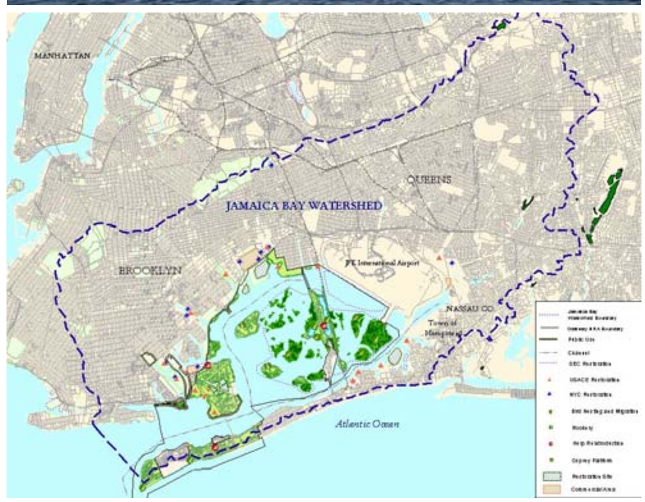


Jamaica Bay Watershed Protection Plan
Volume II – The Plan

New York City Department of Environmental Protection
Emily Lloyd, Commissioner
October 1, 2007

www.nyc.gov/dep

CHAPTER ONE

WHAT IS WATERSHED PLANNING

WATERSHED PLANNING AND JAMAICA BAY

Watershed planning recognizes the interconnection between land and water, that much of what we do on a parcel of land makes its way to our waterways, bays, and ocean. It is complex because a watershed plan is not just a series of actions to be taken, but it is also a process. To be successful, it must involve the participation of people with different perspectives and priorities. It also requires ridding ourselves of age-old habits and creating a vision that motivates the community to change.

The *Jamaica Bay Watershed Protection Plan* strives to create awareness of the issues facing the Bay; develop comprehensive planning strategies to benefit the Bay and its watershed; and serve as a template for the future. It is intended to serve as a vision for what strategies could be used, and describes necessary implementation steps for a process to accomplish the vision for a sustainable Jamaica Bay.

Given the complexity of the issues facing Jamaica Bay, this *Jamaica Bay Watershed Protection Plan* does not provide solutions to all of the issues facing the Bay, but rather makes recommendations for certain actions and provides a guide for the next phase forward in this planning effort. Differing views on specific strategies and changes in priority or even approach are expected to occur as this is a living document that will need to be modified to adjust to the successes and new information and technologies that will undoubtedly arise over time, as well as ongoing dialogue. The highest priority of this *Jamaica Bay Watershed Protection Plan* is to guide the ongoing planning process.

ISSUES COMMON TO WATERSHED PLANNING PROCESSES

The preceding volume of this document provides context for the *Jamaica Bay Watershed Protection Plan*. It summarizes the history of Jamaica Bay to the present, identifies key issues and problems, and describes the programs that have occurred or are presently underway to improve water quality, ecological, and human use conditions in the watershed. Taking what is learned from Volume 1, there are several major themes that can be identified:

1. Environmental conditions in the Jamaica Bay are affected by the human population within the watershed. As population increases, so does the stress on natural resources.

2. There is a need to further improve water quality, ecology, and human uses.

3. Issues facing the Bay and its watershed are interrelated and call for a coordinated approach. Implementation of the *Jamaica Bay Watershed Protection Plan* requires coordination among public agencies, environmental organizations, residents, businesses, and stakeholders.

These themes are not unique to Jamaica Bay; indeed other estuaries throughout New York Harbor and the United States are grappling with similar problems. Fortunately, there are many success stories to guide the process.

THE WATERSHED PLANNING APPROACH

This *Jamaica Bay Watershed Protection Plan* adopts a "watershed planning approach" towards management of environmental resources. Because watershed planning has become a buzz-word and can be understood in different ways, it is necessary to define it. An excellent definition has been provided by the Maine Department of Environmental Protection, which defines watershed planning as:

"…[A]n approach to protecting water quality and quantity that focuses on a whole watershed. This is a departure from the traditional approach of managing individual wastewater discharges, and is necessary due to the nature of polluted runoff, which in most watersheds is the biggest contributor to water pollution. Polluted runoff is caused by a variety of land use activities, including development, transportation, agriculture and forestry, and may originate anywhere in the watershed. Due to its diffuse nature, polluted runoff has not been effectively managed through regulatory programs alone. Watershed planning and management involve a number of activities, including: targeting priority problems in a watershed; promoting a high level of involvement by interested and affected parties; developing solutions to problems through the use of the expertise and authority of multiple agencies and organizations; and measuring success through monitoring and other data gathering." (MEDEP, 2006).

The watershed planning approach has been implemented in dozens of estuaries in the United States that have become progressively more degraded from urban development. Chesapeake Bay, San Francisco Bay, and Galveston Bay are examples of this style of comprehensive water quality and ecosystem management planning. In fact, many of these watershed management planning documents were reviewed as the *Jamaica Bay Watershed Protection Plan* was being developed.

The *Jamaica Bay Watershed Protection Plan* adopts the watershed management planning framework that is intended to overcome the hurdles of a potentially disjointed planning process by:

1. Offering a process and a common vision (rooted in ecosystem function and sustainability) to coordinate relevant water quality improvement and ecosystem restoration efforts and allow input from all stakeholders in the watershed.
2. Providing detailed management strategies that specifically address the key issues affecting the Bay.
3. Ensuring that implementation strategies and frameworks are identified so the *Jamaica Bay Watershed Protection Plan* does not "sit on the shelf."
4. Providing a framework to steer future land use planning decisions to ensure the long-term sustainability of environmental health in the watershed.
5. Building flexibility into the management actions and the prioritization process, allowing management strategies to respond to new information and changing conditions.

Let's get started.

REFERENCES

Maine Department of Environmental Protection (MEDEP), Bureau of Land and Water Quality. March 2006. http://www.state.me.us/dep/blwq/watersh.htm

CHAPTER TWO

PLANNING FRAMEWORK

THE PLANNING PROCESS FOR JAMAICA BAY

The Planning Framework used to create the *Jamaica Bay Watershed Protection Plan* starts with a shared, long-term vision. To accomplish this vision, a number of steps have been or will need to be undertaken:

- Identify and categorize the issues facing the Bay including those that are widely known and discussed as well as any that surfaced during the compilation of *Volume 1: Jamaica Bay Watershed Regional Profile*.
- Formulate a comprehensive list of objectives for each set of Jamaica Bay and watershed issues.
- Then, identify management strategies and implementation actions to address the objective.

Ultimately, the development and refinement of these management strategies will be the road map for attaining the future vision of a healthy, sustainable Jamaica Bay.

The management strategies to address Jamaica Bay and watershed concerns are recognized as the key elements of this *Jamaica Bay Watershed Protection Plan*. The strategies are intended to shape the future management of the Bay and its watershed and, accordingly, will be monitored and adapted in the future based on feedback from the Bay's ecological system. The management strategies included in this *Jamaica Bay Watershed Protection Plan* have been evaluated based on environmental, technical and economic feasibility per Local Law (LL71).

There were several important considerations in the development of this *Jamaica Bay Watershed Protection Plan* regarding form and format. It is imperative that the document be well organized and readable; that it be understandable and not overwhelmed by technical jargon. At the same time, it is a critical planning document that will inform future choices; therefore, accuracy and detail are key. It is our hope that the *Jamaica Bay Watershed Protection Plan* is approachable by technical specialists and the general public alike.

The City of New York through the New York City Department of Environmental Protection (NYCDEP) and other City agencies, the federal government through the National Park Service (NPS) and other federal agencies, and New York State through the New York State Department of Environmental Conservation (NYSDEC) and other state departments, have been making considerable efforts to improve the water quality of Jamaica Bay. These City, state and federal agencies are taking steps to protect and restore the Bay's ecological systems and are studying further options to improve the ecological values of the Bay's watershed. Additionally, non-governmental organizations, community groups, and individuals have dedicated countless hours to improve conditions in the Bay and its watershed, and to encourage others to take up that cause. Their combined energies and resources have had a positive effect over the last two decades after the depredations of the previous century. The *Jamaica Bay Watershed Protection Plan* attempts to capture the current projects and initiatives of governmental and non-governmental organizations whose actions have positively impacted the future of Jamaica Bay.

> ***"We do not inherit the earth from our ancestors, we borrow it from our children."***
> ***- Native American Proverb***

An important step in the development of this *Jamaica Bay Watershed Protection Plan* has been the inclusion of stakeholders in the process. Through the activities of the Jamaica Bay Watershed Protection Plan Advisory Committee (the Advisory Committee), and public meetings and workshops held by the NYCDEP, the public has had the opportunity to provide input during the development of the *Jamaica Bay Watershed Protection Plan*. The public commented on key issues, potential management strategies, and suggested outcomes. Thus, the Plan conforms to the stated criteria of a stakeholder-driven management process. Fundamental to the nature of a watershed planning process as well as critical to the ultimate implementation of the *Jamaica Bay Watershed Protection Plan*, this collaborative process will be continued during the implementation phases.

ORGANIZATION OF THE PLAN

The *Jamaica Bay Watershed Protection Plan* is organized into two volumes. *Volume 1: Jamaica Bay Watershed Regional Profile* provides the context within which this *Jamaica Bay Watershed Protection Plan* has been developed. Volume 1 contains the history of Jamaica Bay, the key issues currently affecting the Bay, and current management efforts. This volume, *Volume 2: Jamaica Bay Watershed Protection Plan*, provides the vision, objectives, and management strategies for the *Jamaica Bay Watershed Protection Plan*. These volumes are designed to be stand-alone documents, yet work together for a complete understanding of the current conditions of Jamaica Bay and the future management of its watershed.

Volume I, *Jamaica Bay Watershed Regional Profile,* has several purposes. It is intended to be a comprehensive reference document for Jamaica Bay and provides information needed to identify issues of concern that face the Bay. Volume I sets the stage for the development of management strategies to address these issues, which are provided in this Volume 2.

Volume 2 is intended to serve as a blueprint for the future management of the Bay and its watershed to achieve a shared vision for Jamaica Bay. Therefore, Volume 2 starts with a vision for the Bay and issues that need to be overcome to achieve that vision. For each issue, objectives for the Bay were set, and for each objective, management strategies are identified to address the objective. This *Jamaica Bay Watershed Protection Plan* also documents the steps that will need to be undertaken to implement each recommended Management Strategy. Volume 2 includes:

- An introduction to watershed planning concepts (Chapter 1)
- The framework for the *Jamaica Bay Watershed Protection Plan* including the vision, issues identification, objectives, and management strategies (Chapter 2)
- Objectives, Management Strategies, Evaluation, and Implementation Strategies to address six categories:
  - Category 1: Water Quality (Chapter 3)
  - Category 2: Restoration Ecology (Chapter 4)

  - Category 3: Stormwater Management through Sound Land Use (Chapter 5)
  - Category 4: Public Education and Outreach (Chapter 6)
  - Category 5: Public Use and Enjoyment (Chapter 7)
  - Category 6: Implementation and Coordination (Chapter 8)

- Strategies for Future Consideration (Chapter 9)

THE VISION FOR JAMAICA BAY

The *Jamaica Bay Watershed Protection Plan* begins with a shared long-term vision of what a future Jamaica Bay could be:

The Jamaica Bay watershed is a place where New Yorkers and visitors co-exist with natural areas and clean water that harbor healthy waterfowl, fish, and shellfish populations. It is a place where urban communities embrace environmental stewardship and where wetlands and other natural areas are protected and restored for future generations. The Jamaica Bay estuary is once again a cultural and recreational hub for Brooklyn and Queens, where residents swim, fish, boat, and enjoy nature.

The above vision statement was created early in the planning process, based on discussions between NYCDEP and the Advisory Committee about what a future Jamaica Bay could be to direct and coordinate water quality improvement and ecosystem restoration efforts. The vision was developed to support the planning process and help identify the most appropriate and effective objectives and management strategies.

