BRONX RIVER

ALLIANCE

ECOLOGICAL RESTORATION AND MANAGEMENT PLAN

MAY 2006

BRONX RIVER ALLIANCE
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Bronx, New York 10462

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http://www.bronxriver.org/plans

ACKNOWLEDGEMENTS

Project Partners
The Bronx River Alliance was formed in 2001 to serve as a coordinated voice for the river and work in harmonious partnership to protect, improve and restore the Bronx River corridor and greenway so that they can be healthy ecological, recreational, educational and economic resources for the communities through which the river flows. The Alliance initiated this plan and will guide its implementation. With the City of New York Parks & Recreation (NYC Parks), the Alliance manages the New York City segment of the Bronx River corridor and greenway, implements small-scale restoration projects through the work of its Conservation Crew, coordinates larger scale restoration projects, and supports community-led or -sponsored restoration and development projects.

NYC Parks Natural Resources Group (NRG) works closely with the Alliance to manage the ecological health of the river by planning and implementing restoration and monitoring activities. NRG provided crucial and substantial expertise during this planning process and played a key role in the production of the plan itself.

Many thanks to the dozens of people on the Bronx River Alliance Ecology Team who reviewed and contributed to the plan. Especially important were the contributions of Bob Alpern, Marielle Anelzone, Resa Dimino, Jennifer Epstein, David Kaplan, Todd McDonnell, Aubrey McMahon, Ellen Pehek, Joseph Rachlin, Eric Sanderson, Chad Seewagen, Mike Stringer, Dora Sugar, Tracy Triplett, Barbara Warkentine, and Charles Yackulic.

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EXECUTIVE SUMMARY

PURPOSE

This plan is the result of the collaborative efforts of the more than 80 Bronx River Alliance partners to develop a framework that will ensure a consistent and comprehensive approach to restoring wildlife habitat and water quality in the lower Bronx River — the eight-mile stretch within New York City. Although restoration efforts have been underway since the 1970s, the intensified focus since 2001 on restoring wetlands and wildlife habitat and on improving storm water capture in the watershed requires technical guidance and integrated vision. This plan details a comprehensive, consensus-based approach to improving the environmental health of the river by setting overall restoration goals, creating a context for evaluating future restoration projects and strategies, and addressing specific pollutants that compromise habitat restoration.

At Drew Gardens, just south of Tremont Avenue, the Bronx River serves as a refuge for wildlife as it runs through an extremely urban area.

The Bronx River Alliance and the New York City Department of Parks and Recreation Natural Resources Group (NRG) work closely with grassroots organizations and community residents and also play a collaborative role in the various agency-led initiatives regarding the Bronx River. The New York City Department of Environmental Protection (NYC DEP), U.S. Army Corps of Engineers (ACOE), New York City Soil Survey, and Westchester County Planning Department all actively work towards the improvement of the Bronx River within their own missions and timelines. As important stewards of large portions of the Bronx River watershed, the Bronx Zoo and New York Botanical Garden (NYBG) influence the river's health through the management and operations of their facilities. Within this context, the Bronx River Ecological Restoration and Management Plan provides local practitioners with a blueprint for future restoration and gives recommendations for the work of agencies and organizations.

EXISTING CONDITIONS AND PROBLEMS

The Bronx River begins near Valhalla, N.Y. and flows south for 23 miles through Westchester and Bronx Counties before emptying into the East River. Along the eight-mile stretch that passes through the heart of the Bronx, the river exhibits a diverse range of problems, many of which are typically associated with urban rivers. The northernmost five miles of this stretch, which includes several city parks, the NYBG and the Bronx Zoo, have mostly naturalized banks and a fairly well vegetated, though often low quality, buffer area. Industrial and commercial uses dominate much of the lower three miles of the corridor, as evidenced by its armored shoreline and lack of riparian vegetation. All along the river, the prevalence of exotic invasive vegetation reduces the habitat value of the existing buffer areas.

Impervious surfaces (rooftops, parking lots, roads) cover more than 60 percent of the river's upland areas and inhibit the watershed's natural hydrological function (McDonnell and Larson, 2004). In a well functioning watershed, rain is intercepted by vegetation and absorbed in the soil, where it either infiltrates to the groundwater or travels slowly through the subsurface to stream channels. In the Bronx River watershed, impervious surfaces produce storm water runoff that is conveyed quickly to the river through sewers and drains. This results in disturbed flow patterns within the river channel that cause flash floods, erosion, low habitat value, high water temperatures, low base flow and excessive sedimentation. Drainage systems and surface runoff from the surrounding watershed also discharge untreated wastewater directly into the river all along its length. The resulting degraded water quality is exacerbated by the river's low base flow and lack of a wide buffer of native vegetation.

The close proximity of urban and natural systems in the Bronx sometimes creates additional conditions that compromise the health of the system, such as barriers to fish passage (dams), large quantities of floatable debris and a reluctance on the part of land managers to allow large woody debris to fall naturally into recreation corridors. Specific discussions of all biological, hydrologic and water quality parameters may be found in CHAPTER 3.

GOALS AND ECOLOGICAL OBJECTIVES

The Bronx River Alliance's overall ecological goals for the Bronx River are to:

1. Protect and improve water quality.

2. Protect and improve aquatic and riparian plant and animal biological diversity and habitat.

3. Reduce environmental stresses on the river ecosystem.

In the Bronx River corridor, landform features, stream morphology and vegetation patterns have been so heavily altered that most of the characteristics of a healthy river can never be completely restored. Instead, a more realistic objective is to increase the number and length of river reaches which meet the conditions of an ecologically functional river in order to create a system that is sustainable and resilient and that possesses desired ecosystem conditions. In the context of the Bronx River, ecosystem conditions have been modified based on economic, social and political constraints. Therefore, target ecosystem conditions are not necessarily based on historical, pre-development conditions, but on a new urban-natural equilibrium.

Objectives for the Bronx River watershed—that is, the landscape surrounding and draining into the river—include identifying, establishing and maintaining ecologically beneficial characteristics within the urban landscape. It is difficult to change existing conditions at the watershed level, because many of the preferred changes require large-scale capital improvements, policy and land use changes, and widespread changes in human behavior. For this reason, an overarching watershed plan requires coordination with watershed residents as well as local, state and federal agencies that have the resources and jurisdiction to undertake large-scale capital projects and make policy and infrastructure decisions that can significantly improve the health of the Bronx River. Goals and ecological objectives are discussed in detail in CHAPTER 4.

OPPORTUNITIES AND RECOMMENDATIONS

Through field work, research and experience, Bronx River experts have identified various ways in which they and others can help meet the Bronx River's ecological goals. These include storm water capture and infiltration, aquatic habitat improvement, sediment control, native vegetation reintroduction and establishment, and channel/floodplain improvements.

Targeting these opportunity areas will involve the following types of recommended actions:

- **Projects:** large- and small-scale restoration activities that restore the river corridor and surrounding landscape to improve the health of the watershed
- **Management and maintenance:** structuring daily activities to ensure proper care of resources within the watershed
- **Regulatory enforcement:** acting as river stewards by reporting pollution and environmentally hazardous activities to the proper authorities
- **Planning and design review:** reviewing planning processes and project designs of the relevant agencies to ensure partner coordination, community input and use of ecological design principles
- **Policy/Agency coordination:** working with local city, state and federal agencies to improve policies affecting the health of the river and watershed
- **Monitoring and research:** engaging in and encouraging continued monitoring and research of ecological parameters in the Bronx River and the surrounding watershed
- **Outreach:** encouraging and facilitating community education and involvement in all matters affecting the health of the watershed

Recommended actions have been prioritized based on availability of funds, land ownership, community support and relative ecological benefit. A full list of specific opportunities and recommended actions, as well as how Alliance partners should continue to coordinate with and support ongoing efforts, can be found in CHAPTER 5.

With adequate maintenance and support, the coordinated implementation of this plan will improve water quality and biodiversity as well as reduce environmental stresses on the river and surrounding ecosystem. By basing specific actions and projects on a combination of scientific study and input from partners and community members, this plan will serve as a guide to the restoration and sustainable protection of the Bronx River watershed.

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INTRODUCTION

The Bronx River Ecological Restoration and Management Plan is a result of collaboration by the stakeholders represented on the Bronx River Alliance Ecology Team. It will serve to develop a framework that will ensure a consistent and comprehensive approach to restoring wildlife habitat and water quality in the lower Bronx River. Increasing focus on restoring wetlands and wildlife habitat, as well as on improving storm water capture, requires technical and scientific guidance to ensure informed and coordinated implementation. This plan details a consensus-based, comprehensive approach to improve the environmental health of the river by setting overall restoration goals, creating a context for evaluating future restoration projects and strategies, and addressing pollutants that undermine habitat restoration.

The plan stems from a long history of activism and community-led restoration and seeks to organize and focus future work that will improve this urban river, which is in such need of rehabilitation. The lower Bronx River consistently appears on the New York State Department of Environmental Conservation (NYS DEC) List of Impaired Waterbodies—the 303d list (available at http://www.dec.state.ny.us/website/dow/part1.pdf). It suffers from high bacteria loads and low dissolved oxygen (DO) levels. Humans have so altered the watershed that historically fed this river that the natural connections between land and water have almost been erased. However, problems alone did not motivate this effort. It is the immense potential of the Bronx River as a recreational, educational and ecological resource that inspired the communities around it to call for its improvement. Their restoration activities have already made a difference.

THE STATE OF THE BRONX RIVER

During the nineteenth and twentieth centuries, human activity significantly altered the Bronx River and its watershed, degrading its health and biological diversity. Previously a sinuous, forest-lined waterway that supported a great estuary of complex salt marshes, today much of the river has been straightened, its forests paved and its salt marshes filled with concrete. Though some fragments of open space and forest still exist within the river corridor, most of the lower Bronx River watershed has been urbanized. The result is a river that rises and falls quickly because storm waters flow to it not through the soil and tributaries, but through pipes that deliver polluted water directly from surrounding roads and roofs.

Over the past century, planners and engineers used rock and concrete to force the riverbanks into a straight line that matched the lines of nearby highways and railroads. As a result, humans exchanged the environment's intricate complexities and diverse habitats for faster, more efficient movement of people and goods. Some of the goods that people carried were plants from distant places. Prized either for beauty or utility, some of these plants broke loose of human control and spread in the natural environment, forcing out the native grasses, trees and shrubs that once thrived along the river and provided shelter to the river's resident wildlife.

An understanding of current conditions on the Bronx River is an important step toward preserving and improving the river's health. The first section of this plan therefore provides a more detailed discussion of what is currently known about the ecological health of the Bronx River.

CONTEXT

Work done today on the Bronx River is the result of both community activism and agency initiative. Much of the planned ecological restoration for the Bronx River will be carried out as part of other ongoing studies and projects. Recommendations in this plan reflect these efforts and must be viewed in the context of other planning efforts and projects in the watershed. The following are especially relevant:

Bronx River Alliance Greenway Plan

The Bronx River Greenway is an eight-mile bike/pedestrian path and linear park in the heart of the Bronx that will provide greater access to the river itself, and bring green space to communities that have long lacked such resources. Working in partnership with the NYC Parks, the Bronx River Alliance has developed a plan that conveys a collective vision of the greenway and a framework to guide its realization. The plan describes elements of the greenway which are already moving forward and identifies issues that remain to be resolved to create a complete and continuous route. The Greenway Plan sets out guidelines for ecological performance intended to ensure that the greenway enhances and protects the ecological functioning of the river (Bronx River Alliance and Pratt Center for Community Development, 2006). These principles and practices are also reflected in this Ecological Restoration and Management Plan.

Bronx River Conservation Crew

The Bronx River Alliance Conservation Crew maintains a full-time presence on the river, monitoring river conditions and carrying out ecological restoration projects, in collaboration with Alliance partners, that improve water quality, stabilize the riverbanks and improve habitat in and along the river. Recruited from the local community and trained through a partnership with Sustainable South Bronx, crew members serve as the eyes and ears for the river on a full-time basis. The crew assesses the river corridor and greenway weekly for problematic conditions, and maintains river navigability for small boats and access to the riverbanks by foot. The crew is a primary agent for carrying out small-scale restoration work.

New York City Department of Parks

The New York City Department of Parks (NYC Parks) manages approximately 981 acres of parkland within the Bronx River watershed. Within the river's parkland buffer, NYC Parks is assisted by the Bronx River Alliance. The NYC Parks Natural Resources Group (NRG) works to develop management strategies aimed at preserving and protecting New York City's natural areas. NRG works closely with the Alliance to plan and execute restoration activities within the river corridor. NRG substantially contributed to this plan.

New York City Department of Environmental Protection Bronx River Long Term Control Plan

The Bronx River is one of two pilot project areas in the New York City Department of Environmental Protection (NYC DEP) Urban Watershed Project. Technical analyses for the Bronx River have been completed, and a draft Waterbody/Watershed Facility Plan has been developed. Overall, the NYCDEP aims to complete facility plan development and comprehensive watershed planning by 2007.

New York City Soil and Water Conservation District Soil Survey

The NYC Soil and Water Conservation District (SWCD) Soil Survey is a pioneering study of urban soils, including a citywide reconnaissance soil map, a series of intensive soil surveys and special research projects. The survey is a cooperative effort of the U.S. Department of Agriculture – Natural Resources Conservation Service, Cornell University and SWCD. An intensive survey is planned for the Bronx River watershed. This survey will characterize soils to a level of detail that will enhance the quality of future restoration efforts, especially those that aim at improving infiltration of storm water and reducing contaminants.

New York State Office of the Attorney General

Through its Environmental Protection Bureau, the Office of the Attorney General (OAG) enforces laws that prevent environmental damage, sometimes through prosecutorial action. The OAG has investigated three cases of pollution to the Bronx River that resulted in settlements with the Wildlife Conservation Society/Bronx Zoo (WCS), New York Botanical Garden (NYBG), and City of Yonkers. In 2001, WCS agreed to implement a pollution abatement program and environmental benefit projects in response to claims that WCS was illegally discharging animal wastes and other pollutants into the Bronx River. A 2002 OAG settlement with the NYBG stopped the flow of pollutants, including pesticides, from NYBG's greenhouses into the river. Another OAG investigation found that pipes in the City of Yonkers had been illegally discharging thousands of gallons of untreated sewage each day into the Bronx River since 1999. In response to this case, a State Supreme Court judge ordered the City of Yonkers to stop the discharge of raw sewage by repairing improper pipe connections. Discharges like those cited above cause severe detriment to Bronx River water quality. These OAG actions against polluters help to clean and restore the Bronx River through enforcement, which provides a necessary complement to the physical restoration and environmental policy changes presented in this plan.

U.S. Army Corps of Engineers Bronx River Basin Ecosystem Restoration Study

The U.S. Army Corps of Engineers (ACOE), New York District, in partnership with Westchester County and NYC DEP, is engaged in a study to devise a plan that will provide ecosystem restoration measures for the Bronx River basin. The study will evaluate several measures to provide ecosystem restoration including stream bank stabilization, stream channel realignment and/or redirection, storm water management, sediment and nutrient detention, restoration and/or creation of riparian wetlands, and fish passage creation. While conducting the study, the ACOE plans to fast-track one restoration site in the Bronx (Shoelace Park). All projects recommended for that location should be coordinated with ACOE so that efforts are not duplicated.

Through their work, agencies like NYC Parks, NRG, NYC DEP, NYC SWCD, and ACOE will continue to play major roles in protecting and restoring the Bronx River's wildlife habitat, water quality and soil quality. Alliance partners monitor these efforts, participate in stakeholder groups and ensure that the agencies are coordinating with each other and with the many projects taking place along the Bronx River Greenway.

THE PLAN

Through a coordinated effort with many of its partners, the Bronx River Alliance produced this Ecological Restoration and Management Plan in order to guide the environmental restoration and protection of the Bronx River corridor and watershed. The information and recommendations presented here are intended to serve as a resource for Alliance partners by compiling ecological data and restoration ideas into one comprehensive workplan. The recommended actions are the result of coordinated assessment of current conditions, ecological objectives, and opportunities to meet the goals of this plan.

In order to provide a working guide for Alliance partners as well as a useful document for other practitioners, advocates and interested parties, this plan will:

- Describe the state of the Bronx River at the start of the twenty-first century with specific attention to ecological problems
- Establish sound, achievable ecological goals
- Identify opportunities for restoration of the river
- Suggest priorities for restoration projects, management and policy

TARGET AUDIENCE

More than 80 partner organizations make up the Bronx River Alliance (see APPENDIX L for Partner List). These partners engage in ecological restoration and management work both along the river banks and within the watershed, from organizing volunteer garbage clean-ups to designing and executing major salt marsh restorations to advocating for waterfront access to coordinating large-scale watershed studies. At its most basic level, this plan is for these partner organizations; the Alliance can look to this plan as a guide for ecological work over the next five to ten years. The opportunities and recommended actions laid out here will supply the Alliance and its partners with direction and a foundation for new ideas on how to improve the health of the Bronx River watershed.

At another level, partners can share this plan with others to illustrate the innovative and collective effort behind restoration of the Bronx River. The Alliance depends on the continued support of public officials, policy makers and local, state and federal agencies to continue toward the goal to protect, improve, and restore the Bronx River corridor and greenway so that they can be healthy ecological, recreational, educational and economic resources for the communities through which the river flows.

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THE BRONX RIVER IN THE BRONX

(Geography, Infrastructure, Community and Historical Conditions)

INTRODUCTION TO THE BRONX RIVER

This brief introduction to the geography of the Bronx River in both Westchester and Bronx Counties precedes a more specific examination of the four sections of the Bronx River within Bronx County. The division of the Bronx County portion of the river into four sections is based on broad land-use and physical characteristics and is used throughout this plan. The second part of this section reviews land use history within the Bronx River watershed and the historic conditions within each section of the Bronx River.

Overview

The Bronx River begins in Valhalla, N.Y. near the Kensico Reservoir and flows south, draining a narrow, relatively low-lying, 56 square-mile watershed and emptying into the East River between Soundview and Hunts Point in the South Bronx {FIGURE II.1}. The Bronx River serves as a tributary to the Long Island Sound and Hudson River Estuary systems via the East River. The upper 15 miles of the river flow through Westchester County, where the watershed is characterized primarily by suburban development. Along the river's last eight miles through the Bronx, however, the landscape transitions to increasingly dense urban development, both residential and industrial {FIGURE II.2}, and is dominated by impervious surfaces such as roads, rooftops and parking lots. The Bronx River valley functions as a transportation corridor, with the Bronx River Parkway and the Metro-North Harlem railroad line bordering and crossing the river for most of its length. The last two miles of the river serve as a federally designated navigable waterway for use by commercial barges.

Throughout its length, the river also serves as a recreation corridor lined with parks, gardens, canoe launches and a planned greenway (Bronx River Alliance & Pratt Center for Community Development, 2006). Recreation in the river includes canoeing and kayaking and, despite public health advisories, swimming and fishing. The parklands north of the Bronx draw a considerable number of bicyclists; plans to extend this greenway and make it continuous through the Bronx are expected to greatly increase the number of bicyclists using the corridor.

The physical characteristics of the Bronx River watershed and the human actions within it affect the water quality and hydrology of the river, as well as the flora, fauna and human activities the river is capable of supporting. Despite being highly affected by pollution and urban development, the Bronx River supports aquatic insects, fish, small mammals, and diverse vegetation. It is also an important tributary feeding regional water bodies downstream including the East River and Long Island Sound.

