95 to the north and the Metro-North Commuter Railroad tracks to the south. It is owned by Rye City and maintained as a passive public park. The marsh is dominated by common reed with a forested fringe, particularly along the side fronting the railroad tracks. Several ponds exist within the wetland, creating open water habitat for wildlife. Public access is from South Road, which is west of the wetland. Although the habitat value of this wetland has been diminished by the monoculture of common reed, its value for water quality protection is still substantial. The removal of common reed would benefit wildlife, but short- and long-term impacts resulting from the disturbance as well as monetary costs outweigh the benefits from a water quality perspective.

Other Freshwater Wetlands

Several smaller freshwater wetlands also exist in Rye City, such as those adjacent to Blind Brook immediately north of Playland Parkway, at the corner of Playland Parkway and Midland Avenue, the former Sloan-Kettering site on the Boston Post Road, and a wetland immediately northeast of North Street near Beaver Swamp Brook. No restoration opportunities were noted for these wetlands. However, protection and preservation of these wetlands through properly administered and enforced wetland regulations is the best applicable management action.

Tidal Wetlands

Blind Brook/Milton Harbor

Rye City has the richest supply of tidal wetlands in the WAC 3 study area, and perhaps of any other municipality on the Long Island Sound coast in Westchester County. The most significant of these is the tidal wetland complex at the mouth of Blind Brook or head of Milton Harbor. This complex encompasses wetlands at Marshlands Conservancy, a county-owned park that includes upland forest, a large meadow and approximately 30 to 35 acres of marshes and mud flats. They also include wetlands at Rye Country Club, immediately north of Marshlands Conservancy.

The Blind Brook/Milton Harbor complex includes approximately 50 to 55 acres of low and high marshes and mud flats on the northwest side of the brook/harbor. Of this total, approximately 30 to 35 acres exist at Westchester County-owned Marshlands Conservancy. Over the past 25 years, the extent of low and high marshes on the northwest side of the brook has significantly diminished, being replaced by mud flats and open water. The loss of vegetated tidal wetlands at the mouth of Blind Brook and head of Milton Harbor is presumed to have had a detrimental impact on water quality in Blind Brook, Milton Harbor and Long Island Sound. Therefore, WAC 3 recommends a study to determine the cause(s) and affect(s) of this loss as well as possible solutions to its arrest.

In 1996, the County Planning Department had applied to the U.S. Environmental Protection Agency, Region II, for a federal grant to study the marsh to determine why it is shrinking and how to stop or, if possible, reverse this phenomenon. Although the EPA, Region II, included the County's application on a short list of other recommended grant applications in the region, EPA headquarters in Washington did not approve funding for the study. The County Planning Department applied for the same grant in 1997, when a greater pool of money may increase its chances of acquiring the funding. Action on the application was pending at the time of this report.

In 1996, the County Board of Legislators passed an act designating Marshlands Conservancy as a "nature center and wildlife sanctuary" to be used and developed for "habitat management and wildlife protection in an environmentally sensitive manner." The act restricts the preserve's use to passive recreation and prohibits facilities and activities that will be deleterious to flora and fauna. The preserve also has been designated by the New York State Department of State as a Significant Coastal Fish and Wildlife Habitat (see attachment).

The preserve, especially the tidal marshes, provides habitat for a number of wading birds, shore birds, ducks and migratory geese. Some of these birds, which feed and seek shelter at the marsh, are part of the breeding populations at Huckleberry Island in New Rochelle, New York and the Stewart B. McKinney National Wildlife Refuge in Connecticut. The preserve also has been identified as a breeding area for the diamondback terrapin.

A small nature center staffed by a naturalist from the Westchester County Department of Parks, Recreation and Conservation (PRC) has been established to educate the public about the preserve's ecosystem as well as that of the north shore of western Long Island Sound.

Over the past 15 to 25 years, PRC staff and others have observed that the size of the vegetated wetlands has noticeably decreased. A review of aerial photographs confirms the accelerated loss of tidal marshes at the preserve since the late 1970s to early 1980s. This shrinkage is largely demonstrated by a decline in the area occupied by smooth cordgrass (Spartina alterniflora), saltmeadow cordgrass (Spartina patens) and spike grass (Distichlis spicata), whose populations are being supplanted with open water and mudflats. The reason for this decline is unexplained, although dredging and boat traffic are suspected contributors - the Blind Brook and Milton Harbor channels have been periodically dredged over the past several decades to accommodate boat traffic from marinas along Blind Brook.

If the EPA grant is awarded, a two-year-long assessment and monitoring study will be conducted to determine the cause(s) and affect(s) of the wetland decline. The study's objective is to determine the cause(s) and affect(s) of the decline, as well as to determine potential action(s), if any, that can be taken to curb or reverse the areal decline of the preserve's tidal marshes. In addition to the recommendations made by WAC 3, the Marshlands Conservancy study has been nominated for the Long Island Sound Study's (LISS) Habitat Restoration Program administered by the U.S. Environmental Protection Agency's Long Island Sound Office in Stamford, Connecticut. The study is placed on the LISS list of potential projects under the Habitat Restoration Program.

The assessment and monitoring study will help naturalists better understand the complex nature of tidal wetland habitats [particularly smooth cordgrass (Spartina alterniflora) marshes] in the Long Island Sound estuary and determine the cause(s) and affect(s) of their areal decline along Blind Brook, Milton Harbor and elsewhere. If the decline is caused by land and water uses and activities, the study also may assist regulators in better understanding the potential environmental impacts from proposed activities, such as land development, harbor management, land clearing/regrading and dredging. This understanding would assist regulators in determining and assessing potential impacts, particularly affecting tidal wetlands. The results of this study also may assist other researchers studying the cause(s) and effect(s) of, as well as solution(s) to, reversing the decline in vegetated tidal wetlands along the East Coast, particularly cordgrass marshes near or in urban centers.

The Blind Brook/Milton Harbor tidal wetland complex also includes a tidal marsh at municipally owned Rye Country Club, adjacent to Marshlands Conservancy. This marsh has been degraded by past filling. Common reed (Phragmites sp.) have colonized part of the marsh, which is an extension of the Marshlands Conservancy marsh and part of the Milton Harbor wetland complex. Restoration of the Rye County Club marsh is recommended. Because it is on land owned by Rye City, cooperation from the City is needed. During a visit to the site in August 1997, staff of the New York Department of State and Department of Environmental Conservation and U.S. Army Corps of Engineers expressed interest in restoring the site. Restoration should include removing all or a portion of the fill that had been placed in the wetland, thereby returning it to its former elevation. Removing the fill is expected to result in the long-term removal of the now dominant common reed. After the fill has been removed, final site topography should be varied to allow for tidal pools, where standing water will remain at low tide, and for slightly different elevations dominated by plant species adapted to specific elevations and hydrology. Further study is necessary to determine specific project scope, design and cost. State and/or federal grants may be available to cover all or most of the project costs.

Manursing Island

A sizeable tidal wetland complex exists at North Manursing Island and Kirby Mill Pond. These wetlands are in relatively good condition and generally contain several species of wetland plants [largely smooth cordgrass (Spartina alterniflora) and salt marsh hay (Spartina patens)], except for a narrow band of the dominant common reed (Phragmites sp.), which nearly encircles the pond. Because of their condition and the fact that they are on private lands, restoration of these wetlands is not warranted.

Freshwater and tidal wetlands also exist at Playland Park and the Edith Read Wildlife Sanctuary. Some areas of freshwater wetland have been overrun by common reed and Japanese knotweed; the latter also has overrun upland areas of the sanctuary. The removal of these invasive and, in the case of the knotweed, exotic species is on the list of candidate restoration sites of the Long Island Sound Study's Habitat Restoration Program. The sanctuary and Playland Lake, a coastal pond, are a New York Department of State-designated Significant Coastal Fish and Wildlife Habitat.

WAC 3 also recommends that additional areas of smooth cordgrass (Spartina alterniflora) marsh be created at Playland Park and Edith Read Wildlife Sanctuary. New cordgrass marsh can be established by planting the cordgrass along the park's and sanctuary's rocky shoreline at elevations similar to those of existing cordgrass marshes. Potential creation sites include the rocky intertidal area between the Manursing Island Bridge and a small peninsula southwest of the sanctuary's nature center building, where a population of smooth cordgrass already exists.

Playland Parkway

A large tidal wetland system exists immediately southwest of Playland Parkway along Blind Brook. This system, which extends from Oakland Beach Avenue to Playland Parkway, flanks Blind Brook and, therefore, is instrumental in protecting the brook's water quality. The marsh is completely dominated by common reed (Phragmites sp.). Although studies have shown that common reed enhances water quality in ways similar to other wetland plants, its value to wildlife is widely regarded as inferior to many other species. Common reed also is susceptible to wildfires. The reeds along Playland Parkway block the view of the Blind Brook corridor. Therefore, replacement of the reeds with other species, such as salt marsh hay (Spartina patens) and marsh elder (Iva frutescens), that are functionally more valuable and lower growing would visually open up the corridor, attract a greater number of waterfowl and other birds and animals, and enhance the corridor's aesthetic quality. Restoration could include revamping the tidal flow through the wetland or other alterations to its hydrology. This hydrologic modification may be a relatively simple task, such as removing, changing or redesigning a tide gate or structural obstruction, or a complex undertaking, such as dredging, redefining or creating tidal channels to improve tidal flow and exchange and hydrology. WAC 3 recommends that the marsh's restoration be examined; a study should determine the feasibility of restoring the marsh, the best way to restore the marsh, and approximate restoration costs.

RYE BROOK

A portion of state-designated freshwater wetland No. G-3 exists in Rye Brook. This wetland straddles the border of Rye Brook and Harrison. Several smaller wetlands also exist in the WAC 3 study area portion of Rye Brook, including several along Blind Brook. No restoration opportunities were identified, except at a public park next to Blind Brook. Rich Manor Park, on Acker Drive, encompasses part of a riparian wetland on Blind Brook. Although much of the park is forested, a portion of it is maintained as closely-cropped lawn next to the brook. The park is occasionally used by Canada geese, which find ideal habitat in the lawn and slow-moving brook nearby. It is recommended that the east bank of the brook, which is eroding and borders the lawn, be stabilized with vegetation, possibly through the use of coconut fiber logs impregnated with the seeds or "plugs" of wetland plants. The lawn is within the brook's flood plain; part of it has wetland hydrologic and soil characteristics and could be converted to an unmanaged wet meadow. A wet meadow will further stabilize the brook bank and discourage the site's use by geese. The remainder of the lawn could be maintained in its current state to allow for more active recreation. The meadow may be established by removing the top few inches of sod and topsoil and sowing the seeds of wetland grasses, sedges and rushes, in addition to flowering wet meadow plants. A footpath, perhaps lined with several educational signs, could be installed through the wet meadow to encourage passive recreation of the site and be connected to other future footpaths elsewhere in the park. Further study is needed for this restoration project, which can be easily designed and constructed at relatively low cost.

State-Designated Wetland G-3

State-designated wetland No. G-3 is a forested wetland in relatively undisturbed and good condition. It flanks Blind Brook not far from that brook's headwaters and it located in both Rye Brook and Harrison. Its importance for water quality and habitat protection and flood control is significant. Its value for these wetland functions is not rivaled by any other existing freshwater wetland in Rye Brook or Harrison. However, a large-scale development proposed for the former High Point Hospital site potentially could impact the wetland's integrity. Unless this development is properly planned and executed from a natural resource conservation and management standpoint, these impacts could be significant. Although restoration of wetland No. G-3 is unwarranted at this time, long-term protection and preservation of the wetland should be a priority for both the New York Department of Environmental Conservation and the municipalities of Rye Brook and Harrison.

PORT CHESTER

No state-designated freshwater wetlands exist in Port Chester. Few other freshwater wetlands were identified in the village. A small number of tidal wetlands exist in Port Chester, but most of these are along the Byram River, which comprises the WAC 2 study area. The few freshwater wetlands that do exist in Port Chester have been signficantly degraded. Restoration of a pond and vegetated wetland system, which is shown as a pond on the National Wetlands Inventory (NWI) map, is suitable for restoration. It exists in southern Port Chester at the end of Alto Avenue. During visits to the village, it was noted that the small pond and associated wetland are slowly being filled, possibly by municipal public works staff. The fill consists of construction debris (largely concrete) and soil, as well as substantial amounts of leaves and brush. The site is owned by the Village of Port Chester. Further filling of this wetland should be immediately stopped. It is further recommended that the fill be removed from the pond and wetland and the site restored to its original condition.

STREAM RESTORATION

A. Stream Status/Water Resource Inventory

To effectively inventory the water resources of the six subwatersheds and obtain a greater understanding of the nonpoint source pollution control needs in each municipality in the WAC 3 study area, Westchester County conducted a water resource inventory as part of the watershed planning process for the Blind Brook, Beaver Swamp Brook and Brentwood Brook (Beaver Swamp Brook West) subwatersheds. The primary objectives of the water resource inventory were:

1. to obtain solid base line information regarding the existing condition of streams throughout the watershed study area; and

2. to identify areas along the stream corridors that display signs of stress or impairment for potential restoration utilizing best management practices.

To meet these objectives, WAC 3 examined existing information and collected new information regarding the condition of streams throughout its study area.

Priority Water Bodies List

The New York Department of Environmental Conservation (NYSDEC) Division of Water prepares a Priority Water Bodies List (PWL), which identifies surface waters which have one or more uses that are not fully supported or are threatened by declining water quality. This list is used as a base resource for NYSDEC program management (funding, reclamation, restoration and preservation) and is usually updated every two years. Individual water body data sheets for priority water bodies describe the conditions causes, and sources of water quality problems for specified watercourses as well as water bodies. The individual data sheets note the resolution potential (high, medium or low) of a resource on the PWL. Resolution potential indicates that the water quality problem has been deemed worthy of expenditures (time and dollars) because of the level of public interest and the expectation that the commitment of these resources will result in a measurable improvement in the water quality of the resource.

The 1996 PWL contains five streams or water bodies in the WAC 3 study area: Beaver Swamp Brook, Blind Brook, Guion Creek, Milton Harbor, and Long Island Sound. These sites and systems are described in the following sections, which also provide detailed discussion of each stream segment.

"Streamwalk"

In addition to utilizing existing information such as the PWL, the WAC undertook a "hands on" field inspection of the streams throughout the watershed using the Volunteer Streamwalk Program, which is supported by the USDA-Natural Resource Conservation Service (NRCS) Earth Team Volunteer Program. A dedicated team of volunteers participated in the program and assessed most of the study area's streams. These volunteers, formed into "Stream Teams," were trained by Planning Department staff to identify overall stream corridor conditions and identify specific areas where physical conditions may be indicative of adverse water quality conditions (impaired sites). As the volunteers walked through the stream systems, they filled out two inventory analysis forms: (1) a segment assessment survey, designed to collect data that would provide a general description of the stream corridor, and (2) an impaired site assessment sheet, which identified areas along stream corridors where physical signs of adverse water quality conditions were present (See Appendix A). A summary of the identified water resource impairments (including PWLs) are discussed below.

Impaired Site Identification

In the WAC 3 study area, 28 impaired sites were inventoried (see impaired sites map). Sixteen of these sites are in Harrison, 14 are in Rye City, four are in Rye Brook, and two are in Mamaroneck Village. Where impairments exist in sections of Blind Brook that form the municipal boundary between Harrison and Rye City and between Harrison and Rye Brook, the impaired sites were accounted for in both municipalities.

Blind Brook has the highest number of impaired sites of any of the major tributaries in the WAC 3 study area; it also is the longest tributary. Blind Brook has 19 impaired sites. It is listed on the PWL, as is Milton Harbor and Long Island Sound, to which it drains. Beaver Swamp Brook had the second highest number of impaired sites with five. It is listed on the PWL, as is Guion Creek (the tidal section of Guion Creek) and Long Island Sound, to which it drains. Brentwood Brook (Beaver Swamp Brook West) had three impaired sites (the surface portion of this stream is not substantial), while Otter Creek had the fewest number of impaired sites with only one. Table 5 identifies the major impairments noted in each of the streams in each municipality. Table 6 lists the recommended actions that should be taken at each impaired site to improve its condition.

<u>Town/Village of Harrison</u>

Approximately 8.5 square miles of Harrison are within the WAC 3 study area. Nineteen stream miles of Blind Brook, Beaver Swamp Brook and Brentwood Brook flow through Harrison. No PWL site has been noted by NYSDEC in Harrison, although the Rye City segments of Blind Brook and Beaver Swamp Brook, which flow through Harrison, have been listed. The Streamwalk identified 16 impaired sites in Harrison.

Blind Brook

Headwaters Reach

- Four of the headwaters impairments (Impaired Site Nos. 13, 14, 15 and 16) were located on the west and far-west tributaries of the brook between the stream crossings at Cottage Avenue to that portion of the brook which intersects with the Hutchinson River Parkway;
- Three impaired sites (Nos. 1, 2 and 3) were located in the headwaters reach along the main stem of the brook between Lincoln Avenue and the Hutchinson River Parkway. This reach denotes the municipal boundary between Harrison and Rye Brook.
- One priority water body listing was noted in the upper western reach of Blind Brook at Anderson Hill Road, just south of Old Oaks Country Club.

Middle Reach

- One impaired site (No. 4) was noted along the middle reach of Blind Brook between Westchester Avenue and the Westchester Expressway (I-287). This reach denotes the municipal boundary between Harrison and Rye Brook.
- Two impaired sites (No. 5 and 6) were noted along the middle reach of Blind Brook between Westchester Avenue to just below Purchase Street. This reach denotes the municipal boundary between Harrison and Rye.

Beaver Swamp Brook

Headwaters Reach

- One impaired site (No. 20) was noted in the headwaters section of Beaver Swamp Brook, just south of Polly Park Road.

Middle Reach

- Two impaired sites (Nos. 22 and 23) were identified along the main stem of the Brook located south of the New England Thruway (I-95) to just north of Park Avenue. This reach denotes the municipal boundary between Harrison and Rye City.

Brentwood Brook (Beaver Swamp Brook West)

Headwaters Reach

- One impaired site (No. 25) was noted in the headwaters section of Brentwood Brook at the stream crossing with Union Avenue.

Middle Reach

- Two impaired sites (No. 26 and 27) were identified along the main stem of the brook south of I-95.

<u>City of Rye</u>

Rye City makes up approximately six square miles of the WAC 3 study area. Approximately 10 stream miles of Blind Brook and Beaver Swamp Brook flow through Rye City. The Streamwalk identified 12 impaired sites in the city. Three PWL sites have been identified by NYSDEC: Blind Brook, Beaver Swamp Brook, and Milton Harbor (of course, Long Island Sound also is on the PWL).