ISSUES IDENTIFICATION

The Key Issues

To achieve the *Vision for Jamaica Bay*, the *Jamaica Bay Watershed Protection Plan* must address five key issues facing the watershed. These issues, as identified in Volume 1, are:

- Water Quality;
- Ecology;
- Land Use and Development;
- Public Education and Outreach; and.
- Public Access, Open Space, and Recreation.

A summary of each of these issues is provided below. For a full description of each, see its applicable chapter in Volume 1, *Jamaica Bay Watershed Regional Profile.*

Water Quality

The water quality of Jamaica Bay and its tributaries has degraded over time. Impairments to water quality in the Bay can be attributed to several factors:

- Increasing human populations in Brooklyn, Queens, and Rockaway and the associated increase in human waste products (in terms of sewage and solid wastes).

- Increasing volumes of surface runoff as a result of urban development and the spread of impervious surfaces.
- Landfill operations displacing freshwater wetlands in the upper watershed and tidal wetlands in the estuary, impeding natural wetland filtration processes and altering tidal circulation patterns.
- The continuing westward extension of the Rockaway Spit, which may be contributing to the lack of circulation and mixing of Bay waters in the estuary.
- Dredging operations in the Jamaica Bay estuary, which have increased the bathymetric depth of the Bay and resulted in a decrease in circulation and mixing.

NYCDEP has a number of programs in place to upgrade the wastewater treatment plants that discharge into the watershed and to address combined sewer overflow (CSO) discharges. Current programs and additional measures under consideration to address water quality issues are discussed in Volume 2, Chapter 3, *Water Quality.*

Ecology

Impairment and loss of ecosystem function in the Jamaica Bay watershed has occurred since New York City expanded into Brooklyn and Queens at the turn of the 20th century. The primary drivers of ecosystem disturbance are:

- Direct displacement and fragmentation of habitat by residential, commercial, industrial, and transportation infrastructure.
- Landfilling of ecologically sensitive areas, especially tidal wetlands around the perimeter of the Jamaica Bay estuary and freshwater wetlands and riparian areas in the upper watershed.
- The introduction of invasive exotic flora and fauna into the watershed, which can prey on or out-compete the native species for available resources.
- Degraded water quality (discussed above) in marine and brackish environments that can lead to direct and indirect health problems for aquatic organisms.
- Changing climate patterns, which has a myriad of effects (many of them poorly understood or unforeseen) on ecosystems in the Jamaica Bay watershed.

NYCDEP is implementing a number of Jamaica Bay restoration projects including restoration of three landfills and a large wetland restoration effort in Idlewild Park. A number of public and private entities are also undertaking projects to restore environmental features and ecological functions including the joint restoration project at the Elders Point Salt Marsh Islands by NYCDEP, U.S. Army Corps of Engineers (USACE), NY/NJ Port Authority (Port Authority), NYSDEC, Natural Resource Conservation Service (NRCS), and NY/NJ Harbor Estuary Program (HEP). Current programs and additional measures under consideration to promote ecological restoration and enhancements are discussed in Volume 2, Chapter 4, *Restoration Ecology*.

Land Use and Development

Transportation, and residential, commercial, and industrial development patterns running along the perimeter of the Jamaica Bay estuary make it difficult for neighboring communities to access the Bay.

While private boating access is available, public boating access is very limited. Additionally, public access to fishing, hiking, bird watching, and swimming is only available in portions of the Bay.

A number of planning proposals develop options for amenities for and access to Jamaica Bay. Current programs and additional measures under consideration to address public access are discussed in Volume 2, Chapter 7, *Public Use and Enjoyment*.

Public Access, Open Space, and Recreation

Since 1636, when the first Dutch settlers began to populate the areas now known as Brooklyn and Queens, drastic alterations have occurred within the Jamaica Bay watershed. The primary mechanisms of transformation have been directly or indirectly related to human disturbance. Urban development, with the associated residential, commercial, industrial, and transportation infrastructure, has had a direct impact on water quality in the receiving waters of the Jamaica Bay estuary. The health of upland, wetland and estuarine ecosystems has resulted in impaired uses of the local environment. The primary impact of urbanizing environments – the covering of soils with impervious concrete and asphalt surfaces – decreases ground water infiltration, while increasing the volume and rate of stormwater runoff.

NYCDEP has a number of programs in place to address on-site stormwater runoff and is working with other agencies to provide greater stormwater control. Current programs and additional measures under consideration to address land use and development are discussed in Volume 2, Chapter 5, *Stormwater Management through Sound Land Use and Development*.

Public Education and Outreach

The physical barriers to the Bay, combined with extensive urban development, have disconnected the Bay from those who live in its watershed. Several water quality and ecological issues can be attributed to a lack of public awareness about the Bay, its current conditions, and related impacts of human activities. The public can help improve the Bay's condition through many options, such as conserving water, landscaping yards with native or noninvasive species, and participating in beach clean-ups. Education and outreach programs exist to increase the visibility of Jamaica Bay, yet one challenge is coordinating the many entities to effectively target or reach the diverse population groups – public officials, property owners, business owners, school children, etc. – throughout the watershed.

As mentioned, governmental agencies, non-governmental organizations and educators have programs to increase public awareness and stewardship through outreach and education activities. Current programs and additional measures under consideration to promote education and outreach are discussed in Volume 2, Chapter 6, *Public Education and Outreach.*

OBJECTIVES

As touched upon in the introductory text for this chapter, for each of the five issue categories, a set of achievable and relevant Objectives has been identified to address the issue. The five categories and their respective Objectives are listed below:

Category 1: Water Quality

- Objective 1a: Reduce nitrogen loading to the tributary basins and Jamaica Bay.

- Objective 1b: Reduce CSO and other discharges into the tributary basins to improve pathogen and DO levels.
- Objective 1c: Increase dissolved oxygen levels in tributary basin areas of chronic hypoxia to improve ecological productivity.
- Objective 1d: Develop a robust and coordinated scientific monitoring program.

Category 2: Restoration Ecology

- Objective 2a: Restore the salt marsh islands in Jamaica Bay.
- Objective 2b: Preserve and enhance natural areas along periphery of the Bay and watershed.

Category 3: Stormwater Management through Sound Land Use

- Objective 3a: Promote the use of on-site Best Management Practices in new and existing development.
- Objective 3b: Promote the use of off-site stormwater Best Management Practices.

Category 4: Public Education and Outreach

- Objective 4a: Raise awareness of Jamaica Bay's Unique Assets and Challenges.

Category 5: Public Use and Enjoyment

- Objective 5a: Increase public access to Jamaica Bay.
- Objective 5b: Improve public access to a wider range of landscape types in the upper watershed in order to expand the public's understanding of the entire Jamaica Bay watershed.

MANAGEMENT AND IMPLEMENTATION STRATEGIES

Overview

For each Objective, individual Management Strategies define a set of actions. The development and refinement of these management strategies is the proposed road map for attaining the future vision of a healthy, sustainable Jamaica Bay.

Chapters 3 through 7 are each dedicated to one of the 5 issues categories. Each chapter presents Objectives, related Current Programs, and Management Strategies. Each Management Strategy is described and evaluated; recommendations are made to select promising strategies; and implementation steps for recommended strategies are identified along with cost and schedule information where available.

Interrelationship Between Strategies

Although the management strategies are placed into one of five categories in this *Jamaica Bay Watershed Protection Plan*, it is important to recognize that many of the strategies within the categories are interdependent. For example, objectives and strategies related to wetlands, buffers, fish, and wildlife comprise Chapter 4, *Restoration Ecology* due to the direct interconnections between these types of restoration projects and expected impacts. However, the strategies identified in Chapter

4 are also expected to have a direct positive impact on the Bay's water quality, which is addressed in Chapter 3, *Water Quality*. This is common across all categories of issues, objectives, and strategies where the expected benefits of specific strategies transcend more than one issue.

The key issues and the interrelationships between the sources of perturbation, the resulting stressors, ecosystem effects, and human use impacts are further illustrated in the Ecosystem Model (Figure 2.1) developed as part of this planning process. This diagram displays the cause and effect of various disturbances that historically or presently occur in the Jamaica Bay watershed, detailing how natural and human-influenced processes have altered the environment. It is hierarchical in organization, meaning that the higher up in the diagram an element is located, the greater range of influence it has over other factors. For instance, the "sources" are ultimately the root causes of alteration, which lead to a series of environmental "stressors." If a "source" of alteration is mitigated, then the "stressor" will ultimately disappear. "Stressors" influence ecosystem elements, triggering an "ecosystem response." Finally, changes to the ecosystem influence the "human uses" of the landscape, which feed directly back to the original driver of perturbation, urbanization and landscape alteration.

Advisory Committee Recommendations

Many Management Strategies provided in Chapters 3 through 7 closely match the preliminary recommendations of the Advisory Committee submitted to the City Council and NYCDEP on June 29, 2006 and the recommendations of the Advisory Committee's response to the March 1, 2007 Draft Plan submitted in June 2007. As a result of an integrated process between NYCDEP, the Advisory Committee, and the stewards of Jamaica Bay, many Management Strategies contained in this *Jamaica Bay Watershed Protection Plan* were developed through communications with the Advisory Committee and the public, or the case may be that their recommendation was consistent with NYCDEP's approach for actions necessary to improve the Bay and its watershed.

NYCDEP generally supports the Advisory Committee's recommendations that promote Jamaica Bay as a natural and recreational resource for New York City. However, despite a robust capital investment program, the NYCDEP's budget for capital investments is not limitless and there are many competing needs for these funds citywide. These dollars must be carefully programmed for drinking water protection, infrastructure repair and maintenance, as well as for water quality protection of all the City's waterways.

Several of the Advisory Committee's recommendations are also outside of NYCDEP's authority or mission. For many of these recommendations, NYCDEP recognizes the direct benefits to the Bay that these strategies offer and will continue to work with other agencies and entities to pursue them. However, other City, state and federal agencies experience similar levels of financial responsibility to program limited funds throughout the City. Therefore, their support for projects must be considered in the context of other agency mandates.

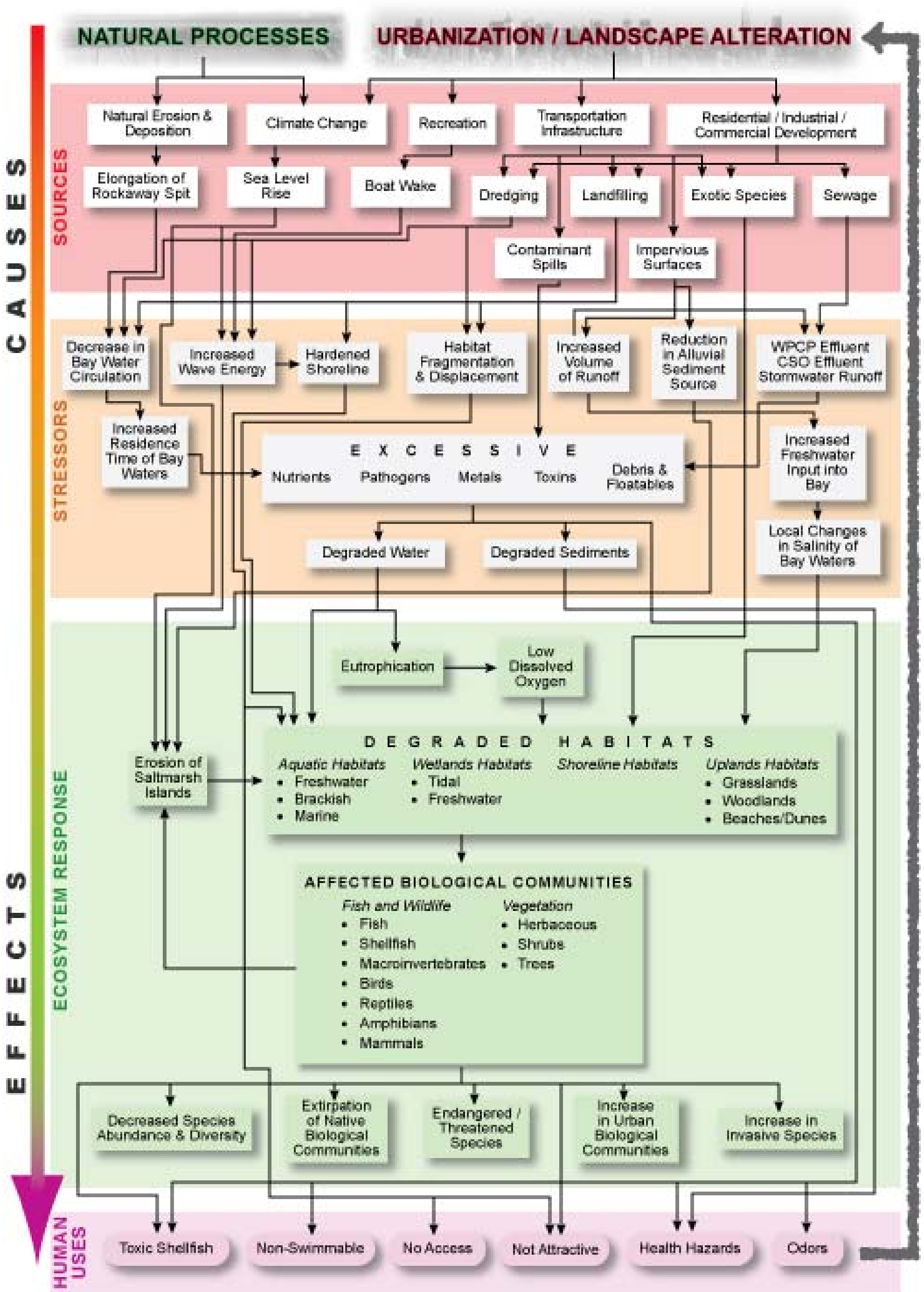


FIGURE 2.1. Jamaica Bay Watershed Ecosystem Model; Source: Biohabitats

This diagram helps to explain interrelationships between ecosystem elements as well as provide a tool for evaluating recommendations intended to alleviate the sources and stressors associated with ecosystem and human use impacts.