FIGURE II.1:

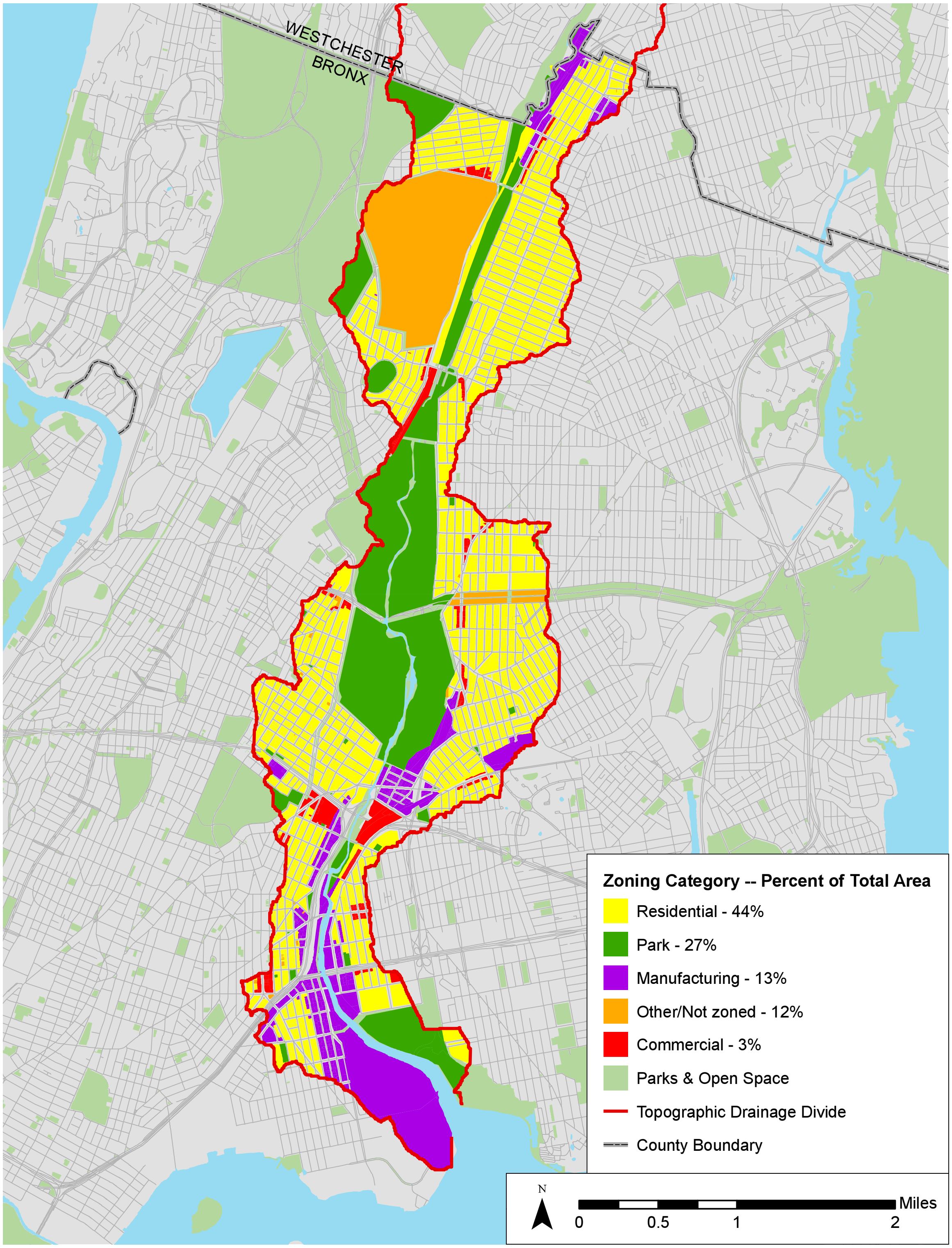
THE BRONX RIVER WATERSHED

The topographic drainage divide (red line) encompasses the 56 square mile Bronx River watershed, or region of land where water from rain or snowmelt drains downhill into the river. The drainage basin includes both the streams and rivers that convey the water as well as the land surfaces from which water drains into those channels.

TOPOGRAPHIC DRAINAGE DIVIDE PROVIDED BY THE ACOE.

FIGURE II.2:

ZONING IN THE BRONX RIVER WATERSHED



This zoning map gives a characterization of the watershed in the Bronx. From north to south it transitions to increasingly dense urban development, both residential and industrial and is dominated by impervious surfaces such as roads, rooftops and parking lots.

The Bronx County Portion of the Bronx River

In order to provide detailed descriptions of the conditions and opportunities for restoration work, the Bronx portion of the river has been divided into four sections based on broad land-use and physical characteristics {FIGURE II.3}. From north to south these are: the Parkland Section (3.5 miles), the New York Botanical Garden/Zoo Section (1.8 river miles), the West Farms Section (0.4 miles) and the Estuary Section (2.5 miles).

Parkland Section The Parkland Section extends from the Westchester/Bronx border (roughly Nereid Ave./241st St.) to the northern limit of the NYBG at Kazimiroff Ave. {FIGURE II.4}. The northernmost park in this section is Muskrat Cove, which provides public access to pedestrians and bicyclists and is located just north of the Metro North Woodlawn train station. Shoelace Park begins one-quarter mile south of Muskrat Cove, and lines the eastern edge of the river for one mile, while the Bronx River Parkway borders it to the west. Public access continues through the Bronx River Forest, which contains the last remaining floodplain forest in the Bronx and was restored between 2004 and 2005. In total, nine bridges cross the river in the Parkland Section.

Botanical Garden/Zoo Section For almost two river miles, the Bronx River flows through the New York Botanical Garden and the Bronx Zoo which contain both significantly modified and relatively undisturbed reaches {FIGURE II.5}. The three dams on the river in the Bronx are located in this section. These dams, from north to south, are the Snuff Mill Dam in the NYBG, the double dam in the Bronx Zoo at the equivalent of 190th St., and the 182nd St. dam at the southern border of the Bronx Zoo. Changes to the river channel are apparent today both upstream and downstream of these dams. In contrast to the considerable changes visible in the other sections, the soil and vegetation in the Botanical Garden/ Zoo Section are relatively undisturbed. Unlike much of the surrounding watershed, which is covered by impervious surfaces, rain and storm water infiltrates into the ground more naturally in this portion of the watershed, reducing storm water runoff and increasing base flow to the river. In addition to manicured garden areas, the Botanical Garden also contains a 40-acre tract of natural woodland that borders the river and provides a buffer more than 1,200 feet wide in places. In the Zoo, the bison pasture and five acres of forest, known as the Wild Asia exhibit, border the river.

West Farms Section The West Farms Section extends from the 182nd St. dam downstream to the Cross Bronx Expressway (approximately 176th St.) and includes River Park located downstream of the 182nd St. Dam. A pathway runs along the west bank of the river from 180th St. to Tremont Ave. and passes through the small Bronx River Park nestled behind residential housing and commercial development at 179th Street. Industrial buildings line much of the east bank of the river.

This river section is predominantly freshwater, with some tidal influence reaching north as far as Tremont Avenue. South of Tremont Avenue and situated adjacent to Lorraine Hansberry Academy (PS 214), is Drew Gardens, a community garden managed by Phipps CDC Beacon School program. At the southern end of the West Farms Section, on the east bank opposite Drew Gardens, is the northernmost combined sewer overflow (CSO HP-007) in the Bronx. Another CSO (HP-004) discharges 100 feet downstream. During storm events, these CSOs discharge untreated sewage, storm water, and other pollutants to the river, which results in poor water quality conditions in this section of the river.

FIGURE II.3:

BRONX RIVER WATERSHED: BRONX COUNTY PORTION

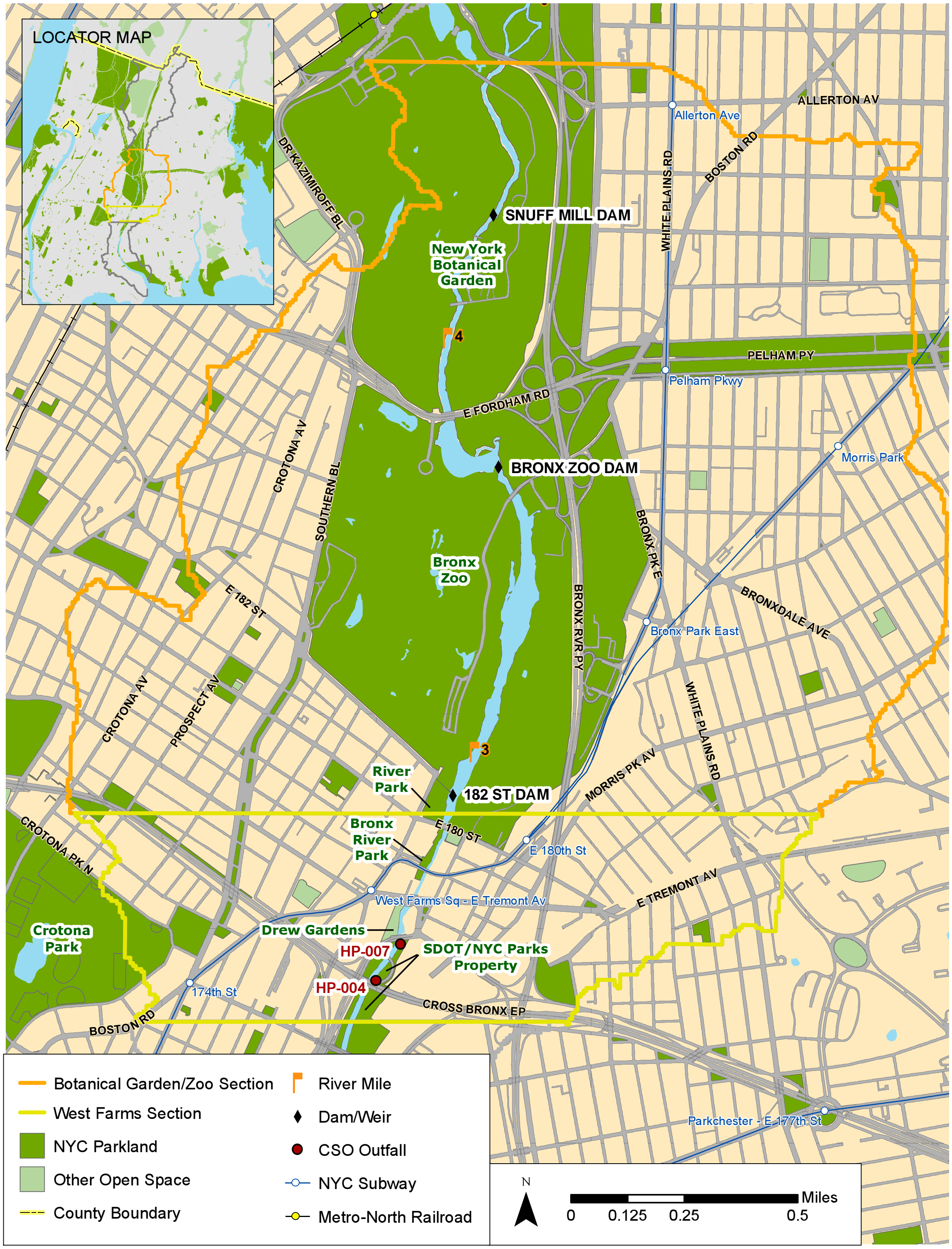
The area bounded by the red line is the Bronx River Watershed, or all of the land that drains to the river. The river's watershed in the Bronx is the area addressed by this plan.

FIGURE II.4:

BRONX RIVER: PARKLAND SECTION

FIGURE II.5:

BRONX RIVER: BOTANICAL GARDEN/ZOO AND WEST FARMS SECTIONS



Estuary Section

The Estuary Section extends from the Cross-Bronx Expressway (Interstate 95) interchange south of Drew Gardens to the mouth of the river {FIGURE II.6}. During the 1800s water-powered industry occupied the banks in this area. At the upstream end of this section, the eight-acre Starlight Park borders the river on the west. This park is currently undergoing an environmental investigation and remediation due to soil contamination from a manufactured gas plant located on the site in the early 1900s. Across from Starlight Park, the east bank remains undeveloped and heavily vegetated. It is also largely cut off from the nearest community by the Sheridan Expressway, but is slated for redevelopment into parkland by New York State Department of Transportation (NYS DOT), which will then convey it to NYC Parks as a part of the Bronx River Greenway.

At the southern end of Starlight Park, near 173rd St., a weir marks the upstream end of the dredged, navigational channel of the river. Below Westchester Ave., an abandoned concrete plant occupies six acres on the west bank. This property was turned over to NYC Parks in 2000 and is currently the site of an extensive reclamation and shoreline restoration project. About one-half mile downstream from Concrete Plant Park, Hunts Point Riverside Park (situated at the east end of Lafayette Ave.) offers the southernmost public access to the river on the west bank. This narrow park is located between a scrap metal facility and the Hunts Point Market food distribution center.

Soundview Park, a 130-acre park built on an inactive landfill, is the largest park in the Estuary Section, and occupies about one mile of the east bank at the mouth of the river. The 15- to 30-foot banks created by large boulder riprap and other debris limit access to the river along much of the Soundview Park shoreline. Narrow strips of littoral shelf still remain at the toe of the banks in some places, and are the focus of a NYC Parks NRG shellfish restoration project. Two CSOs (HP-008 and HP-009) discharge sewage and polluted storm water into the river within the estuary section.

For more information on planned and existing parks along the Bronx River, see the Bronx River Greenway Plan at http://www.bronxriver.org/plans.

FIGURE II.6:

BRONX RIVER: ESTUARY SECTION

HISTORY AND DEVELOPMENT

History of the Bronx River

Before humans made significant changes to the landscape, small tributaries in the upper reaches of what is now the Kensico Reservoir comprised the Bronx River's headwaters. For most of its course, the river meandered through floodplain forests, with wetlands, beaver dams, and oxbows in a low-gradient valley. In some places, the river valley narrowed through occasional bedrock ravines such as the long ravine at what is now the NYBG. The river ended in an expanse of salt marsh at the confluence with the East River {FIGURE II.7}.

The Bronx River attracted European traders in the early 1600s for the beaver that proliferated there (McNamara, 1984). In 1639, a wealthy Swede named Jonas Bronck purchased 500 acres from the Mohegan Indians that lived along the river. Over time, mills began to sprout up along "Bronck's River." By the mid-1700s as many as 12 mills were obtaining water power from the river to manufacture products that included paper, flour, pottery, tapestries, barrels and snuff. The river valley remained thickly forested well into the 1800s. The water was considered clean enough that during the 1820s and 1830s the New York City Board of Aldermen debated tapping into it to supply the growing city with drinking water.

Construction of the New York Central Railroad in the 1840s completed the transition of the Bronx River valley into an industrial corridor. In 1885, most of the water in the headwaters of the river began to be diverted for New York City's water supply as part of the New Croton Aqueduct. A dam was built to collect water in the Bronx River Reservoir (now known as the Kenisco Reservoir) and supply it to the Bronx River Pipeline. Completion of the Kensico Dam in 1915 held the upper reaches of the river in the reservoir near New Castle and reduced the river's flow by one-quarter. During this time, people often used the river for waste disposal. By the end of the nineteenth century the Bronx River had degenerated into what one official commission called an "open sewer" (Bronx Valley Sewer Commission, 1896).

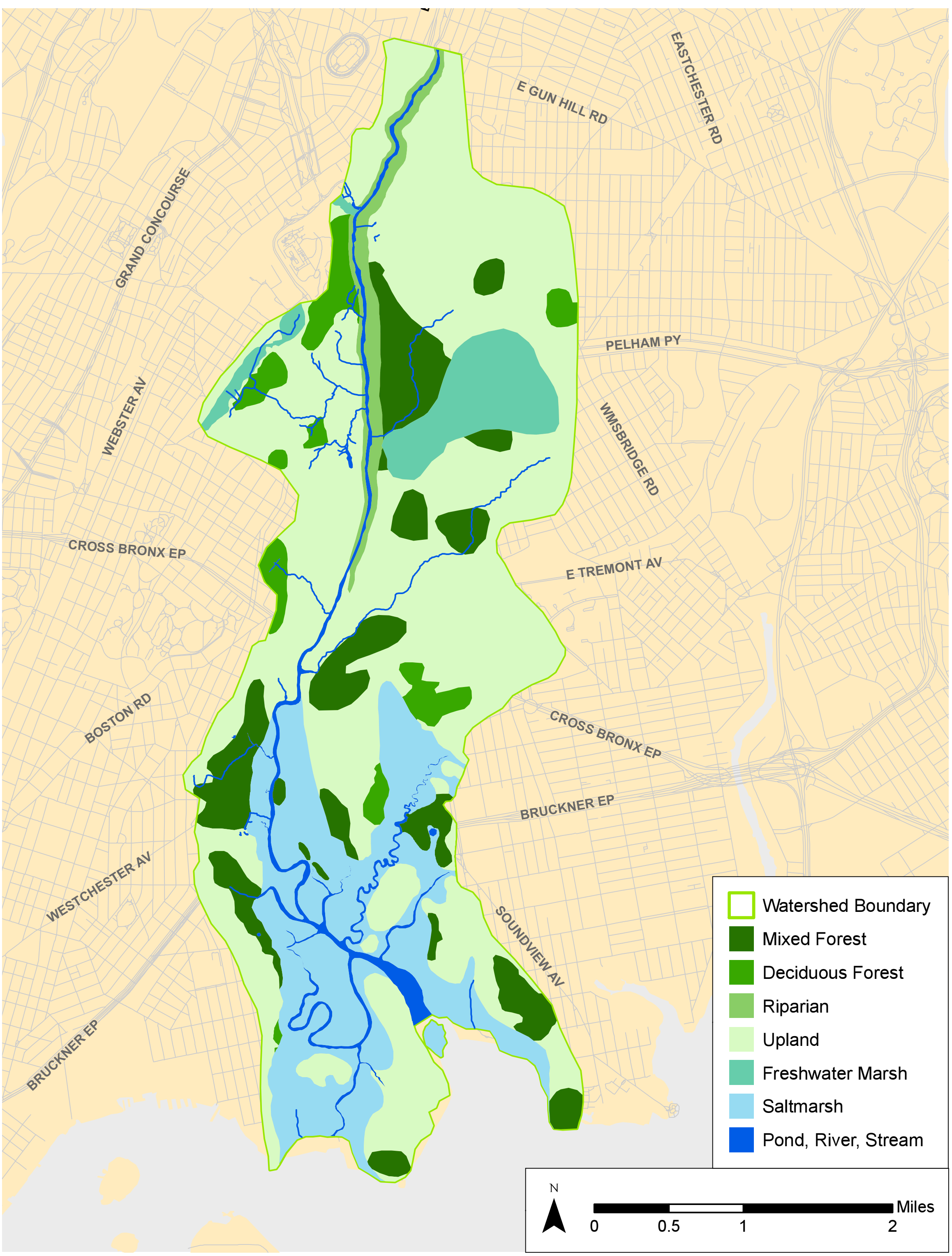
In response to the decrepit state of the river and the escalating forces of urbanization, the turn of the twentieth century also saw the beginning of attempts to reclaim and protect the river. Sewage was diverted from the river, and upland areas bordering the river were set aside for preservation. Ironically, construction of the Bronx River Parkway was seen as a conservation measure at the time. Though the parkway did help to preserve large tracts of parkland that still exist today (including Garth Woods, the NYBG and the Bronx Zoo), reclamation work during also included straightening the river, armoring the banks and filling the floodplain, acts that contribute to many of the river's current environmental problems.

In 1974, a small band of community activists formed Bronx River Restoration and began the arduous process of cleaning up and restoring the river. Their effort gained strength and numbers in 1997 when Partnerships for Parks convened the Bronx River Working Group and brought together more than 60 community organizations, public agencies and businesses committed to reclaiming the river and improving access to it throughout the Bronx.

Ecological restoration of the Bronx River took another tremendous step forward in 2001 when the Bronx River Working Group created the Bronx River Alliance as a permanent 501(c)(3) organization to continue this work into the foreseeable future. As a result, efforts intensified in both Westchester and the Bronx to restore habitat, limit invasive vegetation and study watershed solutions.

FIGURE II.7:

HISTORICAL BRONX RIVER (1781 – 1851)



Prior to widespread settlement and development, the Bronx River was much more sinuous and its watershed dominated by natural systems like forests, wetlands, and salt marshes.