Blind Brook

Middle Reach

Nine impaired sites were noted along the middle reach of Blind Brook:

- Two of these sites (No. 5 and 6), located just north and south of the stream crossing at Purchase Street, denote the municipal boundary between Harrison and Rye City.
- Six of the impaired sites (Nos. 7, 8, 9, 10, 11 and 12) were inventoried along the main stem of the brook. These sites, wholly within Rye City, are located between Hillside Road south to Playland Parkway.
- One impairment (No. 19) was identified in a small tributary east of the main stem. This impaired site includes a wetland near Ridgeland Terrace.

Lower Reach

- One PWL has been identified at Milton Harbor, near the stream's mouth in Rye City. Approximately 40 acres of the Milton Harbor tidal flats have specifically been included on the PWL.

Beaver Swamp Brook

General Stream

- One PWL has been designated for Beaver Swamp Brook, entirely within the Rye City.

Middle Reach

- One impairment (No. 21), entirely in Rye City, was identified immediately south of North Street.
- Two impaired sites (No. 22 and 23) were identified along the main stem of the Brook located to the south of the New England Thruway to just North of Park Avenue. This reach denotes the municipal boundary between Harrison and Rye City.

<u>Village of Rye Brook</u>

The Village of Rye Brook comprises approximately three square miles of the WAC 3 study area. Nine stream miles of the east and west (main) branches of Blind Brook flow through the village. The "Streamwalk" identified six impaired sites in Rye Brook.

Blind Brook (main branch)

Headwaters Reach

- Three impaired sites (No 1, 2 and 3) are located in the headwaters reach, along the main stem of the brook between Lincoln Avenue and Hutchinson River Parkway. This reach denotes the municipal boundary between Rye Brook and Harrison.

Middle Reach

- One impaired site (No. 4) exists along the middle reach of Blind Brook between Westchester Avenue and the Westchester Expressway. This reach forms the municipal boundary between Rye Brook and Harrison.
- Two impaired sites (Nos. 17 and 18) are located on an eastern tributary of the middle reach of Blind Brook. These impairments are located in Rich Manor Park and just south of Westchester Avenue.

<u>Village of Mamaroneck</u>

Mamaroneck Village comprises approximately 0.75 square miles of the WAC 3 study area. A combined total of approximately 1.8 linear miles of Guion Creek, Beaver Swamp Brook and Otter Creek flow through the village. The "Streamwalk" identified two impaired sites throughout Mamaroneck Village.

Beaver Swamp Brook/Guion Creek

Middle Reach

- One impairment (No. 24) was located just south of Rye Neck High School

Lower Reach

- A one-mile segment of the lower reach of Beaver Swamp Brook (also called Guion Creek, a tidal segment) from Hornidge Road downstream to Mamaroneck Harbor, in Mamaroneck Village, has been included on the PWL.

Otter Creek

Stream Mouth

- One impairment (No. 28) was noted at the outfall of Otter Creek at Mamaroneck Harbor.

B. Recommendations and Restoration Opportunities

Table 1A identifies 11 Best Management Practices (BMPs) that can correct impairments throughout the subwatersheds of Blind, Beaver Swamp and Brentwood brooks. There may be other means for corrective action, but these BMPs and those found in Section II of this report provide the reader with a foundation for understanding BMPs and the ways in which they can assist in improving and protecting water quality. BMPs recommendations for each municipality is noted below, as are recommendations of practices on a watershed-wide basis.

Municipal Summary

Town/Village of Harrison

The most appropriate BMPs for Harrison's 16 impaired sites include:

- buffer/bank enhancement
- mowing practices;
- natural channel restoration; and
- nutrient management.

City of Rye

The most applicable BMPs for the City's 12 impairments include:

- buffer/bank enhancement;
- stream stabilization;
- erosion and sediment control; and
- natural channel restoration.

Village of Rye Brook

The most appropriate BMPs for the Village's six impaired sites include:

- buffer/bank erosion;
- nutrient management;
- natural channel restoration; and
- stream restoration.

Village of Mamaroneck

The most applicable BMPs for Mamaroneck Village's three impaired sites include:

- channel restoration;
- stream stabilization; and
- bank manipulation.

Best Management Practices

Buffer/ Bank Enhancements

- Sixty-four percent of the impairments throughout the WAC 3 study area noted impairments attributed to diminished riparian buffers.

Riparian buffers are transition zones between a watercourse and upland area. Buffers are naturally vegetated strips of land that protect water resources from disturbance. Buffers are designed to intercept surface and subsurface stormwater flows, thereby reducing velocities which allow for attenuation of pollutants before stormwater enters a wetland or water body. Riparian buffers significantly improve water quality in many ways. They stabilize stream banks and reduce channel erosion, regulate channel shape and size, moderating runoff and stream temperatures, and control the velocity, quantity and quality of stream flows to mention a few.

Where feasible, WAC 3 recommends that riparian buffers (riparian zones) be enhanced, restored and, in appropriate places, established to a width of 100 feet from the edge of streams, wetlands and water bodies (see buffers section in Part 2).

Stream Bank Stabilization

- Forty percent of the noted impairments in the study area are caused by stream bank erosion.

Eroding stream banks contribute sediment to the water and stream bed and can also cause increased water temperatures. Stream bank erosion has the potential to change the hydrology of the entire stream system due to the physical interaction between the flow of water and the channel that directs its path. Stabilizing areas along stream channels will help reduce sediment deposition into the water and channel, assist in the filtration of potential contaminants and restore the hydrology of the stream.

Where practical, WAC 3 recommends that eroding stream banks be stabilized through the use of vegetative water quality best management practices such as live staking and branch packing. Section II briefly describes some of the more commonly used practices.

Natural Channel Restoration

- Forty percent of all stream systems in the WAC 3 study area are impaired by either channel or bank manipulation. The “Streamwalk” noted that impoundments and fish blockages as a high concern on 18 percent of the impaired sites.

Structural modification to a stream bank or stream channel impacts the natural behavior of a stream. Most channel manipulation usually occurs in the form of channel straightening, allowing for a faster means to convey quantities of water. Lining a stream with concrete or other artificial material, redirecting a stream into a culvert and creating an impoundment all prohibit the system from developing a natural pattern on the landscape. Impoundments specifically encourage sedimentation and affect the passage of fish and other aquatic life through the system. While modification of a natural stream system may be beneficial in some instances for flood control, water quality protection dictates the importance of slowing the velocity of water and allowing pollutants to settle or filter out of the water column.

Channel and bank manipulation is more often than not one of the most expensive water quality impairments to improve in a stream. Given the level of urbanization and the highly manipulated condition of the streams in the watershed, WAC 3 recommends that municipalities in its study area to fully explore alternatives to manipulation when faced with a development proposal and if the opportunity arises, restore existing manipulated areas to their natural state.

Nutrient Management

- Twenty-four percent of the impaired sites noted a concern regarding nutrients in the stream system, as evidenced by the condition of streams adjacent to golf courses and residences, excessive algae in many of the stream reaches, and suspected septic system discharges.

  Excess nutrients (phosphorus and nitrogen) can lead to undesirable algae blooms throughout stream reaches and enhance eutrophic processes. Golf course turf grass is extremely rich in nutrients so that an exceptionally thick , green, golfing surface is created. Home owners apply nutrients to their lawns to keep them green and have a tendency of mowing to the streams edge (destroying any buffer capacity) and aging septic systems may fail and contribute nutrients to the soil.

  WAC 3 recommends the development of a program for golf course management be created for all of the golf courses (public and private) throughout the watershed study area. This program should emphasize educating golf course managers about turf grass management and water quality techniques. Home owners should also be educated as to the proper application of fertilizers on their lawns, as well as the benefits of riparian buffers.

Erosion and Sediment Control

- Approximately 10 percent of impairments are related to construction activities and sedimentation.

  Construction site erosion and sedimentation can drastically deteriorate water quality in streams. It can reduce the capacity of storm water conveyance systems resulting in localized flooding; it can create unwanted habitat for fish and other aquatic life, and it can alter water temperature, affecting the overall chemical composition of the water.

  WAC 3 recommends that proper construction site erosion control practices be implemented and maintained on disturbed areas and that local municipalities in the watershed enforce or create construction site erosion control ordinances.

Stormdrain Retrofit

- Pipe discharges are noted as problems in four percent of the study area’s streams.

  Some storm drain outlets can be a significant source of pollution. Some outlets contribute to channel erosion, channel scour and sedimentation. To retrofit these negative impacts, WAC 3 recommends that outlets in need of repair and maintenance be retrofitted to include filter screens, velocity reduction devices, back filling and revegetation of damaged stream banks.

Septic System Maintenance

- Potential septic system failures were noted at 7 percent of the study area’s impaired sites.

  While septic systems are not abundantly used throughout the WAC 3 study area, those that are used and improperly maintained, designed or constructed may pose a significant threat to water quality, allowing nutrients (phosphorus and nitrogen) into the soil and water. As discussed earlier, excess nutrients not only poses a threat to human health, but it also fuels the growth of algae and limits oxygen in streams and water bodies. Maintenance is the single most important consideration in making sure a septic system will work well over a long period of time.

Some watershed residents are not served by public sewers. Those that have septic systems often times do not maintain them and many are so old that they are failing. WAC 3 recommends that municipalities examine possible septic system maintenance programs for homeowners that have septic systems in the WAC 3 study area.

Mowing Practices

- Mowing practices were identified as a water quality inhibitor at 29 percent of the study area's impaired sites.

It is common to find streams or water bodies cutting through residential areas or through golf courses. More often than not, the adjacent lawn area to these streams is mowed up to the water's edge. This not only inhibits natural buffers along stream corridors, but also reduces the filtering capacity provided by such an area. A naturally vegetated buffer is especially important where a property owner uses fertilizer and other lawn care products because it acts as a filter to reduce opportunities for the harmful products to reach the water body. Buffers consisting of woody vegetation, such as shrubs and trees, are generally more efficient at filtering nonpoint source pollutants than buffers made up of herbaceous vegetation, such as grasses.

Where practical, WAC 3 recommends that landowners adjust mowing heights along streams and other water bodies. Where feasible, this should be combined with the establishment of riparian buffers (riparian zones), established to a width of 100 feet from the edge of a stream bank.

Sediment Removal

- Sediment is a characteristic of degradation at 29 percent of the study area's impaired sites.

Sediment, whether from road sanding practices, construction activities, eroding stream banks etc., is a water quality inhibitor. Among other things, sediment "smothers" the natural habitat within a stream, harming aquatic life. WAC 3 recommends that where sediment is noted as an impairment, the source of the sediment be determined and adjusted to reduce sediment deposition in the water body. For example, if construction activity is the source of sediment deposition in a water body, proper erosion and sediment controls should be implemented and maintained, including enforcement on the construction site and the existing sediment in the water body should be removed in an attempt to restore the water body to its natural condition.

Housekeeping Practices

- Eighteen percent of the impairments in the watershed are likely related to improper "housekeeping" (maintenance and dumping) practices at commercial businesses located in the WAC 3 study area.

It is important to note that where litter and/or hazardous containers and odors were detected, it is the responsibility of the business owner to ensure proper disposal of materials. WAC 3 recommends that these impairments be cleaned up and where suspected hazardous contaminants are identified, proper state action be taken.

FUNDING

A. Existing Programs and Funding Sources

The major contribution of nonpoint source pollution to the degradation of the nation's waters has prompted local, state and federal governments to initiate programs to abate nonpoint source pollution. Often the impetus for these programs has been the desire to protect particularly valuable waterbodies, such as Long Island Sound.

In part, state and local governments have taken action because existing Federal programs are not intended to address the wide range of specific problems caused by nonpoint source pollution. Although Federal agencies, such as the Department of Agriculture and the Environmental Protection Agency (EPA), have limited available resources to address some nonpoint source pollution categories and provide some funding for state and local programs, these programs are very small compared to the magnitude of the nonpoint source pollution problems across the nation.

The purpose of this section is to describe particularly effective state and local nonpoint source pollution funding mechanisms so that Westchester municipalities will have an understanding of these approaches as they implement their own nonpoint source pollution control programs.

Rainwater runoff which creates most nonpoint source pollution takes many forms and, as a result, solutions to NPS problems must be varied. The problems range from runoff from the vast acreage of farms and forests across the country to drainage from suburban lawns and golf courses to runoff from city streets.

Only recently have government agencies begun in a more comprehensive way to identify the types of nonpoint source pollutants, measure the volume of nonpoint source loadings which affect surface and ground waters, and design effective watershed projects and regulatory programs to abate nonpoint source pollution. Only a few states have been implementing nonpoint source pollution control watershed projects to reduce loadings and improve water quality for more than five years.

In 1989, Congress appropriated the initial funds for the Environmental Protection Agency to award demonstration grants to states to develop and implement statewide NPS management programs under Section 319 of the Clean Water Act. Section 319 specifies that states shall "to the maximum extent practicable, develop and implement a management program under this subsection on a watershed-by-watershed basis within such State."

Section 319 grants provide sufficient funding to allow state agencies to hire nonpoint source pollution control staff and carry out several projects each year. This grant program can be considered an initial step toward a national effort by EPA to assist states to abate nonpoint source pollution. However, it is clear that much more will be necessary if the nation as a whole is to succeed in abating nonpoint source pollution.

Prior to the initial appropriation of Section 319 funds, other federal agencies, most notably the Department of Agriculture (USDA), provided funding and technical assistance to producers, such as farmers and coal operators, to encourage voluntary reduction of nonpoint source pollution created by their economic activities. USDA, for example, provides direct grants (cost sharing) to individual farmers to pay part of the cost of selected practices used by the farmer to reduce runoff. Technical assistance to the farmer which facilitates implementation of the practices is often provided by the USDA Natural Resources Conservation Service (NRCS) and local Soil and Water Conservation districts.

In some cases, state and local governments have decided not to rely on national solutions and have developed their own, often unique, programs for controlling non point source pollution and equally unique means to pay for the control programs. An understanding of selected nonpoint source pollution control programs operated by local and state governments can assist other communities in developing and funding effective nonpoint source pollution abatement programs in the future.

The New York State Clean Water/Clean Air Bond Act, passed in 1996, should provide an additional source of funding for water quality improvement projects. Of the $1.75 billion Bond Act, $200,000,000 is earmarked for Long Island Sound projects including wastewater treatment improvement projects, nonpoint source abatement and control program projects, and aquatic habitat restoration projects.

Revolving Funds

Regarding state revolving funds, which already exist in every state (funded by EPA grants and the state match), each state decides whether to use its fund for nonpoint source pollution programs, municipal treatment plants or estuarine projects. Consequently, state environmental officials and legislators currently have the authority to decide whether or not to use the very large, existing sums in revolving loan funds for nonpoint source pollution purposes.

The existence of large state revolving funds (SRFs), which have been established since the Clean Water Act Amendments of 1987 by annual capitalization grants from EPA and state matching funds, provides all states the opportunity to use these funds to finance local and state nonpoint source pollution control projects. SRF loans are particularly suitable for funding structural best management practices (BMPs), such as extended detention and retention basins. Generally, these loans are not suitable for other program costs, such as salaries and indirect costs.

SRFs were originally established to assist states to upgrade their sewage systems, but the authorizing statute also specifies that nonpoint source pollution control activities are eligible for SRF loans. As the number of states meeting performance levels for municipal waste treatment increases, additional states will have the option of using all or part of their SRF resources for nonpoint source pollution abatement.

Use of Special Fees and Taxes

Thus far, the NPS funding techniques discussed here have been designed primarily to pay for specific best management practices or BMPs, such as detention basins or septic systems. Other state and localities have taken a different approach. They have established goals for improving water quality in a waterbody and have also found the funding mechanisms to raise the necessary resources to accomplish these goals.

One impressive example of this type of approach is Maryland’s Critical Area Program (CAP). To reduce nonpoint source pollutant loadings, Maryland employs a land use management program in a 1,000-foot-wide strip along the state’s portion of the Chesapeake Bay. Consequently, most of the activities which reduce or prevent loadings (e.g., spacing of housing development and creation of filter strips) are paid for by individuals or corporations.

However, state and local governments also provide funding for many planning and legal functions, as well as providing more direct assistance to landowners; for example, cost-sharing of agricultural BMPs. This blending of public and private resources is only one of the many interesting and environmentally valuable aspects of the Critical Areas Program.

Similarly, in Colorado, the Cherry Creek Basin Water Quality Authority uses the authority of state law to obtain revenues to fund both point and nonpoint control of runoff causing eutrophication in the Cherry Creek reservoir. This case study was selected to help other localities which are seeking ways to finance controls for localized nonpoint source pollution problems.

The Iowa Ground Water Protection Act represents a good example of a user fee/tax program established to fund nonpoint source pollution projects and programs. The Iowa law places fees and taxes on the sale of fertilizers and pesticides, waste disposal and underground storage tanks. In this type of program, there is a delicate balance between establishing an economic disincentive which results in water quality benefits and an economic hardship which may be a critical factor for business survival. In Iowa, the fees on the sale of pesticides and fertilizers were balanced with an extensive technical assistance and education program which actually resulted in substantial savings to many of the users.

B. Recommendations

Grants - Apply for state and federal grants related to implementation of nonpoint source management and education programs and natural resource restoration and protection programs, such as those under Sections 319 and 404 of the federal Clean Water Act, the U.S. Environmental Protection Agency's Environmental Education Grants Program and Wetlands Protection Program, and U.S. Fish and Wildlife Service's Challenge Cost Share Program.

State Revolving Funds (SRF) - Utilize the SRF, which is particularly suitable for funding retrofits and construction of structural best management practices, including detention, extended detention and retention basins.

New York State Clean Water/Clean Air Bond Act - Propose projects for funding through the Clean Water/Clean Air Bond Act. Eligible projects include nonpoint source control, habitat restoration and flood control.

Special Fees and Taxes - Review the examples provided in this document which explain "user fee" and tax programs and determine if such examples are appropriate for the Long Island Sound watershed communities in this study area.

Environmental Protection Fund (EPF) - Propose projects for funding through the Environmental Protection Fund (EPF).

Clean Vessel Act Pumpout Grant Program - Propose new marina pumpout facilities or improvements to existing facilities for funding through the Clean Vessel Act Pumpout Grant Program.

WATERSHEDS AND WATER QUALITY

A. Impacts on Water Quality

Water quality is a product of the watershed. Land-based activities significantly determine the quality of Long Island Sound. Urbanization, therefore, has a significant influence on water quality. By comparing a stream or wetland in a developed area to one in a more natural setting, detrimental impacts of nonpoint source pollution can be more easily identified. Specifically, the typical urban stream and wetland exhibits a lesser density and diversity of microbic life forms; aquatic organisms in these water resources are typically associated with environments stressed by hydrologic changes and point and nonpoint source pollution. Detrimental impacts associated with development include massive “pulses” of sediment during construction, increased wash-off of pollutants (trash and debris, trace metals, nutrients, toxics, hydrocarbons), increased stream temperatures, and nutrient enrichment and subsequent algal growth. Nutrients and pollutants may be dissolved in water or may adsorb (attach) to sediment particles. These particles may then wash downstream where they can accumulate in depositional areas or be released into other water resources. The net effect of urbanization often is an increase in pollutant export by at least one order of magnitude over pre-development levels. This impact is not only seen in stream or wetlands, but is felt by downstream receiving waters such as lakes, rivers and estuaries. Results of the Long Island Sound Study conclude that the water quality of Long Island Sound exhibits the symptoms of urban stress.