Plan Framework's Relationship to Local Law 71

In 2005, the New York City Council took up the challenge of protecting Jamaica Bay and its watershed – on June 30, 2005 it passed by a vote of 50-0 LL 71 of 2005 "To amend the administrative code of the city of New York, in relation to a watershed protection plan for the watershed/sewershed of Jamaica Bay." This is the first substantive legislation at a governmental level for a watershed approach to the protection of Jamaica Bay.

LL 71 required that several points be addressed as part of the process of preparing this *Jamaica Bay Watershed Protection Plan*, or be included in it. First, LL 71 requires in Subdivision (b) that: "The commissioner shall assess the technical, legal, environmental and economical feasibility of including the following measures, at a minimum, in the plan…" The noted measures and their respective locations in this *Jamaica Bay Watershed Protection Plan* are summarized in Table 2.1.

TABLE 2.1 Local Law 71 Elements and the *Jamaica Bay Watershed Protection Plan*

Required Measure	Specific Item	Category in Plan
"(1) best management practices for the minimization and control of soil erosion and stormwater runoff and reduction of both point and non-point source pollution, including, but not limited to, the promotion of development practices such as…"	"on-site detention and infiltration of stormwater runoff"	Water Quality and Land Use (see Chapter 3 and 5)
	"the minimization of impervious surfaces"	Land Use (see Chapter 5)
	"the creation of natural systems to control and minimize stormwater runoff"	Water Quality and Land Use (see Chapter 3 and 5)
"(2) measures to address threats to aquatic habitat, including, but not limited to…"	"stabilizing and restoring salt marshes, wetlands, soils and other natural areas"	Restoration Ecology (see Chapter 4)
	"strengthening ecological buffers"	Restoration Ecology (see Chapter 4)
	"restoring natural features to Jamaica bay watershed/sewershed shoreline"	Restoration Ecology (see Chapter 4)
	"reestablishing water flows"	Restoration Ecology and Land Use (see Chapters 4 and 5)
"(3) land use acquisition and land use planning practices and opportunities, including, but not limited to"	"incentives, such as expedited permitting and property tax relief, for infill, brownfield redevelopment and other environmentally beneficial development"	Restoration Ecology and Land Use (see Chapters 4 and 5)
	"disincentives, such as stricter development guidelines, for development that may adversely impact Jamaica bay"	Land Use (see Chapter 5)
"(4) a protocol for coordination with appropriate federal, state and city governmental entities that have jurisdiction over the Jamaica bay area, with respect to, but not limited to…"	"efforts to restore and maintain the water quality and ecological integrity of Jamaica bay"	Water Quality, Restoration Ecology, and Implementation and Coordination (see Chapters 3, 4 and 8)

TABLE 2.1 Local Law 71 Elements and the *Jamaica Bay Watershed Protection Plan*

Required Measure	Specific Item	Category in Plan
	"notification regarding proposed development projects within the Jamaica bay watershed/sewershed that may adversely impact Jamaica bay"	Land Use and Implementation and Coordination (see Chapters 5 and 8)
"(5) a protocol for coordination with the office of environmental coordination…"		Land Use and Implementation and Coordination (see Chapters 5 and 8)
"(6) a public education program, including, but not limited to programs for schools, developers, commercial facilities, civic groups and other local organizations and entities to	"increase awareness about the ecological significance and degradation of Jamaica bay"	Public Education and Outreach (see Chapter 6)
	"restoration and watershed stewardship activities undertaken by the department and others involving Jamaica bay"	Restoration Ecology and Public Education and Outreach (see Chapters 4 and 6)
	"methods and practices to reduce pollution in Jamaica bay"	Water Quality, Land Use and Public Education and Outreach (see Chapters 3, 5, and 6)
"(7) a program to target enforcement efforts that will help reduce polluting behaviors and operations that may adversely impact Jamaica bay"		Implementation and Coordination (Chapter 8)

C H A P T E R   T H R E E

CATEGORY 1, WATER QUALITY

INTRODUCTION AND ISSUES IDENTIFICATION

Jamaica Bay is one of the largest tidal and most important wetland complexes in New York State. It is located on the Atlantic Coastal Flyway bird migration route and provides ample resources for food and shelter for at least 325 bird species, 91 species of fish and 54 species of moths and butterflies. Jamaica Bay remains a vibrant local and regional ecological resource in spite of the many significant biological physical and chemical changes to the Bay and its watershed over the last 150 years. Listed below are some of the more important physical and chemical changes that have occurred:

- Over 12,000 acres of the original 16,000 acres of wetlands within Jamaica Bay have been lost due to filling operations.
- Natural shallow waterways of approximately 12 ft to 20 ft have been dredged to depths of 40 ft to 50 ft in some locations to allow for navigation needs and to provide fill material for upland development projects. An estimated 125 million cubic yards of sand have been removed from the Bay.
- Tidal exchange with the Atlantic Ocean has been altered by the filling of inlet connections to the ocean in the southeastern portion of the Rockaway Peninsula (Sommerville Basin – "Gateway to the Atlantic") and constriction of the western end due to the natural extension of the western spit by nearly 16,000 ft (three miles) over the last 125 years.
- Receives approximately 259 million gallons per day (Fiscal Year 2006) of treated effluent from the four wastewater treatment plants responsible for treating sanitary waste from almost two million people in the drainage area. This treated effluent is responsible for contributing a large portion of the nitrogen loading into Jamaica Bay.
- Significant alterations to natural features of watershed have resulted from the replacement of natural areas with expanses of impervious surfaces. This reduces the natural attenuation of stormwater and upland pollutants which would normally occur through transpiration, biogeochemical processes and soil storage.
- Hardened shorelines around the perimeter of Jamaica Bay prevent natural inland migration of marshes and the input of upland sediment.

These changes have resulted in water quality changes including aesthetically displeasing periodic algal blooms, depressed dissolved oxygen (DO) levels during the summer months in select areas of the Bay (from nutrient enrichment and poor tidal flushing), and possibly the preclusion of the minimum environmental conditions required for additional ecosystem diversity and recruitment, such as the return of submerged aquatic vegetation (SAV), including eel grass (*Zostera marina)*. However, in spite of these changes, Jamaica Bay remains a vital ecological "powerhouse" that is unrivaled by any other regional natural resource. To help reduce some of the negative attributes of these often irreversible alterations and to help improve the ecological integrity and biodiversity that will lead to more suitable habitat conditions for natural biological regeneration and sustainability, the *Jamaica Bay Watershed Protection Plan* (JBWPP) has identified potential management strategies that focus on: 1) Water Quality, 2) Restoration Ecology, 3) Public Use and Enjoyment, 4) Sound Land Use and Development, 5) Public Education and Outreach and 6) Coordination and Implementation. While this chapter focuses on Water Quality, all the strategies do not operate and cannot be thought of in isolation to one another, but rather synergistically interacting with one another to provide a more sustainable environment.

One of the ways to determine the health of a waterbody is to measure the amount of DO within the water column. Healthy waterbodies typically have dissolved oxygen greater than 5.0 milligrams per liter (mg/l) at all times to support adequate environmental conditions for all developmental stages of aquatic life. Although hypoxia can occur naturally, lower levels of DO can suggest that some type of pollution, altered physical properties and currents, and/or excess nutrients is affecting the ecosystem. Overall, mobile adult aquatic life forms are more tolerant of lower DO levels on a temporary basis, but larval and juvenile stages that are dependent upon tidal circulation for movement are more sensitive to lower DO levels.

Healthy Waters ≥ 5.0 mg/l
Hypoxia (Less than 2.0 mg/l)
Severe Hypoxia (0.2 mg/l – 2.0 mg/l)
Anoxia (0 mg/l - 0.2 mg/l)

To date, much of the focus and research of the NYCDEP, the NYSDEC and others to determine the environmental health of Jamaica Bay has primarily centered on meeting the required DO standards of the Bay and its tributaries. While this is a critical determining factor, the complexity and challenges of meeting the required DO levels in specific highly physically altered geographic regions of the Bay (*i.e.*, Grassy Bay and North Channel) potentially excludes from consideration the improvement to other valuable habitats through the reduction of chlorophyll and dissolved inorganic nitrogen (DIN) levels within select areas of Jamaica Bay. Grassy Bay and North Channel represents a relatively small surface area of the Bay (approximately 12 percent). The remaining 88 percent of the Bay has demonstrated improved ecological health, as demonstrated by increased biological diversity.

Jamaica Bay is classified by the NYSDEC as Class SB saline surface waters. Class SB applies to the open waters of Jamaica Bay, Shellbank Creek, Gerritsen Creek and Mill and East Basins. The remaining tributaries of Jamaica Bay; Shellbank Basin, Fresh Creek, Hendrix Creek, Spring Creek, Bergen Basin, and Thurston Basin are classified as Class I. The best usages of Class SB waters are primary and secondary contact recreation and fishing. These waters are also suitable for fish propagation and survival. Class I waters are best suited for secondary contact recreation (*i.e.*, boating) and fishing. The current DO standards for SB and I waters are 5.0 mg/l and 4.0 mg/l, respectively. Certain areas of Jamaica Bay such as Grassy Bay, North Channel and the tributaries, do not consistently meet these standards, particularly in the bottom waters and during the summer months.

TABLE 3.1. New York State Water Classifications Best Use

Class	Usage	DO (mg/l)
SA	Shellfishing for market purposes, primary and secondary contact recreation, fishing. Suitable for fish propagation and survival.	≥ 5.0
SB	Primary and secondary contact recreation, fishing. Suitable for fish propagation and survival.	≥ 5.0
I	Secondary contact recreation fishing. Suitable for fish propagation and survival.	≥ 4.0

The nitrogen loading sources to Jamaica Bay and their respective percentages on an annual basis can be summarized as follows:

- Water Pollution Control Plants (WPCPs) (95%);
- Combined sewer overflows (1.1%);
- Stormwater runoff (1.2%);
- Atmospheric deposition (1.2%); and
- Landfills (1.4%).