HISTORICAL DATA PROVIDED BY SANDERSON AND LABRUNA, 2006

History of the Bronx County Portion of the River

Parkland Section From the Westchester border downstream to the edge of the NYBG, the river historically meandered through a hilly, marshy valley (Greenburgh, 1983). Since construction of the railroad in the 1800s, the Bronx River Parkway in the 1930s and work to straighten the river in the 1950s much of the floodplain has been filled or cut off from the river. However, remnants of the floodplain in the Bronx River Forest still remain intact and are periodically flooded. A project carried out between 2004 and 2005 restored much of the floodplain and improved its ecological function.

Botanical Garden/Zoo Section The narrow, relatively steep river valley that existed between the northern limits of the NYBG and the 182nd St. dam was an ideal source of water power for industry in the seventeenth and eighteenth centuries. Beginning in the 1600's, the river was impounded at what is now 182nd St., and throughout history there were as many as six additional dams operating in this section of the river (Bronx Valley Sewer Commission, 1896). Remnants of these barriers include the Snuff Mill Dam (historically Lorillard Dam) in the NYBG, the double dam in the Bronx Zoo (historically the Bolton Dam), and the 182nd Street dam (historically Richardson, DeLancy Falls or Lydig Dam).

Although these dams transformed free-flowing reaches of the river into pond-like impoundments, other aspects of this section of the river have remained in a more natural state. Except for the spread of some invasive species, the vegetation cover bordering the river has remained relatively unchanged because of the City's acquisition of the land in 1888. This land is now occupied and preserved by the NYBG and the Bronx Zoo/Wildlife Conservation Society.

West Farms Section During the late nineteenth century, when large parts of the former Westchester County were annexed to New York City, the Bronx River served as a significant geographical divider. In 1874, three communities to the west of the Bronx River, Morrissania, Kingsbridge and West Farms (previously part of Westchester County) were annexed to New York City.

In the 1970s, Bronx River Restoration focused much of its early clean-up and restoration in the West Farms Section of the river. Physical evidence of their West Farms work still exists in the terraces of tires (once considered a state-of-the-art technique) they used to stabilize the banks near 179th St.

Estuary Section Before the Bronx River was dredged to accommodate boat traffic, the tidally influenced channel in the estuary was narrow, deep and serpentine. It was bordered by extensive salt marshes and fed by several tributaries (Sanderson and LaBruna, 2005). More than 100 acres of salt marsh and several miles of tidal tributaries to the river were filled between the end of the nineteenth and the middle of the twentieth century.

3

STATE OF THE RIVER:
Existing Conditions and Problems

INTRODUCTION

Existing physical, geochemical and ecological conditions of the Bronx River are summarized below and data gaps are identified. The State of the River, as well as the overall Bronx River Ecological Restoration and Management Plan, is clearly focused on the Bronx portion of the watershed and river. However, it is important to note that conditions of the Bronx River in the Bronx are also significantly influenced by conditions in Westchester County, which contains two-thirds of the watershed.

Existing Conditions and Problems

The current state of the Bronx River is described here based on available data and reports as well as the experience of restoration practitioners. Understanding these conditions and problems will provide a basis for decision-making on how best to restore the Bronx River corridor and watershed. In some instances where a dearth of data stands in the way of proper assessment, further study would greatly enhance the characterization of certain environmental parameters. Despite this lack of information, the following points summarize the state of the Bronx River.

- **Disturbed hydrology** exacerbates erosion, sedimentation and habitat disturbance. This is caused by heavy development in the watershed and leads to physical changes in the stream through scouring and deposition. Sediment loadings have not been modeled, but appear to be excessive and prohibitive of benthic community health.
- **Poor water quality** caused by input of sewage and animal wastes into the river has lead to impaired water quality that violates health standards and makes the water unsuitable for public recreation. Sewage inputs also contribute to low dissolved oxygen (DO) levels that limit the growth and survival of aquatic organisms.
- **Invasive vegetation** limits the diversity of the vegetative community and contributes to bank instability. These invasives also exclude trees from the river bank, thus limiting the supply of large woody debris (LWD) necessary to create certain habitats.
- **Degraded habitat** is a cumulative effect of riparian management, channel alterations, hydrology and water quality. Diverse flora and fauna is prevented from establishing without proper high-quality habitat.
- **Dams** limit connectivity between river sections and impede passage of diadromous fish (species that use both marine and freshwater habitats during their life cycle). These barriers also disturb natural sediment flow.

Objectives and Constraints

In the Bronx River corridor, landform features, stream morphology and vegetation patterns have been so heavily altered that most of the characteristics of a healthy river can never be completely restored. Instead, a more realistic objective is to increase the number and length of river reaches which meet the conditions of an ecologically functional river in order to create a system that is sustainable and resilient and that possesses desired ecosystem conditions.

Ecological objectives for the Bronx River and the landscape surrounding and draining into the river include identifying, establishing and maintaining beneficial characteristics in the urban landscape. This Plan will provide objectives and recommendations to help:

- **Improve hydrology** to reduce erosion, sedimentation and habitat disturbance and increase base flow through storm water infiltration;
- **Improve water quality** by reducing direct and indirect sewage inputs and illegal discharges and by increasing natural treatment of storm water through infiltration, thus reducing direct releases from combined sewer outflows (CSOs);
- **Increase plant diversity** through targeted removal of invasive vegetation increasing the area of native vegetation and restoring healthy soil conditions;
- **Restore habitat** through ecologically sound riparian management techniques, improved hydrology and water quality, and restorative channel alteration;
- **Increase connectivity between reaches**, facilitate passage of diadromous fish and restore natural sediment flows.

Several factors limit the attainability of some of these ecological objectives. Most geographic, human population and infrastructure characteristics of the watershed are fixed and unavoidable. These limit the extent to which restoration work can bring about higher levels of change within the watershed. For example, the estuary's water quality is dependant on the water quality of the East River with which it mixes. Some other challenges to consider when evaluating and planning ecological restoration and protection within the Bronx River include the following.

- Activities upstream in Westchester County affect the hydrology, channel morphology, invasive species transport and water quality in Bronx County.
- High-density urban development and a highly engineered sewer system have profoundly altered the water cycle in the Bronx, preventing groundwater infiltration and redirecting the natural conveyance of storm water to the river.
- Limited open space in the Bronx reduces area available for restoration work, which forces efforts to be concentrated along the river corridor.
- A lack of data describing natural processes in the watershed highlights the need for more widespread monitoring that will improve ecological and wildlife assessments.

In the next two sections, these existing conditions and constraints are discussed in more detail. The first section, Physical and Geochemical Conditions, discusses water quality, hydrology, channel morphology and in-stream habitat. The second section, Biological Conditions, covers vegetation and wildlife.

PHYSICAL AND GEOCHEMICAL CONDITIONS

Water Quality Water quality problems in the Bronx River are largely caused by infringements in the riparian corridor, loss of wetlands, reduced base flow, sedimentation, channel aggradation, floatable garbage, diffuse waterfowl and pet waste, stream bank erosion, and runoff from impervious surfaces and other point and non-point sources of pollution, including CSO (ACOE, 1999). Throughout the river's 21.5 mile-long freshwater section (including Westchester), storm water from parking lots, sidewalks, roads and roofs flow directly into the Bronx River through more than 100 discharge pipes (Main, 2003). Because this water enters the river through pipes instead of the ground, it is warmer and carries contaminants and sediments picked up from the impervious surfaces over which it originally flowed. These pipes also often carry additional wastes from illegal connections to residential sanitary systems, gas stations, Laundromats or other small industries.

In the Unified Watershed Assessment for 1999 and 2000, the New York State Department of Environmental Conservation (NYS DEC) rated the Bronx River Basin as a category 1 watershed—the lowest of three ratings (NYS DEC, 2005). Category 1 watersheds do not meet, or face imminent threat of not meeting, clean water and other natural resources goals and are in need of restoration. All sections of the Bronx River are listed on NYS DEC's Final 2004 Section 303(d) List of priority water-bodies (NYS DEC, 2004A). These are priority waters in New York State identified for total maximum daily load (TMDL) development and do not support appropriate uses (NYS DEC, 2004B). In this listing, the problem parameters cited for the Bronx River are DO and fecal coliform.

Healthy aquatic flora and fauna require a minimum level of DO in the water. When oxygen is scarce, the river's capacity to sustain life is limited. High levels of fecal coliform, a bacterium that can cause human health problems, triggers state and federal regulations that preclude certain uses for the water that include drinking, swimming or even bodily contact.

Water quality in the Estuary Section of the river is influenced by upstream and tidal waters from the Hudson River estuary, New York Harbor and Long Island Sound. Low DO levels are of special concern in the Bronx River, where four CSOs are located. In the Bronx, most storm water and sanitary sewers feed into the same system {FIGURE III.1}. This means that storm water, which is normally directed to water treatment plants, can during heavy rains overload the carrying capacity of the system. When this happens, the combined storm water and sewage flow is directed to the river through CSOs, discharging raw human waste and many other untreated pollutants.

In the Estuary Section, DO levels are especially constrained by the conditions in the East River, which is an extension of the Long Island Sound. Because the oxygen carrying capacity or saturation point of salt water is lower than that of fresh, DO levels in the Bronx River estuary are limited by the degree to which water from the East River is able to flow into the estuary. Salt water is denser than fresh water and the two do not completely mix upon contact. As a result, the salt water incursion forms a wedge beneath the surface, and the reach of this "salt wedge" into the estuary depends on the tide as well as base flow from the two mixing water bodies.

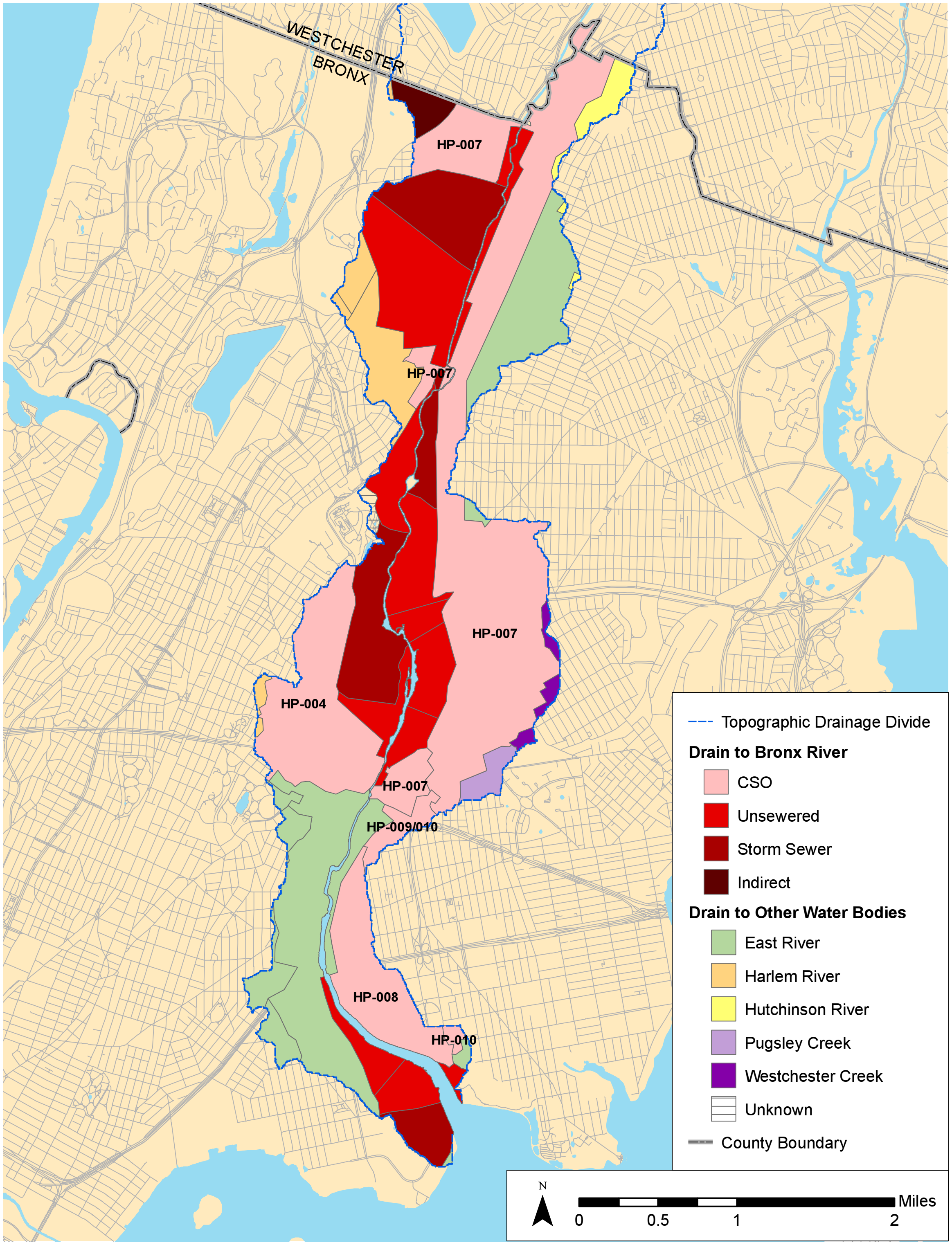
Water quality data sources and more detailed information can be found in **APPENDIX A**.

Hydrology The hydrology, or flow characteristics, of a river system is determined by the river basin geology and landscape features, and influences the river's physical channel conditions, its water quality and the aquatic habitat it supports. In an undeveloped landscape, precipitation is intercepted by vegetation and absorbed into the soil, where it either infiltrates to the groundwater or travels slowly through the subsurface to stream channels. In a developed landscape such as the Bronx River watershed, impervious surfaces carry storm water quickly to surrounding streams and rivers through surface runoff or sewers and drains. Thus, the runoff volume generated from a given storm event is larger and reaches a river more quickly in an urban watershed than in an undeveloped watershed. These development changes are visible in flow data and affect the frequency and magnitude of channel erosion and sedimentation.

On the Bronx River, data collected from a flow gauge located about 10.5 miles upstream of the mouth show changes in flow conditions due to urbanization of the watershed over the last century. The highest, or peak, annual flows increased in magnitude from 1944 to 1968, reflecting the increase in impervious area associated with development. Annual peak flows stabilize around 1969, suggesting that the watershed had essentially become fully developed.

FIGURE III.1:

SEWER SHEDS WITHIN THE BRONX RIVER TOPOGRAPHIC DRAINAGE DIVIDE



In 3200 acres of the 4500 acre Bronx River watershed in the Bronx, storm water is captured and piped to water treatment plants located outside of the watershed. This map shows how the watershed is divided into smaller "sewersheds".

DRAINAGE AREA BOUNDARIES COURTESY OF NYC DEP, BUREAU OF ENVIRONMENTAL ENGINEERING; TOPOGRAPHIC DRAINAGE DIVIDE BOUNDARY COURTESY OF ACOE.

These data also show that commonly occurring flood events are larger today than they were at the beginning of the last century (Inter-fluve, 2002). For example, what was a five-year flood event of approximately 1,900 cubic feet per second (cfs) now occurs every two years. These increasingly frequent high-flow events lead to greater erosion of the banks and more frequent disturbance of the bed and in-stream habitat. Frequent channel disturbance can also lead to sediment scouring along the bed in steeper reaches. Further downstream, the eroded sediment is then deposited on the channel bed filling interstitial pore spaces that provide habitat in the substrate and provide oxygen to benthic fauna.

Although the Bronx River exhibits the flashy hydrologic characteristics typical of an urban stream, the degree to which dry weather, or base, flow conditions have been altered by development is not discernable from the gage records. Base flow typically declines in urban areas due to reduced groundwater recharge. In the Bronx River watershed, flow contributions were also reduced in the 1930s, with the diversion of 10 square miles in the headwaters for the construction of the Kensico Dam and Reservoir.

Finally, the development of the Bronx River watershed in the Bronx, has led to a complete disconnection between the watershed and the channel in some places. In 3200 acres of the 4500 acre Bronx River watershed in the Bronx, storm water is captured and piped to water treatment plants located outside of the watershed. Only during storms when the capacity of the system is exceeded is some of the storm water (combined with sewage) released to the river at CSOs in the tidal reaches (NYC DEP, 2004).

More detailed hydrology information can be found in APPENDIX B.

Channel morphology and in-stream habitat Characterizing and classifying river reaches according to geomorphologic features helps to identify areas that have similar physical and habitat conditions, and may respond to disturbance, protection or restoration in the same way. Straightened channels, armored banks, riprap and rubble, disturbed hydrology, and dams complicate the application of traditional channel classification systems in the Bronx River. Nevertheless, classifying the Bronx River reaches primarily by channel slope and substrate (Montgomery and Buffington, 1993) and secondarily by channel width and depth and flood-prone width (Rosgen, 1996) reveals three general freshwater types of channel, and a fourth estuary channel type {FIGURE III.2}.

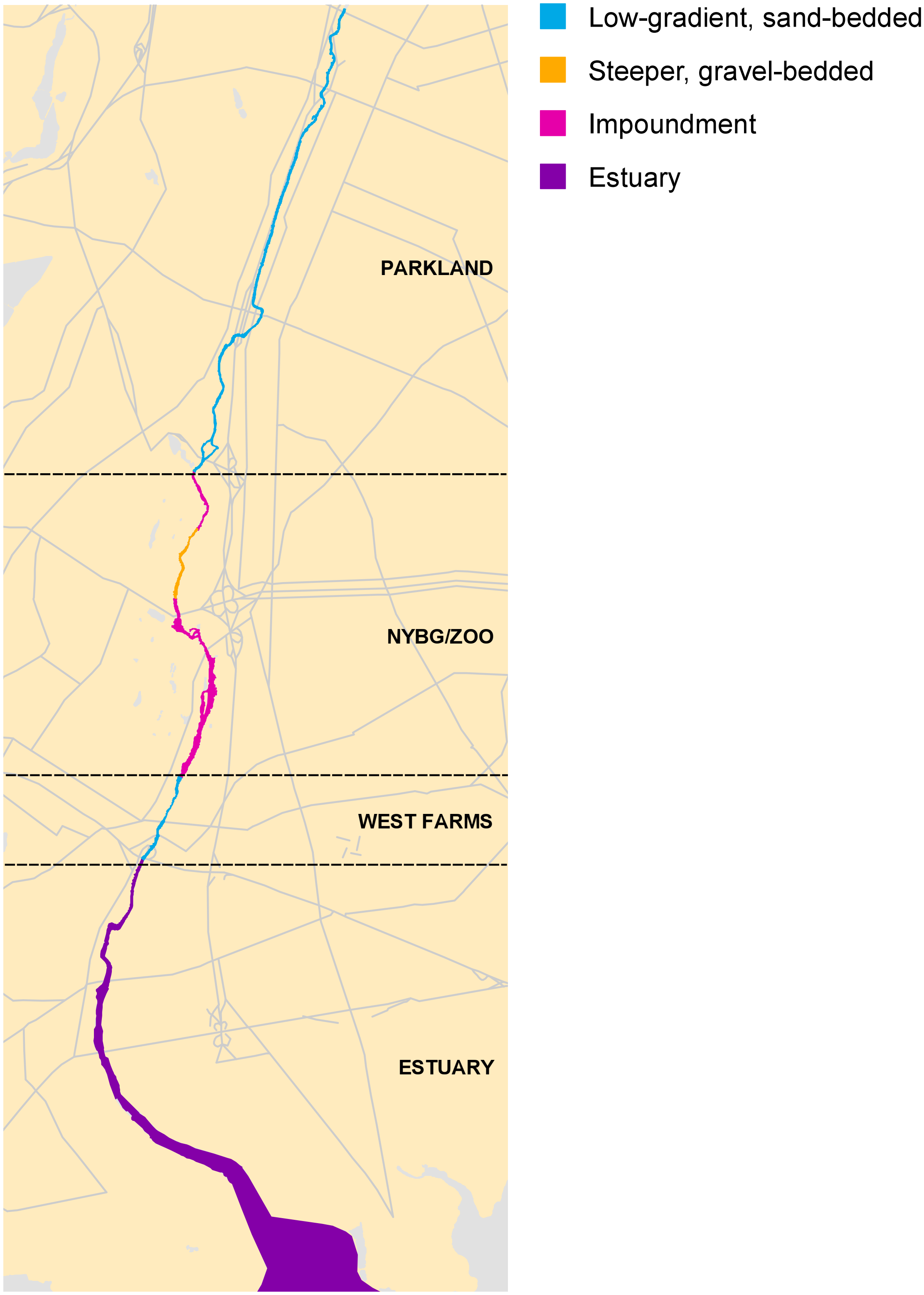
The longest free-flowing freshwater stretch of river in the Bronx is a low-gradient, sand-bedded channel (similar to "dune-ripple" or Rosgen B5 channel types) in the Parkland Section. These flat reaches have very low slopes, ranging from 0.08 to 0.1 percent, and are predominantly sand-bedded with occasionally by short sections of cobble (50 to 200 feet long), where riprap has been placed. This low-gradient, sand-bedded channel is typically 50 to 60 feet wide and is highly uniform, with few pools or in-channel bars. The natural form of these flat reaches is highly meandering with a wide floodplain, as in the Bronx River Forest, where the floodplain is up to 200 feet wide. However, most of the tight meanders have been straightened, and the remaining bends have been anchored by grouted riprap and concrete.