Urbanization reduces the amount of stormwater that is absorbed by the ground, thereby increasing stormwater runoff volume. The vast parking lots, buildings, roads and other impervious surfaces associated with urban areas result in large amounts of stormwater runoff, resulting not only in less water infiltration but also less available water to recharge ground and surface waters. Urban stormwater runoff also transports pollutants (nonpoint source pollution) from land surfaces to water resources, such as wetlands, streams and lakes.

In addition to nutrients and toxicants that are generated from existing residential and commercial land use, there are numerous other nonpoint pollution sources which need additional attention, including construction site erosion, and runoff from waste disposal sites and resource extraction industries, such as mining and sand and gravel operations. These sources cumulatively have a tremendous effect on the water quality of streams, freshwater water bodies, wetlands, and, ultimately, Long Island Sound. The most prevalent types of nonpoint pollution are discussed below.

B. Types of Nonpoint Source Pollutants

The major urban nonpoint sources of pollution in the Long Island Sound watershed are sediment, excess nutrients, bacteria, hydrocarbons (petroleum), trace metals, chemicals, chlorides, and thermal impacts. The following is a description of the water resource impacts of each of the primary nonpoint source pollutants.

Sediment

Suspended sediments constitute the largest mass of pollutant loadings to surface waters. Sediment has both short- and long-term impacts on surface waters. adversely impacts water resources in many ways. Suspended sediment in streams causes increased turbidity, transport of excess nutrients and pollutants to the water column, reduced light penetration, reduced prey capture for sight feeding predators, impaired respiration of fish and aquatic invertebrates, reduced spawning and juvenile fish survival, and impairment of commercial and recreational fishing resources. Additional impacts result after sediment is deposited in the slower moving “receiving” waters. These impacts include the smothering of aquatic organisms living on the bottoms of streams, ponds and estuaries, changes to the composition of stream and water body bottoms, speedier filling of small impoundments which creates the need for costly dredging, and reduction in aesthetic values. Sediment also can be an efficient carrier of toxic substances and trace metals. Pollutants in these enriched sediments can be re-mobilized under suitable environmental conditions, posing a risk to aquatic and other life.

The greatest sediment loads are exported during the construction phase of development sites. In dense urban areas, sediment discharged to streams and lakes from developed sites generates between 10,000 to 100,000 tons/square mile/year of sediment. This is an average estimate of erosion. The amount of sediment reaching a water body from a particular site is highly variable and is very dependent on factors such as size of disturbed areas, proximity to waterways, soil type, and slope. In any construction activity, proper measures can be taken to reduce nonpoint source pollution and the consequent deleterious effects on water quality.

Nutrients

Excessive loadings of phosphorus and, particularly, nitrogen into marine ecosystems can result in eutrophication and depressed dissolved oxygen (DO) levels due to elevated phytoplankton populations (algal blooms). Excessive algae and aquatic plant growth (except for eelgrass beds, which tend to decline during eutrophication) can choke open waters and consume oxygen, mainly through plant die-off. Fish and aquatic organisms, recreational values, and other uses of the resource are thereby impacted. Bioassays have indicated that the typical nutrient concentrations in urban runoff are more sufficient to stimulate excessive algal growth; a majority of the nutrients in urban runoff are present in soluble forms which are readily taken up by algae. Thus, any additional nutrient load from nonpoint source pollution will only increase degradation of the system.

Aside from promoting growth of dense mats of algae, nutrients can enhance eutrophic processes in urban lakes, detention basins and other fresh and tidal waters. These systems will show evidence of surface algal scums, water discoloration, strong odors, depressed oxygen levels, release of toxins, and reduced palatability. Nitrogen contamination of drinking water significantly above the drinking water standard may also cause methoglobinemia (“blue-baby” syndrome) in infants and has forced closure of several water supplies (primarily wells). As a general rule, nutrient export is greatest from development sites with sizable impervious areas and managed landscape components, such as lawns.

Bacteria

Bacteria (and viruses) include infectious agents and disease-producing organisms normally associated with human and animal wastes. The principal concern is the survival and transmission of such organisms and their impacts on drinking water supplies, contact recreational waters, and fish and wildlife or domestic animals. Bacteria multiply faster during warm weather. A twenty-fold increase in bacterial levels may occur from winter to summer.

Older and more intensively developed urban areas produce the greatest bacterial export. The problem is especially significant in urban areas which experience sewer overflows and septic system failures, which export bacteria in untreated or partially treated human wastes. In surface water, bacterial survival is dependent on temperature and salinity, but few species can live in brackish water. Coliform bacteria tend to be common, and may indicate sewage pollution if they are of the fecal coliform group.

Oxygen-Demanding Substances

Decomposition of organic matter, both natural (such as sewage and algae) or synthetic (such as PCBs, pesticides and herbicides), depletes dissolved oxygen (DO) levels in receiving waters such as lakes and estuaries. Natural decomposition of these materials may deplete dissolved oxygen levels in bottom waters. As a result, DO levels may be reduced below the threshold necessary to maintain aquatic life, impairing or killing slower-moving fish and other aquatic biota, especially shellfish and crustaceans. DO depletion is measured by examining the amount of easily oxidized organic matter present in water. Data have shown that urban runoff with high concentrations of decaying organic matter can severely depress DO levels after storm events.

Oil and Grease

Petroleum hydrocarbons are derived from oil products, and the source of most such pollutants found in urban runoff is vehicles - auto and truck engines that drip oil. Hydrocarbons (oils and other petroleum compounds) are known to be toxic to aquatic life at relatively low concentrations. Hydrocarbons are lighter than water and are initially found in the form of a rainbow colored film on the water's surface. Hydrocarbons tend to have a strong affinity for sediment, and much of the hydrocarbon load eventually adsorbs to particles and settles out. If not trapped by control measures, hydrocarbons tend to rapidly accumulate in the bottom sediments of lakes and estuaries where they may persist for long periods of time, and have long-term adverse impacts on fish, wildlife and microorganisms, habitat and public water supply sources.

The major source of hydrocarbons in urban runoff is through leakage of crankcase oil and other lubricating agents from automobiles. As might be expected, hydrocarbon levels are highest in the runoff from parking lots, roads and service stations. Residential land uses generate less hydrocarbon export, although illegal disposal of waste oil into storm sewers can be a local problem.

Trace Metals

Trace metals are primarily a concern because of their toxic effects on aquatic life, and their potential to contaminate drinking water supplies. Significant amounts of trace metals become attached, or adsorbed, to sediment, which then may transport the trace metals to other water resources or other areas of the same resource if the sediment becomes suspended in the water column of streams and rivers. Metals can be discharged to surface water and groundwater from a variety of sources including industrial plating operations, waste oil discharges, and pesticides.

Toxic Chemicals

Toxic chemicals may enter surface waters either in dissolved form in runoff or attached to sediment and organic materials and may enter groundwater through soil infiltration. The principal concerns in surface waters are their entry into the food chain, bioaccumulation, toxic effects on fish, wildlife and microorganisms, habitat degradation, and potential degradation of public water supply sources. The groundwater impacts are primarily related to water supply sources.

Chlorides (Road Salts)

Chlorides, or salts, often wash off into streams and water bodies after they are applied to remove ice and snow from roads, driveways, parking lots and sidewalks. Salt levels in snowmelt runoff have been reported to exceed several thousand milligrams per liter, which can be dangerously high for some water resources. Due to its extreme solubility, almost all chloride applied for snow removal purposes ends up in stormwater runoff. At high levels, chlorides are toxic to many freshwater aquatic organisms which can withstand only relatively low salinity.

Thermal Impacts

Elevated water temperatures can have detrimental impacts on water quality. Elevated stream temperatures can exceed fish tolerance limits, reducing survival and lowering disease resistance. A rise in water temperature of just a few degrees over ambient conditions can reduce or eliminate sensitive stream insects and fish species, such as stoneflies, mayflies and trout. In general sustained summertime water temperatures in excess of 70 degrees Fahrenheit are considered to be stressful, if not lethal, to many cold water organisms.

A number of factors can increase summertime water temperatures in urban headwater streams. Of these, three factors often act synergistically to increase water temperatures. First, as the urban landscape heats up on water summer days, it tends to impart a great deal of heat to any runoff passing over impervious surfaces, such as parking lots. Second, few trees may exist on streambanks to shade stream channels. Third, runoff stored in shallow wet ponds and other impoundments may be heated between storms, and then may be released in a rapid pulse during and shortly after storms.

C. Best Management Practices

Reducing, restoring and preventing the impacts of nonpoint source pollution can be accomplished in part by using best management practices (BMPs). Numerous BMPs have been developed to decrease soil loss and the transport of nutrients and other contaminants. Effectiveness in preventing nutrient export, technical feasibility, social acceptability and cost vary widely among the practices. Some practices are more suitable for new developments than for developed areas. Although BMPs seldom provide a complete solution in restoring natural resources and water quality, they are key elements in an evolving strategy that recognizes that natural resources can be managed and protected only in the context of the watershed in which they exist. BMPs are defined as the most effective practicable (including technological, economic, and institutional consideration) means of preventing or reducing the amount of pollution generated by nonpoint sources to a level compatible with water quality goals.

BMPs consist of a wide range of pollution prevention techniques. They range from structural practices, such as detention basins, to non-structural techniques, such as pollution prevention programs and regulatory controls. Nonstructural BMPs seek to prevent contamination of runoff through planning, design, maintenance, and education. They are a proven, cost-effective way to manage urban runoff. Non-structural BMPs focus on pollution prevention, information and education, and regulatory controls which reduce nonpoint source pollution. Implementing nonstructural BMPs requires cooperation and participation from municipal personnel, project proponents, and the public.

Structural BMPs are structures specifically designed and constructed for the reduction of nonpoint source pollution. There are a variety of structural BMPs, both vegetation and nonvegetated. Vegetative structural BMPs range from filter strips and grassed swales to artificial wetlands. Non-vegetative practices and consist of bank stabilization structures, stormwater detention basins, water quality inlets and oil and grease catch basins. A combination of vegetated and non-vegetated structures can also be used.

The following is list of various construction and structural BMPs which can be used to reduce nonpoint source pollution. Table 3 provides a comparative assessment of the effectiveness of the most widely used management practices listed below.

- Infiltration Practices
- Wet/Dry Detention Basins
- Streambank Stabilization Structures
- Grassed Swales
- Filter Strips
- Filter Fences and Other Construction Site Erosion Controls
- Education
- Land Use Planning/Zoning
- Construction Erosion Control
- Comprehensive Site Planning
- Sanitary Waste Management
- Buffer Zones
- Setback Requirements
- Easements
- Catch Basin Cleaning
- Alternative Salting Methods
- Street Sweeping
- Combined and Separate Storm Sewer Systems
- Petroleum Storage Tank Regulations
- Spill Prevention Programs
- Animal Waste Collection
- Proper Pesticide and Fertilizer Use and Application
- Neighborhood Recycling Program

MUNICIPAL REGULATORY AND NON-REGULATORY TOOLS

Health regulations, zoning ordinances, land acquisition and voluntary controls are some of the options available to local governments in their mission to manage the water resources that protect the public health, safety and welfare. Health regulations can address both proposed and existing development and their impacts on water quality. Zoning controls are limited in that they are prospective--they typically apply only to future development and not to existing activities which are exempt or “grandfathered.” General police powers are available under a community’s home rule powers to protect the public health, safety, and general welfare. Non-regulatory options may include educational efforts, monitoring, the adoption of certain best management practices, and land acquisition.

The type of control that a community may consider also will help determine who should be involved in the local community. For example, if boat sanitary waste dumping is considered a threat, the local harbormaster should be involved in drafting regulatory measures. It also would be valuable to gather support from local marinas that may be affected by new mooring and pumpout regulations.

Many of the tools listed in this chapter are designed for protection of groundwater, focusing on preventative action for coastal waters because polluted groundwater can be a significant source of contamination in surface waters. For both surface and groundwaters, pollution prevention is much cheaper than clean-up after the fact.

A. Regulatory Tools

Zoning Regulations

Zoning techniques offer another powerful tool to protect water quality. These are often overlooked. The use of floor area ratios (FAR), and maximum building and lot coverages limit the conversion of land to impervious surfaces (lot coverage differs from building coverage because it includes all impervious surfaces, such as paved areas, in addition to buildings). This allows for greater infiltration of stormwater and minimizes the potential for pollutant-carrying runoff. These criteria could be enhanced by excluding land areas unsuitable for building, such as wetlands, steep slopes, etc.

Zoning regulations have been used throughout the country, in coastal and inland areas, to segregate different and possibly conflicting activities into different areas of a community. The following are important zoning techniques that can be used to protect coastal resources.

Overlay Water Resource Protection Districts

One technique designed to update regulations for protection of a surface or groundwater resource is the creation and adoption of overlay water resource protection districts by law. The law, which may vary by municipality in its approach toward resource protection (i.e., prohibition of various uses versus special permitting and/or performance criteria), defines the resource by mapping watershed boundaries and enacting specific legislation for land uses and development within these boundaries.

Watershed Zoning

A new zoning technique that has been instituted in a few communities (but not yet tested extensively) is watershed zoning. This is simply the idea of extending zoning districts onto water bodies. Under traditional zoning, specific areas of a community are set aside for various land uses. Under zoning, certain areas of the water body are set aside for such water-dependent uses as navigation channels, mooring areas, water-skiing, and so on.

Prohibitions of Various Land Uses

Virtually every community that has adopted zoning prohibits certain land uses from specific sections of the community, although the rationale behind such prohibition may or may not be related to water resource protection. While not the most creative or effective approach toward resource protection, prohibition of land uses such as gas stations, sewage treatment plants, landfills, or others involving the use, storage and disposal of toxic and/or hazardous materials is a first step toward the development of a comprehensive water resource protection strategy.

Special Permitting

If applied strictly, the special permitting process can be used effectively to regulate uses and structures that may potentially degrade water quality. For example, many communities use the special permitting process to regulate underground storage tanks or limit lawn fertilizer use within critical areas.

Large Lot Zoning

Large lot zoning, as the title implies, seeks to limit water resource degradation by reducing the number of buildings and, therefore, septic systems within a protection area. Large lot zoning is sometimes difficult to enact depending on circumstances, such as existing zoning and growth characteristics. Nevertheless, when used as part of an overall protection strategy, large lot zoning within resource-contributing areas can be an effective tool against water contamination. There is no definition of “large lot” zoning, although case law has upheld different variations on local government’s use of minimum lot size.

Transfer of Development Rights

The idea of “transfer of development rights” (TDR) is based on the concept that a parcel of land has a bundle of different “rights” associated with it. A TDR program allows a landowner to separate his or her right to develop the land, as permitted by zoning, from other rights associated with the land, and sell those development rights.

To implement a TDR program, a governmental entity such as the town would prepare a plan designating the parcels or districts from which development rights could be transferred (a “sending” or “donor” parcel), and the parcels or districts which would receive those development rights and be developed at a higher density than allowed by the underlying zoning district (a “receiving agent”).

Typically, a sending parcel or district might be within a contributing area to an estuary or other water resource. A receiving parcel is able, both from a physical standpoint and in terms of the community’s growth program, to accommodate additional development beyond that allowed as-of-right by zoning. In selling his or her development rights, a landowner would gain the cash value of whatever development rights the market associates with the land, and yet would keep the land in a less intensive use and help protect the resource in question. A perpetual easement or some other development restriction would be recorded with the deed of the sending or donor parcel. The purchaser of the development rights gains the ability to develop the receiving parcel the receiving parcel at a higher density than allowed "as-of-right" and can recapture the cost of the purchased development rights through the more intensive use of the receiving parcel.

Cluster Development

Cluster zoning is an alternative to the standard grid-style subdivision. It allows buildings to be "clustered" more densely on a portion of the site most suitable for development, in exchange for preserving the rest of the site, including any sensitive coastal areas, as contiguous open space. In a cluster development, smaller building lots are allowed, with resulting land savings set aside in contiguous areas of open space.

Subdivision or zoning regulations should contain provisions that enable a developer to modify minimum lot size and other dimensional requirements as part of the subdivision approval process. This "clustering" technique allows for a grouping of dwelling units on one or more portion s of the site with the remainder set aside as common open space. This process encourages diversity in housing design, preserves open space and allows development to account for variations in the natural environment. Clustering also is a way for developers to minimize expenses for development, with shorter sewer and utility lines and a smaller road system. Clustering provides tremendous flexibility for both the developer and municipality, and often allows for greater creativity in the division of large land parcels.

Growth Controls/Timing

Growth controls are techniques that are used to slow or guide a community's growth, ideally in concert with its ability to "support" growth. The term "support" has been broadly defined, and can include issues ranging from a city or town's physical and financial ability to provide public facilities (roads, water, sewer, schools and public safety) to its ability to retain its once rural, historic character. Growth controls vary in their application and have included outright moratoria to limitations on numbers of building permits issued in any twelve-month period. One of the most widely referenced examples of growth control is the 1969 Ramapo, New York ordinance that limited growth and development in the community to a rate commensurate with the town's ability to provide services to new (an existing) residents.

Falmouth, Massachusetts used growth controls to limit land subdivision within the rapidly developing watersheds to its coastal ponds. In 1985, the town adopted a subdivision phasing regulation designed to slow development within these sensitive resource areas. The idea was to "buy time" for the town to implement other management controls such as rezoning, land acquisition and monitoring to protect the coastal water resources.

Performance Standards

Performance standards are based on the assumption that any given resource has a threshold, beyond which the resource's ability to function deteriorates to unacceptable levels. Performance controls assume that most uses are allowable within a designated area provided that the uses do not and will not overload the resources. A good example of a performance standard is one designed to protect surface water quality by setting a critical threshold for contaminants. Those land uses which will cause the threshold to be exceeded in the water body are not allowed.

Approximately one year before Falmouth, Massachusetts adopted the growth controls noted above, the town instituted a unique and precedent-setting approach to manage development in watersheds to the town's coastal resources. All development within defined, mapped areas (mapped as an overlay zoning district) was required to adhere to strict performance standards. In effect, these standards were designed to ensure that all development within watersheds to coastal ponds, when analyzed cumulatively, would not exceed the assimilative capacity of the resources.