Water quality sampling and water quality models have shown that Jamaica Bay is a eutrophic system, a system that contains excess nutrients, typically in the form of nitrogen. However, in spite of this, water quality indicators (*e.g.*, DO) suggest that the water quality of Jamaica Bay remains good, with the exception of seasonally-specific geographic areas, like Grassy Bay and North Channel. The eutrophication that occurs primarily results from the treated wastewater discharge of nearly two million people from four WPCPs and other sources that discharge nitrogen to the Bay. Eutrophication promotes the growth of planktonic algae. The primary macronutrients that are required for algal growth are nitrogen and phosphorus. If either nitrogen or phosphorus concentrations in the water column are low, algal growth becomes nutrient-limited. In most estuarine systems, nitrogen is typically the limiting nutrient, which means that algae typically deplete nitrogen in the water column before they deplete phosphorus. However, within Jamaica Bay, nitrogen and phosphorus are in excess and, before these can be depleted, light required for chlorophyll production becomes the limiting growth factor from high turbidity levels that reduce light transmission through the water. These excess nutrients lead to increased algal blooms that increase biological oxygen demand (BOD), reduce the DO levels, lower ecological function in limited areas, and have the potential to decrease aesthetic qualities of Jamaica Bay.

The Comprehensive Jamaica Bay Water Quality Plan (CJBWQP) demonstrated that current water quality standards for DO could not be fully attained even with the relocation of all WPCP discharges to the ocean. The primary reasons for this are the altered bathymetry of the Bay that results in changes to circulation patterns and stratification issues in the deeper portions of the Bay. Even with the relocation of all WPCP discharges, the baywide and Grassy Bay annual average for percent attainment with water quality standards is approximately 99.7% and 98.8%, respectively.

Currently, the Bay receives approximately 40,100 lb of nitrogen per day (12-month rolling average through July 2007) but is roughly estimated to only be capable of naturally assimilating approximately up to 20,000 lb of nitrogen per day. The location of the treatment plant effluent in proximity to the DO hot spots also seems to be an important consideration and, therefore, it is prudent to target nitrogen reductions at particular treatment plants (26th Ward and Jamaica WPCPs) rather than apply a uniform nitrogen reduction at all four treatment plants. The reduction of nitrogen can be expected to reduce the intensity and duration of algal blooms that result in poor water quality and reduce the overall negative qualities sometimes experienced on the Bay. Lower levels of nitrogen may also provide the potential to reintroduce important and extirpated habitats such as eel grass beds, to limited areas of Jamaica Bay. In addition to the habitat improvements, the reintroduction of eel grass would provide additional nitrogen reduction through plant uptake. Potential areas suitable for eel grass are primarily in the western and southeastern sections of the Bay where chlorophyll (a measure of nutrient enrichment) levels are lower than the eastern and northeast sections of the Bay. The water quality models suggest that additional nitrogen reductions will bring chlorophyll levels closer to the environmental conditions that permit their re-introduction.

The appropriate approach to evaluating and developing potential solutions requires a proactive position that is technically informed and is based in sound scientific principles and study. The understanding of these scientific principles and studies provides a better framework in the development of potential measures that can improve ecological productivity, minimize environmental damage and improve water quality.

While eutrophication and nutrient loadings into the Bay are key factors that impair water quality, they are not the only factors. The changes to water quality that have occurred within the Bay and its tributaries are the result of many significant alterations, including bathymetry changes, introduced WPCP and CSO discharges, hardened shorelines, and a near complete replacement of natural attenuating features within the watershed to impervious urban features and structures that significantly reduce precipitation infiltration, natural cleansing abilities and substantially increases stormwater runoff. These changes have resulted in increased nutrient loading, and altered tidal flushing patterns that would otherwise help "cleanse" the Bay of these additional loadings. The enormity and permanent nature of many of these changes makes it difficult, if not impossible to remedy the situation and certainly not always in an expeditious manner.

To advance these goals and to further improve upon existing efforts, the JBWPP has developed a number of management strategies to address the following water quality objectives:

- Objective 1A: Reduce Nitrogen Loading to the Tributary Basins and Jamaica Bay;
- Objective 1B: Reduce Combined Sewer Overflow (CSO) Loadings into Tributary Basin to Improve Pathogen and DO Levels;
- Objective 1C: Increase Dissolved Oxygen Levels in Tributary Basin Areas of Chronic Hypoxia;
- Objective 1D: Reduce Flooding Throughout the Jamaica Bay Watershed; and
- Objective 1E: Develop a Robust Scientific Monitoring Program.

The Objectives and Management Strategies discussed in this Chapter utilize sound environmental engineering construction methods, environmentally friendly and ecologically sustainable practices, and innovative techniques that will assist in reducing nitrogen loading and improving aquatic and wildlife habitats. Other strategies focus on reducing the potential for CSO events, reducing pathogen loading and improving DO levels within the tributaries. These strategies include infrastructure upgrades, cleaning sewers, and dredging within CSO tributaries to remove accumulated sediment. These efforts will not only improve water quality, but will also restore a higher quality benthic habitat. These practices are consistent with standard ecological watershed planning principles and are in agreement with many of PLANYC 2030 Water Quality Initiatives for a greener, greater New York.

OBJECTIVE 1A: REDUCE NITROGEN LOADING TO THE TRIBUTARY BASINS AND JAMAICA BAY

Current Programs

Since the early 1990s, NYCDEP has implemented a number of programs to reduce nitrogen loading and improve DO conditions within Jamaica Bay. These programs include:

- Retrofit BNR enhancements at the 26th Ward WPCP, including the addition of baffles, mixers, and froth control hoods to the aeration basins;
- Optimizing the treatment of centrate in separate aerator tanks to reduce nitrogen discharges;
- Best efforts to minimize the importation of sludge from locations outside of Jamaica Bay; and
- Ongoing Jamaica WPCP improvements.

To date, these efforts have reduced nitrogen loadings to the Bay by approximately 25 percent, with further improvements anticipated upon the completion of current upgrades and planned upgrades at the 26th Ward, and Jamaica WPCPs.

The Management Strategies below discuss additional proposals to reduce nitrogen loads to Jamaica Bay not included in previous planning efforts.

Management Strategy 1a1: Carbon addition facilities at 26th Ward and Jamaica Water Pollution Control Plants.

STRATEGY DESCRIPTION

Jamaica Bay is not alone in facing water quality issues that affect its ecological health and productivity. The Long Island Sound Study led to an agreement by the stakeholders to reduce the overall nitrogen discharges to Long Island Sound 58.5 percent from the baseline load of 106,807 pounds per day by the year 2017. The agreement establishes interim 5 and 10 year targets to measure progress. As of July 2007, the reduction of nitrogen discharges into Long Island Sound had decreased 21 percent from the high discharges of the early 1990s.

As shown in Figure 3.1 below, the reduction in total nitrogen (TN) to Jamaica Bay over a similar time period as a result of NYCDEP efforts has shown a reduction of nitrogen of 25%. The NYCDEP is currently in negotiations with the NYSDEC regarding the CJBWQP. The plan had proposed a Level II - Step Feed Biological Nutrient Removal (BNR) upgrade at both 26th Ward and Jamaica WPCPs, along with recommending some type of bathymetric restoration of the Bay that includes the efforts of all stakeholders. Based on ongoing discussions with the NYSDEC, the proposed CJBWQP will most likely be modified. The new approach will include establishing equivalency factors for all four WPCPs to help quantify specific nitrogen reduction goals for each WPCP and additional cost effective nitrogen removal alternatives including supplemental carbon addition. Jamaica Bay has its own unique issues that need to be incorporated into the final approved plan.

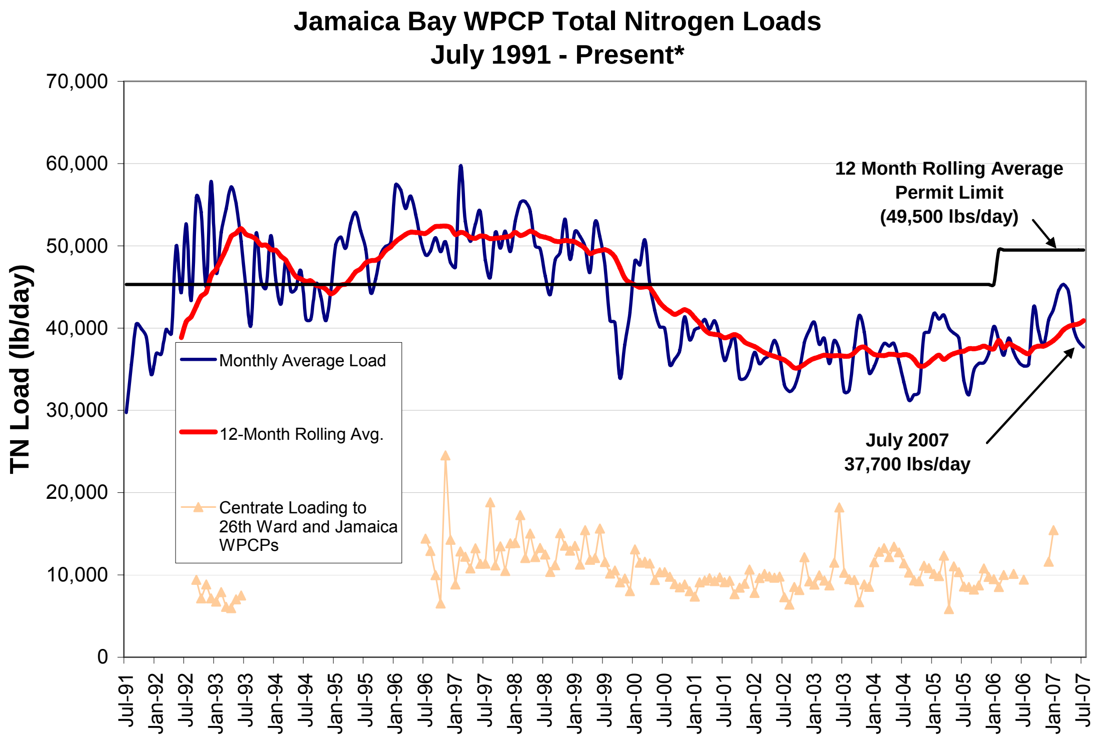


FIGURE 3.1 Summary of Jamaica Bay Nitrogen Discharges from July 1991 to July 2007
Source: NYCDEP

Prior to the finalization of these negotiations, NYCDEP is determining the feasibility of an interim supplemental carbon system at the 26th Ward WPCP that could be implemented fairly quickly in conjunction with dewatering the Jamaica WPCP sludge at the plant on a regular basis to take advantage of the existing separate centrate treatment process and interim supplemental carbon addition system.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Over the last 10 years, NYCDEP has significantly reduced nitrogen loading to Jamaica Bay, from a high of approximately 53,000 lb/day in 1996 to an average of 40,100 lb/day today. While this represents a substantial reduction in nitrogen of nearly 25 percent, it is not within the estimated natural assimilative capacity of the Bay, as evidenced by the fact that areas of the Bay still experience hypoxia and elevated concentrations of algae.

This significant reduction has improved environmental improvements within Jamaica Bay. However, water quality models seem to indicate that the further lowering of nitrogen does not necessarily provide additional substantial water quality benefits for leading water quality indicators such as DO levels.

While DO is a major focus of NYCDEP's planning efforts, this *Jamaica Bay Watershed Protection Plan* takes a broader approach in its consideration of ecosystem restoration objectives. Additional nitrogen reductions can be a precursor to the recovery and restoration of additional habitats, such as the Eastern oyster and *Zostera mariana* (eel grass) beds and can potentially slow the observed accelerating loss of salt marsh.

Based on a comparison of model output for 1) permit conditions (Baseline), 2) 2006 current conditions, and 3) 2006 current conditions with carbon addition and upgrades at Jamaica and 26th Ward WPCPs, additional nitrogen reduction appears to do little for improving DO levels.