Habitat in the low-gradient, sand-bedded channel reaches is greatly influenced directly and indirectly by bank vegetation. For example, tree roots stabilize banks and create overhanging banks. Fallen limbs and trunks become large woody debris (LWD) that provide in-stream habitat and food for microorganisms and macro invertebrates. Scoured areas around LWD create pools that serve as refuge for fish and other aquatic organisms.

Many of the habitat features expected in a low-gradient, sand-bedded channel are uncommon in the Bronx. Due in part to the lack of LWD in the channel, past channel straightening and high sediment loads, there are only about one-quarter the number of pools as would be expected in a similar, undis-

FIGURE III.2:

BRONX RIVER MORPHOLOGY



This figure shows the locations of the different channel types described in the Channel Morphology and In-stream Habitat section. Characterizations of river reaches describe physical and habitat conditions as well as how the reach may respond to disturbance, protection or restoration.

turbed channel. Scarcity of pools, sparse in-stream and woody lower bank cover and frequent disturbance of the sandy channel bed create a high disturbance environment with little refuge. To combat this condition, reach-level management and projects that increase refuge and cover, and watershed-wide efforts to manage sediment loads and storm water runoff need to be pursued.

The pond-like areas of slow-moving water backed up behind dams constitute another reach type found in fresh- and tidal-water known as impoundments. In the Bronx, there are three impoundments, all located within the Botanical Garden/Zoo Section. The impoundments vary in width from 50 to 60 feet at the Snuff Mill Dam in the NYBG to 250 feet at the dam in the Bronx Zoo. Depth in the impoundments varies from one to six feet and substrate composition varies from unconsolidated, fine organic debris to sand. At impoundments, the decreased water velocity causes sediment carried in the water column to collect on the bed. Typically, coarser sediments settle first, at a lower minimum velocity, and finer sediments are carried further downstream.

Impoundments provide slower-moving, slightly deeper habitat than the free-flowing, low-gradient, sand-bedded reaches of the river. However, the shores of impoundments tend to be shallower, and slower-moving water there provides refuge from periods of high flow. Since the impoundments in the Bronx are relatively well vegetated, lightly developed landscapes, LWD and overhanging vegetation are abundant along the shores. Despite relatively shallow depths, little aquatic emergent vegetation is found in any of the impoundments in the Bronx River. In the largest downstream impoundment at 182nd St., however, abundant submerged aquatic vegetation is present, and its influence on sedimentation, organic matter deposition and water quality needs to be investigated. During low-flow periods, the impact of flow stagnation and warm temperatures on habitat quality is also a potential problem. Sediment deposition has reduced deep water habitat area and caused bars and islands to grow which are becoming dominated by exotic invasive plants such as purple loosestrife (*Lythrum salicaria*) and Japanese knotweed (*Polygonum cuspidatum*). Habitat diversity will continue to decrease unless sediment loads are managed.

The least common channel type is the steeper, gravel-bedded channel ("plane-bed" or Rosgen B3) found in the NYBG and West Farms. The slope is about 0.5 percent, the width is 50 to 60 feet, and the substrate consists predominantly of gravel, cobbles and boulders. These reaches are relatively straight, either because of a natural valley constriction (as in the NYBG ravine) or artificial straightening (as in West Farms). Steeper, gravel-bedded channels have high sediment transport capacity and a relatively narrow floodplains. These reaches are therefore less sensitive to changes in sediment load, local floodplain development or hydrologic disturbance than the other reach types. The stream bed is characterized by cobble- and boulder-sized rock, since the smaller gravel has been flushed downstream, and upstream dams trap gravel and prevent downstream replenishment. The pools in these steeper reaches, though infrequent, are relatively permanent, since the high-energy flow prevents sediment deposition.

Steeper, gravel-bedded channels also provide fast-flowing habitat where water can be cooled and aerated. These areas also often serve as a passageway between slow-flow environments. The large gravel and cobble found here provides hiding and clinging surfaces for aquatic organisms. In West Farms, this reach type has been heavily modified by straightening, confinement and dumping of concrete rubble. These alterations have increased slope and flow energy and have contributed to scouring of the channel bottom. As a result, some aquatic invertebrates may be unable to burrow into the channel bed to find refuge or lay eggs.

Due to the high-flow-energy environment of the steeper reaches, riparian vegetation on the bank influences the in-stream physical habitat structure less than in other areas. Even in pristine streams, LWD has to be large and frequent enough to provide cover or refuge from high flow in such channels. Consequently, where the channel has been artificially widened or confined, in-stream habitat will not usually benefit from enhancement of bank vegetation alone. In these areas, in-stream habitat is most effectively influenced by adding in-stream structures such as appropriately sized boulders that obstruct flow in strategic locations.

The fourth reach type, estuarine, refers to the area from approximately the upstream tidal limit (where the channel is about 70 feet wide) to the mouth of the river, (where the channel is about 800 feet wide). From Drew Gardens to the 174th St. weir, the banks of the river are filled and hardened with grouted boulders. At the weir and downstream, a historic bend is anchored in place by bedrock and artificial banks. The tight angle of the bed produces a backwater where suspended sediment settles, creating a shallow flat of fine, unconsolidated sediment downstream of the weir. From the weir to Westchester Ave., average channel width is about 100 feet and the banks consist mostly of concrete walls, piling, riprap, and bedrock. Downstream of Westchester Ave., the channel widens to about 200 feet at Concrete Plant Park. A protruding bulkhead several hundred feet downstream creates a backwater allowing sediment deposition and creating a littoral shelf. Downstream of Concrete Plant Park, both banks of the river are lined with riprap, steel bulkhead and fill. At intermittent locations in this part of the river, short sections of narrow littoral shelf are exposed at low tide. In the past, the Army Corps of Engineers has maintained a minimum river depth of six feet from the mouth to the weir (NOAA, 2000). The last dredging was in 1991 and there are no known plans to dredge in the near future.

For more detailed information on channel morphology, see APPENDIX C.

BIOLOGICAL CONDITIONS

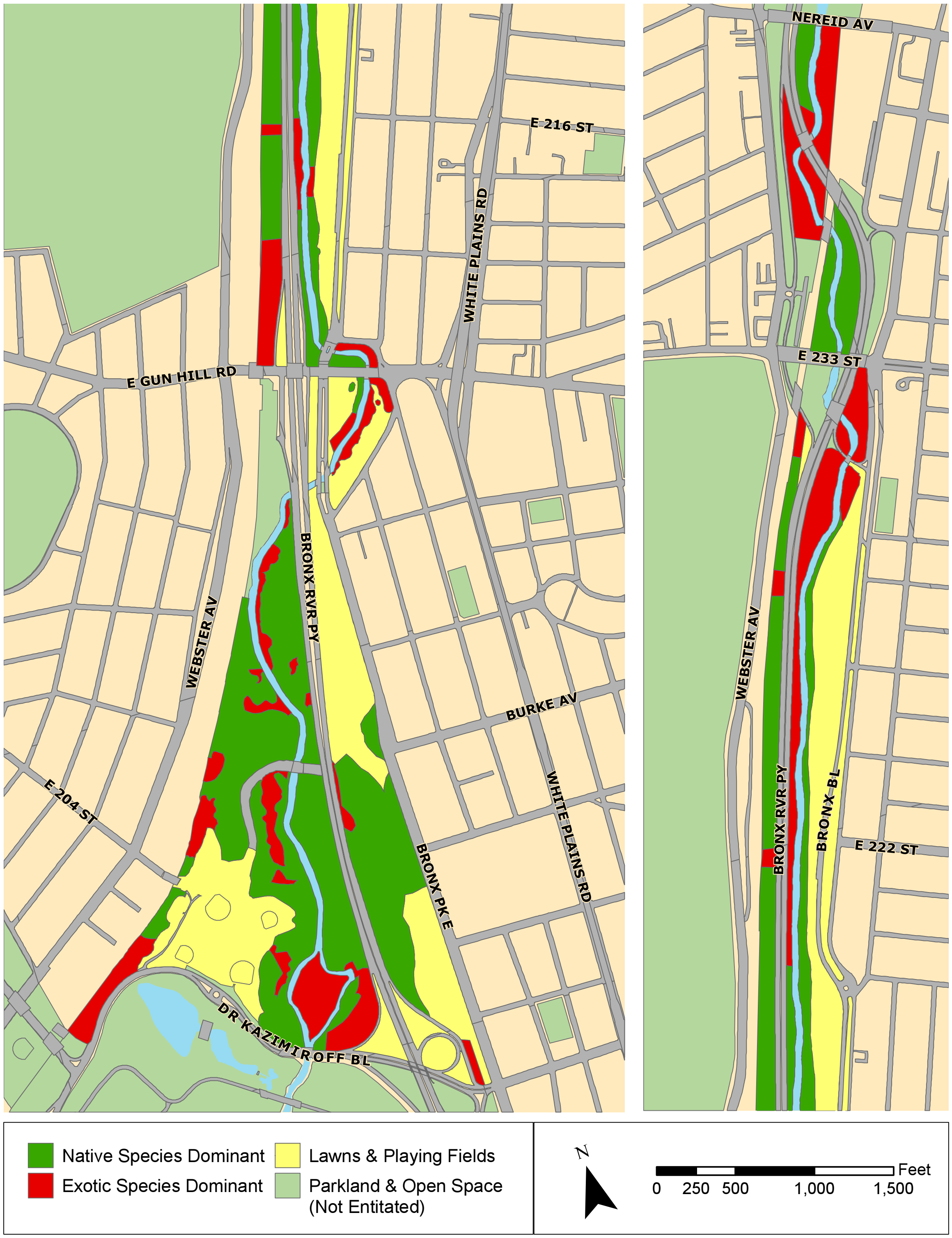
Vegetation

The river and the vegetation along its corridor (the riparian zone) are highly interconnected. Flooding and sediment transport influence habitat for vegetation through erosion and accretion, and affect soil characteristics including grain size, oxygen availability and nutrient content. Vegetation provides many ecological services that maintain the health of the river, such as shade, which lowers water temperatures, as well as habitat and food for wildlife. Native plant species provide the most desirable ecological services, because they are best adapted to creating diverse complexes of plants. The presence of a given plant community depends on physical characteristics including soil conditions, the availability of light, water, and nutrients, as well as biotic interactions such as herbivory and competition with invasive exotic species. Invasive species like Japanese knotweed tend to crowd out the native species, replacing diverse complexes with monocultures {FIGURE III.3}. Strategies for characterizing and controlling invasive species will evolve as groups like NYS DEC's Invasive Species Task Force research and debate the necessity and efficacy of various invasive management activities

The following sections provide an overview of the plants that commonly occur in the four sections of the river in Bronx County. There has not been a comprehensive vegetation survey of the Bronx River corridor, so information in this section is based primarily on field notes of Natural Resource Group (NRG) and Bronx River Alliance staff, information from site-specific vegetation studies, and the Bronx River BioBlitz (a census of plant and animal life) in 2005. Since 2000, NRG and the Alliance have brought about notable changes in the vegetation structure of certain areas through invasive vegetation removal and native plantings {FIGURE III.4}.

FIGURE III.3:

DISTRIBUTION OF EXOTIC VEGETATION IN THE BRONX RIVER FOREST + SHOELACE PARK

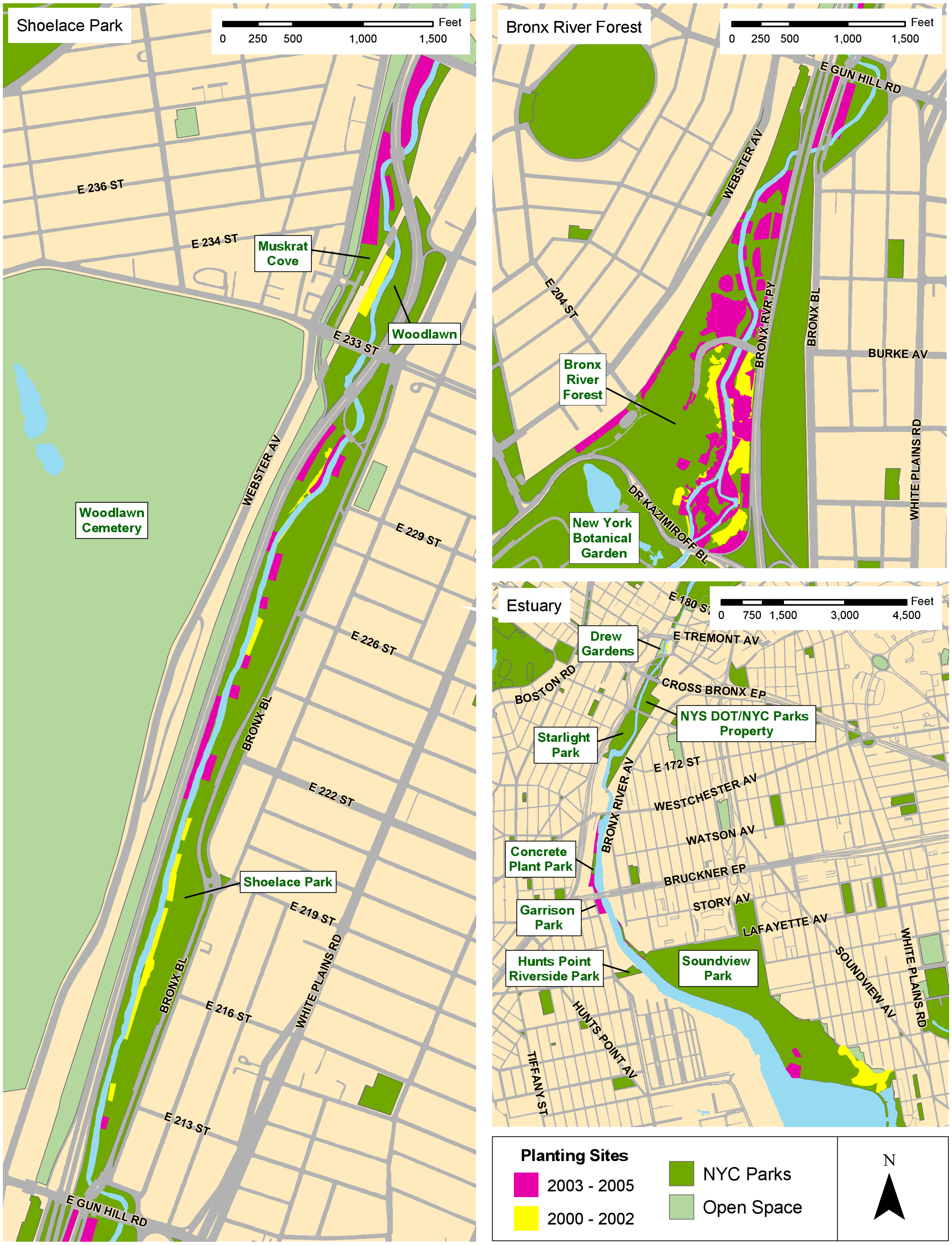


Invasive species are so reproductively successful and aggressive that they can dominate an area, often to the point of becoming a monoculture. They interfere seriously with the natural functioning and diversity of the system where they become established. Some debate exists over which exotic species are truly invasive.

Area boundaries were determined by entitation, a process of delineating ecological communities based on species composition and structure. NRG staff entitated the Bronx River Forest and Shoelace Park in the summer of 2005. Areas are estimates, and are intended for illustrative use only.

FIGURE III.4:

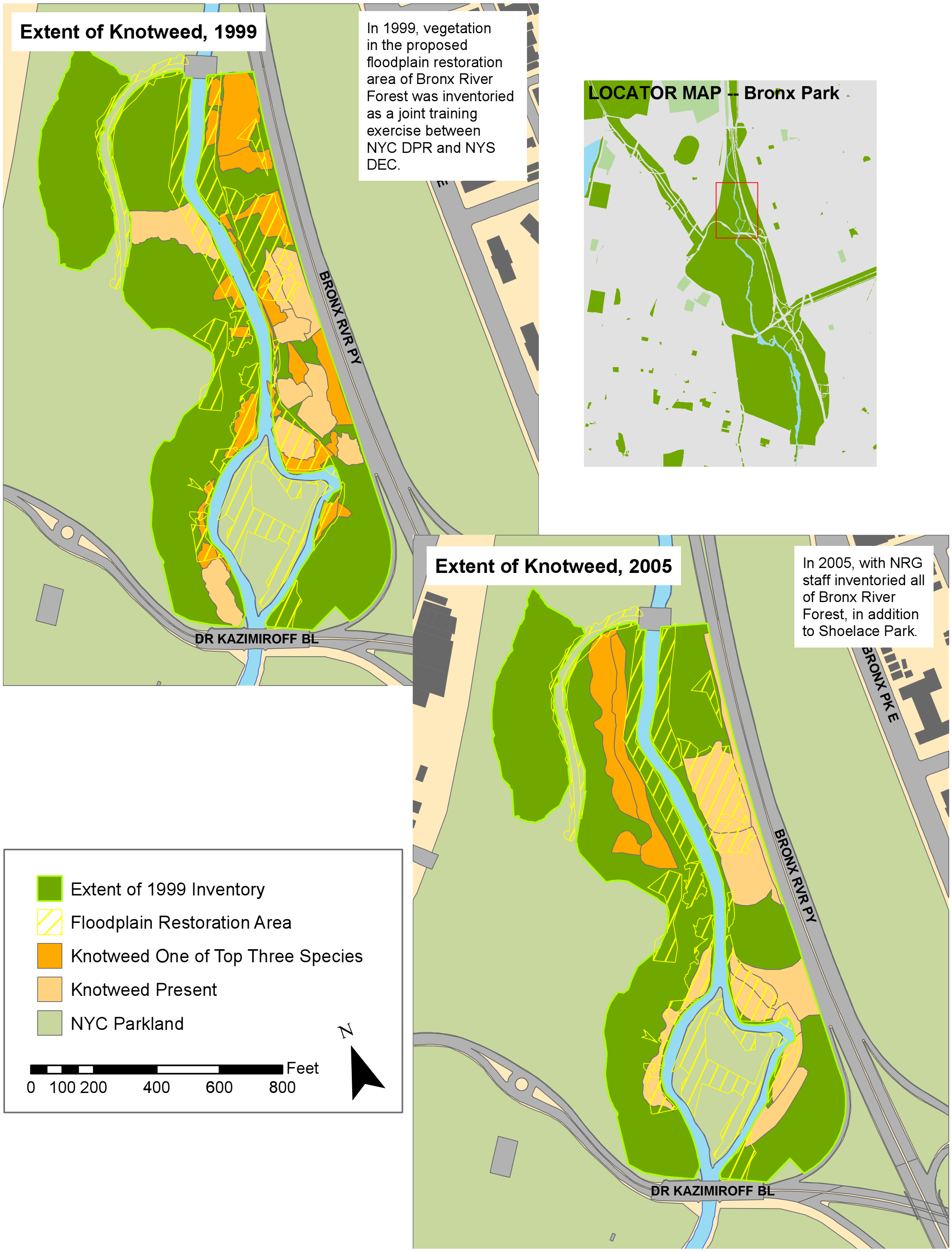
BRONX RIVER PLANTING + RESTORATION SITES



Since 2000, the Bronx River Alliance and NRG have implemented numerous restoration projects to improve the river's health. This map shows a general distribution of where their work has taken place and when it was done.