Health Regulations

The development of health regulations is an extremely effective method of rounding out a community's regulatory protection program. The following are examples of well-accepted techniques using health regulations to protect coastal and water resources.

Underground Storage Tanks

Leaking underground storage tanks may be the single largest source of groundwater contamination in the nation. The larger underground gasoline storage tanks associated with automotive service stations have caused numerous groundwater contamination incidents. As noted earlier, if compounds from these tanks enter estuaries, they may be accumulated by shellfish, presenting a health risk to consumers.

Potential components of tank regulations are: leak testing and construction standards for new, large tanks such as those at automotive service stations; prohibition of new residential underground storage tanks if they cannot be adequately monitored; removal of existing residential underground storage tanks; and prohibition of all new underground tank installation (except for replacements) within watersheds.

Privately-Owned Small Sewage Treatment Plants

Privately-owned small sewage treatment plants (SSTPs) have been utilized as a technological solution to prevent overloading of the natural capabilities of land and associated water resources to assimilate wastewater discharges. The use of these small treatment plants has, in some cases, allowed development of land beyond the development that would be possible using conventional, individual septic systems.

The effectiveness of SSTPs is dependent upon the proper functioning of more components than that associated with a standard septic system. SSTPs also require supervised operation and maintenance. Consequently, they are more likely to malfunction and their use may be a risk in critical resource areas. To eliminate these risks in critical water resource areas, some communities have entirely banned the use of SSTPs.

Septic System Maintenance

The maintenance of on-site septic systems is frequently overlooked. The result is typically an overloading. The result is typically an overloading of solids moving to the leaching facility and subsequent clogging. When this occurs, the system needs to be rehabilitated. This is commonly done with the use of strong acids or organic solvents. However, these chemicals are contaminants and can degrade ground and surface water quality. To minimize this danger and to ensure proper maintenance of septic systems, many communities have developed a voluntary septic system maintenance program. The key component of such a program is pumping every two to three years for residential septic systems.

Boat Pumpout Facilities and Head Use Limitations

Since near-shore dumping of human wastes from boats can cause contamination of shellfish beds and swimming areas as well as nutrient enrichment, some communities have enacted limitations on dumping and taken action to provide pumpout facilities. For example, Kent County, Maryland requires all new or expanding marinas to install pumpout facilities and to provide signs notifying boaters of the facility. In Prince William County, Virginia, the county supplements state requirements to ensure that at least one pumpout facility is available on any tidal creek with a marina.

Subdivision Rules and Regulations

Subdivision regulations fine-tune zoning ordinances in that they focus less on land use and more on engineering concerns, such as road construction, utilities and site plan layout of individual subdivisions. Protecting coastal water resources via subdivision control is, therefore, less effective than via zoning, but can still be used to ensure that drainage and landscaping designs fit with the goal of resource protection. Following are some important techniques to consider.

Stormwater Management

A key component of nonpoint source pollution is stormwater runoff (see Chapter ---- for additional information). As lands become more developed and more urbanized, less precipitation reaches the earth where it can be absorbed and naturally filtered. In addition to flooding and stream channel erosion, the increased runoff carries with it pollutants from developed areas, which accumulates and finally discharges into natural waterways. While many municipalities recognize the important of controlling water quality to prevent downstream flooding, few municipal regulations actually provide volume standards; fewer still provide standards to protect stormwater runoff water quality. The usual approach of extrapolating stormwater management authority from existing ordinances, such as subdivision, zoning or flood controls, was found inadequate for two reasons: 1) ordinances for other purposes are not easily adapted, and 2) enforcement is difficult because courts have been reluctant to rule in favor of ambiguous regulatory authority and against well-established private property rights. This strongly suggests the need for specific local stormwater management ordinances.

As understanding of pollutant contributions from runoff grows, guidelines are developed to effectively treat runoff for water quality. These include:

- NYSDEC SPDES General Permit for Stormwater Discharges from Construction Activities (Effective August 1, 1993-1998)
- NYSDEC Division of Water Technical and Operational Guidance Series 5.1.8: Stormwater Management Guidelines for New Development (1990)
- NYSDEC Reducing the Impacts of Stormwater Runoff from New Development (1992)
- Westchester County Best Management Practices Manual for Stormwater Runoff Control (1984)

Guidelines recommend the capture and treatment of the “first flush” (the first half inch of runoff) from impervious surfaces. It also identifies the order, or hierarchy, in which a control measure is selected; infiltration is most preferred, then retention, and, lastly, extended detention (refer to stormwater section for complete discussion).

Currently, only Mamaroneck Town has developed a special ordinance covering stormwater management. Mamaroneck Village, Larchmont, and New Rochelle contain references to stormwater management in other existing ordinances, such as subdivisions and building regulations, but they are very generalized, focus mainly on quantity, and do not provide the specificity needed to ensure consistent implementation of effective control measures. All municipalities have adopted Floodplain

Damage Prevention ordinances, but these are based on Federal Emergency Management Agency (FEMA) requirements for flood insurance and refer generally to the prevention of downstream flooding so as to minimize life endangerment and property damage. Though already densely developed, the villages of Pelham and Pelham Manor could benefit from standards that might be incorporated into existing ordinances or combined under new regulations as recommended herein.

Drainage Requirements

Overland runoff from subdivisions often contributes nutrients, metals, and other contaminants to surface waters. To help control this problem, drainage requirements may be established by local planning commissions and boards as part of subdivision review processes. (Drainage best management practices are also effective in non-subdivision areas.) The table below shows costs and benefits from seven drainage management options:

Comparative Costs of Stormwater Management Techniques			
Technique	*Construction Costs*	*Maintenance Costs*	*Water Quality Benefits*
Grassed swale	Low	Moderate	Moderate
Infiltration basin	Moderate-high	High	Moderate-high
Infiltration trench	Low-moderate	Moderate-high	Moderate
Porous pavement	High	High	Moderate
Detention pond	Low-moderate	Moderate-high	Moderate-high
Retention pond	High	Moderate-high	High
Constructed wetland	High	Low	High

Effective drainage management should minimize the volume of runoff generated as well as enhance filtration. Steepness of constructed slopes should be minimized, and bare surfaces revegetated as quickly as possible.

Environmental Impact Assessments

Proposed subdivisions which exceed a certain number of proposed lots may be required to prepare environmental impact assessments or statements. These environmental analyses may require varied information depending on community needs and water resource protection goals. Possible requirements are: identification of sensitive water receptors downgradient on- and off-site; information on the existing condition of these resources; and potential impacts from the proposed development on coastal areas or other nearby sensitive areas.

Performance Standards

Subdivisions may be regulated on the degree of impact the full development could have on water resources. Performance standards, such as nitrogen and phosphorus loading limitations, may thus be specified to keep contamination from the subdivision below assimilation capacity of the downgradient water resource. The developer can be required to determine impacts, perhaps through the EIA process (above).

Site Design/Landscaping

Water quality protection may be enhanced via requirements for vegetated buffer zones, natural landscaping in key areas, and the reduction of impervious areas through stringent coverage standards and alternative roadway designs. In establishing landscaping requirements, communities should encourage xeriscaping techniques under appropriate conditions. Xeriscaping focuses on the use of native plant materials having lower water and nutrient requirements than standard landscape species. Use of highly demanding exotics should be discouraged.

Steep Slopes

Sloping topography typically has greater potential to erode. This has led some municipalities to create special ordinances regulating development on steep slopes. While the definition of steep slopes can vary, slopes of 15 percent (that is, 1.5 feet of vertical rise for every 10 feet of horizontal run) or greater have been identified as the threshold for special controls.

In WAC 3, there are a modest number of steep slopes. According to the County's Environmental Planning Atlas, which is based on USGS topographic maps, Port Chester has no slopes of 15 percent or more. Rye City, Mamaroneck Village and Rye Brook have a modest number of slopes greater than 15 percent. However, many of these areas are either already developed or are preserved as open space. Harrison has the largest number of slopes greater than 15 percent. Therefore, Harrison has the greatest need for a steep slopes ordinance, though Rye City, Mamaroneck Village and Rye Brook also would benefit from such an ordinance.

Wetland Regulations

It is a well-documented fact that wetlands are a critical component in the protection of both surface and groundwater quality. Wetlands absorb and contain floodwaters and have been shown to remove significant quantities of pollutants through a combination of physical, chemical and biological processes.

The necessity of local ordinances is clearly evident. There are both federal and state laws that regulate impacts to freshwater wetlands. However, under the New York State Freshwater Wetlands Act (Article 24 of the Environmental Conservation Law), regulated wetlands are generally limited to those which are 12.4 acres or larger in size. The U.S. Army Corps of Engineers (ACOE) regulated disturbance to virtually any wetland or water body under Section 404 of the Clean Water Act.

Tidal wetlands also are both federally and state regulated. The ACOE regulates tidal wetlands under Section 404 as well. The State regulates tidal wetlands under the Tidal Wetlands Act (Article 25 of the Environmental Conservation Law) and its implementing regulations 6 NYCRR Part 661. The State tidal wetlands regulations generally are more comprehensive, including a 300-foot-wide regulated adjacent area under many circumstances. However, there are limitations. The adjacent area goes no further than the seaward side of an existing man-made structure, such as a bulkhead or seawall, and it calls for only a 75-foot-wide buffer instead of 100 feet. Co-regulation would be beneficial in allowing more stringent controls or providing a venue for arranging compensation for wetland losses as is being done in the City of Rye.

Four of the five municipalities in the WAC 3 study area have a local freshwater wetland ordinance. The existing freshwater wetlands ordinances were reviewed in comparison with A Model Ordinance for Wetland Protection 1988), prepared by the Westchester County Soil and Water Conservation District (SWCD). Other guidance used include: Stormwater Management Guidelines for New Development (1990), prepared by the New York State Department of Environmental Conservation (NYSDEC) (these guidelines are also known as Division of Water Technical and Operational Guidance Series 5.1.8): the 1989 Federal Manual for Identifying and Delineating Jurisdictional Wetlands, prepared jointly by the

ACOE, the U.S. Environmental Protection Agency (EPA), the U.S. Fish and Wildlife Service, and the U.S.D.A. Natural Resources Conservation Service; a Memorandum of Agreement (dated February 1990) between the ACOE and the U.S. EPA; and the NYSDEC's Reducing the Impacts of Stormwater Runoff (1992). No model ordinance currently exists for tidal wetlands. In Westchester County, only the City of Rye has adopted a local tidal wetlands ordinance.

While most municipalities with a wetland ordinance also regulate activities within an adjacent area of up to 100 feet, these "adjacent areas" do not carry with it the same weight on a true "buffer." A buffer is a protected area adjacent to a resource where certain activities or encroachment is prohibited. In the current ordinances, activities to be conducted within an adjacent area are merely brought under regulation; there are no prohibitions or standards to preserve adjoining areas as buffers to the wetland resource.

Other features that are advocated in the model ordinance or guidance documents, but are missing or unclear in the existing ordinances, include: a scientifically-based methodology for delineating wetlands; specific standards for basing permit decisions; the requirement that wetlands only be used for final polishing if part of a stormwater management plan; mitigation sequencing requirements, which calls for wetland permit applicants to first demonstrate that wetland impacts cannot be entirely avoided, then to demonstrate that unavoidable impacts have been minimized, and finally to compensate for any remaining impacts; and a no-net-loss objective.

It is recommended that every municipality create or improve upon their existing freshwater wetlands ordinance by incorporating the SWCD model ordinance standards and the state and federal guidelines. Clearly, the first step in protecting water quality is to protect the wetlands themselves, both by enforcing applicable state regulations to their fullest extent and, where authorized by statute, by adopting local laws to protect wetlands and wetland functions. Following are some techniques for protecting wetlands.

Natural Vegetated Buffers

Natural vegetated buffers have tremendous value in protecting wetland sand surface waters from a variety of impacts. Buffer strips aid in reducing direct stormwater runoff discharge to surface waters, stabilize shoreline areas and provide wildlife habitat corridors. Buffer strip widths may vary depending on the resource in question. For example, Queen Anne's County, Maryland, requires a 300-foot buffer around tidal wetlands and waters, 50 percent of which must be forested. If not currently wooded, trees must be planted. The non-wooded portion is maintained as natural ground cover.

Surface Water Discharges

Land development frequently results in increased discharges of surface runoff to wetlands and watercourses which may cause downstream flooding, severe alterations to wetlands hydrology, and degradation of water quality. To prevent this, direct discharge of surface runoff from roads and other paved areas to wetlands and watercourses can be prohibited by local ordinances. Developers can be encouraged to minimize the extent of paving within buffer zones and to use permeable paving materials where possible. Surface runoff should be recharged on site, using a combination of vegetated swales, detention basins and similar techniques (see also stormwater management and drainage controls under Subdivision Regulations, above).

Erosion and Sediment Control

The discharge of sediments to wetlands and waterways often has severe consequences, ranging from direct sedimentation of wetland flora and fauna to reduction in water quality. Therefore, strict erosion and sedimentation controls for construction activities should be enacted. Different types of erosion controls will clearly be required for different slopes, soil conditions and construction activities. Subsequent revegetation requirements can also be specified, to insure long-term stability.

Many guidelines have been developed which offer technical guidance, including the Westchester County Best Management Practices Manual for Erosion and Sediment Control (1991) and NYSDEC Division of Water's "Erosion and Sediment Control Guidelines for New Development" (Technical and Operational Guidance Series 5.1.10). In addition, the Soil and Water Conservation District produced A Model Ordinance for Erosion and Sediment Control (1986), which provides guidance for developing an effective local ordinance for controlling erosion and sediment.

Mamaroneck Village has a distinct ordinance for erosion and sediment control. These regulations include many of the features recommended in the aforementioned model ordinance, but not all. It is recommended that all municipalities adopt separate erosion and sediment control ordinances to ensure that all types of land development are required to implement proper controls. Those with such ordinances need only amend their existing regulations to incorporate some additional standards that would further strengthen these ordinances.

Restrictions on Pesticides and Fertilizers

Fertilized lawns often contribute substantial levels of nutrients, pesticides and herbicides to surface waters directly, via surface water runoff, and indirectly, via leaching to groundwater. Therefore, limiting the extent and controlling the location of lawns in any buffer adjacent to wetlands, streams, ponds and the Sound is recommended.

B. NON-REGULATORY TOOLS

Many communities have recognized that over-reliance upon regulatory tools merely programs a municipality for development and allows little flexibility if the original program was inaccurate, of if better information has been made available since the program was devised. Consequently, an effective resource program should also utilize non-regulatory tools.

Although many non-regulatory water resource programs are available to cities and towns, they have traditionally focused on the categories noted below:

Land acquisitions, land donations, and conservation easements (the following three techniques) are all management techniques that may be more efficiently conducted by non-profit land conservation organizations than by municipalities. These organizations are frequently created as land trusts for particular towns, counties, or watersheds, and often have names such as "Smith County Land Trust," "Friends of Pleasant Lake," or "Jonesville Conservation Trust." These organizations are tax-exempt, no-for-profit corporations. Therefore, donations and bargain sales to the conservation trust are usually considered charitable donations and may have positive federal and state tax consequences. These organizations can provide expertise in arranging land transfers, drafting conservation easements, and explaining advantages and disadvantages of real estate transfers to both land purchasers and sellers; coordinate with and solicit aid from various foundations; and, in some cases, have the capacity to provide funds for acquisition or to serve as landowners and stewards. Some of these organizations can only serve as temporary landowners while others may hold lands permanently.

Land Acquisition

One obvious way for a community to protect a resource is to buy the land outright. Acquisition priorities may include wetlands and stream banks within coastal watersheds, often for access opportunities as well as for resource protection. Outright purchase of land can take four variations:

a) Purchase at fair market value: The buyer (community or conservation group) pays the seller the fair market value for the property.

b) Bargain purchase: The purchase of property below fair market value by a conservation organization or municipality. The difference between fair market value and the reduced price may qualify as a charitable deduction from income taxes for the seller.

c) Installment purchase: The property is purchased over a period of years. Installment purchases allow the town to spread the purchase costs over a number of years.

d) Purchase with a reserved life estate: The property is transferred to the town upon the death of the individual landowner. This option allows landowners to sell now, but to continue to use their property during their lifetime and/or the lifetimes of other members of their immediate family. Because of the continued use, the purchase price may be lower than fair market value.

An innovative technique for land acquisition is the land bank. Land banks receive a percentage of fees generated by real estate transfers, and use this money to fund land acquisition. Land banks are usually created by the state legislature and may apply to specific regions or statewide.

A more traditional, frequently controversial, form of land acquisition is through eminent domain. If a community can demonstrate the value of a given parcel for the public good, it can take ownership of that parcel. However, due compensation must be given to the previous owner, in accordance with the Fifth Amendment to the U.S. Constitution which states, "...nor shall private property be taken for public use without just compensation." Public approval is usually required for eminent domain action, since public money is spent to compensate the previous owner. Eminent domain takings are frequently contested by the previous owner, who may believe the land to be worth more than is offered by the community.

Eminent domain takings should not be confused with a "takings" claim, where a landowner challenges a town that a zoning bylaw or other regulation prohibits him from all uses of his land, i.e., his land has effectively been taken without any compensation.

Land Donation

Landowners are often in the position of being able to donate a piece of land either to the community or a non-profit organization such as local land trusts. If so, they will find that giving the land for preservation costs them far less than they might think, particularly when a variety of tax savings are taken into account.

The initial benefit to the person donating the land comes in the elimination of estate of capital gains taxes. In addition, real estate taxes, insurance and maintenance costs are avoided. And, the entire value of the donation can be deducted, over time, from federal, and, in many cases, state income tax obligations.

Donations of ecologically significant land with coastal watersheds can be a particularly important technique for resource protection. Donations which provide access to water often help fulfill community goals of increased public access to waterways.

Conservation Easements

An easement is a limited right to use or restrict land owned by someone else. Easements are either positive (rights-of-way) or negative (conservation, scenic) and may take a variety of forms. Easements can effectively assist a community in protecting land from development by restricting all or a portion of the property to open space or limited development uses. The granting of a conservation easement does not involve the transfer of ownership of the land; instead, it means giving up certain development rights of the property. For example, a conservation easement may restrict the number of houses to be built upon a parcel; restrict the types of development allowed on the parcel; or specify that portions of the parcel remain undeveloped in perpetuity.

Water Quality Monitoring

Water quality monitoring is becoming a very important aspect of a non-regulatory approach to water protection. Local governments have developed programs to identify problem areas in their community where contamination has already affected water quality. In addition, monitoring can be used to measure the effectiveness of the water protection program or as an early warning of threats. Monitoring can be conducted by state and local governments and water utilities, or industry and commercial entities may wish to develop their own water quality monitoring programs. Frequently, volunteers, particularly retired citizens and high school or university classes, can serve as effective resource quality observers.