The four NYCDEP WPCPs that discharge into Jamaica Bay currently have a 12-month rolling average TN interim permit limit of 49,500 lb TN/day to allow for construction upgrades at the 26th

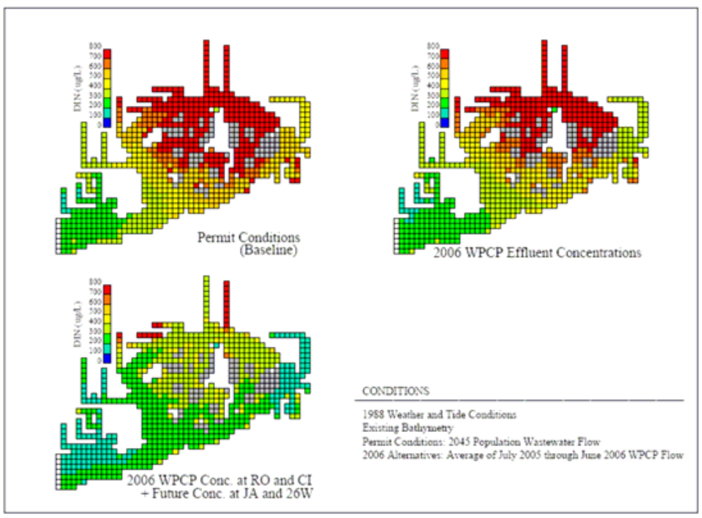
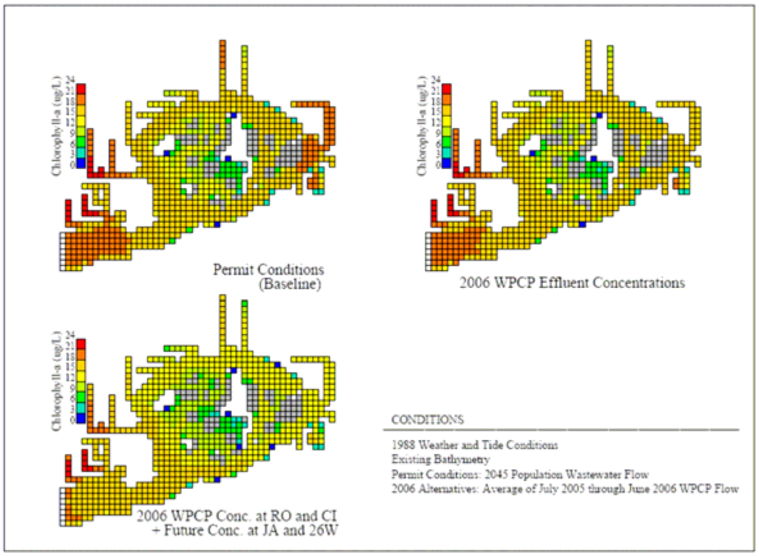


FIGURE 3.2 Baseline, Existing and Future Concentrations, Summer Average DIN (ug/L); Source HydroQual

Ward WPCP. Following completion of Contract 12 improvements to the 26th Ward WPCP, the 12-month rolling average TN permit limit will be reduced to 45,300 lb TN/day. Under current conditions, the four WPCPs discharge approximately 36,000 to 40,100 lb TN/day on an annual basis. From June 2001 through July 2007, the average TN load from the four Jamaica Bay WPCPs was approximately 37,300 lb TN/day.



Baseline, Existing and Future Conditions, Summer Average Surface Chlorophyll-a

FIGURE 3.3 Baseline, Existing and Future Conditions, Summer Average Surface Chlorophyll-a; Source: HydroQual

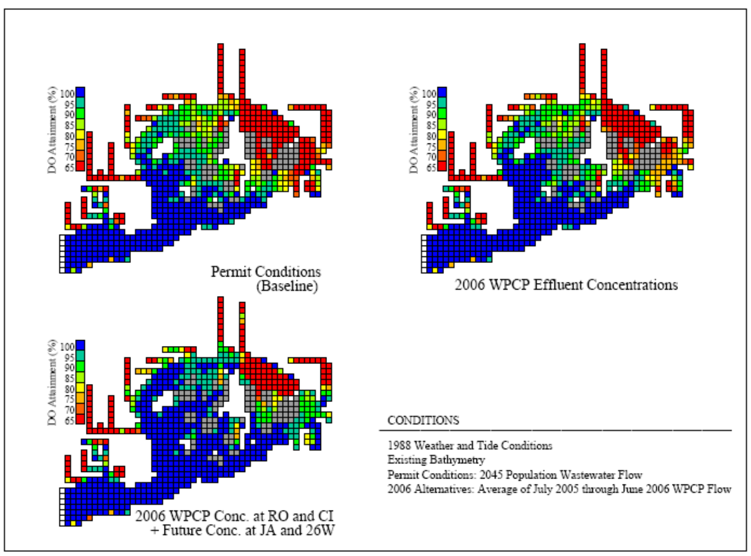


FIGURE 3.4 Baseline, Existing and Future Concentrations, Summer DO Attainment; Source: HydroQual

Table 3.2 summarizes the expected nitrogen effluent discharges from various BNR treatment alternatives. Current negotiations with the NYSDEC evaluate the different permutations of the original alternatives to determine the most cost-effective means of both reducing nitrogen to Jamaica Bay and improving dissolved oxygen and the ecosystem. One alternative currently being investigated includes incorporating carbon addition with Level II BNR at the Jamaica and 26th Ward WPCPs along with other process enhancements including optimization of the dewatering operations.

TABLE 3.2 Projected Nitrogen Concentration For Treatment Alternatives		
Scenario	**Projected TN Discharge**	**Approximate Percent Reduction from Baseline**
Baseline (1996)	17 mg/l – 26 mg/l	
Low Level Step Feed BNR	12 mg/l – 16 mg/l	34%
Mid Level Step Feed BNR	9 mg/l – 13 mg/l	48%
High Level Step Feed BNR	5 mg/l – 9 mg/l	68%
Note: Reductions in discharge are from CY 1996 and permutations of minor optimization to Mid Level Step Feed BNR with supplemental carbon addition suggest that effluent discharges similar to that of High Level Step Feed BNR may be achieved at a lower cost.		

The Jamaica Bay Eutrophication Model (JEM) was used in this analysis to assess the water quality benefits predicted from the proposal to add carbon (methanol) to the WPCP nitrogen removal process. For this scenario, the water quality model was set-up for a baseline scenario that included the following:

- 2045 WPCP flows;
- 1988 rainfall data;
- Contract 12 Upgrades at 26th Ward WPCP, Low Level Step Feed BNR at Jamaica WPCP;
- Current Grassy Bay bathymetry to remain and not be filled; and
- Paerdegat CSO retention facility operational.

Based on Jamaica Eutrophication Model (JEM) modeling, carbon addition is predicted to result in only a small improvement in attainment of the DO standard. However, this reduction is the precursor to reducing chlorophyll and DIN to levels that would reduce algal blooms, improve aesthetic qualities and increases the potential for more diverse habitats (*e.g.*, eel grass and oysters) to be restored in limited areas of the Bay. Attainment of the DO standard in Grassy Bay during the summer increases from 47.8 to 48.2 percent based on model results with this additional amount of TN removal.

The following tables present a comparison of model output for permit conditions, the 2006 current conditions and for the 2006 current conditions with upgrades at the Jamaica and 26th Ward WPCPs plus carbon addition at these two plants. Table 3.3A shows that on an annual average basis, the DO concentration declines slightly in the North Channel near Hendrix Creek, near the Marine Parkway Bridge adjacent to Rockaway, and near Beach Channel adjacent to Rockaway, while it increases slightly in Grassy Bay. This decline is associated with a small reduction in the phytoplankton biomass as is noted by the calculated reduction in chlorophyll concentrations. Most of the lower DO concentrations calculated by the model for the carbon addition scenario occur during the colder months when the DO concentration is well above the standard. The minimum DO concentration in these locations does increase, with the exception of minor decrease near the Marine Parkway Bridge. The minimum DO concentration in Grassy Bay increases significantly from the permit condition to the proposed plan.

The results in Table 3.3B show that carbon addition is more effective in reducing the water column nitrogen concentrations in these two locations. Summer TN is reduced by approximately 50 percent at one location (Beach Channel) and summer DIN is reduced by approximately 47 percent at another location (Grassy Bay) with the upgrades to the WPCPs and the additional of carbon to the treatment process. This results in a small (approximately 6-14 percent) reduction in the chlorophyll concentrations. Table 3.3C shows an even greater reduction in DIN and chlorophyll in the far eastern sections of the Bay (Thurston Basin and Head of Bay) where summer DIN is reduced by as much as 67 percent and summer chlorophyll is reduced by 15 to 20 percent.

TABLE 3.3A. Relative Change In Water Quality Parameters Due To Carbon Addition

		Outside Hendrix Creek			Grassy Bay		
		Baseline Condition	**Baseline Condition + Carbon Addition**	**Percent Change**	**Baseline Condition**	**Baseline Condition + Carbon Addition**	**Percent Change**
Annual Statistics	Average Bottom DO (mg/L)	9.92	9.88	-0.42	8.42	8.85	5.16
	Minimum Bottom DO (mg/L)	4.48	4.81	7.37	1.01	1.72	70.30
	Maximum Difference in Bottom DO from Recommended Plan [Scenario - Recommended Plan]	--	0.81		--	-1.07	
	Average Water Column DIN (mg/L)	0.49	0.27	-45.97	0.93	0.32	-65.67
	Average Water Column TN (mg/L)	1.80	1.21	-32.66	2.58	1.36	-47.28
	Average Water Column Chlorophyll-a (ug/L)	29.18	26.16	-10.34	31.71	27.93	-11.91
Weekly Average for week w/ highest Water Column Chl. a conc. in Grassy Bay (Day 71)	DIN (mg/L)	0.14	0.08	-41.91	0.53	0.09	-82.88
	TN (mg/L)	1.62	1.05	-35.08	2.46	1.28	-47.97
	Chlorophyll-a (ug/L)	58.45	41.94	-28.25	62.16	50.62	-18.56
	DO (mg/L)	12.19	12.82	5.21	11.35	13.54	19.35

TABLE 3.3B. Relative Change In Water Quality Parameters Due To Carbon Addition							
		Marine Parkway Bridge (near Rockaway)			Beach Channel (near Rockaway)		
		Baseline Condition	**Baseline Condition + Carbon Addition**	**Percent Change**	**Baseline Condition**	**Baseline Condition + Carbon Addition**	**Percent Change**
Annual Statistics	Average Bottom DO (mg/L)	9.42	9.38	-0.38	10.14	10.06	-0.76
	Minimum Bottom DO (mg/L)	6.06	6.03	-0.50	5.30	5.83	10.00
	Maximum Difference in Bottom DO from Recommended Plan [Scenario - Recommended Plan]	--	-0.32		--	-090	
	Average Water Column DIN (mg/L)	0.32	0.26	-16.94	0.37	0.18	-50.20
	Average Water Column TN (mg/L)	1.22	1.05	-14.30	1.67	1.12	-33.15
	Average Water Column Chlorophyll-a (ug/L)	22.96	21.56	-6.06	29.27	25.05	-14.41
Weekly Average for week w/ highest Water Column Chl-a conc. in Beach Channel (Day 115)	DIN (mg/L)	0.15	0.16	0.32	0.08	0.04	-49.07
	TN (mg/L)	1.21	1.06	-12.40	1.56	1.03	-34.14
	Chlorophyll-a (ug/L)	48.52	44.30	-8.71	56.85	43.09	-24.21
	DO (mg/L)	12.01	11.82	-1.62	12.10	11.41	-5.73

TABLE 3.3C. Relative Change In Water Quality Parameters Due To Carbon Addition							
		Far Rockaway (East of JFK Airport)			**Head of Bay**		
		Baseline Condition	**Baseline Condition + Carbon Addition**	**Percent Change**	**Baseline Condition**	**Baseline Condition + Carbon Addition**	**Percent Change**
Annual Statistics	Average Bottom DO (mg/L)	9.53	9.35	-1.95	9.27	9.06	-2.26
	Minimum Bottom DO (mg/L)	2.83	3.79	33.92	2.22	3.13	40.99
	Maximum Difference in Bottom DO from Recommended Plan [Scenario - Recommended Plan]	-	-1.32		-	-1.52	
	Average Water Column DIN (mg/L)	0.27	0.11	-58.73	0.22	0.10	-56.82
	Average Water Column TN (mg/L)	1.69	1.04	-38.55	1.62	1.01	-37.70
	Average Water Column Chlorophyll-a (ug/L)	29.57	22.05	-25.41	29.42	21.14	-28.14
Weekly Average for week w/ highest Water Column Chl-a conc. in Beach Channel (Day 115)	DIN (mg/L)	0.09	0.07	-23.25	0.07	0.03	-58.19
	TN (mg/L)	1.60	1.08	-32.61	1.55	1.04	-33.18
	Chlorophyll-a (ug/L)	48.96	35.88	-26.73	46.81	35.89	-23.33
	DO (mg/L)	9.76	14.36	47.16	9.51	14.40	51.44

An additional analysis was conducted to determine whether carbon addition at all four Jamaica Bay WPCPs would provide additional water quality benefits. The results of this analysis not shown herein indicate there is little if any noticeable change in the model calculations as a result of the addition of carbon at the Coney Island and Rockaway WPCPs. The NYCDEP is in the process of developing "trading ratios" demonstrating the relative impact per pound of nitrogen discharge has on the attainment of water quality standards from each of the four WPCPs in the Bay.