FIGURE III.5:

DISTRIBUTION OF JAPANESE KNOTWEED IN BRONX RIVER FOREST



Vegetation inventories in the Bronx River Forest were completed using entitation, a process of identifying and describing discrete vegetation units ("entities") based on species composition and structure. A 2005 restoration project reduced the amount of Japanese knotweed, but ongoing work is necessary to keep this extremely invasive plant under control. The Alliance Conservation Crew and NRG will continue to restore and maintain the Bronx River Forest. Due to these efforts, the distribution of knotweed can change on a short timescale.

Parkland Section In the Parkland Section, there is a narrow corridor of vegetation along the river through Muskrat Cove and Shoelace Park that widens in the Bronx Forest. The riparian area in Shoelace Park is 20 to 30 feet wide, but filling has raised the elevation of the banks and eliminated the connection to the floodplain. Construction of the Bronx River Parkway and Metro North railway straightened the river in this section. As the river enters the Bronx River Forest, the floodplain widens to 300 feet. Management of the Parkland Section has allowed some accumulation of LWD, contributing to pool development and in-stream habitat diversity.

The forest canopy within the Parkland Section is composed of a mixture of invasive trees (e.g. white mulberry (*Morus alba*), Norway maple (*Acer platanoides*), cork (*Phellodendron amurense*), sycamore maple (*Acer pseudoplatanus*), and tree of heaven (*Ailanthus altissima*)) as well as native trees (e.g. willow (*Salix spp.*), maple (*Acer spp.*), sycamore (*Platanus spp.*), oak (*Quercus spp.*), ash (*Fraxinus spp.*) and elder (*Sambucus spp.*)). Although invasive trees dominate the canopy in a few areas, native trees are still very common throughout the Parkland Section and there are some areas, such as the remnant floodplain forest in the Bronx River Forest, that are still dominated by native trees.

The understory, however, is clearly dominated by invasive species in many areas. Forest fragmentation throughout the parkland section produces a high "edge to area ratio". This means that the ratio of edges to interior area is higher than in healthy intact woodlands. Edge habitat typically borders paths, roads or other open spaces that were cleared of forest. It no longer supports old growth trees and shade-tolerant forest understory species, and instead presents physical conditions conducive to invasion and dominance by weedy or invasive species. In addition, the reduction of the natural floodplain contributes to flashy stream flows and high sediment loads that favor invasive species such as Japanese knotweed, which is ubiquitous on the riverbank. Porcelainberry (*Ampelopsis brevipedunculata*), multiflora rose (*Rosa multiflora*), mugwort (*Artemisia vulgaris*) and lesser celandine (*Ranunculus ficaria*) are also common in the understory. Invasive shrubs and herbaceous plants are controlled in areas that are frequently mowed, in areas of deep shading from canopy trees, and in maintained restoration sites.

In 2005, NRG completed a restoration of the forest floodplain in the Bronx River Forest. The work included removal of invasive vegetation (mostly Japanese knotweed) throughout much of the area. FIGURE III.5 illustrates how invasive cover has changed in the forest since 1999. With proper maintenance, it may be possible for forest managers to continue improving the vegetation structure by removing re-sprouting invasives and planting additional natives.

Botanical Garden/Bronx Zoo Section The New York Botanical Garden (NYBG) and Bronx Zoo create a large, vegetated area around the river, providing a buffer as wide as 1,200 feet between the river and urban development. The NYBG contains a 50-acre tract of predominately native, mixed hardwood forest with a canopy dominated by oaks, tulip and sweet gum. This increasing deciduous hardwood population may be the result of the decline of eastern hemlocks in recent years — a decline caused by the infestation of the hemlock wooly adelgid and hemlock scale (Forrest, 2004). The riparian forest in this section is not intensively managed, especially in the Bronx Zoo, resulting in more over-hanging trees and LWD than in other sections of the river. The dams in this section have altered the historic flooding regime, but the large forested area and dense canopy appear to help maintain a predominantly native vegetation community, with diverse understory and herbaceous layers, and limit invasion by exotic species. The banks of the river are less dominated by invasive species than the Parkland Section, though Japanese knotweed and purple loosestrife are still common in some locations.

A dense community of submerged aquatic vegetation, predominantly common waterweed (*Elodea Canadensis*), curly leaf pondweed (*Potamogeton crispus*) and horned pondweed (*Zannichellia palustris*), occurs in the Bronx Zoo section of the river. This impounded section is wide and shallow with low flow velocity and receives high direct sunlight. The presence of curly leaf pondweed is indicative of high nutrient loads. The plant is an aggressive competitor that can exclude native aquatic species. The plant can also have negative impacts on water quality because it dies off and decomposes in the middle of summer contributing to low DO levels.

West Farms Section The floodplain in this section is restricted to a small remnant on the east bank opposite River Park. Along the majority of the rest of the bank, concrete walls and masonry have eliminated most of the riparian vegetation. River Park, Bronx River Park (179th), and Drew Gardens provide a limited buffer between the river and adjacent development. In small areas, box elder, maples, and Japanese knotweed grow through cracks in the armored banks. Purple loosestrife is also found in River Park. The proximity of development in this section limits the extent and abundance of vegetation along the river.

Estuary Section Although industrial and commercial developments line the river banks of the lower estuary, some of the northern tidal reaches are lined by parkland. Fill material has covered nearly all of the historic tidal marshes and raised the elevation of the banks several feet higher than historic levels. Very little land remains for tidal wetland vegetation to occupy between the mouth and the freshwater sections of river. The tree canopy consists of both wetland and upland species, ranging from predominantly exotic species on construction fill, as at the Concrete Plant, to a mix of exotic and native trees such as silver maple (*Acer saccharinum*) and red maple (*Acer rubrum*) on the fill soils upstream and across from Starlight Park.

Several salt marsh cordgrass restoration projects have been implemented in the Estuary Section to expand a community already present near the ABC Carpet store on the non-parkland east bank. Common reed forms a monoculture along most of the east bank south of Bruckner Boulevard. In Soundview Park, the banks rise as high as 30 feet nearly vertical and inhospitable to plants. At the very southern end of the river, the Soundview Park lagoons contain remnants of both low and high salt marsh. Narrow strips of littoral shelf still remain at the toe of the banks in some places. Downstream of the Bruckner Expressway, remnant patches of cordgrass exist intermittently along a strip of land 30 to 50 feet wide at low tide.

Wildlife

The Bronx River and surrounding green areas support a variety of wildlife species. The presence or absence of a particular species depends on its ability to tolerate the altered conditions of an urban river system. The composition of wildlife communities within streams (i.e. fish and benthic macroinvertebrates) is sensitive to changes in hydrology, fluvial geomorphology, water quality, and in-stream and overhanging vegetation. Wildlife in neighboring forests, on the other hand, is sensitive to changes in the stream communities, as well as changes to their forest habitat and landscape conditions.

Information about wildlife along the Bronx River is uneven, with some groups such as benthic invertebrates fairly well studied and others such as amphibians, reptiles and mammals less studied. The following sections summarize our understanding of various groups.

For detailed lists of existing vegetation and preferred restoration plants, see APPENDIX D.

Benthic Macroinvertebrates Benthic macroinvertebrates include insects, worms, bivalves and crustaceans that live on and in the bottom (benthic) substrate of a water body. They play important and diverse roles in the aquatic food web, breaking down leaf litter, grazing on periphyton, removing organic matter from the water column and in turn serving as prey for many fish species. Assessments of the benthic community are commonly used to evaluate stream health (Barbour et al., 1999). Benthic macroinvertebrates are useful indicators of habitat and water quality because they are affected by multiple and synergistic effects of different pollutants, are sensitive to both chemical and physical impacts on their habitat, and are less mobile than fish, making it difficult for them to avoid stresses (NYS DEC, 2002). The benthic species composition and abundance also provides an indication of water quality, because certain species are sensitive to pollutants, while others thrive under altered conditions.

The aquatic invertebrate population of the Bronx River has been studied by NYS DEC in both Westchester County and northern Bronx County and by NRG throughout the Bronx County portion of the Bronx River. Both NYS DEC and NRG analyzed their data on benthic macroinvertebrates to determine the values of four different indices of water quality at different sites (see APPENDIX E for more information).

According to NYS DEC criteria, the biotic index values calculated for the Bronx River classify the river as moderately impacted, which is defined as “altered to a large degree from the pristine state” (Bode et. al., 1999 and 2003). Annual sampling between 2002 and 2004 by NRG at eight sites suggests that the trend is more complicated within the Bronx County portion of the river (see APPENDIX E). Among the eight sites sampled the lowest water quality was observed within the Botanical Garden (at approximately river mile 4.1), a finding which is probably the result of impoundments and long-term pesticide runoff from the garden that has only recently been mitigated. Conversely the best water quality was observed within the Bronx River Forest (river mile 5).

Fish Despite the construction of many dams, which have artificially fragmented and disconnected fish populations since the 1600s, and the history of polluting industries lining the river’s banks, the Bronx River fish community is surprisingly intact—although species diversity appears to be slightly lower today than in the past. More than 30 species of fish have been collected in recent surveys, including several pollution-sensitive species (Schmidt, 1984; Larson, 2004).

The current fish assemblage in the Bronx River, while representative of an urban system, is quite diverse. The fish assemblage found in the estuarine section, for example, is similar to that found at the less degraded Pelham Bay Park. Although many of the expected species are present, their abundance is low. The predominant species are tolerant of disturbed and polluted environments, but variability in species composition and abundance from year to year indicates system instability. For example, conditions in 2003, including high flows and dredging in the East River, resulted in extremely poor fish sampling results in the estuary, a stark change from previous years.

In March, 2006, NYC Parks took the first step toward re-establishing an anadromous fish community in the Bronx River by introducing 201 alewife just upstream of the 182nd Street dam. If these fish spawn successfully, the surviving young will swim out to sea after a few months, and return in three to five years. In the meantime, project partners are studying possible designs for fish passage that would allow returning fish to reach their spawning ground while satisfying aesthetic and structural requirements.

There are no fish species currently in the river that are ecologically detrimental and must be removed. The invasive common carp (*Cyprinus carpio*) is found in such low numbers that it is unlikely to be a problem. More specific findings, including the composition of the fish community in different areas of the river, are available in APPENDIX F.

Birds Comprehensive data on Bronx River bird populations do not yet exist. The following characterization is based on the few localized studies that have taken place and on general observations and species lists kept by active birders.

Although river corridors can provide a diverse array of habitats for waterfowl, shorebirds and songbirds, the current bird community along the Bronx River is representative of an urbanized system. An NRG survey in the Bronx River Forest from May to July 2003 suggested that the resident bird community is representative of a disturbed ecosystem, unsurprising considering the predominance of edge habitat, lack of diverse native understory and lack of a mature tree canopy (Pehek, 2005). The resident community is dominated by a few generalist species that are common in urban and suburban scrub habitats, most notably the gray catbird (*Dumetella carolinensis*) and the American robin (*Turdus migratorius*). More than 80 species have been observed along the Bronx River corridor, but this is lower than is found in similar, less-developed riparian areas. The avian community is dominated by generalist species; forest interior species and species that are sensitive to habitat degradation are rare.

Still, New York City's parks in general, and Bronx Park in particular, play an important role as a stopover habitat for neotropical migrants passing through on their way to northern breeding grounds or southern wintering grounds. Preliminary results from the New York Bird Monitoring Program, a study initiated by the Wildlife Conservation Society in 2004, suggest that Bronx Park is indeed an area where neotropical migrant passerines can adequately restore depleted energy reserves, both in fall and spring and whether they are mainly frugivorous or insectivorous (Seewagen, 2005).

Lastly, the estuary section, near Soundview Park, provides an important congregation area for winter waterfowl in the region. Rafts of ducks observed here include the canvasback (*Aythya valisineria*), ruddy duck (*Oxyura jamaicensis*), and scaup (*Aythya marila*) (Feller, 2005). Shorebirds, including great blue heron (*Ardea Herodias*), snowy egret (*Egretta thula*), great egret (*Ardea alba*), ring-billed gulls (*Larus delawarensis*), and others are common sights in the estuary. Species lists and other detailed avian information can be found in APPENDIX G.

Amphibians, Reptiles and Mammals Though there is very little quantitative data on the abundance and distribution of amphibians, reptiles and mammals in the Bronx River watershed, there are strong indications that many of these animals do live in and around the river. For example, muskrat populate the river in sufficient numbers that sightings are frequent. During the Bronx River BioBlitz in 2005, snapping turtles of varying sizes were found in the impoundment above the 182nd St. Dam and students from a local middle school discovered a red-back salamander during a field trip to the river.

Since these organisms play an important role in natural ecosystems, the Bronx River system could be better assessed if more data on Bronx River communities existed. This plan specifically recommends that more studies of wildlife occur before an accurate description of the communities and/or target habitat improvement for specific groups be set. APPENDIX H lists species that are known to exist and was compiled from field notes of NRG staff, Bronx River Crew, the Bronx River BioBlitz and WCS/Bronx Zoo Riverwalk lists.

ECOLOGICAL OBJECTIVES

INTRODUCTION

Ecosystem management and restoration planning should proceed from the identification of desired ecosystem conditions, which have been modified based on economic, social and political constraints (Kern, 1992). The ideal or target ecological conditions are not necessarily based on historical, pre-development conditions, but on a new equilibrium condition that supports a functional, ecologically intact system (Manci, 1989). In pristine river systems, for example, the dynamic processes of flooding, erosion, sediment deposition, and large wood falling and collecting in the river create habitat and associated biological diversity. Since these processes are not all achievable within an urban system, those ecological functions and values that are likely to be recovered in the Bronx River watershed must be identified. Setting specific objectives or targets is an important step in prioritizing restoration, management efforts, and resources.

An ecologically functional system is sustainable over time and resilient to external stresses. These characteristics are indicated by self-perpetuating native populations of flora and fauna and minimal threats to the system, as achieved through stabilization or reduction of invasive species populations (Parrish et al., 2003). In fragmented, highly urban and disturbed systems such as the Bronx River, relatively few populations or systems have the potential to be entirely self-sustainable. Instead, a suitable level of management and maintenance should be identified that might be considered acceptable to protect and sustain them.

Ecological Objectives for the Bronx River

In the Bronx River watershed, landforms, in-stream structures and vegetation have been so altered that most of the characteristics of a healthy river can never be fully replicated. Instead, a more realistic objective is to increase the number and lengths of river reaches where the conditions of a functional ecologically intact river are met. In general, restoration work should aim to create a river ecosystem that:

- Conveys the water flow and sediment it receives without resulting in excessive erosion or deposition
- Is a continuous network allowing unimpeded water and sediment transport as well as fish and wildlife passage throughout
- Allows groundwater exchange in the channel and floodwater exchange, retention and infiltration in the floodplain and on upland slopes within the watershed
- Supports riverbank vegetation and heterogeneous bedforms such as pools and riffles to provide varied habitat for fish and wildlife
- Supports aquatic communities that are not impaired by the quality of the water within the river

Ecological Objectives for the Watershed

Objectives for the Bronx River watershed, or the landscape surrounding and draining into the river, include identifying, establishing and maintaining ecologically beneficial characteristics in the urban landscape. Undisturbed (unpaved and relatively uncompacted), vegetated soil, for example, permits infiltration and storage of storm water, and recharge to the river and groundwater. Vegetative communities of almost any kind have some value in reducing ambient temperatures and protecting soil in an urban environment. The vegetation community can provide additional ecological functions, such as perpetuating floristic biological diversity, habitat for native fauna and soil conservation and enrichment. The degree to which these functions are present within a patch of vegetation depends on factors intrinsic to the patch (e.g. the current species composition and structure and the frequency and degree of disturbance) as well as various landscape factors (e.g. the size, shape and degree of connectivity to other vegetated areas). Ideally, the landscape surrounding the Bronx River should contain flora and fauna that are not only predominantly native, but also contains both pollution-sensitive and pollution-tolerant species.

Performance standards for ecological objectives

Whenever possible, ecological objectives should include quantifiable parameters or indicators that can be measured to evaluate success. Quantifiable objectives can help set priorities, drive the implementation of management plans and provide performance standards against which to assess the effectiveness and efficiency of restoration and management efforts (Parrish et al., 2003). Using performance standards to assess progress also encourages the implementation of adaptive management — if objectives are not met, management and restoration approaches should be re-assessed and adjusted to better reach stated goals. Alternatively, the performance standards themselves may need to be adjusted or changed to better reflect what is possible and important to achieve.

Quantifiable parameters include indicators of significant ecosystem attributes, such as the presence of focal species, native species regeneration or stream channel stability. Many ecosystem attributes, however, are difficult or costly to measure or there may be insufficient baseline data to develop a meaningful quantitative performance standard for them. In these cases, a qualitative standard can serve to guide restoration and conservation projects. While some ecological attributes improve quickly in response to a single restoration project other attributes may need to be monitored over a period of months or years to identify trends (Haynes and Moore, 1988).

ATTRIBUTES AND INDICATORS

Here, the attributes and indicators of an ecologically functional Bronx River corridor are discussed. Though many of these characteristics are inter-related, they are discussed under the following headings: water quality, hydrology/storm water management, channel stability, in-stream and riparian habitat, riparian vegetation, benthic macroinvertebrates, fish, and birds. A general goal is set for each and the ecological significance of the associated attributes is described. Relevant indicators and commonly used measures or regulatory standards are presented, if they exist, as are the challenges to establishing performance standards, if they do not.

In the tables that follow, the attributes and associated performance standards with quantitative measures are listed first. “Very good” is typically an ideal condition for an undisturbed river and watershed, rather than an assessment relative to an urban stream. In practice, “Good” may be the objective for a given attribute on the Bronx River. For most attributes, evidence that there is a positive trend, or at least not negative trend, in performance measures may be as important as achieving a “Good” ranking. Measurement methods are discussed briefly to provide some understanding of the level of effort required to conduct the monitoring to apply performance standards. At the end of each section, the current conditions, based on the proposed performance standards, are summarized.

Below, the attributes and performance standards that are most important to the Bronx River are summarized based on their significance in reflecting ecological conditions and function and their ability to be monitored given anticipated resources.

WATER QUALITY

Goal: To improve water quality for public health and recreational benefits and to support sensitive life stages of aquatic organisms

Significance and standards

Improvements in water quality are necessary both to increase recreational access to the river and improve ecological health. Although several metrics can be used to evaluate water quality, dissolved oxygen (DO) and fecal coliform are the two of greatest interest in the Bronx River. They are used by state and federal agencies to regulate water quality to protect human health and the environment {TABLE IV.1}. The concentration of fecal coliform bacteria is an indicator of human and animal waste discharge into water and is used to establish permitted recreational uses of the river. Combined sewer overflows (CSOs) discharge a mix of sewage and storm water, both containing fecal coliform, when heavy rainfall overloads the sewage system. High levels of fecal bacteria are linked to pathogens that can cause illness in humans, so public health standards have been developed to determine whether the water is safe for swimming, fishing and boating.

Since healthy aquatic flora and fauna require a minimum level of DO, the river's capacity to sustain life is limited when oxygen is scarce. High fecal coliform counts are also linked to increased biochemical oxygen demand in the river and decreased DO levels. Biological indicators that are directly impacted by DO levels are also important and are discussed in further detail in following sections.