For example, in Rhode Island, the volunteer Salt Pond Watchers monitor water temperature, clarity, nutrient, chlorophyll, and bacterial levels in coastal lagoons. The state Department of Environmental Management has used the Watchers Program data to determine shellfish and beach closures. In Chesapeake Bay, approximately 130 stations are monitored by volunteers for pH, dissolved oxygen, turbidity, water depth and temperature, air temperature, weather conditions, and rainfall.

Hazardous Waste Collection

Another non-regulatory protection tool is the collection of household hazardous waste. Although these materials are generated in small amounts, they can represent large threats to surface and groundwater quality. Motor oil allowed to drain onto the land surface when automobile oil is changed, excess paint discarded in the gutter, fungicides and herbicides left in a shed that is flooded during a hurricane are possible routes from contaminant container to water. To avoid these scenarios, many communities, including Westchester County, have implemented hazardous waste collection days. In other areas, these wastes are collected continuously. For example, in Arlington County, Virginia, the Water Pollution Control Plant accepts household hazardous wastes from residents. The Plant chemist classifies and stores the wastes and periodically ships them to a licenses hazardous waste facility.

Public Education and Outreach

There are many examples around the country where innovative public education programs on water use issues have been developed. Public education can be used to build support for regulatory efforts, or to implement voluntary protection efforts such as water conservation, waste oil collection, and water quality monitoring. Public education and outreach are discussed further in the next chapter.

EDUCATION AND OUTREACH

A. Purpose

As part of any watershed management program, particularly one whose principle aim is to reduce nonpoint source pollution, an education strategy should be implemented to inform and educate the public about their role in controlling nonpoint source pollution. This strategy should be aimed at people who live and work in the villages, towns and cities comprising the watershed.

Public information and education are crucial components of any watershed plan. A large part of the strategy to curb nonpoint source pollution should be to educate the public about this form of pollution and the tremendous impact their attitudes and lifestyles can have on the quality of Long Island Sound and its tributaries. A public education initiative should teach citizens about the issues and problems of nonpoint source pollution and involve them in the solutions.

The Long Island Sound watershed in Westchester County is very diverse in its landscape and develop character and the people who live and work here. This diversity should be considered when developing an information dissemination and education strategy. An initial step in developing a public awareness program is to frame the message; determine what information about nonpoint source pollution is to be to conveyed, and stress this message at every opportunity. The tone and level of complexity of the message depend on the community's composition and sophistication. The program should include concrete information about using and disposing of toxic substances in homes yards, farms, and work places.

Nonpoint source pollution affects everyone in the community. On the issue of control, business people, developers and homeowners each have an individual agenda. A public awareness program should consider these individual needs and interests. Messages and presentations should be tailored to specific groups, for example, school faculty, city employees, developers, public and private organizations, and youth groups.

The following groups should be involved in the public awareness strategy:
- local government and community leaders
- residential property owners and tenants
- civic, environmental and other public and private organizations
- business and industry leaders
- grade school and college students and faculty

The table on the following page indicates the most effective use of various public education techniques.

Table 2A

PUBLIC EDUCATION TECHNIQUES
WATERSHED MANAGEMENT

METHOD	MOST EFFECTIVE USE	RESULTS
Newsletters	Announce meeting time and dates, update information on actions already taken, list issues to be discussed at upcoming meeting	Public awareness
Newspaper articles	Same as newsletter - provide additional detail about local stories, photos of citizen activities; feature articles provide information about problems and solutions	Public awareness
Demonstration sites	Exhibit innovative technology - should be accompanied by signs, brochures, or permanent on-site interpretive staff	Public awareness, knowledge, understanding
Printed and taped material (e.g., fact sheets, videos)	Explain new technology, describe case studies, provide training information for new employees, outline facts to stakeholders	Public awareness, knowledge, understanding
Signs	Mark watershed boundaries, identify critical areas, promote specific behaviors in specific places, identify cooperators in project, explain adjacent project and its BMPs, provide interpretive natural resources information	Public awareness, knowledge, understanding
Meetings	Share information, plan actions, evaluate process	Public awareness, knowledge, understanding, desire/ability to act
Field trips	Observe resources to be protected, view installed BMPs, learn how BMPs operate, monitor (assessment or compliance type) BMPs	Public awareness, knowledge, understanding, desire/ability to act
On-site inspections	Identify problems, recommend corrective actions, evaluate effectiveness of pollution controls, identify noncompliant stakeholders, educate individuals	Action
Training	Provide new skills to stakeholders	Action
Technical assistance	Identify problems, recommend solutions, assist with installation of BMPs, educate individuals, evaluate effectiveness of solutions	Understanding, desire/ability to act, action

Source: Terrene Institute, Clean Water In Your Watershed: A Citizen's Guide to Watershed Protection, 1991

Community Education and Citizen Involvement

Because nonpoint source pollution is a continuing issue related to development and individual lifestyles, a water quality program must be established and embraced to succeed. Organization and ordinances mean nothing without community support. The community must buy in and accept the program, just as it does a sewage treatment system.

To gain support, you must understand your community. Is your community small or large? Are residents primarily retired or parents with young children? Are residents commuters or do they earn their living in the community? Do most residents stay in the community all year or seasonally? How much do residents know about nonpoint source pollution? How will they be affected by a nonpoint source management plan? How can they be expected to react to the proposed plan?

A public opinion survey or series of well-publicized public hearings throughout the watershed and in your immediate community will help you get to know the community and give you a basis for measuring public opinion.

- **Public awareness**. Public information and education are important ways to curb nonpoint source pollution, since the solution lies largely in changing individual behavior and lifestyle. An information program must educate citizens about the problem and make citizen involvement part of the solution.

- **Framing the message**. An initial step in developing a public awareness program is to frame your message. Determine what information about nonpoint source pollution you wish to convey, and stress this message at every opportunity. The tone and level of complexity of your message depend on the community's composition and sophistication. The program should include concrete information about using and disposing of toxic substances in homes, yards, farms, and workplaces.

- **Targeting the audience**. Nonpoint source pollution affects everyone in the community. On the issue of control, business people, developers, and homeowners each have an individual agenda. Make sure your public awareness program considers these individual needs and interest.

  Tailor your messages and presentations to specific groups - for example, college faculty, city employees, developers, civic organizations, or youth groups. Involve environmental groups such as the Izaak Walton League, state associations of conservation districts, and other public or private organizations.

- **Reaching your audience**. A targeted public awareness campaign uses a variety of tools to convey your message and attain your goals. Some of the tools include:

  - *Media*. Techniques include press releases, articles, photos with captions, talk shows, news programs, public service announcements, newsletters, and public notices to publicize your message.

  - *Community events*. River/lake festivals, county/city fairs, and other special events are educational and public awareness opportunities to make your message known to a variety of audiences.

- *Awards*. Broaden your visibility, recognize good work, and gain a variety of advocates for your program through conservation awards for young people, public service awards, and participation and sponsorship awards.

- *Meetings*. Use public gatherings, club meetings, special conferences, and workshops to explain your program; customize your message to the needs and interests of your audience.

- *Speakers' bureau*. Face-to-face communication to a specialized audience provides a powerful opportunity to deliver your message, answer questions, and clarify ambiguities.

- *Educational materials*. Brochures and posters obtained from EPA, the state water authority, or other groups can be distributed to schools, civic groups, and businesses to further support your message.

- **Using a variety of information/education tools**. The numerous techniques available to make your community aware of the nonpoint source problem and its solutions are limited only by your imagination and budget. See the following list 4 for ideas to ensure support from your community:

  - Publicize your program in all possible ways - use fact sheets inserted into utility statements, flyers, radio, TV, newspapers, public hearings, group meetings; develop personal contacts with reporters - offer story and photo opportunities.

  - Tailor your message to various levels of knowledge - from those who understand the concept of nonpoint source pollution to those who have never heard of it.

  - Form communities to work on specific aspects of the program; include representatives from all interest groups.

  - Offer field trips to groups. Seeing the watershed's problem has much more impact than reading about it.

  - Distribute drafts of the plan to interested groups for review.

- Set up meetings using existing organizations such as 4-H or Extension Service and organize community informational watershed workshop.

- Involve schools - make presentations to classes or conduct field trips.

- Set up nonpoint source pollution displays at every opportunity - county fairs, local Earth Day events, conferences, school events.

- **Citizen monitoring**. Environmentally conscious citizens have made great contributions to local programs nationwide. Groups such as the Chesapeake Bay Watch and the Streamwalk Committee in Seattle, Washington, have become integral parts of the water quality program. Citizen groups can collect valuable information on basic parameters - they can monitor and identify problems, collect surface water samples, and measure turbidity.

Local officials see two advantages to citizen monitoring. First, these activities are an economical way to gather high quality data. Second, citizen monitoring is a valuable tool to build grassroots interest in water quality issues. In addition to helping officials identify and avert potential water problems, citizen groups build public support for nonpoint source programs and remedial actions, when necessary.

Despite these benefits, a volunteer program needs careful handling. Everyone is not suited to be a volunteer monitor. Groups and individuals may have difficulty staying motivated throughout an entire sampling project. In appropriate training or procedures can result in useless data. Sampling also involves a slight risk of injury; local governments must have sufficient liability insurance to cover such situations.

Consider the following recommendations concerning volunteer monitoring programs:

- Citizen monitoring projects should not stand alone but should be integrated into a total water quality management program.

- A qualified water quality specialist should develop the sampling design, analyze the data, and prepare the final report.

- A qualified water quality specialist should train and supervise volunteers in the field, review data frequently, and work closely with the state water quality agency.

- The sample design should be relatively simple and not dependent on precise measurement.

- Volunteers should be carefully recruited and trained; periodic training may be necessary to replace dropouts and refresh monitoring skills of current volunteers.

- The water quality specialist should encourage frequent reports, personal presentations at group meetings, and media coverage to keep the group motivated.

The Missing Link - Community Partnership

The optimum situation - informed watershed planning to identify and correct existing problems and prevent future problems - will achieve the best environment possible. But all planning, no matter how complete, must be done *with* your community, not *for* it.

The advantages of the prevention/restoration ethic are impressive and would tempt any community - clean, usable waterbodies attract business and recreational dollars and measurably improve the economic health of the community. Remedial measures, designed to address current environmental conditions, can return water resources to an acceptable purity level.

However, billions of dollars are lost on public works projects, declining property values, and missed revenues from tourism, recreation, and other uses because of the missing link - community partnerships. Without community buy-ins by educated citizens who understand their individual responsibility and the community's needs, remediation will need to be repeated in each generation, if not more often.

Planning and prevention within the total community and watershed area comprise a vital permanent solution to water quality issues. In some cases, eliminating the cause of pollution may not be enough - the waterbody will still need rehabilitation. In other cases, communities must restore the quality of a waterbody even as they prevent further harm. Therefore, plan for the optimum, seeking guidance and cooperation from your community along the way. When the community agrees to implement the plan you know will work, you will have served them - and the environment - well.

STORMWATER MANAGEMENT

A. The Nature of Stormwater Runoff

Stormwater runoff is that part of the total precipitation that flows over the ground. Under natural conditions, during and following precipitation, stormwater within a watershed flows to lower elevations where it is either recharged to groundwater or drains as runoff to streams, ponds, bays, and other surface waters. The amount of runoff from an undeveloped watershed area depends upon:

- storm characteristics
- type and amount of vegetative cover
- soils and soil permeability
- slope characteristics
- type and capacity of natural drainage systems

Storms are characterized by their:

- duration (period of rainfall)
- total precipitation
- intensity
- frequency
- number of antecedent dry days

The number of antecedent dry days is one of the most important variables determining the amount of runoff and concentration of contaminants in stormwater due to its impact on the water storage capacity of soil and buildup of contaminants.

A portion of stormwater runoff also evaporates during overland flow and from surface waters. Recharge water (infiltration water) is that portion of stormwater that infiltrates the soil and moves downward to recharge the aquifers. A portion of the infiltration water is taken up by plants and lost to the atmosphere by evapotranspiration.

Due to the gradual percolation of much of the rainfall into the soil in relatively undisturbed watersheds, both the volume of runoff and rate of overland flow are reduced, thus maximizing aquifer replenishment in some areas and minimizing erosion. In developed watersheds, the amount of runoff also depends upon:

- amount of impervious surface area
- existing stormwater control measures
- other factors

The presence of impervious surfaces and of stormwater drainage systems that conduct runoff from the site may increase the volume, accelerate the flow, and in some cases, contribute to soil and streambank erosion. In areas where stormwater drainage systems have been installed, stormwater flows to stormwater management basins or other drainage structures for detention, extended detention, retention, or infiltration. In coastal areas, stormwater is sometimes discharged directly into surface water bodies or streams; in other cases, the overflow of drainage structures is directed into surface waters.
Stormwater as runoff or infiltration water is the vehicle by which pollutants move across land and through the soils to ground or surface waters.

Contaminants will accumulate or be disposed of on natural and urban land surfaces. Sources of contaminants include:

- animal wastes
- highway deicing materials
- decay products of vegetation and animal matter
- fertilizers
- pesticides
- airborne contaminants deposited by gravity, wind or rainfall
- general urban refuse
- by-products of industry and urban development
- improper storage and disposal of toxic and hazardous material

The contaminants associated with and carried in stormwater runoff include the following major categories:

- Metals
- Organic Chemicals
- - Base Neutral Compounds
  - Acid Compounds
  - Volatiles
  - Pesticides
- Organic Chemicals
  - Phosphates
  - Nitrates
  - Chlorides
- Bacteria and Viruses
- Oxygen Demanding Substances

Raindrops dislodge soil particles and contaminants from land surfaces. This material is then carried in solution or suspension and travels with the runoff. Suspended particles are deposited en route if/when the velocity of stormwater decreases. Contaminants carried in stormwater solution enter the soil through the larger pores at the soil surface and move downward and horizontally through the pore network. Water diffuses into the smaller pores by capillary or soil moisture tension. The rate of movement through the soils and surficial materials depends on the size, shape, continuity and arrangement of the pore network system. The most soluble constituents such as nitrates and chlorides and many organic chemicals continue to move downward through the aquifer system or t the bays. Soils with a high clay, fine sand, or silt content or with the presence of interspersed clay lenses retard the rate of movement of water and some contaminants through the soil; contaminants may adsorb to soil particles. A portion of the nutrients and pollutants also may be used by plants and soil bacteria.

B. Stormwater Management Basins

Two major types of stormwater systems exist in Westchester: nonstructural and structural.

Nonstructural

Nonstructural systems attempt to deal with stormwater problems at their source. A variety of techniques are used to minimize stormwater runoff and erosion, maximize recharge and to maintain natural stormwater receiving areas. These include the use of:

- ecological and land use planning
- conservation easements
- zoning ordinances (establishment of the amount of site development and coverage)
- maintenance of natural vegetation
- the use of swales, depressions and other grading and planting techniques

Vegetative controls provide contact between stormwater runoff and vegetated areas and accomplish pollutant removal by a combination of filtration, sedimentation and biological uptake that reduce pollutant concentrations, and/or by a reduction in runoff volume due to infiltration and evapotranspiration.

Structural

Structural controls use built systems such as:

- stormwater sewerage systems
- detention basins
- extended detention basins
- retention basins
- infiltration basins
- sedimentation basins
- dry wells
- other systems

The treated water from these systems may be discharged into a stream or other surface waters.

Most of the runoff into stormwater management basins comes from impervious surfaces. Occasionally pervious surfaces are a source of runoff when the infiltration rate and water holding capacity are exceeded due to periods of high intensity rainfall. The so-called "first flush," or first half-inch of runoff from land which has been made impervious, delivers a disproportionately large load of pollutants during the early part of storms due to the rapid runoff of accumulated nutrients and pollutants. From 70 to 90 percent of the contaminants in stormwater can be removed by detaining the first flush of runoff.

Stormwater management basins can be classified into the following three categories:

- Dry Basins - These are basins with the outlet located at the bottom. They are almost always dry, except for relatively short periods following larger storm events. The outlet size is restricted to limit the maximum flow rate. Dry ponds are often used for flood and erosion control and are not as effective as extended detention and retention basins for water quality purposes. They may, however, be retrofitted to achieve water quality control.
- Extended Detention Basins - These basins employ an outlet structure that will cause stormwater runoff from most storms to pond in the basin. Following a storm, these basins drain in about 24 hours or more and will be dry at all other times. The outlet structures may be either perforated risers or subsurface drains. They provide a practical technique for retrofitting dry ponds to obtain water quality benefits, and can provide particulate (and the associated pollutant) removal efficiency nearly equivalent to that of wet ponds.

- Wet Basins - These basins employ outlet structures designed to maintain a permanent pool of water, which is not released except by means of evaporation, infiltration, or attenuated release when runoff volume exceeds the present storage capacity of the permanent pool. They can provide high removal efficiencies for particulates, and have been observed to effectively reduce soluble nitrogen and phosphorus concentrations by means of biological activity.

C. Design of Structural Stormwater Management Basins

Proper management of stormwater requires informed judgment in order to interpret data and evaluate empirical runoff projections. Knowledge of the quantitative and qualitative characteristics of rainfall and the watershed is needed to permit the prediction of rates of runoff. Since there is considerable variation in the frequency, intensity and duration of rainfall, the designer must rely upon data derived from observations over long periods of time. Rain gauges have been used for almost a century to measure the intensity, duration and amounts of rainfall from specific storms. Historical records can be used to identify future probabilities.

Storm Characteristics

Several general conclusions can be drawn concerning storms in Westchester:

- Intense storms usually cover small areas and are of short duration; storms of lower intensity tend to cover larger areas and are of longer duration
- Storms of high intensity and/or high total rainfall tend to have relatively lower frequencies of occurrence
- Storms of high intensity often cause flooding and damage due to erosion and sedimentation

Design of Closed Stormwater Drainage Systems

The most important consideration in designing stormwater control systems is to provide sufficient capacity to accommodate the peak rate of runoff. It is also necessary to determine the total amount of runoff for a given time period to insure adequate storage capacity of runoff. Stormwater drainage and stormwater systems are sometimes underdesigned due to high costs. The “rational method” is generally used as a first step for computing stormwater runoff for the design of closed stormwater drainage systems when the contributing area is less than 200 acres. This calculation method is based on selecting a design storm event that is characterized by its duration, average intensity and frequency of occurrence. This technique provides the average peak rate of runoff from a storm, but it does not provide a description of the actual storm. The formula for the Rational Method is Q = CiA where:

- **Q** equals the amount of discharge (peak runoff rate) in cubic feet per second (SFS)
- **C** equals the runoff coefficient(s) of the drainage area
- **I** equals the intensity of rainfall inches per hour
- **A** equals the area of the watershed (acres)

Also considered i the design of stormwater management basins is the basin volume needed to store the required number of inches of rainfall. For instance, the volume of rainfall from a 5-inch storm for a 100-acre watershed would be determined as follows:

$$\frac{5''}{12''/\text{ft}} \times 100 \text{ acres} \times 43{,}560 \text{ ft.}^2/\text{acre} \times \text{the runoff coefficient } (0.30)$$

$= 554{,}500 \text{ ft.}^3$

The storage area of the basin is then calculated.