These and other measures, such as improved stormwater management through on-site and off-site Best Management Practices and an increase of vegetation as a result of efforts under PLANYC 2030 to plant 1 million trees throughout the City over the next 20 years, have the potential to provide cumulative environmental improvements that may not be perceptible with current modeling efforts.

Positive environmental effects that are currently not easily assessed may result from the synergy of many small important interacting improvements.

Technical

There are few technical issues associated with carbon addition. It is a proven technology that is also proposed for use at other NYCDEP WPCPs. Carbon addition involves construction of relatively small facilities which contain liquid storage system and feed systems. Methanol and/or ethanol are flammable and precautionary measures will be taken during operations. The market for supplemental carbon is volatile and is expected that alternate supplemental carbon sources will be identified and utilized as market conditions dictate.

Legal

NYCDEP currently has State Pollutant Discharge Elimination System (SPDES) permits that define the requirements relative to the minimum effluent limits for the WPCPs discharging wastewater into Jamaica Bay. Further, NYCDEP and NYSDEC have a Nitrogen Consent Order that further specifies City requirements related to effluent nitrogen from WPCPs. One requirement of this Consent Order was the mandate that NYCDEP develop a plan for improving DO levels within Jamaica Bay as they are impacted by the discharge of nitrogen. The CJBWQP was a requirement of the Consent Order. NYCDEP and NYSDEC are currently in discussions on the recommendations proposed in the CJBWQP. NYCDEP may modify the recommendations in the CJBWQP as negotiations advance.

Cost

See *Implementation Strategies* below.

RECOMMENDATION

As part of the negotiation process with NYSDEC, NYCDEP will propose carbon addition at the 26th Ward and Jamaica WPCPs as a potential strategy for further reducing nitrogen loadings to Jamaica Bay. This recommendation is subject to ongoing discussions and negotiation with NYSDEC with respect to the final approved CJBWQP. See also *Implementation Strategies* below.

IMPLEMENTATION STRATEGIES

Carbon Addition Facilities at 26th Ward and Jamaica WPCPs

As discussed above, NYCDEP will propose carbon addition at 26th Ward and Jamaica WPCPs as potential strategies to reduce nitrogen loadings as part of ongoing discussions on the CJBWQP with NYSDEC.

Schedule: To be determined based on negotiations with NYSDEC.

Cost: The incremental costs for the construction and maintenance of carbon addition facilities at the 26th Ward and Jamaica WPCPs beyond that of the existing upgrades will be developed pending negotiations with NYSDEC.

Interim Carbon Addition Facilities at 26th Ward WPCP and Reroute Jamaica WPCP Centrate Processing to 26th Ward WPCP

To implement additional nitrogen reductions in the near term, temporary carbon addition will be put in place in several aeration tanks at the 26th WPCP. Once these changes are put in place, NYCDEP will consider rerouting Jamaica WPCP centrate processing to 26th Ward WPCP to maximize the effects from the temporary carbon addition.

Schedule: To be determined, but not less than 36 to 40 months.

Cost: To be determined.

Management Strategy 1a2: Evaluate and implement alternative technologies.

STRATEGY DESCRIPTION

Algae and Sea Lettuce Harvesting

This strategy is to evaluate the potential for harvesting excess algae and sea lettuce (*Ulva lactuca*) as a limited means to reduce nitrogen, improve aesthetic qualities, and produce biofuel and byproducts (glycerol) as a potential carbon source for BNR operations. This strategy is limited to those temporal and spatial events (*e.g.,* lowest low tides and weather conditions) that enable the maximum amount of harvesting to occur from the surface without impacting existing marine organisms. The strategy will not harvest Ulva from below the surface or on the bottom of Jamaica Bay to prevent disturbance to benthic organisms. Additional information regarding these unique conditions is required before moving forward to determine the feasibility. Jamaica Bay currently experiences algae blooms on average approximately two times a year, from February through April and again in mid-August through September. The decomposition of the algae increases the BOD, lowers the DO of the water column, and creates stress for aquatic organisms.

Under favorable environmental conditions, algae can grow very rapidly. While a number of sources of bio-feedstock are currently being examined for biofuel production, algae have emerged as a promising source that requires greatly reduced energy inputs to produce when compared to agriculturally derived feedstock sources (Haag, 2007).

Sea lettuce and other types of algae grow in salt or brackish waters, particularly in those that are nutrient-rich or polluted. Nutrients enter Jamaica Bay from several sources including point sources (end-of-pipe discharges coming from municipal and industrial wastewater treatment plants), nonpoint sources (runoff), and atmospheric deposition (exhaust and emissions). When areas become overgrown with algae, DO is reduced as the algae begin to decompose and settle to the bottom of the water column.

NYCDEP is investigating the potential use of existing skimmer vessels for the purposes of piloting this strategy.

Algal Turf Scrubbers

Algal Turf Scrubbers® (ATS) are a unique wastewater treatment technology that cultures diverse, natural assemblages of benthic organisms, bacteria, and phytoplankton on an inclined flow-way and screen substrate to remove a variety of nutrients or contaminants from polluted waters (Adey *et al*., 1993; Adey *et al*., 1996). The first algal scrubbers were patterned after marine algal mats found on the surfaces of coral reefs. Later versions of ATS were found to be readily adapted to estuarine and freshwater sources with algae native to those ecosystems. The ATS process is a patented water treatment technology developed by Dr. Walter Adey and is held by the Smithsonian Institution.

For large scale applications, ATS mimics a constructed artificial stream ecosystem designed to promote algal growth as the pollutant uptake and removal mechanism which is driven by high rates of photosynthesis (Craggs *et al*., 1996). Long, slightly sloped, shallow raceways of impermeable material are stretched across the ground surface or a raised support frame and dosed with effluent in regular pulses. The use of natural sunlight is the norm for these systems and, as the seasonal photoperiod changes, so does algal productivity. Smaller systems utilize very high output lights and greenhouse structures to maintain high algal productivity and pollutant removal efficiency during non-summer seasons.

Periodic harvesting of the algal turf removes nutrients and pollutants from the system while stimulating continued algal growth and dramatically increasing algal uptake efficiencies (Adey and Loveland 1991). There is practical interest in the use of the harvested algae as fertilizer (Mulbry *et al*., 2005), a high protein feed stock for animals (Pizarro *et al*., 2006), or as a source for biodiesel production (Briggs, 2004). An additional by-product of the ATS is glycerol, which has the potential to be used an alternative carbon source at the 26th Ward and Jamaica WPCPs. A current pilot study by NYCDEP, the PO 55 Pilot Study, is evaluating alternative sources (other than methanol and ethanol) to be used as a carbon source for additional nitrogen reduction. Initial results of this study indicate that glycerol has a high potential as an alternative carbon source. The additional use of the algae as a beneficial by-product makes the treatment of wastewater with ATS potentially very cost-effective.

The ATS eco-technology has been employed for marine coral mesocosm research, groundwater contaminant removal, dairy manure waste treatment, agricultural run-off phosphorus removal, aquaculture wastewater, and municipal wastewater treatment (Adey and Hackney, 1989; Adey and Loveland, 1991; Adey *et al*., 1993; Adey *et al*., 1996). The application of these systems for the removal of water-based pollutant loads is broad, but is limited by the space required for very large hydraulic loading rates. Typically for larger hydraulic loads, such as with municipal wastewater treatment plants, only a percentage of the WPCPs total load is diverted to the ATS system to achieve a greater degree of treatment. A small percentage of the final effluent volume could be treated with ATS to provide additional nitrogen reductions beyond that expected with the implementation of carbon addition facilities at the 26th Ward and Jamaica WPCPs and provide valuable sustainable by-products.

TABLE 3.4 Algal Turf Scrubber Maximum Nitrogen Removal Efficiencies

Reference	Effluent Type	Maximum N Removal *
Craggs *et al*., 1996	Municipal Secondary Treated	1110 mg/m^2/day
Blankenship, 1997	Municipal Secondary Treated	2886 mg/m^2/day
Mulbry and Wilkie, 2001	Dairy Manure	350 mg/m^2/day
Kebede-Westhead *et al*., 2003	Dairy Manure	1330 mg/m^2/day
Pizarro *et al*., 2002	Dairy Manure	5700 mg/m^2/day

** Removal rates for water treatment systems that require area as a key component of their treatment process are commonly expressed as mg/m^2/day*

Of the above applications, municipal secondary wastewater treatment has been applied in at least two instances, one in central California and one on Maryland's eastern shore. The Maryland ATS system was implemented at a wastewater treatment plant in Fruitland, diverting 15% of the treatment plant's 500,000 gallons per day (GPD) discharge (75,000 GPD) down 10 parallel, 100 yard raceways. Inorganic nitrogen content entering the ATS was approximately 20 mg/L, with reductions reported to approximately 3-4 mg/L (Blankenship, 1997). Unfortunately, there has been little published scientific data related to its operational efficiencies. For this reason, the Patterson, California ATS system (described below) TN uptake rates are used for analyzing the potential for application at select Jamaica Bay WPCPs, given current space constraints.

The benefits and challenges of using ATS can be summarized as follows:

- Nitrogen and phosphorus uptake are driven by high rates of photosynthesis and could provide additional limited "polishing" of treated wastewater;
- Using ATS requires 3 to 5% of the land area of comparable treatment wetlands;
- Using ATS is less effective during colder months; and
- Harvested algae could be processed to produce limited quantities of biofuel.

Oyster Restoration

Oysters are known as a keystone species and an "ecosystem engineer" that has the ability to modify it environs through its life processes. A keystone species is one whose impact on its community or ecosystem is disproportionately large relative to its abundance (Paine, 1996). The oyster plays an important role in stabilizing and maintaining other species diversity within systems that support sufficient densities. They are such an important piece of the ecological puzzle that when they are removed from the environment, structures and functions of the ecosystem can become unstable, affecting overall ecological health. They serve as important filter feeders, were an important historical commercial fishery, and provide important habitat for many other commercially important species. In 1609 oyster reef habitat was so abundant (approximately 350 square miles of oyster reef habitat) within New York's coastal waterways that they often presented navigation hazards to shipping (Gaia, 2007). In addition, it is believed that 18 trillion gallons of water within Chesapeake Bay were once filtered every 3 or 4 days; this now takes approximately 1 year for the same filtering (Chesapeake Bay Foundation, 2007). The approximately 80 billion gallons of water within Jamaica Bay could have been filtered within the same time frame with the aid of oyster reef habitat. The water within Jamaica Bay could be filtered providing some treatment with the aid of oyster reef habitat.