TABLE IV.1: Conditions and performance standards for Water Quality, based on New York State Surface Water Quality Standards (Schmidt et al., 1981)

Poor	• DO concentrations below the survival threshold for most aquatic organisms for more than one week in parts of the river • Monthly geometric mean fecal coliform and monthly geometric mean total coliform counts only suitable for secondary contact with water and fishing; coliform counts adequate for fish propagation and survival
Fair	• DO concentrations below levels required for growth by most aquatic organisms for more than one week • Monthly geometric mean fecal coliform counts and monthly median total coliform counts suitable for primary and secondary contact with water and fishing; coliform counts are adequate for fish propagation and survival
Good	• DO concentrations above levels required for growth by most aquatic organisms year-round • Monthly geometric mean fecal coliform counts and monthly median total coliform counts suitable for primary and secondary contact with water and fishing; coliform counts are adequate for fish propagation and survival
Very Good	• DO concentration levels greater than 7 mg/l year-round • Monthly median total coliform counts suitable for commercial shellfishing, primary and secondary contact with water, and fishing; coliform counts are adequate for fish propagation and survival

Measurement methods

Standard protocols exist to provide a quantitative determination of many parameters of interest. Adequate measurements require moderate (i.e. temperature and pH) or high (i.e. bacteria and nutrients) level of effort. Field methods, as well as location and frequency of sampling, depend on the objectives of the sampling (Behar et al., 2000).

Current condition: FAIR

Monitoring indicates that the Bronx River currently experiences periods of low DO levels (hypoxia) that may have adverse effects on sensitive organisms and on juvenile life stages. The hypoxic conditions (below 4.8 mg/l DO) do not seem to persist for long periods and tend to be limited to impoundments and areas near CSOs. The primary sources of fecal coliform bacteria are CSOs after rain events, waste from wildlife and domestic animals and illegal sewage discharges through storm sewer hookups.

HYDROLOGY

Goal: To increase connectivity between the Bronx River and its historic floodplain, to promote storm water infiltration and to reduce peak storm water flows

Significance and standards

Urban development increases impervious area in the watershed, creating a "flashy" hydrologic regime in which more storm water runoff is transported to the river channel more rapidly. The highest flood flows (measured as the annual peak discharge) become higher, and the low (base) flow can become lower. In addition, the volume of runoff after a storm is higher and passes through the stream system more quickly. Typically, degradation of the natural stream biota is observed in watersheds with impervious area of 10 percent or greater (Booth and Reinelt, 1993). Imperviousness in the Bronx River watershed is greater than 60 percent.

Despite well-documented hydrologic impacts of development, quantifying the level of hydrologic disturbance is often difficult because continuous historic flow records are usually unavailable. Even when historic and on-going monitoring data is available, identifying a target for hydrologic restoration may still remain difficult for several reasons. First, an understanding of the most biologically or morphologically significant hydrologic parameters is lacking for restoration. Second, reversing landscape changes caused by development is usually not feasible in an urban environment. Third, metrics such as peak discharge vary annually and are not sensitive to individual, localized restoration projects. Finally, in highly urban areas, the watershed can be ecologically uncoupled from the river. In Bronx County a combined sewer system conveys most storm water to discharge points downstream in the estuary, making hydrologic restoration even more difficult to measure.

Although quantifying the target can be difficult, hydrologic disturbance can be reversed or at the very least mitigated, and it is important to do so. Restoration attempts will never be entirely successful without addressing the causal factors of disturbance. Reversal of hydrological disturbances is achieved through incremental alterations to the volumes and areas of detention and infiltration of storm water. Over time these incremental changes can lead to measurable increases in base flow and decreases in the frequency and volume of discharges through CSOs and other indicators of hydrologic disturbance.

TABLE IV.2: Conditions and Performance Standards for Hydrology	
Poor	• Little or no floodplain available for flood retention • Annual peak flows significantly greater than pre-development conditions • No storm water best management practices implemented • Substantial implementation of storm water best management practices requires major reconstruction • High imperviousness (>40%), with development increasing
Fair	• Some historic floodplain available for flood retention • Annual peak flows not increasing over the long term • Some storm water best management practices implemented • Some potential for implementation of storm water best management practices • High imperviousness (>40%), but development has stabilized
Good	• Much of historic floodplain available for flood retention • Annual peak flows decreasing • Frequent implementation of storm water best management practices • Great potential for implementation of storm water best management practices
Very Good	• Maximum possible area of floodplain available for flood retention • Annual peak flows similar to pre-development historic conditions • Aggressive implementation of storm water best management practices • Measurable increases in storm water infiltration and retention

Measurement methods

Continuous surface water monitoring conducted by the U.S. Geological Survey (USGS) is the ideal source of data for evaluating hydrologic conditions. However, because it is primarily useful for assessing long-term trends, not incremental changes, it is not practical for assessing progress towards meeting goals. Another option is to monitor changes in watershed conditions that affect the in-stream hydrologic regime (e.g. the amount of impervious area or floodplain and storm water retention area or number of best management practices). Monitoring should occur on a site-by-site basis, by measuring the volume of storm precipitation, runoff captured and area of impervious surface converted to pervious surface at the site.

Current condition: POOR

Peak annual flows at the USGS stream gauge at Bronxville have increased since the 1940s with increased development in the watershed (USGS, 2005). Recent one-year storm hydrographs show a higher peak and shorter duration than fifty years ago, which means that more runoff is conveyed to the channel over a shorter period of time. Land development has created frequent flashy flows and low ground water recharge. Very little active floodplain or pervious area remains in the watershed of the Bronx River to absorb precipitation and storm runoff.

CHANNEL STABILITY

Goal: To establish or maintain channel stability

Significance and standards

Channel stability refers to the ability of a river system to convey water and sediment from upstream through a reach without excessive sediment deposition or bank erosion. Although rivers are dynamic systems, healthy rivers also maintain a degree of stability. A stable bank is thoroughly rooted by native plants, exhibits stable undercut (overhanging banks), and is dominated by soil or bedrock rather than artificial armor. Signs of bank erosion or channel sedimentation should be interpreted within the context of the local geology as well as where they are found in a reach, within the system, and in relation to other structures.

Excessive bank erosion is indicated by erosion along banks in a straight reach as well as beneath tree roots at the lower bank or outside a river bend. Other indicators of excessive erosion include high banks that cannot be flooded annually, exposed bridge abutments, vertical, eroded, crumbling or sloughing banks, recently exposed tree roots, and the absence of native vegetation rooted along the water line. A bank supporting native vegetation is one that is thoroughly rooted by native plants, exhibits stable undercut or overhanging banks, and is dominated by natural landforms such as soil or bedrock rather than artificial armor (Barbour et al., 1999).

Excessive sedimentation is characterized by the deposition of more material into a channel reach than can be transported out of the reach over time. Sedimentation usually occurs on the downstream side of a bar or on a point bar on the inside of a river bend. If sedimentation occurs across the whole channel, the channel will widen and become shallow. These signs of channel instability occur along a continuum. Indications of bank erosion or channel sedimentation must be interpreted with regard to local geology, position in the stream reach and overall stream system, and proximity to structures.

TABLE IV.3: Conditions and Performance Standards for Channel Stability

Poor	• Few parts of bank support native vegetation • All reaches exhibit excessive sedimentation or erosion • Banks held only by hard points • Channel is straightened or dammed in most reaches
Fair	• Some parts of bank support native vegetation • Most reaches exhibit excessive sedimentation or erosion • Channel is straightened or dammed in some reaches
Good	• Many parts of bank support native vegetation • Few sites exhibit excessive sedimentation or erosion • Few sections of channel are straightened or dammed
VeryGood	• Most parts of bank support native vegetation to water line • No signs of excessive sedimentation or erosion • Natural channel configuration

Measurement methods

It is relatively easy to observe and describe stability conditions qualitatively within a reach. Both erosion and sedimentation can also be quantified at a given site using surveying, permanent bench-marks and tools such as erosion pins (Harrelson et al., 1994). The channel width and depth at a given location can be compared to a stable reach on the same river or regional stream widths and depths at comparable drainage areas as a means of identifying erosion or sedimentation problems. Some of the indicators identified for assessing in-stream habitat (below) can also serve as indicators of channel stability.

Current condition: POOR to FAIR
Conditions vary from poor to fair in the freshwater reaches of the Bronx River. In the very low-gradient reaches, much of the channel has been straightened, banks are often steep and high, the channel bed is covered with fine sediment and frequently re-mobilized, and fine sediment accumulates rapidly on the bars. In the impounded reaches, the number of bars are increasing and the channel is becoming shallower. Banks are largely artificially armored (and therefore stable) in the tidal and estuarine reaches of the Bronx River and are mostly unarmored throughout the freshwater reaches.

IN-STREAM HABITAT

Goal: To conserve and increase in-stream and bank habitat for fish, benthic invertebrates, reptiles and other wildlife

Significance and standards
Excessive erosion and sedimentation, a flashy or urban hydrologic regime, and human activity such as floodplain development and channel straightening and clearing, can reduce or obliterate important channel features. These features include:

- Diffuse flow energy as well as varied flow depth and substrate
- Habitat for algae and micro-organisms (food for invertebrates and fish)
- Shelter for fish and aquatic organisms from direct sunlight
- Areas of refuge from predators and high water flow
- Breeding sites for fish
- Features that serve as markers for territorial or migratory species
- Grade controls on the channel bed to help stabilize banks

Habitat conditions vary depending on location in the river system and which species are of concern. Typical parameters of interest include cover availability (quantity and quality) in the channel, embeddedness (the degree to which the larger substrate on the bed is buried in fine sediment), flow and channel bed variability, riparian vegetation, and degree of bank armoring. One of the more quantifiable parameters in lowland streams for which sufficient data has been collected is the frequency of pools (Scholz and Booth, 2001). Pools are areas of local depressions with a depth (or residual pool depth) significantly deeper than the surrounding streambed. For a stream the size of the Bronx River, pools with residual pool depth greater than 2.5 feet are ideally found every five to seven channel widths in low-gradient, sand-bedded reaches and every three to five channel widths in steep-gradient, cobble-bedded reaches (Leopold, 1964).

Large woody debris (LWD) is another feature that has significance for cover, flow variability and stability that can also be readily quantified (Kaufman and Robinson, 1997; Beechie and Sibley, 1997). The size of wood that will have a structural influence on the channel varies by stream size, but for the Bronx River any piece of wood larger than 10cm in diameter and longer than 1m in length can be considered LWD.

TABLE IV.4: Conditions and Performance Standards for Habitat Features	
Poor	• Few parts of bank support native vegetation • Most parts of bank armored or channelized • Pools absent • LWD absent • Floodplain entirely developed, filled or abandoned
Fair	• Some parts of bank support native vegetation • Many parts bank armored or channelized • Pools rarely present • LWD rarely present • Floodplain partially developed, filled or abandoned
Good	• Many parts of bank support native vegetation • Some parts of bank armored or channelized • Pools sometimes present • LWD sometimes present • Floodplain partially undeveloped, unfilled or active
VeryGood	• Most parts of bank support native vegetation • Few parts of bank armored or channelized • Pools present where expected • LWD present where expected • Floodplain predominantly undeveloped and active

Measurement methods

Habitat conditions can be evaluated quantitatively or qualitatively using a number of measures with varying levels of effort. Most measures involve low to moderate effort, but are most effective for describing existing conditions rather than assessing trends or setting priorities. Habitat data that is reliable, species-specific and replicable despite flow and site variability is much more time-consuming to collect and interpret. Information on habitat conditions can also be obtained from the measures discussed under Channel Stability above.

Current condition: POOR to FAIR

Conditions along the Bronx River vary from poor to predominantly fair in the freshwater reaches where there are areas of active, undeveloped floodplain and there is some large wood in the channel and native trees on the banks. In the tidal reaches, conditions are mostly poor due to channel straightening, filled floodplains, bank armor and sparse native vegetation.

RIPARIAN VEGETATION

Goal: To reduce the spread of invasive species and increase populations of native vegetation for improved habitat conditions and storm water retention

Significance and standards

Invasive exotic plants such as Japanese knotweed (*Polygonum cuspadatum*), Oriental bittersweet (*Celastrus orbiculatus*) and other vines are one of the most visible threats to ecological integrity on the Bronx River. Invasive species change the structure of the riparian community, reducing the abundance and diversity of native species and decreasing habitat diversity. Along the Bronx River, invasive species also reduce the number of shade trees over the water, the extent of woody roots that stabilize the bank and the amount of LWD in the river.

A variety of metrics, including the presence or prevalence of rare or sensitive plant species, regeneration of native species and prevalence of invasive species, can be used to evaluate the condition of the vegetation community. Although there are no standards for these metrics, they are often used to evaluate change or trends from a baseline condition or to a specific or assumed reference condition. The presence and distribution of rare plants can help determine the degree of disturbance in an area and whether protection or management approaches are effective. The regeneration of native species, survival of native plantings and presence of invasive species are also important measures of management success and long-term viability of restoration programs. NYS DEC has included in their permit requirements that 85 percent of the native plants installed in a restoration project are alive after five years (Larson, 2006). In addition, increased vegetative cover increases storm water holding capacity of the landscape.

The rationale behind conserving and enhancing the native diversity of plants along the Bronx River is to maximize biological and physical habitat diversity for both the vegetation and the animals it supports. One approach towards this goal is to re-establish native plant community assemblages that were once predominant along the riparian corridor. Because floodplain forests are so variable and diverse, however, a broader emphasis is placed in the Bronx River on native species suited to a floodplain and on the heterogeneous local conditions created by centuries of disturbance, rather than a specific target community composition. In other words, the appropriate vegetation goal for the Bronx River is establishing native floodplain species suitable to local conditions instead of replicating historical plant communities.

The proposed targets are based on attributes commonly monitored at restoration sites. Goals for controlling invasive species still need to be established for individual restoration sites and the entire river corridor. The rankings below should also be refined based on reference sites in the watershed, comparisons to similar, but less impacted rivers, and values in the literature. Finally, realistic expectations for management and maintenance to protect and sustain native plant communities need to be factored into vegetation community goals.

Measures for evaluating health of the vegetative community include:

- Regeneration of native species by seed at the rate necessary for a self-sustaining population (rate of new plants reaching maturity more than or equal to death rate)
- Invasive species regenerating at a slower rate than native species
- Greater abundance and diversity of native aquatic and marine vegetation than currently exist
- Greater abundance of overhanging and submerged riparian vegetation than currently exist

TABLE IV.5: Conditions and Performance Standards for Vegetation	
Poor	• Absence of native tree cover in canopy layer of riparian areas • Absence of native plant cover in shrub and herbaceous layers of riparian areas • Rare or sensitive species absent • No native plant regeneration
Fair	• Some native tree cover in canopy layer of riparian areas • Some native plant cover in shrub and herbaceous layers of riparian areas • Few occurrences of rare or sensitive species • Isolated or inconsistent native plant regeneration
Good	• Abundant native tree cover in canopy layer of riparian areas • Abundant native plant cover in shrub and herbaceous layers of riparian areas • Some occurrences of rare or sensitive species • Consistent native plant regeneration
Very Good	• Mostly native tree cover in canopy layer of riparian areas • Mostly native plant cover in shrub and herbaceous layers of riparian areas • Common occurrence of sensitive species; rare species present as expected • Successful native plant regeneration, with plants at multiple ages

Measurement methods

Vegetation characteristics can be monitored using standard sampling methods depending on the size of the area and the parameter to be assessed. Randomly placed, permanent plots and subplots are typically used in reference sites or in project areas to evaluate the success of plantings, plant response to treatments or changes in control conditions. On a larger scale, mapping (or entitation) can be used to subdivide vegetation into recognizable entities or preliminary types with information such as the dominant species in each vegetation layer.

Current condition: POOR to FAIR

Invasive species currently dominate the vegetative community along the banks of much of the Bronx River and the survival of native plantings is typically less than 85 percent after 5 years. Moreover, there are few rare or sensitive species and native plant regeneration is poor. Although survival rate is low, native vegetation cover is increasing due to the invasive vegetation removal and native planting efforts.

MACROINVERTEBATES

Goal: To increase the abundance and diversity of invertebrate and pollution-intolerant species in the Bronx River

Significance and standards

Benthic macroinvertebrates comprise a heterogeneous assemblage of animal groups that live in or on stream channel sediments or other bottom substrates in the aquatic environment. They are typically larger than 0.5mm and are primarily aquatic insect larvae, annelids (worms), mollusks, flatworms and crustaceans in freshwater systems or polychaetes, crustaceans and mollusks in estuarine systems. They are extremely useful as monitoring indicators since they are abundant and diverse, not artificially stocked, have short life cycles, are sensitive to subtle changes in water quality, play an important role in food webs, including larger wildlife, and are relatively sedentary. (Fore et al., 1996; Rosenbery and Resh, 1993; Vannote et al., 1980).

The NYS DEC assesses water quality in freshwater riffles using four types of benthic macroinvertebrate analysis: the Hilsenhoff biotic index measures the richness of pollution-sensitive groups (Ephemeroptera, Plecoptera, and Trichoptera), species richness, and the degree of similarity between the observed benthic community and an ideal community (Percent Model Affinity, or PMA). Higher species richness values (indicating increased diversity) and higher proportions of pollution-sensitive species such as mayfly, cadddisfly, stonefly and damselfly are associated with better water quality and less disturbance in the surrounding landscape. The exact values of these indices that are associated with the NYS DEC's water quality ratings vary according to sampling method and habitat type. Therefore, while table IV.6 lists the criteria that apply to samples taken from freshwater riffles using a kick sampling method, different criteria may be more appropriate for data obtained using a different sampling method. Furthermore, PMA is only used as a standard within freshwater riffles. In the name of consistency with the rest of this document the NYS DEC's rating of none impacted, slightly impacted, moderately impacted and severely impacted have been converted respectively to **very good**, **good**, **fair** and **poor**.

TABLE IV.6: Conditions and Performance Standards for Macroinvertebrates*	
Poor	• Absence of pollution-sensitive macroinvertebratesand freshwater mussel species
Fair	• Presence of some pollution-sensitive macroinvertebrates and freshwater mussel species • Species richness low
Good	• Presence of many pollution-sensitive macroinvertebrates and freshwater mussel species • Species richness moderate
Very Good	• Presence of most pollution-sensitive macroinvertebrates and freshwater mussel species • Species richness high

*Based on NYS DEC classification of stream invertebrate communities

Measurement methods

Sampling by NRG has used the Hess sampling technique at all sites, but other methods of sampling may be more appropriate, particularly at locations where riffles are scarce and the water is deep. In addition, comparison to state standards would be more straightforward if kick sampling replaced Hess sampling in the future. Regardless of the method chosen, sampling generally requires low effort. On the other hand, the next step after sampling, sorting and identification of benthic invertebrates, requires significantly greater effort and requires the aid of a skilled taxonomist. The amount of effort spent on this step can be reduced considerably if NYS DEC standards are followed and a sub-sample of 100 is analyzed instead of the full sample from each site. In addition to the water quality indices discussed above and in other sections, benthic data can also be used to determine the probable sources of impacts. This can be done both through examination of the species present and by using NYS DEC protocols for Impact Source Determination.

Current condition: FAIR

Macroinvertebrate assessments conducted by the NYS DEC in 1998 and 2003 identified a site within the north Bronx part of the Bronx River as "moderately impacted" (NYS DEC, 2003). The assessment identified point source discharges, high sediment loads and high hydrologic variation as causes of degradation. NRG conducted additional studies near this site and at six other sites closer to the river mouth between 2002 and 2004 (U.S. EPA, 2005). The overall assessment at the seven sites was that the river was "moderately impacted" or in fair condition. However, individual sites varied from border-line moderately/slightly impacted to severely impacted and the major causes of degradation appear to vary along the river.

FISH

Goal: To increase the abundance and diversity of fish and shellfish in the Bronx River

Significance and standards

The fish community provides an integrated indicator of ecological health based on organisms that are affected by multiple environmental factors over their life span. To increase the health and abundance of the fish species already present in the river and to attract new species from upstream, habitats within the river and connectivity between habitats must be restored. Habitat such as floodplains, which are already a restoration priority, not only increase storm water retention in the system, but also provide excellent nursery grounds for fish and optimal environments for many invertebrates (Bayley, 1995). Reconnecting the floodplain with the river would increase fish populations both directly, by restoring nursery grounds, and indirectly, by increasing prey abundance and decreasing hydrologic variability.