Soil and surficial permeability rates are used to determine the capacity of stormwater management basins. The USDA-Natural Resources Conservation Service has classified soils into hydrologic soil groups ranging from hydrologic soil group A, which has a low runoff potential and a high infiltration rate, to soil group D, which has a very low infiltration rate. Soil storage capacity is dependent upon other soil characteristics in addition to the infiltration rate. For instance, a fine sandy loam may have the highest storage capacity but will have a lower percentage of large pores than a sand or loamy sand. A find sandy loam has a high storage capacity because of soil moisture tension. It should be noted that once the recharge basin is in operation, the permeability rates may decrease due to sediment clogging of the soil pores or they may increase due to the establishment of vegetation and associated increased soil porosity. Test drilling should be performed at each proposed recharge basin site to determine whether there is a clay lens beneath the site.

Runoff Coefficients

Runoff coefficients refers to the percentage of ratio of runoff to the total amount of rainfall that will reach a stormwater management basin. A watershed that is completely forested and located on gentle slopes will have minimum runoff following a storm of relatively high intensity and duration due to the high retention capacity and low runoff coefficients associated with natural groundcover. A watershed that is primarily developed with extensive impervious surface areas has limited storage capacity and high runoff coefficients. The amount of runoff is a function of the amount of rainfall, amount of evaporation and plant evapotranspiration (seasonally variable), soil permeability, slope, and possibly texture of the surface area. Runoff from impervious surfaces usually varies from 80 percent to more than 90 percent. Therefore, the runoff coefficient as a ratio is 0.80 or 0.90 accordingly. The runoff ratios from pervious surfaces usually vary from 0.10 (natural vegetation) to 0.60 (compacted bare soils) or higher. The runoff ratio for a lawn or golf course is approximately 0.20 to 0.35. The coefficients used to calculate runoff from pervious surfaces may be low in some cases, particularly during a storm that occurs when the ground is frozen. If snow is present, runoff is further increased due to snow melt.

Key Problems

In the past, stormwater runoff systems were designed to get stormwater off the site and into stormwater drainage systems or onto roadways as fast as possible, sometimes at the expense of neighbors and downstream communities. Although a portion of the inland runoff was directed toward stormwater management systems, most of the stormwater and associated contaminants from areas adjacent to coastal waters were discharged untreated through drainage system outfalls and from roadways into surface waters and wetlands with impervious and modified pervious surfaces. Individual sites were developed without providing land for the recharge or treatment of stormwater and erosion control measures. Over time, this resulted in increased volumes and rates of runoff. Accelerated erosion and sedimentation were associated with the higher rates of runoff. An increase in runoff (and sedimentation) created the need for more extensive drainage systems to prevent the accumulation of water in streets and flood-prone areas. Since stormwater runoff is a transport vehicle for contaminants deposited on impermeable or relatively impermeable surfaces, it is often an important contributor to surface water degradation. To compound the problem, many coastal and inland wetlands were filled and developed, further reducing the storage area for stormwater, sediments and contaminants associated with the sediments. These conditions resulted in the following major effects:

- increased local expenditures for the installation and maintenance of stormwater drainage systems and roadway maintenance

- increased outlays for channel maintenance
- increased flooding of roads and of lowland areas resulting in hazardous driving conditions, dangerous flash floods and property damage
- loss of viable wetlands due to sedimentation
- increased concentrations of contaminants in groundwater
- the closing of a large portion of the area's shellfishing grounds due to high coliform concentrations introduced by stormwater
- changes in the values of aquatic and estuarine water quality parameters with possible adverse affects on aquatic and marine species

Health Related Problems

Stormwater runoff and stream base flow are important sources of pollutant loadings to Westchester streams, ponds and bays. Two categories of runoff to estuarine waters have been observed: upland runoff entering the freshwater portions of streams and conveyed thereby to the Sound, and overland runoff that enters the Sound (or the tidal portions of the streams) usually by direct overland flow or storm drainage systems. Impervious surfaces constitute the major source of stormwater runoff to streams and bays, but some runoff from pervious surfaces also occurs.

Stormwater runoff has been associated with high concentrations of bacteria in estuarine water and the closing of shellfishing areas due to high indicator bacteria counts. A study on Long Island involved monitoring bacterial counts following storms in freshwater storm events. It was calculated that stormwater runoff accounted for at least 93 percent of the total and fecal coliform discharge. Sedimentation rather than bacteriological die-off appears to be the mechanism for the attenuation of bacteria in stormwater runoff from ponds before discharge into marine water.

Nitrogen and phosphorus from fertilizers and other sources enter fresh and marine waters by stormwater runoff, stream flow and groundwater flow. Elevated nitrogen levels can result in a phytoplankton bloom and rooted aquatic growth (e.g., eelgrass), since nitrogen is a limiting growth factor in estuarine waters.

Impacts On Fresh Surface Waters

Biological monitoring has been used to measure the impact of stormwater upon aquatic communities. Increased pollution in urban ponds and streams has resulted in marked changes in the type and number of species present. High concentrations of phosphorus from fertilizers applied to landscaped areas and phosphorus from other sources in the immediate watershed area can result in algal blooms and other eutrophic conditions.

The depletion of oxygen as measured by high biological oxygen demand (BOD) values in receiving waters is one of the most important impacts on freshwater systems. When high BOD loadings are discharged to surface waters, the resultant depressed oxygen levels eliminate those species that cannot survive at low oxygen levels. Aquatic life changes over time as high oxygen demanding species are replaced by those that can tolerate lower dissolved oxygen (DO) levels. This is an especially important problem in lakes and ponds. A pond that once had species indicative of good water quality such as mayflies, stoneflies and caddisflies may now have large numbers of worms such as Tubifex and Limnodrilus udekamianus. Other types of worms may be present that have special types of blood or breathing mechanisms that allow them to adapt to waters with low DO levels.

Grease and oil products are sometimes disposed of on the land, into storm sewers, or directly into surface waters. If sufficient concentrations of these products are found in the water column or accumulate on aquatic plants, they can harm or kill aquatic biota. High concentrations of salts from highway deicing practices also may impact aquatic vegetation and aquatic ecosystems.

Basin Bank Stabilization

One of the most important features to include in basin designs and bank stabilization is to establish a vegetative buffer around stormwater management basins. The establishment of a vegetative buffer, utilizing a diversity of native plant species, is the most practical and cost-efficient alternative to protect and prevent degradation of detention ponds. Vegetative buffers should be established at or near the shoreline and continue landward for a desired distance ranging in size from 20 to 30 feet for most urban basins to 100 feet or more depending on the management objectives. Aquatic plant species also may be established in shallow water areas, or benches, along the shoreline. A vegetative buffer around the perimeter of a detention, extended detention or retention basin serves to:

- reduce stormwater runoff from adjacent lawns, roads, and rooftops by encouraging infiltration
- stabilize the banks and shoreline of the basin to prevent soil and bank erosion
- filter nutrients and contaminants from runoff to prevent water quality degradation
- provide shade for aquatic species and reduce the effects of thermal pollution
- provide fish and wildlife habitat for feeding, breeding, avoiding predators, and shelter
- maintain a diversity of native plant species, including grasses, herbs, shrubs and trees
- discourage large nuisance flocks of Canada geese and gulls, who do not like habitat with taller grasses, shrubs or trees

D. Existing Management Practices: Local and State Controls

Stormwater runoff management in Westchester generally consists of local laws and ordinances, standards and guidelines for stormwater collection systems that are predominantly structural in nature. These standards and guidelines are based on the premise that watershed characteristics and various types of development will produce specific quantities of runoff. Collection systems are based on design standards and engineering practices that include the use of empirical formulas (such as the “rational method”), the construction and use of stormwater management systems according to a specified storage capacity (number of inches of rainfall), or the use of leaching systems, catch basins, dry wells or other structures deemed appropriate. The use of these standard structural systems has generally been successful. However, they have not always proved to be the best in respect to long-term environmental impacts, are implemented too infrequently, and are not the most cost beneficial in terms of maintenance costs.

A comprehensive approach to stormwater runoff management, in which performance standards and site development techniques are used to protect a site's natural resources and downstream watershed, is becoming more widely accepted. Drainage designs are increasingly based on individual site characteristics and watershed management goals. This type of approach implements certain stormwater management objectives, such as preserving the integrity of natural drainage patterns to prevent flooding and damage to stream channels or other surface waters. It also requires adherence to standards that will insure the attainment of these objectives. The requirement that stormwater runoff from a developed site not exceed that generated under natural or undisturbed conditions is an example of such a standard. In this instance, developers are not required to install a specified type of drainage facility but are given the flexibility to choose the stormwater management system best suited to the needs of each development, subject to the requirements of a performance standard. The type of system that should be installed will be determined by the system's effectiveness given the variations of:

- slope
- lot size
- vegetation
- water resources
- soils
- type of development under consideration

The State Environmental Review Act (SEQRA) review process can be used on a local level to incorporate environmental concerns, including stormwater management, into the planning and decision-making processes for development. According to SEQR, each municipality can, under its own local law, provide a list of those critical environmental areas (CEAs), such as existing natural drainage systems, flood prone areas, wetlands and watercourses (and associated uplands), and/or steep slopes or areas prone to erosive forces where potentially hazardous or harmful environmental impacts may occur. Following CEA designation, the potential impact of any Type I or Unlisted Action on the environmental characteristics of the CEA is a relevant area of environmental concern and must be evaluated in the determination of significance of adverse environmental impact. This local law procedure can become a tool for the protection of the environment from the adverse impacts of inadequate or improperly designed stormwater controls.

E. Generalized Recommendations

Regulations and Administration

The following recommendations comprise preventive measures that can be used to minimize stormwater contamination of surface waters and groundwater resulting from site development and future land use activities as well as suggestions for reducing or eliminating existing impacts. For specific recommendations for municipalities in the WAC 5 study area, see Section 1 of this plan. Criteria are also provided for the selection and installation of appropriate stormwater control measures including both nonstructural and structural techniques. This section also describes a number of management practices, erosion and sediment control measures and the suitability of these measures for various types of site conditions.

Municipalities, County and State

- On publicly-owned lands adjacent to surface waters and wetlands, limit development and the establishment of impermeable paving.
- Prohibit any new direct discharge of stormwater runoff into surface waters of freshwater or tidal wetlands.
- Evaluate existing stormwater systems that currently discharge into surface waters to determine whether the systems can be modified to include additional control measures to minimize impacts on surface waters and adjacent areas:
  - Inventory direct discharges and assign remediation priority ratings based upon environmental impacts.
  - Determine if there is sufficient land area to develop cost-effective energy dissipation areas and sediment basins as well as extended detention or retention basins to eliminate or reduce direct discharge and accompanying nutrient, pollutant and sediment loadings to surface waters and wetlands.
- Local governments need to develop more complex design requirements for stormwater management basins and wetlands. The frequent practice of specifying a fixed treatment volume may not be sufficient to assure reliable pollutant removal. Local governments may wish to develop additional design criteria to improve pond and wetland performance. These might include requirements for sediment forebays, minimum length to width ratios, redundant treatment techniques, and greater structural complexity for wetlands.
- Ensure adequate long-term maintenance of stormwater management basins through public acquisition, easements or permit/approval conditions. The retention and maintenance of these areas will facilitate the recharge and treatment of runoff, thus reducing the amount of stream flow following a storm and the subsequent associated high coliform loadings that would otherwise reach the bays. A reduction in coliform loadings to the Sound can be achieved through the use of basins to retain sediments thus allowing for the die-off of most coliform bacteria.
- Do not mow or remove vegetation in or adjacent to stormwater management basins unless such removal is part of a prescribed maintenance program because plant growth generally enhances infiltration and nutrient/pollutant removal.
- Incorporate the erosion and sediment control recommendations into municipal law (see separate municipal laws section).
- Require adherence to the following performance standards for all new site development:
  - Protect and maintain the natural functions of the site by maintaining the absorptive, purifying and retentive functions that existed on the site before construction began.
  - Limit the post-construction volume and rate of runoff leaving the site to that calculated on the basis of natural or predevelopment conditions. The peak release rate of stormwater from all developments where retention is required should not exceed the peak stormwater runoff from the area in its undeveloped state for a storm of any intensity up to and including the 100-year frequency, and for rainfall of any duration. Calculations of the rate should be based upon an assumed runoff coefficient of 0.20, 0.25, and 0.35 for average slopes of 2 percent, 2 to 7 percent, and more than 7 percent, respectively.
  - Design the site stormwater system so that the runoff release rate from natural drainage channels will not exceed the natural carrying capacity of the channel.
  - Limit the release rate for stormwater systems serving new development. The volume and velocity of runoff discharged should not exceed the safe capacity of the existing drainage systems into which the discharge flows.

- Require a stormwater management plan for any property when
  - a plat is to be recorded
  - land is to be subdivided
  - an existing drainage system may require alteration

Site Planning Recommendations

Success in the reduction of stormwater related impacts and the costs of installing stormwater systems depends, in large measure, on proper site analysis and the selection and placement of development suited to the site.

- Undertake a careful site analysis to identify any developmental constraints affecting the design of a stormwater control system that may be imposed by the location of existing on-site and off-site features.

The site analysis process should include the following steps:

  - Prepare a key map locating the site within the watershed
  - Prepare a watershed analysis map showing the site drainage system in relation to the watershed. Locate all natural drainage swales, depressions, steep slopes, high points, low points, flood prone areas, areas with depth to seasonal high water table less than six feet, areas of existing vegetation, sensitive wildlife habitats, and soil constraints. Stormwater impacts can be minimized by avoiding soil conditions with severe or moderate constraints
  - a *slight constraint* indicates no limitations or a few that can be overcome with relatively little cost
  - a *moderate constraint* indicates limitations that are more difficult and expensive to correct
  - a *severe constraint* indicates the soil is very poor and will require replacement filling or modification if used (filling is not recommended)
- Locate on-site areas suitable for the treatment of stormwater
- Locate on-site areas suitable for development. Site building and paved areas only where the presence of the environmental conditions are favorable. The following soil and slope conditions may indicate soil suitability for development:
  - nearly level or moderately sloped terrain (less than 15 percent gradient)
  - moderately to rapidly drained soils (moderate to high permeability rate)
  - a coarse or medium textured soil
  - a seasonal high *water table* more than six feet below the surface
  - other soil listed under *slight* constraints in the USDA-NRCS Soil Survey of Putnam and Westchester Counties (1994)

Use proper site design, including the following:

- Minimize grade changes and site clearing
- Retain native vegetation on steep slopes, in swales, on soils with a high content of silts, fine sands and clays, and in areas with a high water table or adjacent to surface waters
- Avoid the use of paved surfaces such as parking lots and roadways where the presence of the following conditions indicate potential problems:
  - severely sloped terrain
  - floodplains
  - existing swales
  - depressions or lowlands
  - soil constraints listed as *severe* or *moderate*

- Incorporate the following general stormwater controls checklist into the site design as needed to meet the performance standards listed:
  - Reduce the extent of impermeable surfaces insofar as possible
  - Use swales and shallow depressions to collect stormwater on-site, wherever possible
  - Preserve swales in their natural state; avoid disturbance of existing grades, vegetation (particularly ground cover) or soils and the alteration of surface hydrology
  - Provide temporary on-site areas to receive stormwater runoff flows that are generated by construction and other site development activities
  - Do not allow increased sediment resulting from the construction or operational phase of site development to leave the site or to be discharged into stream corridors or tidal or freshwater wetlands
  - Minimize the amount of soil area exposed to rainfall and the period of exposure. Cover or plant exposed soils as soon as possible
  - Do not allow the dumping or filling of excess soil or other materials generated from site development into swales and surface waters
  - Detain runoff on-site and direct stormwater from road surfaces to sediment basins before discharge to a sump wherever topography limits or precludes on-site detention or retention. At sites where vertical drainage is not feasible, all runoff from a 25-year frequency, 24-hour storm from unstabilized soil areas should be collected, desilted, and released into stable channels at an acceptable design velocity appropriate for channel characteristics

Once the site plan has been partially completed, undertake the following steps:

- Calculate the amount of stormwater entering the site
- Calculate the amount of natural runoff from the site
- Calculate the additional amount of runoff due to the proposed installation of impermeable paving and other surfaces
- Locate areas on-site for the storage and recharge of stormwater
- Re-evaluate the site plan if the storage and recharge area capacity is not sufficient

Combine Development and Stormwater Controls

- Use cluster development as a viable alternative to conventional subdivision layout to preserve environmentally sensitive qualities of wetlands, aquifer recharge areas, swales and woodlands
- Reduce the length of roadways, thereby reducing the extent of cut and fill and stormwater runoff volumes and minimizing the possibility of erosion/sedimentation
- Reduce the area of other impermeable surfaces such as walkways, patios and recreational facilities
- Allocate open space for recreation and water quality protection

Natural Vegetation

- Use natural vegetation as an important nonstructural alternative in the control of stormwater runoff and erosion/sedimentation. Natural vegetation includes woodland, free-standing trees, old fields, unmowed grasses, and wetlands. When left undisturbed, vegetation stabilizes steep slopes, streambanks, and drainageways by:
  - reducing stormwater velocity, allowing for absorption of water by soils to occur, thus recharging the aquifer below and allowing for greater filtration of nutrient-rich and contaminated water;
  - acting as a filter by trapping sediment particles
  - holding soil particles in place.

- Identify site locations where existing vegetation will not be disturbed by grading, filling or removal; removal exposes valuable topsoil, making it highly susceptible to erosion/sedimentation
- Stabilize exposed slopes during and after construction, by using temporary and/or permanent, structural or nonstructural stabilization measures. All areas not to be covered with an impervious surface should be temporarily stabilized immediately following disturbance. Permanent stabilization measures should be installed as soon as possible.

Natural Depressions

- Use natural depressions to collect runoff from the surrounding devilment and slow its velocity, allowing for recharge. Natural depressions consist of gently sloping land, vegetated with grasses, understory vegetation, and/or trees. Depressions also function as runoff holding areas, allowing sediment particles and debris to settle out before discharge to nearby surface waters. Except during storm events, depressions also may serve as recreational open space.

Wetlands

- Do not discharge untreated stormwater runoff directly into tidal or freshwater wetlands, and do not construct stormwater management basins in naturally-existing wetlands.