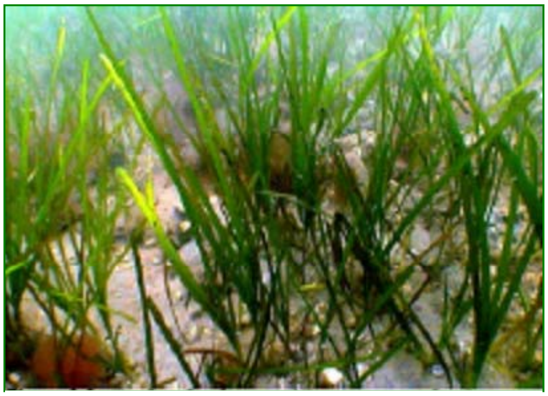
Oyster (*Crassostrea virginica*)
Source: Maryland Sea Grant

By providing clearer water (*e.g.,* fewer algae blooms) oyster reef restoration increases the potential for the successful re-introduction of the extirpated submerged aquatic vegetation eel grass (*Zostera mariana*), which is light dependent. Current water turbidity in the eastern sections of the Bay and the "head" end of all the tributaries prohibit eel grass systems and, to some degree, suppress oyster habitats from becoming a fully functional and valuable component of the Jamaica Bay ecosystem. However, western sections of Jamaica Bay and the "mouth" of several of the tributaries already satisfy oyster requirements and, with improvements in nitrogen reduction from the expected enhanced nitrogen removal at the 26th Ward and Jamaica WPCPs, these areas will be closer to meeting the requisite environmental conditions capable of supporting eel grass. The natural filtering capabilities of oysters can help remove nitrogen and suspended sediments from the water column within an eel grass bed and may provide sufficient environmental conditions to support eel grass. A single mature oyster can filter approximately 2.5 gallons per hour or 35 gallons per day and can remove, through sediment sequestration of pseudo feces, approximately 20% of the nitrogen it takes in (South Carolina Oyster Restoration and Enhancement, 2007). Although they do not occupy the same ecological niche, they are spatially related to one another and eel grass and oyster restorations are beginning to become linked to take advantage of the filtering benefits of oysters. See Tables 3.5 and 3.6 for details regarding habitat requirements of oysters and eel grass, respectively.

Ribbed Mussels

Ribbed mussels are commonly found growing around the perimeter of Smooth Cordgrass (*Spartina alterniflora*), mudflats and other suitable marine substrate. In addition to their habitat value, they provide important wetland soil erosion control by forming dense mats that reduce wave energies and permit the potential build up of sediments. They are found in most parts of Jamaica Bay, in varying densities. "Like the Eastern oyster, ribbed mussels (in enough numbers) can filter high volumes of water in the tidal marshes during each cycle, are crucial to the cycling of energy and nutrients and are an important prey species of birds and the blue crab" (Chesapeake Bay Program, 2004).

Analogous to the approach of using oysters to filter additional nitrogen from the water, there is also interest in using ribbed mussels (*Geukensia demissa*) to improve water quality within the CSO tributaries of Jamaica Bay. In addition to their nitrogen removal characteristics, ribbed mussels have also been identified to be potentially efficient in sequestering pathogens from the environment (Gaia 2007). While pathogen levels are not an issue within the open waters of Jamaica Bay, periodic CSO events do negatively impact the affected CSO tributaries. A high density of ribbed mussels may help reduce pathogen levels within these select tributaries and improve water quality. However, the level of performance of the ribbed mussels and the density required to reduce pathogens will need to be tested through a pilot study.



Beds of eel grass (*Zostera mariana*), Source: Hudson River Foundation

TABLE 3.5. Summary Of Key Environmental Requirements For The Eastern Oyster Adapted From The Hudson River Foundation "Target Ecosystem Characteristics For The Hudson Raritan Estuary" (Shumway, *et al.* 1996)	
Parameter	**Description**
Habitat and Setting	
Depth	0.6 – 5.0 m
Suspended Particles	Larvae prefer food particles of between 20-30 um and adults can effectively use particles >3 um, but particle composition is important; suspended sediments at about the 0.5 g/L + concentration can kill eggs and larvae (Kennedy, 1991); larvae and adults can vary their ingestion rate to respond to particle volume concentrations between 2 and 100 x $10^5$$um^3$ (Kennedy *et al*.,1996)
Temperature	Larvae: optimum ~20.0-32.5 C (Calabrese and Daives, 1970); adults: 2.0-36 C
Salinity	Larvae: 10-27.5 ppt (17.5 ppt optimum in LIS; Calabrese and Davis, 1970) adults: 5 to 40 ppt
Dissolved oxygen	20-100% saturation; larvae avoid hypoxia by swimming to surface but adults can survive several days at <1.0 mg/l (Kennedy, 1991)
pH	Larvae prefer between 6.75-8.75 (Calabrese and Davis, 1970)
Substrate	Exposed and clean oyster, other shell or hard surface
Circulation	No ideal rates found, but enough to provide food and remove wastes and to keep larvae in the vicinity of the parent reef (Lenihan, 1999)
Retention and sources	Spatially and temporally interlinked larval source and set opportunities for reef persistence and expansion
Sediment stability	Hard enough so that oyster growth rate can overcome any submersion
Sediment deposition	Neutral sediment balance on reef
Toxic chemicals	Concentrations below health and reproductive impairment (see Kennedy, 1991; Kennedy *et al*., 1996)
Disease and parasites	MSX and DERMO (to a lesser extent) mortality rates can be partially controlled by focusing on lower salinity (~< 12 ppt) and temperature (~<20˚ C) areas and the use of MSX resistant oyster larvae/seed stock (S. Ford, Haskins Shellfish Lab., Bivalve, NJ; Pers. Comm., 2005)
Population Properties	
Critical Oyster Densities	A minimum number of oysters per hectare for successful reproduction and to overcome competition with sessile benthos are known to be important but current research and data do not support a specific value
Connectivity among reefs	Larval dynamics considered across spatially interlinked reef clusters or complexes to sustain estuary scale recruitment

TABLE 3.6. Summary Of Key Environmental Preferences Of Eel Grass (*Zostera mariana*) Summarized From Kemp *et al.* (2004) And Moore (in press) Adapted From The Hudson River Foundation "Target Ecosystem Characteristics For The Hudson Raritan Estuary"

Parameter	Value
Water Movement	Minimum velocity 3-16 (cm^{s-1})(and maximum 50-180 (cm^{s-1})
Hydrodynamics of erosion and accretion	Regime that is closely balanced
Wave Tolerance	<2 m in height for growth and meadow formation
Depth Transmission	Subtidal, typically to 2 meters, minimum of required light through water column is >22% of light
Light	Minimum requirement >15% light at leaf
Total Suspended Solids	<15 m/1
Plankton Chlorophyll a Levels	<15 ug/l
Dissolved Inorganic Nitrogen	<0.15 mg/l
Dissolved Inorganic Phosphorus	<0.01 mg/l
Dissolved Oxygen	>2 mg/l at bottom
Sediments	Grain size, 0.4-72% silts and clays and organic matter
Pore water Sulfide	Healthy Plants, < 1 mm Reduced Growth, >1 mm Death, >2 mm
Temperature	5-30° C with optimum growth and germination range of 10 – 15° C
Salinity	Avoids brackish water, optimum salinity range 10 – 39 psu

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Algae and Sea Lettuce Harvesting

Areas within Jamaica Bay, Grassy Bay and Bergen Basin typically experience the highest chlorophyll levels and corresponding algal growth. For 2003, Grassy Bay had a summer chlorophyll mean of 50.9+/-9.7 ug/L and a peak monthly mean in August of 84.9+/-48.3 ug/L, indicating a fairly sustained period of intense algal blooms. In Bergen Basin, summer chlorophyll means reached 61.9+/-11.1 ug/L and peaked in August at 96.1+/-19.8 ug/L.

Based on existing literature values (Haag, 2007), the harvesting of algae during widespread blooms in Jamaica Bay has the potential for limited nitrogen removal from the Bay (algae is 1% to 6% nitrogen by dry weight), but may have other potential positive environmental benefits: reducing negative aesthetic issues and providing potential alternative energy sources from biofuel production.

Algal Turf Scrubbers®

Application of ATS ecologically engineered technology at the 26th Ward and Jamaica Bay WPCPs may achieve effective degrees of water quality improvements. An initial feasibility analysis at each facility follows.

The model for this analysis is an ATS system constructed in Patterson, California for the treatment of a portion of the municipality's secondary treated waste stream. The City of Patterson is situated in the Central Valley of California approximately 70 miles southeast of San Francisco. The treatment train at the Patterson wastewater treatment facility has a mean hydraulic loading of approximately 800,000 GPD (3028 cubic meters/ day). The flow-way for the system is 500 ft (152.4 m) long and 22 ft (6.7 m) wide with a total surface area of 10,990 ft^2 (1021 m^2). The hydraulic loading rate to the ATS averages over 231,415 GPD (1021 sq m), approximately 29% of the treatment plant's daily capacity. Total nitrogen removal by the ATS for the fall quarter was measured at 4.4 mg/L at a hydraulic loading of 234,849 GPD (889 m^3/d) (Craggs *et al*., 1996).

TABLE 3.7. Calculations based upon performance of Paterson, CA ATS treatment system (Craggs *et al.,* 1996)

WPCP Flow / TN (data year)	ATS Hydraulic & TN Load as % of Total WPCP Load	Expected ATS TN Discharge after ATS Treatment	ATS TN Removal / % ATS Load (% Total WPCP Load)
26th Ward 67 MGD / 13.7 mg/L (2005)	15.2%	9.3 mg/L	336.9 lb/d 32% (5%)
Jamaica Bay 82 MGD / 21.0 mg/L (2005)	11%	16.6 mg/L	336.9 lb/d 21% (2.3%)

The nitrogen removal rates in Table 3.7 may be reasonably expected to occur in the hypothetical Jamaica Bay ATS system described above, under natural solar conditions. However, there is the promising potential to enhance the Jamaica Bay ATS system with the inclusion of artificial lighting and thermo-regulators, which have been shown to improve nutrient removal rates (Adey & Loveland, 1991; Kebede-Westhead *et al*., 2003). There is great potential for ATS systems in the Jamaica Bay watershed to capitalize on the "free" energies from WPCP and landfill gas capture and conversion to heat and power. Utilizing the methane produced from landfills or the WPCP anaerobic digestors fed with algae to power high output lighting and heating systems would augment ATS treatment capacities far beyond the stated treatment rates in Table 3.7, especially during the non-summer seasons. This may provide a cost-effective way to achieve significant treatment with low to no net energy input.

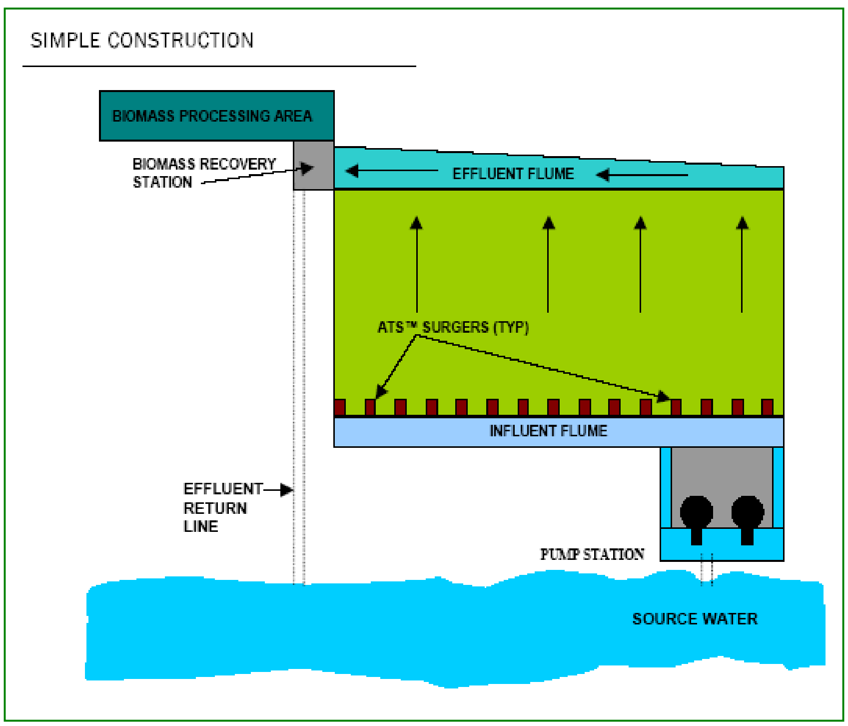


FIGURE 3.5 ATS Flow Schematic; Source: Hydromentia, Inc.