The connection between the freshwater and estuarine reaches is also necessary so all fish can freely move up and down the entire river. This would not only increase the health and abundance of diadromous species like river herring (*Alosa pseudoherrengus* and *Alosa aestivalis*), striped bass (*Morone saxatilis*), blue crab (*Callinectes sapidus*), and American eel (*Anguilla rostrata*), which require both aquatic/estuarine and marine habitats to complete their life cycle, but is also necessary for resident species that are currently depleted in part due to habitat fragmentation. Habitat fragmentation reduces the amount of habitat accessible to each individual, limiting options for refugia, prey, and spawning, and divides populations, increasing the chance of extinction for each smaller population and decreasing genetic mixing.

A run of anadromous fish (those that spawn in freshwater and live their adult lives in saltwater) is the only component of the fish community that is obviously missing from the Bronx River. Connectivity would also take advantage of important habitat for the catadromous (spawns at sea and lives its adult life in freshwater) American eel, a species in such serious decline that the Atlantic States Marine Fisheries Commission is considering nominating it for the Endangered Species List (Kritzer, 2005). The eel population, already present in the river, would be expected to increase with improved connectivity.

Targets for the fish community could be based on Indices of Biological Integrity that have been developed since the 1980's and implemented by many states to monitor fish communities and assess the ecological health of rivers (Karr, 1981; NJDEP, 2000). Targets could also be based on the presence and abundance of pollution-sensitive species such as largemouth bass (*Micropterus salmoides*), redfin pickerel (*Esox americanus americanus*), yellow perch (*Perca flavescens*), and creek chub (*Semotilus atromaculatus*). Comparison to fish assemblages in other rivers in the region of similar size, but with less development could also be used. Although declines in species richness, local extirpation of sensitive species and decreases in abundance have been documented in fish communities due to urbanization, these metrics can only be expected to change over a long period as a result of cumulative improvements of habitat restoration and pollution-reduction efforts.

TABLE IV.7: Conditions and Performance Standards for Fish*	
Poor	• Absence of pollution-sensitive fish species • No reaches passable by anadromous fish • Striped bass absent • Public health standards prohibit fish consumption
Fair	• Presence of some pollution-sensitive fish species • Some reaches passable by anadromous fish • Striped bass present, though scarce • Public health standards restrict consumption of eel and crabs
Good	• Presence of many pollution sensitive fish species • Many reaches passable by anadromous fish • Striped present in low numbers • Public health standards restrict consumption of striped bass
Very Good	• Presence of most pollution sensitive fish species • Most reaches passable by anadromous fish • Striped bass abundant • Public health standards allow unrestricted fish consumption

***** Based on Index of Biotic Integrity (Karr 1981) modified for New Jersey by NJDEP and personal communication with Joe Rachlin

Measurement methods

Fish surveys can use various tools, such as creel census by interviewing people fishing, spot sampling various sections of the river using baited and unbaited traps, small 4' x 4' or 4' x 10' seine nets with 1/8th to 1/4 inch mesh, and small Fyke net sets deployed for three hours with mouth facing upstream. Larval fish can be sampled using either 500 micron mesh drift or plankton net sets.

In the Federal Channel of the estuary fish are typically sampled by sequential 10 minute tows using a modified shrimp net deployed from the stern end of an appropriate vessel at speeds not to exceed one knot. All sampled fish are identified to species, weighed to the nearest 0.5 gram, measured for standard length (tip of the snout to the end of the hypural plate), counted and released. These data can then be used to assess catch per unit effort, species richness, condition, diversity, and species evenness in addition to the above mentioned indices.

Current condition: FAIR

More than 30 species of fish have been collected in recent surveys, including several pollution-sensitive species (Schmidt and Samaritan, 1984; Larson et al, 2004). The current fish assemblage in the Bronx River, while representative of an urban system, is quite diverse and is similar to that found at Pelham Bay Park, a less degraded area. Although most of the expected species are present, they are found in low abundance.

The predominant species are tolerant of disturbed and polluted environments and the variability in species composition and abundances from year to year indicates system instability. For example, conditions in 2003, including high flows and dredging in the East River, resulted in extremely poor fish sampling results in the estuary, a finding that was very different from previous years (Rachlin, 2005). There are no fish species currently in the river that are ecologically detrimental and must be removed. The invasive common carp is found in such low numbers that it is unlikely to be a problem.

BIRDS

Goal: To increase the abundance and diversity of resident bird species and over-wintering waterfowl in the Bronx River corridor

Significance and standards

Avian community conditions and performance standards are based on the presence of bird species that occur in riparian areas in this region and are sensitive to habitat fragmentation and disturbance. Targets for species richness or species diversity indices could also be developed based on reference sites.

Along much of the Bronx River, the riparian forest is not wide enough to support a typical interior woodland bird community. Increasing the extent of unfragmented forest would be important for these species, but opportunities for reforestation are restricted in this urbanized watershed. An increase in the nesting abundance of sensitive species such as wood ducks (*Aix sponsa*) and pileated woodpecker (*Dryocopus pileatus*) could indicate an improved habitat along the river.

TABLE IV.8: Conditions and Performance Standards for Birds	
Poor	• Absence of forest interior and disturbance-sensitive riparian species
Fair	• Few nesting forest interior and disturbance-sensitive riparian species • Species richness low
Good	• Some nesting forest interior and disturbance-sensitive riparian species • Species richness moderate
Very Good	• Many nesting forest interior and disturbance-sensitive riparian species • Species richness high

Measurement Methods

Bird surveys have been conducted by Chad Seewagen on Bronx Zoo property adjacent to the river and point counts conducted by NRG in the Bronx River Forest. Other lists of Bronx River birds have been generated through sightings by Chrissy Word at Drew Garden, the Bronx River Crew, NRG, the Bronx River BioBlitz and others. Although not formal studies, these latter sightings form an important data set of birds that have historically appeared in the Bronx River watershed.

Current condition: FAIR

The current bird community along the Bronx River is representative of an urbanized system. The number of resident species is lower than in less-developed riparian areas and forest interior species and species that are sensitive to habitat degradation are rare. More than 80 species have been observed along the Bronx River corridor throughout the year, but the resident community is dominated by generalist species.

Though described as fair overall with regard to its avian community, the Bronx River's small forest fragments do serve as habitat for breeding pairs of a diverse array of native birds. These species use the Bronx River for the range of habitat that it provides. By protecting existing fragments of habitat, these common species should remain common.

5

OPPORTUNITIES + RECOMMENDATIONS

IDENTIFYING OPPORTUNITIES FOR CHANGE

This plan aims to identify ways to:

1. Protect and improve water quality.

2. Protect and improve aquatic and riparian plant and animal biological diversity and habitat.

3. Mitigate environmental factors that stress the river ecosystem.

The previous chapter named a number of objectives to improve the physical, chemical and biological conditions of the Bronx River. This chapter describes opportunities to influence the environmental conditions along the river that will directly or indirectly help move towards achieving these ecological objectives.

Many agencies, organizations and individuals already participate in protecting and improving the health of the Bronx River (see APPENDIX L: Partner List). Each of these parties is considered a stakeholder in the Bronx River. Management and restoration strategies require the cooperation of many stakeholders to achieve successful outcomes that will enhance ecosystem function, wildlife habitat and water quality in a sustainable way. With consideration to known past and present work on the river, the following recommendations identify planned and potential projects and/or management techniques that are a priority for Bronx River stakeholders.

TABLE V.1 provides an overview of the types of opportunities that arise from particular ecological problems. In most cases, there are multiple ways to reduce an environmental stressor or increase the health of an ecological parameter. For example, poor water quality can and should be addressed through storm water management, erosion control, and native riparian vegetation restoration. End of the pipe regulation is neither sufficient nor preferred. Similarly, many of the techniques listed as opportunities address multiple problems. This general list of opportunities encompasses most of the ecological strategies and actions that factor into this plan's specific recommended actions.

TABLE V.1: Ecological Improvement Opportunities	
PROBLEM	**OPPORTUNITIES**
Water Quality	**Storm water management** • Reduce nutrient, fecal and other pollutant input from CSOs • Increase infiltration, retention and storage of storm water **Sediment control** • Identify and control upstream and in-channel sediment sources **Native vegetation restoration** • Increase native riparian vegetation for shade and biofiltration **Aquatic habitat enhancement** • Increase habitat for native filtering organisms in estuary
Hydrology	**Floodplain connection** • Reconstruct banks to maximize connection to floodplain • Reclaim floodplain where possible to accept flood flows **Storm water management** • Reduce impervious areas on banks and in floodplains to maximize storage, roughness and retention • Maximize storm water capture, infiltration, retention and storage in watershed, which can decrease peak flow volume and frequency **Native vegetation restoration** • Increase vegetation in watershed to maximize storage and retention
Channel Stability and In-stream Habitat	**Channel and floodplain restoration** • Reconstruct or restore banks to allow re-connection to floodplain **Sediment control** • Identify and control upstream and in-channel sediment sources • Install roughness features to promote side bar deposition and narrowing of low-flow channel **Native vegetation restoration** • Manage LWD recruitment and anchoring in channel • Use bioengineering for bank stabilization • Plant inundation tolerant species on lower bank **Aquatic habitat enhancement** • Install cover structures where needed • Create passage to reduce fragmentation of habitat
Vegetation and Riparian Habitat	**Native vegetation restoration** • Plant native species tolerant of altered soil and hydrology, and capable of competing with exotic invasives • Include invasive species management and maintenance in all planting projects • Manage upstream and upper watershed invasive species • Reduce transport of invasive species (i.e. via fill material) • Review project designs to ensure native species utilized • Use local plants suited for bioengineering harvest and propogation

APPROACH AND TYPES OF OPPORTUNITIES

The previous table presented the types of opportunities for addressing certain ecological problems. Within each opportunity, various types of actions can be taken. Stormwater management, for example, can mean installation of a discrete bioretention project, working towards a change in city-wide storm water control policies or educating property owners about the benefits of installing green roofs. Each of these different types of actions is defined below.

Projects

Habitat restoration, planting, bank stabilization or other environmental improvement projects These in-the-ground projects are aimed at improving habitat by planting native vegetation, removing invasive plants, stabilizing banks, and creating in-stream or other habitat structures. Successful habitat restoration projects require careful planning, design, and sustained management.

To ensure effective removal of invasive species, native vegetation should be chosen on a site-specific basis to accommodate soil and hydrologic conditions and out-compete invasive vegetation (see APPENDIX D for guide to native vegetation). Similarly, bank stabilization techniques should address a sufficient area upstream and downstream of eroded areas to ensure that erosive force of flow is not displaced to an adjacent area. Due to the complexity of natural systems, an appropriate specialist (i.e. forester, hydrologist, environmental engineer, etc) should advise on all restoration plans. Adaptive management and sustained maintenance are often necessary for project success.

Storm water management retrofits Storm water control methods, referred to here as storm water retrofits, capture water though various retention, detention and infiltration structures throughout the watershed. Some examples are green roofs, rain gardens, disconnected rain gutter downspouts, swales and detention ponds. Since the effect of each individual retrofit is relatively small, it is recommended that they be implemented wherever and whenever possible throughout the watershed.

The storm water infiltration and detention achieved through widespread implementation of storm water retrofits in the watershed can help improve water quality and in-stream habitat in the river and provide several additional environmental benefits. Short descriptions of some of these methods may be found below; however proper design and implementation requires a somewhat complex site-specific analysis of hydrology, soils, and infrastructure.

- **Rain garden/Bioretention:** a clustered planting of flood tolerant species placed strategically where storm water collects
- **Greenstreet:** vegetation planted in street median or traffic/parking lot island; ideally, these plantings are recessed below the grade of surrounding impervious surfaces with strategically placed curb cuts that allow maximum flow of water to the area; Greenstreets can calm traffic and provide shade to reduce fuel volitalization. NYC Parks oversees the design and maintenance of most Greenstreets throughout the city and is now incorporating storm water capture into all new designs (Gunther, 2006).
- **Green roof:** a vegetated rooftop containing a porous medium such as soil that can support vegetation and has an increased water holding capacity over traditional rooftops, resulting in less water flowing into the combined sewer system; green roofs typically last twice as long as conventional roofs, saving money and materials
- **Disconnected downspout:** redirection of a rooftop's downspout from an underground pipe to irrigation system for nearby gardens and green spaces, either directly or using storage techniques like rain barrels

- **Swale:** a long narrow depression that can vary in depth and vegetation type; swales retain water following a rainfall event; swales and are generally used along roadways and in combination with other storm water systems
- **Detention ponds/wetlands:** store and treat storm water; sediment and particulates settle out and plants absorb nutrients and pollutants
- **Storm water infiltration basins:** built with loose porous material to maximize retention and infiltration, thus using the soil as a filter to treat storm water

In addition to controlling storm water runoff, the vegetation that many of these methods employ creates habitat for wildlife, increases green space for community use and decreases the urban heat island effect. The additional ecological, social and health benefits of these storm water management techniques are numerous and should be included in any cost-benefit analysis of their implementation.

Management and maintenance

Infrastructure maintenance This includes maintenance of debris-catching devices, LWD jams, or blockages, swales, parking lots, storm drains and CSO traps to ensure proper function. Maintenance activities of the Bronx River Alliance Conservation Crew include removal of floatable debris and other garbage directly from the banks and river channel.

Natural resource management This covers maintenance and management of newly planted vegetation including invasive plant management, irrigation, protection from vandalism, and erosion control on trails, banks and hill slopes. In both the river channel and forested areas, habitat enhancing structures, like LWD, must be managed as well. As discussed earlier, project success often depends on sustained maintenance. Natural resource management will continue in parkland along the river through the work of the Bronx River Alliance Conservation Crew and NRG.

Regulation enforcement

Certain federal, state and city policies exist to protect the health of the river and the environment in general. Organizations such as the U.S. Environmental Protection Agency, New York State Department of Environmental Conservation, New York City Department of Environmental Protection, New York City Department of Parks and Recreation and others must be held accountable for ensuring that rules and regulations are followed within each of their jurisdictions. Some examples of the types of activities prohibited or regulated are:

- Dumping solid materials or fluids
- Sediment and erosion control at construction sites
- Destructive recreation such as motor biking
- Pet waste management
- Non-permitted sewer discharges that discharge coliform and other pollutants

Alliance partners and other Bronx River advocates can promote enforcement by reporting pollution and environmentally harmful activities using a spill protocol (available at http://www.bronxriver.org/whatWeDoEcol.cfm) and by following up on these reports with the regulating agencies to make sure that the offenders as well as regulators are held accountable.

A more detailed discussion of specific rules and regulations will appear in the Intermunicipal Bronx River Watershed Management Plan being developed by the Bronx River Alliance, NYC Parks and Westchester County Planning with support of the NYS Department of State (scheduled for early 2007 completion).

Planning and design review

As other planning efforts and projects move forward, including the Bronx River Greenway and the ACOE Bronx River Ecosystem Study, the Bronx River Alliance will work to ensure that capital construction projects and restoration activities that take place within the watershed incorporate sound ecological principles into their designs. Whenever possible, the Ecology Team will review project plans and encourage the use of sustainable materials, storm water capture techniques, native vegetation and the protection of sensitive natural areas. The Ecology Team will encourage designers to use available sustainable construction guidelines such as those put forth by Department of Design and Construction (DDC) (Brown et. al. 2005). See APPENDIX J for design objectives and guidelines.

Policy/agency coordination

Many agencies and groups engage in direct and regulatory activities along the river that can have both positive and negative impacts on the health of the river. Therefore, it is important that the Bronx River Alliance (especially the Ecology Team) work with these agencies and influence their direction as much as possible to ensure the most ecologically beneficial outcomes.

Monitoring and research

The Alliance and its partners are still a long way from fully understanding the complex dynamics of the Bronx River watershed, how it functions and how best to protect and restore it. Further research into existing conditions and processes will yield an improved understanding of the problems and offer more opportunities to develop effective solutions.

After implementation, project success and ecosystem improvement can best be determined by monitoring the immediate project area or measuring changes within the river that reflect the cumulative results of many separate projects. Monitoring is an overall recommendation — specific methodologies will be referenced in Plan Implementation and Maintenance.

Outreach

The Bronx River's urban surroundings affect every aspect of its ecological health. Through their trash disposal, construction projects, water usage and political choices, the people living within the watershed determine the health of the river as much as the scientists and practitioners that implement projects along the river corridor. In turn, the river has the potential to positively impact these communities through its scenic beauty and value as an educational, recreational, environmental and economic resource.

Ecological improvement efforts will be most effective and sustainable if pursued in communities and with the support of community members. Therefore, in addition to agency coordination, community outreach and coordination should be included in every ecological restoration study or project.

RECOMMENDED ACTIONS

Primary Recommendations

Primary recommendations are actions that are considered highly feasible, address identified ecological concerns, have a strong chance of getting funding, do not require significant funding to initiate, or can be implemented within three to five years assuming available funding and resources as well as community or agency commitment. The previous sections provide an explanation of the watershed's problems and a description of the types of activities that will improve watershed health. This table lists specific recommended actions. See FIGURE V.1 for locations indicated in "ID #" column.

TABLE V.2a: Projects

Recommendation	Location	ID #	Implementing Agencies
Install in-stream cover to improve habitat conditions and riparian function	Between 233rd St. and Bronx River Parkway	1	NYC DPR, BxRA
Control invasive species, install woody plants, remove bank armor	a. Muskrat Cove b. Woodlawn c. east side Shoelace Park	2a-c*	NYC DPR, BxRA
Manage storm water flow, erosion control, hill slope re-vegetation to combat erosion and non-point source pollution	a. 219th St. in Shoelace Park b. 211th St.	3a-b*	NYC DPR, BxRA
Stabilize and re-vegetate banks, develop appropriate vegetation and construction management approaches with MTA and DOT for pruning and herbicide usage	Metro North Railroad in Bronx River Forest near 207th St.	4	NYS DOT, MTA, NYC DPR, BxRA
Design and construct fish passage for dams blocking anadromous fish access to freshwater reaches	a. NYBG Snuff Mill dam b. Zoo double dam c. 182nd St. Dam	5a-c	WCS/Bronx, NYBG, NOAA, NYCDPR, BxRA
Construct storm water retrofit in Zoo parking lot during renovation to prevent untreated storm water from draining into river	Bronx Zoo at East entrance	6*	WCS/Bronx Zoo
Install in-stream cover and construct bank to support riparian vegetation on west bank	River Park at 180th St.	7	NYC DPR NRG
Restore woody riparian vegetation and cover during greenway construction and plant understory with native vegetation	Bronx River Park at 179th St.	8	NYC DPR
Restore salt marsh restoration to increase biological productivity on previously hardened shorelines	a. Starlight Park b. Concrete Plant c. Lafayette Avenue d. Soundview Park lagoons	9a-d	NYC DPR, ACOE, NYS DOT, BxRA
Install green roofs and disconnect downspout	a. YMPJ, b. BRAC, and watershed-wide	10a-b	YMPJ, BRAC
Restore/create shellfish habitat to increase the populations of these water quality enhancing organisms	River channel adjacent to: a. Concrete Plant b. Soundview Park c. Hugo Neu	11a-c	NYC DPR, Gaia Institute

*Site identified during CWP workshop

TABLE V.2b: Management and Maintenance			
Recommendation	**Location**	**ID #**	**Implementing Agencies**
Control invasive species in and adjacent to planting sites, focusing on exotic vine and knotweed removal	a. Muskrat Cove b. Woodlawn c. east side Shoelace Park d. Concrete Plant e. Soundview f. Drew Gardens	12a-f	NYC DPR, BxRA, Phipps CDC
Strategically cable LWD to banks, remove floatable garbage and excess small woody debris from LWD jams, prune LWD and snags to promote smaller jams and prevent trapping of floatable garbage	a. Muskrat Cove b. Woodlawn c. east side Shoelace Park d. Bronx River Forest	13a-c	NYC DPR, BxRA
Develop bioengineering plant material harvest sites as sources of native vegetation for plantings	a. Shoelace Park b. Bronx Forest	14a-b	NYC DPR NRG, BxRA, Community Organizations
Increase garbage collection, invasive plant control (dense stands can encourage illicit activity) and planting protection	West Farms from Tremont Ave to 180th St.	15	BxRA, NYC DPR
Maintain DEP trash boom	River channel adjacent to Concrete Plant Park	16	NYC DEP
Manage river corridor—trash removal, woody debris management, invasives control, and bank stabilization. Bronx River Alliance Crew work plans should comply with Ecological Principles (See APPENDIX J) and be based on recommendtions set forth in this plan	All parkland bordering Bronx River	n/a	BxRA, NYC DPR