Stormwater Detention

- Use stormwater extended detention (temporary detainment of stormwater runoff, with gradual release to surface or groundwaters) to main the same volume and rate of site runoff after development as that which existed prior to the development. Extended detention basins are designed to drain completely 24 hours or more after a storm. An emergency spillway should be provided to allow release of runoff during storms that exceed the design capacity of the retention area. Except during storm event, detention areas also may serve as open space and should be as visually attractive as possible.
- Maintenance of the control facility should be provided to insure sustained flow rates and visual attractiveness.

Case Study: Stormwater Management Basin Retrofit

In the early 1970s, nuisance algae blooms and low dissolved oxygen problems began to plague the Loch Rave Reservoir in Maryland. The cause was an overload of phosphorus generated by agricultural activities and urbanization.

Baltimore County had several phosphorus control programs, but of limited effectiveness. In urban areas, the programs focused mainly on retaining stormwater, primarily via 36 dry detention basins that became inundated only during large storms. Because the hydraulic controls were designed to accommodate only large flows, most stormwater runoff and the sediments, nutrients and contaminants it carried passed through the basins unimpeded. Thus, the basins did little to enhance water quality and the reservoir suffered.

To combat this problem, officials started modifying stormwater basins to detain flows from small storms without compromising the basins' ability to control large storm flows. Before modification, the 36 structures could control stormwater flows from storms that generally occur every two years. 10 years and 100 years. But because most storms are less intense than even the two-year type, engineers and planners needed to adjust the structures to accommodate smaller storms.

To modify the structures, engineers took a two-pronged design approach. First, they needed to know how small the basins could be without restricting their capacity to control runoff from larger storms. Through computer modeling, it was determined that the basins could be modified to accommodate one-year storms - even smaller storms would not be short-circuited. Second, the engineers needed to design the actual retrofits, which would vary the size of the low flow release structure to handle small storms. This was accomplished by designing a special attachment and installation of a trash debris guard.

Each retrofit was tailored to individual outlets and site conditions. Many of the retrofits completed to date are dry basins whose retrofits took less than three days. Retrofitting the wet basins is more complicated and expansion because the basins had to be pumped and their bottoms dredged to uncover the low flow releases from sediment. The wet basins took abut a week to retrofit.

Results indicate that the retrofits remove more than 90 percent of all particulate matter (suspended sediment) and up to 40 percent of the total phosphorus and nitrogen. None of the retrofits clogged, demonstrating the effectiveness of the trash-debris guards. Sediment infilling has not been appreciable despite the basins' estimated high trap efficiency. This is most likely due to the fact that all of the retrofits drain stabilized urban areas that characteristically have low sediment export rates. Sediment infilling is expected to be a concern in areas with construction activity.

Stormwater Retention Ponds

- Stormwater retention should be used to permanently hold stormwater runoff on the site or for long-term detention to allow for the die-off of coliform bacteria. Retention basins can provide recreational and aesthetic benefits for development by supporting certain native plants and aquatic life. They also can provide a habitat for wildlife when the pond is planted with upland and aquatic vegetation. The retention pond should be sized to contain both the normal dry weather water volume and expected runoff flows. It is recommended that the retention pond be designed to accommodate a 100-year, 24-hour storm. In areas where heavy sediment loads are anticipated, the aesthetic value of the permanent ponds and its surroundings will be severely reduced by deposited sediment and debris. Therefore, maintenance will be required or a more easily maintained sediment basin should be constructed immediately upstream from the basin.

Drainage Channels

- Naturally-vegetated swales or other types of drainage channels should be used to carry stormwater. Use grassed or vegetated waterways in areas where design velocities are low and soils have a low erosion potential. Stabilized vegetation also reduces the energy of flow, allowing for infiltration of runoff. Vegetative waterways are usually preferred over structurally-lined channels for reasons of aesthetic value.
- Bare channels should be used only as a temporary measure for construction sites in areas where the slope is minimal, and the runoff velocity is low. Do not install bare drainage channels in areas with highly erodible soils. The permanent use of bare channels should be avoid.
- Structurally-lined channels should be used only as necessary in drainage areas where the slope is high or runoff velocities and concentrations are erosive, particularly in areas of highly erodible soils that preclude the establishment of vegetative cover. The most common structural linings include stone riprap.
- Shallow detention and recharge areas should be used upgradient of natural swales as required so that the existing volume and velocity of runoff into the swales is not exceeded. If this is not possible due to lack of land area or the presence of a high water table, etc., then vegetative and/or structural stabilization measures will be required to provide the swale with the capability to carry and/or recharge runoff without risk of erosion/sedimentation.

- Protect the channel until a uniform vegetative cover has been obtained, eliminating the risk of erosion and/or sedimentation damage. Common channel stabilization methods include the use of seeding, mulches, and sod. Jute netting and other mulching techniques are frequently used to protect channels until vegetation is established.

Diversion Control Measures

- Use diversion control measures to direct stormwater away from an area where it could cause damage from flooding erosion and/or sedimentation. A surface drainageway is one type of a diversion control measure. It is a natural or constructed channel or waterway used to divert stormwater runoff. A berm is another type of diversion control measure. Surface drainageways and berms should be used to divert stormwater away from natural slopes where slopes or soils were exposed during construction and newly constructed fill slopes. Channels and waterways should have the capacity to provide a path for flow to move at non-erosive velocities to a stable outlet. Diversion control measures should not direct stormwater runoff to an adjacent property.

Energy Dissipation

- Use energy dissipation devices to slow the velocity of stormwater runoff to a non-erosive rate. This can be done by establishing a control area immediately adjacent to an outfall or other discharge point. Usually a pile of rocks, stones, gravel/crushed stone or boulders is used to reduce the velocity of the stormwater as it moves through the area. Energy dissipaters may also serve as sediment filters, trapping suspended particles and debris.

Sediment Basins

- Use sediment basins to protect surface waters from increased sediment loads by trapping the suspended solids before the runoff is released.
- Remove accumulated sediment and debris periodically, so that the basin will function properly and its visual attractiveness will remain. Wherever possible, retain vegetation because the roots can increase soil permeability.

Biofiltration Systems

- Use a biofiltration system to detain runoff and reduce contaminant loadings. Biofiltration by a combination of physical and biological processes can minimize concentrations of coliform bacteria, heavy metals, and nutrients carried in stormwater runoff. A biofiltration system is essentially a man-made pond or wetland. The system includes an energy dissipater, located below the inlet pipe, to reduce water velocity and trap suspended solids (sediment and debris). The entire basin is lined with an impermeable vinyl sheet or clay layer to prevent leaching of trapped containment's to groundwaters. The vinyl or clay is covered with clean sand and loam, and planted with indigenous aquatic plant species, such as *Typha angustifolia*, or cattails. All above-water areas are stabilized by plantings of rye grass, *Lolium multiflorum*, or Tall Fescue, *Festuca arundivacea*, or Red Fescue, *Festuca rubra*, to name a few. Removal of pollutants is accomplished as the runoff moves across the plants. After a detention time of several days, during which the contaminants are absorbed by the plants, significant reductions in contaminant levels occur. The treated runoff is then released to adjoining surface waters. The overflow chamber, located at the pond outlet (equipped with backflow and adjustable weir) controls the storage capacity. Maintenance involves the periodic cleaning of the surge tank and overflow chamber of floating debris and sediments, and biannual harvesting of aerial portions of aquatic plants.

Permeable Paving

- Use permeable or "porous" paving for patios, walkways and parking lots to reduce the volume of stormwater runoff by increasing infiltration to the ground below, thus allowing for recharge of the aquifer. Permeable paving may be used in areas where permeability of the soil is sufficient to allow rapid drainage and where a seasonally high water table is not anticipated.

WETLAND AND STREAM BUFFERS

A. Natural Water Filters

A relatively simple way to reduce or eliminate impacts to aquatic resources from adjacent land uses is to maintain buffers around the resources. *Buffers* are vegetated zones located between natural resources and adjacent areas subject to human alteration. In some locations, a buffer may be referred to as a *vegetated filter strip*. The emphasis on the filtering functions of buffers is derived from their widespread use to remove sediments and other waterborne nutrients and pollutants from surface runoff.

In general, riparian and wetland buffers do the following:

- moderate runoff and stream temperatures (runoff from pavement is significantly warmer than runoff that passes through soil and vegetation, and trees provide shade for streams);
- control the velocity, quantity and quality of stream flows;
- enhance wildlife habitat diversity;
- stabilize streambanks and reduce channel erosion;
- regulate channel shape and size, reducing potential future impacts on adjacent properties;
- provide principal energy source for the base of the food chain (detritus/leaf litter);
- enhance food web and species richness;
- reduce potential formation of fish migration barriers (shallow areas and accumulated sediment);
- enhance recreational opportunities;
- attenuate nitrogen from shallow groundwater flows to streams;
- mitigate the effects of watershed imperviousness;
- increase property values;
- allow for future restoration/reforestation of stream corridors.

Recent research has shown that stream and wetland buffers can improve the quality of water resources by removing or ameliorating the effects of pollutants in runoff and increase the biological diversity and productivity of stream and wetland communities by improving habitat and adding to the organic food base. Forest buffers can function, often simultaneously, as filters, sources, transformers and sinks.

Forest buffers filter sediment and other suspended solids from surface runoff. Sediment is probably the most common and most easily recognized of the nonpoint source pollutants. Sediment suspended in the water can reduce or block sunlight penetration, adversely affecting the growth and reproduction of beneficial aquatic plants. Sediment deposited on stream bottoms can interfere with the feeding and reproduction of bottom dwelling fish and aquatic insects, weakening the food chain. Large deposits of sediment can overfill stream channels and floodplains, greatly increasing the potential for flooding. Furthermore, nutrient and pollutants adsorb to sediment particles. When sediment is transported via erosion, these nutrients and pollutants also are transported.

Several mechanisms of sediment removal work in the streamside forest. Some sediment settles out as the water flow speed is reduced by the many obstructions encountered in forest litter. Additional sediment is filtered out by the porous soil structure, vegetation and organic litter as the runoff flows over and into the floor of the forest buffer.

Phosphorus also is reduced by the filtering action of the forest buffer because about 85 percent of available phosphorus is attached to the small soil particles comprising the sediment. Approximately 4 percent of the phosphorus is bonded to the small soil particles comprising the sediment. Approximately 4 percent of the phosphorus is attached to soil particles too small to be filtered by these processes resulting in a removal of about 80 percent of phosphorus by the forest filter. The minor amount of ammonium which is bound to sediment can be filtered out in the same way. Nitrogen, too, is filtered out in large amounts by the buffer. However, dissolved phosphorus and nitrate must be removed by either microbial or biochemical transformation processes.

The forest buffer also acts as a transformer when chemical and biological processes within it change the chemical makeup of compounds. For example, under oxygenated soil conditions, bacteria and fungi in the forest buffer convert nitrogen in runoff and decaying organic debris into mineral forms. These forms can then be synthesized into proteins by plants or bacteria. When soil moisture is high enough to create anaerobic conditions in the litter and surface soil layers, denitrifying bacteria convert dissolved nitrogen into various nitrogen gasses, returning it to the atmosphere. Studies have shown that the amount of nitrogen in runoff and shallow groundwater can be reduced by as much as 80 percent after passing through a forest buffer.

The forest buffer further acts as a transformer when toxic chemicals such as pesticides are converted to non-toxic forms. Because of continued improvements in the formulation and management of pesticides, only very small amounts manage to leave the area of application. These residues, borne by runoff, are converted to non-toxic compounds by microbial decomposition, oxidation, reduction, hydrolysis, solar radiation and other biodegrading forces at work in the soil and litter of the buffer.

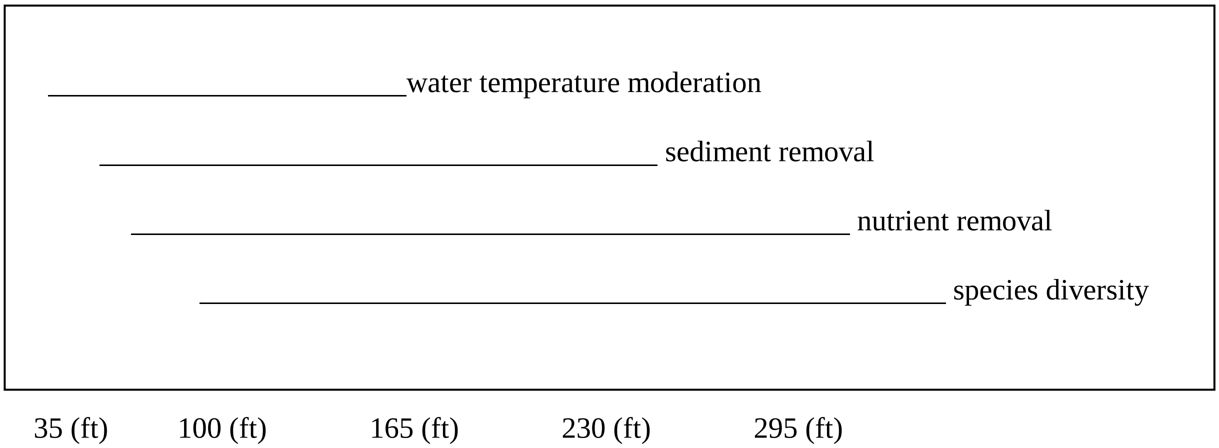
The forest buffer also functions as a sink when nutrients are taken up by plants and sequestered in plant tissue. Some estimates indicate that 25 percent of the nitrogen removed by the forest buffer is assimilated in tree growth which may be stored for long periods of time in woody tissue and possibly removed as logs or other forest products. Nitrogen and other nutrients also may be passed up the food chain when litter can be stored for longer periods as peat. Sediments filtered out by the buffer remain to become incorporated into the forest soil.

Four criteria have been identified for determining adequate buffer sizes for aquatic resources: (i) resource functional value, (ii) intensity of adjacent land use, (iii) buffer characteristics, and (iv) specific buffer functions required. Generally, smaller buffers are adequate when the buffer is in good condition (e.g., dense native vegetation, undisturbed soils), the wetland or stream is of relatively low functional value (e.g., high disturbance regime, dominated by non-native plants), and the adjacent land use has low impact potential (e.g., parkland, low density residences). Larger buffers are necessary for high value wetlands and streams that are buffered from intense adjacent land uses by buffers in poor condition.

B. Buffer Size Requirements

The range of generally appropriate buffer widths for several buffer functions is variable depending on the biological, chemical, and physical characteristics of the buffer. Figure 1 provides a schematic presentation of buffer widths in relation to specific pollutant reduction goals. The results illustrate that buffer sizes may vary widely, depending on specific desired functions and buffer characteristics.

Figure 1. Range of buffer widths providing specific buffer functions



C. Sediment Removal and Erosion Control

Vegetated buffers control erosion by blocking the flow of sediment and debris, by stabilizing streambank and wetland edges, and by promoting infiltration (Shisler et al., 1987). Buffer vegetation forms a physical barrier that slows surface flow rates and mechanically traps sediment and debris. Roots maintain soil structure and physically restrain otherwise erodible soil. Because flow rates are generally lower for sheet flow than for channelized flow, vegetation resists the formation of channels (water will flow more slowly over vegetation, allowing more time for settling of sediments and infiltration).

Wong and McCuen (1982) derived an equation to determine effective buffer widths, based on sediment particle size, slope, surface roughness, and runoff characteristics. While small buffers were found to remove small amounts of sediments, the relationship between buffer width and percent sediment removal was nonlinear; disproportionately wider buffers were required for incrementally greater sediment removal. For example, if the design criteria for sediment removal were increased from 90 to 95 percent on a 2 percent slope, then the buffer widths would have to be doubled from 100 to 200 feet.

Young et al. (1980) found that an 80-foot-wide vegetated buffer reduced the suspended sediment in feedlot runoff by 92 percent, but Schellinger and Clausen (1992) determined that a 75-foot-wide buffer removed just 33 percent of the suspended solids from dairy farm runoff. Horner and Mar (1982) reported that a 200-foot-wide grassy swale removed 80 percent of the suspended solids and total recoverable lead; Broderson (1973) also found that 200-foot-wide buffers effectively control sedimentation, even on steep slopes. According to Lynch et al. (1985), a 98-foot-wide buffer between logging activity and water resources removed an average of approximately 75 to 80 percent of the suspended sediment in stormwater. Greater sedimentation resulted from forested areas that had been commercially clear-cut and then denuded with an herbicide because of channelization, which developed following these activities. Ghaffarzadeh et al. (1992) examined sediment removal by grass vegetated filter strips ranging from 0 to 60 feet on 7 and 12 percent slopes. They found no different in vegetated filter strip performance on either slope beyond 30 feet, where 85 percent of the sediment was removed.

D. Excess Nutrient and Pollutant Removal

Buffers remove pollutants and excess nutrients from runoff, but the rate of removal appears to be a function of the length, slope and soil permeability of the buffer, the size of the contributing buffer area, and the runoff velocity. Therefore, recommended buffer widths for nutrient and pollutant attenuation vary widely. In general, the recommended width is 100 feet or more. However, few opportunities exist in the WAC 5 study area to establish 100-foot-wide buffers. Fortunately, some research indicates that lesser buffers may contribute significantly to the reduction of nonpoint source pollutants. Madison et al. (1992) examined the ability of grass vegetated filter strips (VFSs) to reduce nitrogen and phosphorus during two simulated storm events (the equivalents of the 1-year and 10-year events). Grass VFSs which were 30 feet wide had trapping efficiencies of between 96 and 99.9 percent. Vegetated filter strips wider than 30 feet did not result in further improved trapping efficiencies, according to Madison. Dillaha et al. (1989) reported that 30-foot-wide and 15-foot-wide VFSs removed an average of 84 and 70 percent of suspended solids, 79 and 61 percent of phosphorus, and 73 and 54 percent of nitrogen, respectively. Xu et al. (1992) found that nitrogen concentrations were reduced from 764 mg to approximately 0.5 mg in a 30-foot-wide mixed herbaceous and forested buffer strip in the North Carolina Piedmont. Wooded riparian buffers in the Maryland coastal region were found to remove as much as 80 percent of excess phosphorus and 89 percent of excess nitrogen, most of it in the first 62.3 feet (Shisler et al. 1987). Schueler (1987) suggested that, as an "absolute minimum," an unmanaged/unmowed grass strip should be at least 20 feet wide, but better performance is achieved if the strip is 50 to 75 feet wide, plus an additional 4 feet per each 1 percent of the site's slope.

E. Moderation of Stormwater Runoff and Water Temperature

Wetland stream buffers affect the quantity as well as the quality of stormwater runoff. A vegetated buffer zone that resists channelization is effective in decreasing the rate of water flow and, in turn, increasing the rate of infiltration (Broderson, 1973). Bertulli (1981) concluded that adjacent forest vegetation and litter lowered stream water elevations from 32.3 feet to 17.3 feet for a 100-year flood.