TABLE V.2c: Regulation Enforcement			
Recommendation	**Location**	**ID #**	**Implementing Agencies**
Improve regulation of small industry and maintenance operations to reduce illegal discharges	Watershed-wide	n/a	NYS DEC, NYS OAG, NYC/DPR, BxRA, NYC DEP
Identify sources and enforce controls at storm water outfalls to reduce water quality degradation at storm water outfalls	Watershed-wide (i.e. Nereid Ave. Bridge, Muskrat Cove, between 233rd St. and Bronx River Parkway)	n/a	NYC/DPR, BxRA, NYC DEP, NYSOAG, City of Yonkers, Westchester County
Apply spill protocol whenever spills/dumping activities are reported	Watershed-wide	n/a	BxRA, NYC DPR, NYS DEC, NYC DEP, Bronx River Stewards and other volunteers

*Site identified during CWP workshop

TABLE V.2d: Planning and Design Review			
Recommendation	**Location**	**ID #**	**Implementing Agencies**
Follow construction guidelines and guidelines for ecological performance for greenway projects as directed by the Bronx River Greenway Plan	Watershed-wide (Bx)	n/a	NYS DOT, BxRA, NYC DPR
Produce construction guidelines for storm water capture and incorporate in construction permit process	Watershed-wide (Bx)	n/a	NYC DPR, NYCDOT, NYC DEP
Develop intermunicipal watershed plan (Westchester and Bronx Counties) to better protect and improve river and watershed health through regulations, projects, maintenance, and management.	Watershed-wide	n/a	NYC DPR, BxRA, Westchester County Planning Department, NYS DOS
Remediate Starlight Park soil contamination (DNAPL tar, VOCs, and SVOCs) from former manufactured gas plant through removal of tar and contaminated soils.	Starlight Park	17	Con Edison, NYC DPR, NYS DEC, DOH, BxRA, YMPJ
Adhere to Ecological Principles (see APPENDIX J)	Watershed-wide	n/a	NYS DOT, NYC DPR, BxRA

TABLE V.2e: Policy/Agency Coordination			
Recommendation	**Location**	**ID #**	**Implementing Agencies**
Develop incentives and procedures to educate and promote pollution prevention and storm water capture practices among business and property owners, designers, engineers and contractors.	Watershed-wide (Bx)	n/a	NYC DPR, BxRA, NYC DEP, NYS DOT, NYC DOT, NYS DOS NYS DEC
Communicate regularly with ACOE, NYC DEP, NYS DEC, Con Edison, Westchester County, NYC Soil Survey and NYC DPR in order to provide Bronx River community with current information on plans affecting the river	Watershed-wide	n/a	BxRA and community partners

*Site identified during CWP workshop

TABLE V.2f: Monitoring and Research			
Recommendation	**Location**	**ID #**	**Implementing Agencies**
Encourage DEP to replicate Owls Head, Brooklyn study on cost-effectiveness and feasibility of low- impact development (LID) as a means of reducing combined sewer overflows	Watershed-wide (Bx), or localized study in a sub-sewershed	n/a	NYC DEP, NYC DPR, BxRA
Continue and expand DO and bacteria monitoring	Watershed-wide	n/a	NYC DEP, ACOE, BxRA, Bronx River Stewards, community volunteers
Study wildlife, vegetation and hydrology of the watershed through targeted data collection and watershed-wide studies	Watershed-wide	n/a	NRG, BxRA, ACOE, NYC DEP, Gaia Institute, Lehman College, other academic institutions
Provide technical and training support to volunteer water quality monitors who act as watchdogs for the river	Monitoring stations along the entire river	n/a	BxRA, Bronx River Stewards, other volunteers

TABLE V.2g: Outreach			
Recommendation	**Location**	**ID #**	**Implementing Agencies**
Schedule timely scoping meetings for community members to allow opportunity for comment on major construction projects happening along the river. Also provide educational/volunteer opportunities to share restoration projects and concepts	Watershed-wide (Bx)	n/a	NYC DPR, BxRA, NYS DOT, ACOE, NYC DEP, all other Alliance partners
Provide outreach, education and training about native fish populations, historical extent and restoration potential • Help monitor stocked fish • Fish field trips to active passage site • Help with USFW or DEC monitoring • Oyster gardening • Water quality monitoring	Watershed-wide (Bx) with downstream focus	n/a	NYC DPR, BxRA, RTB, Gaia Institute, Lehman College, SSB, YMPJ and other Alliance partners
Develop website which links to all public data on water quality, fisheries, soils, monitoring programs and restoration projects including data dictionary	Watershed-wide (Bx)	n/a	NYC DPR, BxRA
Provide technical and regulatory education as well as technical training and support to maximize use of storm water retro-fits, green roofs and point and non-point source pollution controls	Watershed-wide (Bx)	n/a	NYC DPR, BxRA, NYC DEP, NYS DEC
Incorporate storm water information into educational materials; visit green roofs and other storm water retrofits with students and community partners; work with volunteers to stencil storm drains	Watershed-wide (Bx)	n/a	BxRA, community partners

*Site identified during CWP workshop

FIGURE V.1:

PRIMARY RECOMMENDATIONS

Numbered locations on this map correspond to primary reccommendations listed in Table V.2. Actions listed as watershed-wide are those that should be pursued wherever possible throughout the watershed.

Site Specific Actions

1. In-stream cover installation
2. Invasive species control, riverbank enhancement
3. Stormwater flow management
4. Riverbank rehabilitation, development of appropriate management approaches
5. Fish passage design, construction
6. Stormwater flow management
7. In-stream cover installation, bank construction
8. Vegetation enhancement
9. Salt marsh restoration
10. Green roofs
11. Shellfish restoration
12. Invasive species control
13. Large woody debris stabilization
14. Plant material harvest site development
15. Garbage collection, invasive species control, planting protection
16. Maintain DEP trash boom
17. Remediate Starlight Park contamination

Watershed-wide Actions

- Manage river corridor
- Improve regulation of illegal discharges
- Identify pollution sources and enforce regulation
- Apply Spill Protocol
- Use Greenway construction guidelines
- Produce specific stormwater capture construction guidelines
- Develop Intermunicipal Watershed Plan
- Adhere to Ecological Principles
- Develop incentives and procedures to promote pollution prevention and stormwater capture
- Coordinate with relevant agencies
- Study cost-effectiveness and feasibility of low-impact development (LID) as a means of reducing CSOs
- Continue dissolved oxygen monitoring
- Study river's wildlife, vegetation and hydrology
- Train and support water quality monitors
- Schedule timely public scoping meetings
- Provide education and training about Bronx River history and environment
- Develop website with public data
- Provide technical information on BMPs
- Provide education on storm water

Table V.3: Secondary Recommendations

Secondary recommendations are actions that address identified ecological concerns, but would be difficult to implement within three to five years due to current lack of funds or funding prospects, project location on private land or lack of community and agency commitment. See FIGURE V.2 for locations.

TABLE V.3a: Projects

Recommendation	Location	ID #	Implementing Agencies
Green Corridor Project: Create below-grade aquifers on Lafayette Avenue	Lafayette Ave. and Edgewater Road	1*	NYC DEP, Gaia Institute
Control erosion and enhance trail to combat creation of desire lines	Shoelace Park	2	NYC DPR, BxRA
Use storm water retrofits within major institutions and agencies	a. West Farms Bus Depot b. Fordham University c. Ranaqua d-h. NYCHA i. Snuff Mill Rd. j. Bronx Zoo	3a-j	MTA, NYC DEP, Fordham University, NYCHA, NYBG, Bronx Zoo
Construct wetland for storm water capture in large areas of under-developed parkland	Soundview Park	4	NYC DPR, BxRA
Restore salt marsh and enhance adjacent vegetation	Adjacent to Bazzini Nut Company piers	5	NYC EDC, NYC DEP, NYC DPR, BxRA
Create greenway/vegetation buffer between shoreline and commercial/industrial uses	Hunts Point Food Market shoreline	6	NYC EDC, NYC DPR, BxRA, SSB, The Point, community organizations

TABLE V.3b: Management And Maintenance

Recommendation	Location	ID #	Implementing Agencies
Control invasive plant in riparian areas dominated by exotic invasive vegetation. Japanese knotweed at upstream end of NYBG and purple loosestrife in depositional bars in Bronx Zoo's southern impoundment	a. NYBG, b,c. Bronx Zoo	7a-c	NYBG, WCS
Manage invasive vegetation and maintain storm water retrofits	SDOT Greenway Segment: a. Starlight Park b. new parkland on east bank	8a-b	NYC DPR, BxRA

TABLE V.3c: Regulation Enforcement

Recommendation	Location	ID #	Implementing Agencies
Improve/enforce regulation of sediment control at construction sites throughout the upland areas to reduce sediment loads to the river.	Watershed-wide		NYS DEC, NYC DEP

*Site identified during CWP workshop

TABLE V.3d: Monitoring and research			
Recommendation	**Location**	**ID #**	**Implementing Agencies**
Fund and encourage university graduate students/researchers and other local experts to conduct surveys of various wildlife living in or migrating through the river corridor	Watershed-wide		BxRA, Community organizations, educational institutions, researchers

TABLE V.3e: Outreach			
Recommendation	**Location**	**ID #**	**Implementing Agencies**
Share environmental improvement strategies with landowners and land managers	Watershed-wide, especially: a. Fordham University, b. WCS, c. NYBG, d. Ranaqua, e. NYCHA, f. Montefiore, g. MTA		BxRA, Community Organizations, NYC EDC, NYC DPR

*Site identified during CWP workshop

FIGURE V.2:

SECONDARY RECOMMENDATIONS

Site Specific Actions

1. Green Corridor with below-grade aquifer
2. Erosion control, train enhancement
3. Stormwater retrofits
4. Wetland construction for stormwater capture
5. Salt marsh and adjacent vegetation enhancement
6. Greenway/vegetation buffer easement
7. Invasive species control
8. Invasive species control, stormwater management

Watershed-wide Actions

- Upland sediment control
- Wildlife surveys, research
- Upland stormwater control

Numbered locations on this map correspond to secondary reccommendations listed in Table V.3. Actions listed as watershed-wide are those that should be pursued throughout the watershed.

RECOMMENDATION SUMMARY

The recommended actions presented in the previous tables should serve as a guide for restoration work along the Bronx River and throughout the watershed, and are not intended as complete descriptions of the work required. These actions may also have to be adapted over time to reflect new information, completed tasks, and changing conditions. Specific design guidelines and protocols for some of these actions can be found in APPENDICES D, I + J. The guidelines are not comprehensive, however, and thorough research and consultation with experts should take place before undertaking any new or complex project.

Implementing agencies listed for each recommendation are those groups that have either expressed interest in similar actions, or those who would are likely to be involved. This suggests neither the preclusion of additional groups nor the requisite participation of those listed. Implementation and maintenance of this plan are discussed in the next section.

6

PLAN IMPLEMENTATION + MAINTENANCE

The goals, information and recommendations presented in this plan provide the rationale and framework for ecological improvement and protection of the Bronx River and its watershed. Publishing this document is only one step towards the plan's implementation. Realizing the recommended actions set forth requires cooperation and hard work among many Bronx River Alliance partners (see APPENDIX L for a complete list). Projects require funding and coordination with implementing organizations to move forward. In addition, project success is dependent upon the continued support of many partners to carry out maintenance and monitoring.

After implementation, most of the recommended actions in this plan, whether ecological restoration, storm water management or policy change, will require maintenance or continued support. Monitoring plans should be developed with each new project. Guidelines for this process are listed in APPENDIX K.

This document must grow and change as the needs and conditions of the Bronx River change. It will serve as a foundation for plans to come such as the Bronx/Westchester Intermunicipal Bronx River Watershed Plan, which will formalize coordination between Bronx and Westchester Counties on improvement and protection of the river.

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GLOSSARY + ACRONYMS

GLOSSARY

accretion: continual deposition of sediments in the riverbed or on banks

anadromous: going from salt water to fresh water to spawn

armored banks: banks lined with a blanket of rock or fill material that touches the river's edge; armoring prevents water from scouring the banks at the expense of also excluding biological productivity on shorelines

bankfull: where stream water just begins to overflow into the active floodplain

base flow: rate of discharge in a stream where only the throughflow and groundwater flow from subsurface aquifers contribute to the overall flow.

bar: coarse grained deposit of sediment from a stream; often separated from the shore by water and more mobile, growing or shrinking with floods

bedforms: structures that are molded on river bed where deposition is taking place

benthic: living on or associated with the bottom of a water body

best management practice (BMP): technique, measure or structural control that is used to manage the quantity and improve the quality of storm water runoff in the most cost-effective manner. BMPs can be either engineered and constructed systems that improve the quality and/or control the quantity of runoff such as detention ponds and constructed wetlands, or institutional, education or pollution prevention practices designed to limit the generation of storm water runoff or reduce the amounts of pollutants contained in the runoff

BioBlitz: a speedy census, conducted in 24 hours, of all animal and plant life in a given area

bioretention: utilizes soils and both woody and herbaceous plants to both remove pollutants from storm water runoff and to retain the water

catadromous: going from fresh water to salt water to spawn

channelized: the artificial enlargement or realignment of a stream channel

coliform: a family of bacteria common in soils, plants and animals, one group of which is fecal coliform

combined sewer: a sewer system that carries sanitary waste and storm water runoff together; can be overloaded during storms, causing raw sewage and excess runoff to be discharged into nearby waterways through combined sewer overflows (CSOs)

curb cut: a break in a continuous curb that allows storm water runoff to flow into a catchment or vegetation area containing soil or another porous medium

desire line: an informal path that pedestrians prefer to take to get from one location to another rather than using a sidewalk or other official route; desire lines can exacerbate erosion and result in trampled vegetation

diadromous: migrating between fresh and salt water

downstream: in the direction of a stream or river's current toward the sea

embeddedness: the degree to which the larger substrate (gravel, cobbles or boulders) on a river bed is buried in fine sediment

entitation: the mapping of vegetation types as homogeneous "entities" using a set of generalized plant communities based on structure (tree, shrub, herb) and dominant species

estuary: the tidal portion of a river where the freshwater enters into a sound, bay or the sea and mixes with salty sea water

exotic species: a species not native to the region (arriving after major settlement in the US)

flat: a level landform composed of unconsolidated sediments—usually mud or sand. Flats are generally continuous with the shore

floatables: floating debris including both street litter (paper, plastics, bottles, etc.) and toilet-generated waste such as hygiene products

floodplain: the flat area adjacent to the channel constructed by the river and overflowed at a recurrence interval of about two years or less.

floodprone width: stream width at the height of twice the maximum bankfull depth

focal species: species that are used as indicators when measuring the impacts of restoration or managmeent activities

frugivore: fruit eater

green roof: a rooftop containing a porous medium such as soil that can support vegetation and has an increased water holding capacity over traditional rooftops

greenway: bike and pedestrian walkway along/within parkland or other open green space

herbivore: plant eater

herps: a contraction for herpetofauna, specifically toads, frogs, salamanders, lizards, snakes and turtles

impoundment: the portion of a river upstream of a dam that tends to be wider than the free-flowing river, and have slower moving water like a pond or lake

Indices of Biological Integrity: a method for describing water quality using characteristics of aquatic communities, such as the types of fish and invertebrates found in the water body; it is expressed as a numerical value between 0 (lowest quality) to 100 (highest quality)

insectivore: insect eater

interstitial: volume between granules of soil or sediment that provides habitat for benthic organisms

invasive species: an organism that is so reproductively successful and aggressive that it can dominate an area, often to the point of becoming a monoculture; it interferes seriously with the natural functioning and diversity of the system where it becomes established

large woody debris: large tree parts, generally at least ten centimeters in diameter and two meters long that have fallen into streams; these pieces can become lodged into a stream bed or banks creating stable structures that help grade controls, scour pools and create cover and habitat for aquatic organisms.

low-impact development: landscape planning and design aimed at maximizing green space, natural soils, and on-site storm water retention utilizing best management practices such as uniformly distributed decentralized micro-scale storm water controls

macroinvertebrate: animal without a backbone usually in a nymph or larval stage; the quantity and diversity of macroinvertebrates provide an indication of the health of a stream system

morphology: characteristics, configuration and evolution of land forms, specifically the river channel in this plan

native species: animals or plants that originated and naturally occur in the area in which they are found

neotropical migrant: bird that nests in temperate regions and migrates to the Neotropical faunal region, which includes the West Indies, Mexico, Central America, and that part of South America within the tropics

periphyton: algae and associated microorganisms growing attached to any submerged surface

point bar: bar deposit that is normally located on the inside of a channel bend

reach: stretch of water visible between bends in a river; or a certain expanse of river

resident species: animals that live in a region year-round

riffle: the shallow, faster flowing section of a stream, where the water surface is broken as it flows over gravel or cobble substrate; shoals or sandbars wholly or partly submerged beneath the water surface; a stretch of choppy water caused by such a shoal or sandbar; a rapid

ripple: the shallow section of a sand-bedded stream, where the water surface is broken into waves by the presence of a shoal or sandbar; a rapid

river mile: the number of miles measured upstream along the course of a river beginning with zero at the mouth of the river

roughness: features that obstruct or create resistance to the downstream movement of water in a channel, including cobbles, boulders, bank irregularities, live and dead vegetation, and other obstructions to flow

salt marsh: a community of organisms in low-lying coastal habitats composed of plants tolerant of tidal inundation and salinity

sewershed: region of a city served by a particular sewer system or waste treatment plant

shellfish: any aquatic animal with a shell, especially mollusks or crustaceans

species richness: the number of species (usually by groups such as birds or mammals) in any given area

storm water: water that accumulates on land as a result of storms, and can include runoff from urban areas such as roads and roofs

understory: the low-growing vegetation (shrubs, seedlings, saplings, small trees) growing under the tree canopy or overstory

upstream: direction opposite a stream or river's current

watershed: region of land where water from rain or snowmelt drains downhill into a body of water, such as a river; the drainage basin includes both the streams and rivers that convey the water as well as the land surfaces from which water drains into those channelsarea drained by a river and its tributaries

wetland: an area that is periodically or permanently saturated with water, and in which plants and animals are uniquely adapted to wet conditions; wetlands are extremely biologically productive and perform a wide variety of important ecological functions

ACRONYMS USED

ACOE	Army Corps of Engineers (U.S.)
BMP	best management practice
BRAC	Bronx River Art Center
BxRA	Bronx River Alliance
CDC	Community Development Corporation
cfs	cubic feet per second
CSO	Combined Sewer Overflow (or Outfall)
DNAPL	dense non-aqueous phase liquid
DO	dissolved oxygen
DOH	Department of Health
LWD	large woody debris
EPA	Environmental Protection Agency (U.S)
MGP	Manufactured Gas Plant
NOAA	National Oceanic and Atmospheric Administration
NRG	Natural Resources Group (NYC Parks)
NYC DPR	New York City Department of Parks and Recreation
NYC DEP	New York City Department of Environmental Protection
NYC EDC	New York City Economic Development Corporation
NYCHA	New York City Housing Authority
NYS DEC	New York State Department of Environmental Conservation
NYS DOS	New York State Department of State
NYS DOT	New York State Department of Transportation
NYBG	New York Botanical Garden
OAG	Office of the Attorney General (New York State)
RTB	Rocking the Boat
SSB	Sustainable South Bronx
SVOC	semi-volatile organic compound
SWCD	Soil and Water Conservation District (NYC)
TMDL	Total Maximum Daily Load
USGS	United State Geological Survey
WCS	Wildlife Conservation Society
VOC	volatile organic compound
YMPJ	Youth Ministries for Peace and Justice

APPENDICES

Appendices A through L can be found on the web at http://www.bronxriver.org/plans