Forested buffers adjacent to wetlands provide cover, thereby helping to maintain lower water temperatures in summer and lessen temperature decreases in winter. Broderson (1973) found that 50-foot-wide buffers provided adequate shade for small streams; further, buffer widths along slopes can decrease with increasing tree height with no significant loss of shading. Lynch et al. (1985) determined that a 100-foot-wide buffer from logging operations maintained water temperatures within 2 to 3 degrees Fahrenheit of their former average temperature.

WETLAND RESTORATION AND CREATION

By the mid-1980s, the idea of restoring and creating wetlands began to be seriously considered as a means of mitigating wetland losses and meeting the "no-net-loss" goal. Proponents believe that these practices can offset the annual loss of natural wetlands.

A. Success and Failure

Natural wetlands are beneficial for a variety of reasons. They convey and store flood waters; are barriers to erosive waves, thereby stabilizing shorelines and streambanks; assimilate natural sediment loads; are essential wildlife habitats; charge ground and surface waters; provide open space and recreational opportunities; are aesthetically pleasing; and protect water quality by removing nutrients and chemical contaminants.

There is general agreement that natural wetlands are important landscape components, providing a variety of ecological, social and aesthetic benefits. Regulatory agencies and scientists have questioned whether created wetlands perform the same functions as their natural counterparts.

In the past decade, research has improved the success fate of wetland restoration and some types of creation projects. But even today, partial or complete failures are widely experienced due to poor planning, design and/or maintenance. Many created wetlands do not persist over time or do not function as they were designed; however, success rates are improving as wetland construction technology advances. Careful siting, monitoring and long-term maintenance are crucial.

The success/failure of restoration and creation also varies with project type. The restoration of emergent marshes, for example, enjoys a relatively high success rate whereas the creation of forested swamps is considerably more difficult and less reliable.

Restoration means reclaiming a degraded wetland to re-establish one or more functions that have been partially or completely lost by such actions as filling or draining. It is the preferred form of mitigation because it typically has the greatest chance of successfully establishing natural wetland functions. It does not, however, necessarily ensure "no-net-loss" of wetlands.

Due to the uncertainty of wetland creation, the U.S. Environmental Protection Agency and Army Corps of Engineers have adopted a "sequencing" approach to wetland regulation under the Clean Water Act, by which applicants must first demonstrate there is no practicable alternative to the proposed development that would be less damaging to the aquatic ecosystem. If impacts are proven to be unavoidable, applicants must then demonstrate that they have been minimized. Unavoidable impacts that cannot be further minimized must be mitigated by restoring or creating new wetlands. The "enhancement" of existing wetlands is, for the most part, an unacceptable form of mitigation since it clearly does not fulfill "no-net-loss."

B. Using Created Wetlands as Water Filters

When multiple functions need not be replicated and land is available, constructed wetlands can effectively treat wastewater. In Arcata, California, municipal effluent is largely treated by created wetlands. When Arcatans "flush," gravity takes their wastewater to a conventional treatment plant at the edge of Humboldt Bay, where it is screened and solids settle out. The effluent is then piped to 50 acres of oxidation ponds, where algae remove more waste and solids. Next, the wastewater flows into two 2.5-acre marshes planted with bulrush and cattail, where the sewage effluent is "polished." Finally, it flows into 45 acres of marsh constructed by the city and California Coastal Conservancy to help restore fish, shellfish, waterfowl, and other wildlife to the area. By the time it flows into the Humboldt Bay, the effluent is cleaner than the bay water itself.

Creation means constructing a new wetland, usually by flooding or excavating lands that were not previously occupied by a wetland. It offers the benefit of maintaining no-net-loss of wetland acreage, but not necessarily wetland functions. Wetlands created for a single purpose can be very effective for that use.

Pollutants entering natural wetlands are "treated" by a variety of physical, chemical and biological processes. These processes modify dissolved and particulate substances from "point" and "nonpoint" sources of pollution by settling, filtration, absorption (attaching to soil particles), volatilization, precipitation, complexing, microbial modification, and plant uptake.

Suspended solids, including sediment particles, have a strong tendency to adsorb pathogenic microbial organisms, organics, hydrocarbons, heavy metals and nutrients. Filtration, precipitation and complexing depend on the hydraulic resistance of wetland plants and the nature and chemistry of wetland soils. Increased ponding time increases the length of time that water is in contact with wetland plants and soils and adds treatment via oxidation and volatilization of certain substances, especially metals.

Microorganisms attached to plants, rocks and sand in waterbodies modify petroleum products, metals, pathogens and nutrients, causing precipitation of some pollutants and recycling and settling-out of others. A dense stand of wetland plants is most effective at pollutant removal because it provides a large surface area for microbial attachment. And the diffused loss of oxygen from plant roots creates an oxygen-rich environment for microorganisms in otherwise saturated soil. The update of nutrients, metals and organic substances by plants permanently removes some pollutants and nutrients and temporarily binds others. The decomposition of herbaceous plants releases many compounds back into the water column after the growing season. Therefore, sedimentation and subsequent microbial modification within the soil profile provide the most effective and permanent pollutant removal mechanisms.

Urban stormwater runoff has been identified as a principle factor in the degradation of the Chesapeake and San Francisco bays and Long Island Sound. Created wetlands used to treat municipal and mine wastewater in the Chesapeake Bay area have successfully removed 80 to 90 percent of the nutrients and metallic ions. But treating urban stormwater runoff with created wetlands is not always successful. Unlike discharges of municipal and agricultural wastewater, urban stormwater has widely fluctuating flows with substantial variability in the types and concentrations of pollutants. Stormwater runoff from the first half-inch of rainfall may carry about 90 percent of the pollutants generated during a storm. This rapid influx of highly contaminated stormwater can "shock load" water treatment systems and water resources, such as streams, ponds, lakes and wetlands. In addition, stormwater runoff often contains greater quantities of sediments and hydrocarbons and, occasionally, heavy metals ;nutrient content, however, is often comparable to secondarily treated municipal wastewater.

For surface runoff, the most effective constructed wetland treatment systems include a combination of retention pond, wet meadow, and emergent marsh. Before these created wetlands are designed, however, the objective(s) of the project and the treatment needed should be determined.

The most effective plants for treating stormwater runoff have high oxygen transfer efficiencies; deep, uniform and dense root masses; low bioaccumulation potential; and high tolerance for local environmental conditions. Created wetlands designed for nonpoint source pollution treatment often consist of combinations of cattails, reeds, bulrush, rush, arrowhead, burreed, and/or sedges.

C. Stormwater Wetlands

Definition: Conventional stormwater wetlands are shallow pools that create growing conditions suitable for the growth of marsh plants. These stormwater wetlands are designed to maximize pollutant removal through wetland uptake, retention and settling. Stormwater wetlands are constructed systems and typically are not located within delineated natural wetlands. In addition, stormwater wetlands differ from artificial wetlands created to comply with mitigation requirements in that they do not replicate all the ecological functions of natural wetlands.

Enhanced stormwater wetlands are designed for more effective pollutant removal and species diversity. They also include design elements such as a forebay, complex microtopography, and pondscaping with multiple species of wetland trees, shrubs and plants.

Pollutant Removal Capability: In general, conventional stormwater wetlands have a high pollutant removal capability that is generally comparable to that of conventional wet ponds. Removal of sediment and some nutrients and pollutants may be greater in well-designed stormwater wetlands, but phosphorus removal is more variable.

Longevity: Well-designed conventional stormwater wetlands should function for many years, but very few stormwater wetlands are yet ten years old.

Feasibility: Enhanced stormwater wetlands can be applied to most development situations where sufficient baseflow is available to maintain water elevations.

Environmental Concerns: if located improperly, the construction of stormwater wetlands may impact existing forests and natural wetlands; shallow wetlands can also contribute to downstream warming.

Environmental Benefits: With careful design and buffers, enhanced stormwater wetlands can create unique and valuable habitat for waterfowl and other wildlife in an urban setting.

Costs: Construction costs for stormwater wetlands have not been systematically analyzed, but are expected to be marginally higher than wet ponds. Maintenance costs may average 3 to 5 percent of construction costs annually.

Adaptability: Enhanced stormwater wetlands can be adapted for most regions of the country that are not excessively arid.

Maintenance Burden: Stormwater wetlands require greater maintenance in the first three years of their life. Thereafter, their management demands are usually similar to other wetland systems.

Usefulness as a Coastal Urban NPS Management Practice: Stormwater wetlands can be beneficial and have great utility in coastal areas throughout most of the United States; therefore, their use in that environment should be encouraged.

Pollutant Removal Mechanisms: Wetlands remove nutrients and pollutants through gravitational settling, wetland plant update, adsorption, physical filtration and microbial decomposition. The degree of pollutant removal is a function of aquatic treatment volume, surface area to volume ratio, and the ratio of wetland surface area to watershed area.

Review of Monitoring Studies: Performance studies of conventional natural and constructed wetlands have been conducted. Removal rates are generally comparable to those reported for conventional wet ponds of similar treatment volume; however, sediment removal rates are often slightly higher and nutrient removal rates are somewhat lower. Some cases of negative removal for ammonia and ortho-phosphorus were reported. Overall performance is greatest during the growing season and lowest during the winter months.

Contributing Watershed Area: Stormwater wetlands can be used in watersheds as small as five acres.

Presence of Baseflow: To maintain a constant water level, it is often necessary to have a reliable dry-weather base flow to the wetland or groundwater supply.

Permeable Soils: It is difficult to establish wetlands on sites with sandy soils, high soil infiltration rates or high summer evapotranspiration rates.

Available Space: Because of their shallow depths, stormwater wetlands can consume two or three times the site area compared to other stormwater quality enhancement options (in some cases, as much as 5 percent of total site area). The land requirements of stormwater wetlands can be sharply reduced by partially substituting vertical extended detention storage for horizontal wetland storage.

Use of Ultra-Urban Areas: The use of these areas is limited due to space constraints. However, pollutant removal can be obtained by modifying existing degraded urban wetlands for stormwater control.

Retrofit Capability: The addition of wetland features to older dry stormwater basins is an effective retrofit technique. Many retrofits utilize a combination of extended detention, wetlands and a permanent pool (retention).

Stormwater Management Capability: In most cases, stormwater detention can be provided in stormwater (constructed) wetlands.

Design: Typically, design costs for constructed (stormwater) wetland systems are slightly higher than for other stormwater management systems due to the need for environmental analyses of the proposed wetland site and the need for specialized planting techniques.

Construction: Very little systematic cost data is available for the construction of stormwater wetlands. The prevailing viewpoint is that stormwater wetland construction costs exceed those of wet (retention) ponds due to the more complex grading and wetland planting costs. Also, stormwater wetlands may require more space than other stormwater management systems, thereby driving up land acquisition costs.

Maintenance: No reliable maintenance cost data is available. It has been assumed that maintenance costs are comparable to those of other stormwater management systems over the long term. However, costs may well be higher in the first few days after construction due to difficulties encountered in wetland establishment and the possible need for reinforcement plantings.

Stormwater wetlands are no longer an experimental technology. They have been proven to be effective and provide moderate to high levels of pollutant removal throughout the year. Stormwater wetland designs are numerous, however, and research needs to be done on the optimal combination of wetlands, extended detention and permanent pool storage.

Other uncertainties include:
- uptake of metals by wetland biota
- ability to maintain wetland target species over the long term
- whether the annual plant dieback exports a pulse of nutrients from the system
- the degree to which removal rates are reduced during the non-growing season
- the potential value of annual plant harvesting to increase removal rates

STREAM RESTORATION

A. Vegetative Streambank Stabilization

Eroding stream and shore banks have a detrimental impact on water quality because of the sediment that is discharged from the eroded banks and because eroded banks usually do not have any or enough stabilizing vegetation that also will act to filter out nutrients and contaminants and keep the stream cool by shading it from excessive sunlight. Although structural and non-structural methods can be used to stabilize eroding stream and shore banks, from a water quality protection standpoint, the best solutions are often those that focus on non-structural methods. Some of these methods are explained below.

- ***Geo-textiles:*** Longitudinal geo-textiles are shaped like a boom or log (under the trade name Fiber-Schine) and are made of natural fibers, such as those from coconut trees, which have been compressed and stuffed into netting. Seeds from wetland vegetation may be planted in the boom or log, which is then installed along stream, pond and lake banks and backfills with soil. The vegetation will become established long before the fibers decay. The geo-textiles also may be shaped like a fibrous mesh, blanket or plugs. The trade names of some of these are Fiber-Textiles, Fiber-Pallet, and Fiber-Plug, respectively.

- ***Live staking:*** Live, rootable vegetative cuttings are inserted and tamped into the ground perpendicular to the slope. Most willow (Salix sp.) species root rapidly.

- ***Live fascine:*** Long bundles of live branch cuttings are placed in shallow trenches dug on the contour of the slope. They are held by stout dead stakes driven through the fascines and stout live stakes inserted directly below the bundles. The fascines are then almost covered by moist earth and mulch is placed between rows.

- ***Brush layering:*** Live branch cuttings are placed on small benches 2 to 3 feet wide, excavated at a slight tilt into the slope. Brush-layered branches serve as reinforcing units, retarding runoff and reducing surface erosion, aiding seed germination and natural regeneration.

- ***Branch packing:*** Alternating layers of live branch cuttings and compacting backfill may be used to repair small localized slumps, holes in slopes, and gullies.

- ***Live cribwall:*** A hollow, box-like interlocking arrangement of untreated log or timber members is filled with suitable backfill material and layers of live branch cuttings. The cuttings root inside the crib structure and extend into the slope, gradually taking over the structural functions of the wood members.

- ***Vegetated rock gabions:*** Rectangular containers of triple twisted, hexagonal steel mesh are placed in position, wired to adjoining gabions, filled with stones, then folded shut and wired at the ends and sides. Live branches placed on each layer between the rock-filled baskets will take root inside the gabion baskets and in the soil behind the structures, consolidating the structure and, in time, binding it to the slope.

- ***Vegetated rock wall:*** A combination of rock and live branch cuttings that differ from conventional retaining structures in that they are placed against relatively undisturbed earth and are not intended to resist large lateral earth pressures.

- ***Joint planting:*** Live cuttings are tamped into soil between open spaces in rocks that have been previously placed on a slope.

B. Stream Channel Improvements

- ***Remove Channel Lining/Establish Natural Channel*** **-** Structural modification impacts on the natural behavior of a stream; it prohibits the system from developing a natural pattern on the landscape. Modification usually occurs in the form of channel straightening, allowing for faster means with which to convey quantities of water. While this may be beneficial in some instances for flood control, water quality protection dictates the importance of slowing the velocity of water and allowing pollutants to settle or filter out of the water column.

- ***Storm Drain Retrofit*** **-** Storm drain outlets are one source of stream pollution. Some outlets contribute to channel erosion, channel scour and sedimentation. To ameliorate these conditions, it is recommended that repair and maintenance practices be implemented. These practices include filter screens, velocity reduction devices, backfilling, and revegetation of damaged stream banks.

C. Urban Housekeeping Practices

- ***Grass Type and Mow Height*** **-** The type of lawn management practices, such as mowing height, are the most important factors when considering water quality benefits from a grass buffer. To improve a stream's riparian buffer for water quality purposes, it is best to allow grassed areas to grow to a more substantial height (increasing filtering and attenuation capacity).

- ***Street Sweeping*** **-** Streams receive a large amount of sediment, not only from eroding stream banks but from stormwater runoff as well. Establishing a street sweeping program or revising existing street sweeping schedules will assist in reducing the amount of sediment entering the stream channel by means of stormwater runoff. To be effective, street sweeping should be conducted once per week, especially during winter and spring months.

Table 3. A comparative assessment of the effectiveness of current urban best management practices							
URBAN BMP OPTIONS*	**RELIABILITY FOR POLLUTANT REMOVAL**	**LONGEVITY***	**APPLICABLE TO MOST DEVELOPMENTS**	**WILDLIFE HABITAT POTENTIAL**	**ENVIRONMENTAL CONCERNS**	**COMPARATIVE COST**	**SPECIAL CONSIDERATIONS**
STORMWATER WETLANDS	Moderate to high, depending on design	20+ years	Applicable to most sites if land is available	High	Stream warming; natural wetland alteration	Marginally higher than wet ponds	Recommended with design improvements and the use of micropools and wetlands
EXTENDED DETENTION PONDS	Moderate, but not always reliable	20+ years, but frequent clogging and short detention common	Widely applicable, but requires at least 10 acres of drainage area	Moderate	Possible stream warming and habitat destruction	Lowest cost alternative to size range	Recommended with design improvements and the use of micropools and wetlands
WET PONDS	Moderate to high	20+ years	Widely applicable, but requires drainage area of greater than 2 acres	Moderate to high	Possible stream warming, trophic shifts, habitat	Moderate to high compared to conventional	Recommended, with careful site evaluation
MULTIPLE POND SYSTEMS	Moderate to high; redundancy in-creases reliability	20+ years	Widely applicable	Moderate to high	Selection of appropriate pond option minimized overall environmental impact	Most expensive pond option	Recommended
INFILTRATION TRENCHES	Presumed moderate	50% failure rate within five years	Highly restricted (soils, groundwater, slope, area, sediment input)	Low	Slight risk of groundwater contamination	Cost-effective on smaller sites; rehab costs can be considerable	Recommended with pretreatment and geotechnical evaluation
INFILTRATION BASINS	Presumed moderate if working	60-100% failure within 5 years	Highly restricted (see infiltration trench)	Low to moderate	Slight risk of groundwater contamination	Construction cost moderate, but rehab cost high	Not widely recommended until longevity is improved
POROUS PAVEMENT	High (if working)	75% failure within 5 years	Extremely restricted (traffic, soils, groundwater, slope, area, sediment input)	Low	Possible groundwater contamination	Cost-effective compared to conventional asphalt when working properly	Recommended in highly restricted applications with careful construction and effective maintenance
SAND FILTERS	Moderate to high	20+ years	Applicable for smaller developments	Low	Minor	Comparatively high construction costs and frequent maintenance	Recommended, with local demonstration
GRASSED SWALES	Low to moderate, but unreliable	20+ years	Low density development and roads	Low	Minor	Low compared to curb and gutter	Recommended, with checkdams as one element of a BMP system
FILTER STRIPS	Unreliable in urban settings	Unknown, but may be limited	Restricted to low-density areas	Moderate if forested	Minor	Low	Recommended as one element of a BMP system
WATER QUALITY INLETS	Presumed low	20+ years	Small, highly impervious catchments (<2 acres)	Low	Resuspension of hydrocarbon loadings; disposal of hydrocarbon and toxic residuals	High, compared to trenches and sand filters	Not currently recommended as a primary BMP option

*** Based on current designs and prevailing maintenance practices.** ***Source: Metropolitan Washington Council of Governments 1992.***