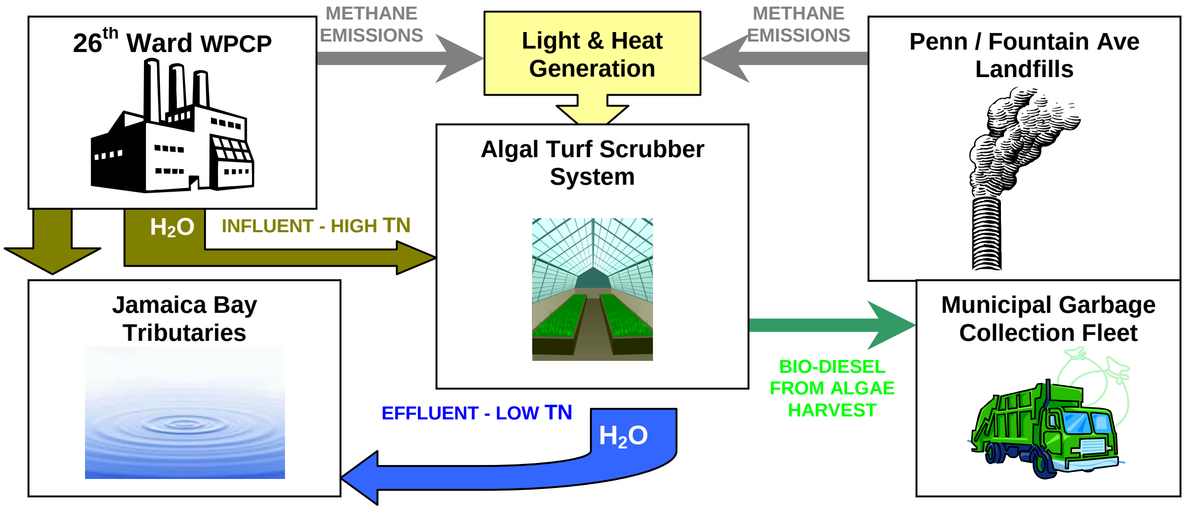


FIGURE 3.6 Schematic Energy Flow Diagram; Source: Biohabitats

Floating Aquatic Vegetation in Final Settling Tanks

While still at the conceptual stage and designs for actual plant selection and configurations have not been developed, NYCDEP will test whether the placement of native floating aquatic vegetation within the final settling tanks (pre-chlorine contact) will have benefits in terms of limited nitrogen removal. Many freshwater wetland plants are notorious for out competing some of the slower grower species and the plants selected for this pilot will need to be evaluated for their invasive potential to avoid adjacent vegetation impacts. However, while this potential is minimized due to the saline waters of Jamaica Bay, the potential for off-site distribution of the selected plants will need to be carefully evaluated.

The principle of placing high nitrogen demanding plants within a nitrogen rich environment is not new and has been applied to constructed wetlands in many other locations. However, while floating aquatic vegetation is typically a nitrogen intensive feeder, the shortened plant/water contact time will limit their full potential for nitrogen removal. High densities may provide additional polishing of the wastewater effluent that, when used in combination with other nitrogen removal technologies, may help to further reduce nitrogen loading.

Technical

Algae and Sea Lettuce Harvesting

In 1993 and 1994, NYCDEP purchased four skimmer boats to service the removal of floatables in New York Harbor tributary waters. Within 24 to 48 hours of significant rain events small vessels are sent out to investigate floating debris from boom and net locations. The inspection vessels are equipped with hand netting tools in order to retrieve small amounts of floatables, allowing the skimmer vessels to focus on servicing sites with larger quantities of material. In dry weather, boom and net inspections occur at least weekly and may occur more often for certain sites where specific tide and wind conditions may cause debris to accumulate. Currently, the skimmer boats are not equipped or capable of removing aquatic vegetation. However, this same schedule/concept could be used to remove algae from known problem areas within Jamaica Bay's open waters and tributaries.

Algal Turf Scrubbers®

Alternative ecologically engineered nutrient removal technologies are emerging as cost-effective methods to achieve water quality goals. The use of natural processes in controlled, ecologically engineered systems are designed and managed to improve water quality in ways that are less expensive, more ecologically sound and provide a greater number of wildlife habitats than traditional technologies (Craggs *et al*., 1996). These processes are found in a range of proposed treatment options, including: algal turf scrubbers, constructed wetlands (included with the on-site and off-site stormwater management BMPs identified under Stormwater Management through Sound Land Use), and bivalve (*e.g.,* oyster) filtration. These alternative methods, either alone or in combination, have the potential to offer economical water treatment for Jamaica Bay's WPCPs while providing considerable secondary ecological benefits. These "soft" technologies are not meant to replace the "hard" engineering solutions as they could not adequately treat the volume of wastewater and stormwater run-off. Rather, they would supplement these techniques to further improve water quality and increase ecological diversity. The JBWPP will implement pilot studies employing each of these treatment options based on the reported nutrient (TN) removal capabilities of each technology and the secondary ecological benefits.

Traditional primary and secondary wastewater treatment systems are optimal for microbial degradation of organic wastes but provide for limited removal of nutrients (Metcalf and Eddy, 1991). Tertiary treatment through physical and chemical or alternate microbial processes are widely used but costly to implement and can be variable in their performance (Randal *et al*., 1990).

A notable hindrance to widespread application of ecological engineering technologies is the amount of area required to achieve desired levels of treatment given the daily effluent volumes generated from each of the Jamaica Bay WPCPs. The following analysis is intended to explore the feasibility of employing each of these treatment options based on the reported nutrient (total nitrogen, TN) removal capabilities of each technology, secondary ecological benefits, specific design constraints, and the risks of implementation.

Land availability is the primary limiting factor to consider when evaluating the treatment potential for ATS systems at WPCPs with large discharges, such as those in the Jamaica Bay watershed. However, it is worth noting that ATS systems are typically non-permanent structures which can be easily disassembled or transported. Often, they are located in greenhouses. For New York State tax purposes some greenhouses are considered non-permanent "temporary" structures (NY State Real Property Tax Law Section 483-C).

The 26th Ward WPCP property includes an 11-acre parcel that historically was used for sludge storage and is currently vacant. Assuming that 10 acres are potentially available for ATS coverage, TN concentration reduction and load removal is calculated for the 26th Ward WPCP using the nitrogen removal rates and effective hydraulic loading capacity demonstrated by the Patterson, CA ATS system (Table 3.7). Although land availability proximate to the Jamaica Bay WPCP is very limited, analogous calculations for the Jamaica Bay WPCP are included here for comparison purposes.

ATS systems require no excavation, are easily constructed, have significant potential in the re-use of algae as a fertilizer or energy byproduct, and are on the "cutting edge" of ecologically engineered water treatment technologies. Provided space is available, a small-scale, pilot ATS system is recommended at the 11-acre sludge storage space available on the 26th Ward WPCP property. Upon successful implementation and demonstrated treatment capability, there is the potential to scale up to a methane emission-powered greenhouse ATS system on all 11 acres.

Oyster Restoration

Oysters are a "keystone" species and were once a prominent feature within Jamaica Bay, and the effect on the ecology of the Bay from their absence is not fully understood. A fundamental premise of the JBWPP is to improve the ecology of Jamaica Bay. Returning a keystone species, like the oyster, to the Jamaica Bay ecosystem may provide additional benefits well beyond the physical limits of the restoration location. Historically, their large filtering capacity likely played a key role in helping to improve water quality within Jamaica Bay and provided significant wildlife habitat benefits. Therefore, to help improve the ecology of the Bay and provide water quality improvements from bivalve filtering, an oyster restoration pilot is being proposed in areas of the Bay that provide suitable habitat. An example location may be near the mouth of Hendrix Creek or in a location that may serve as a natural wave attenuator near existing salt marsh islands. Additional input from Jamaica Bay stakeholders is required to determine the most successful and beneficial location.

Ribbed Mussel Restoration

While ribbed mussels currently exist within the Bay, their densities may not be at historic high levels to affect change within the water column. From a filtering standpoint, the current densities may be limiting their full potential filtering capacity and associated benefits. Therefore, the strategic placement of high density ribbed mussel beds in CSO tributaries may provide another important tool to help reduce pathogen levels from CSO events and improve water quality within the affected tributaries. Through a pilot study, the filtering capacity and required densities of ribbed mussels to improve water quality will be evaluated.

Legal

For the oyster and eel grass restorations, wetland and water quality permits will be required from NYSDEC and USACE. In addition, attractive nuisance controls for the oysters will be required by the New York State Department of Health (NYSDOH). There are no known issues for the implementation of the algal turf scrubber system.

Cost

NYCDEP will pilot a number of the measures discussed above. For costs related to these pilots, see *Implementation Strategies* below.

RECOMMENDATION

It is recommended that the City pursue pilot projects for algae harvesting, algal turf scrubbers, oyster and eel grass restoration and ribbed mussel beds. This would be done through the *Implementation Strategies* listed below.

IMPLEMENTATION STRATEGIES

The pilot studies discussed below are needed because the alternative technologies evaluated in the section are new and have not been implemented on a large scale basis. The pilot studies would be intended to address the uncertainties discussed above under environmental and technical issues.

Algae and Sea Lettuce Harvesting Pilot Study

Using tide information and information from local sources, estimate locations where sea lettuce accumulates. Further, NYCDEP will develop and implement a pilot study to determine if algae harvesting with the use of NYCDEP skimmer boats is a feasible and cost-effective method to remove algae from Jamaica Bay and select tributaries. This pilot study will be implemented in consultation with relevant groups to determine temporal events and known locations of algae accumulation. Additional information regarding the unique conditions of the Bay, as described above, is required.

Schedule: Pilot studies will be developed through a proposed contract. A contractor is anticipated to be retained by mid-2008. Pilot to be initiated in Fall 2008.

Cost: $387,000.

Algal Turf Scrubbers®

Large-scale implementation will be assessed upon completion of a pilot study to determine the most effective configuration.

Schedule: Pilot studies will be developed through a proposed contract. A contractor is anticipated to be retained by mid-2008. Pilot to be initiated in Fall 2008.

Cost: $350,000.

Oyster and Eel Grass Restoration Pilot Study

NYCDEP will develop and implement these pilots in consultation with relevant groups to determine the most ideal candidate locations.

Schedule: Pilot studies will be developed through a proposed contract. A contractor is anticipated to be retained by mid-2008. Pilot to be initiated in Fall 2008.

Cost: Oyster restoration $600,000; eel grass restoration: $350,000.

Ribbed Mussel Restoration Pilot Study

NYCDEP will develop and implement this pilot in consultation with relevant groups to determine the most ideal candidate locations.

Schedule: Pilot study will be developed through a proposed contract. A contractor is anticipated to be retained by mid-2008. Pilot to be initiated in Fall 2008.

Cost: Ribbed mussel restoration $300,000.

Management Strategy 1a3: Limit processing of additional centrate from WPCPs outside of Jamaica Bay.

STRATEGY DESCRIPTION

After ocean disposal of sewage sludge ended in 1992, several NYCDEP WPCPs needed to dewater sludge, or the solids that remain after the wastewater treatment process, to reduce the weight and volume for long-distance transport. The nitrogen-rich water taken from dewatered sewage sludge, known as centrate, is recirculated into the treatment plants for processing, and is ultimately discharged (after a reintroduction to the treatment plant and subsequent nitrogen removal processes) into the Bay's waters. The centrate contains high concentrations of Total Kjeldahl Nitrogen (TKN), typically between 800 mg/l and 1,100 mg/l, and can cause an increase in the nitrogen effluent loadings from the plants. However, the use of BNR systems can remove a significant amount of the nitrogen contained within the centrate before discharging to local receiving waterbodies.

Currently, NYCDEP has the ability to dewater sludge at eight of the City's 14 treatment plants around the City. Sludge dewatering facilities exist at the Tallman Island, Bowery Bay, Wards Island, Red Hook, Oakwood Beach, Hunts Point, Jamaica and 26th Ward WPCPs.

NYCDEP transports sludge from the 14 WPCPs generating sludge to the 8 WPCPs that contain sludge dewatering equipment using a series of forcemains and the fleet of sludge vessels that was previously used to ship sludge to the ocean for disposal. Sludge shipment and dewatering schedules are flexible and highly variable. When and where sludge shipments are made is dictated by a number of factors including.

- Availability and location of sludge vessels;
- Availability of sludge dewatering capacity at the WPCPs;
- Environmental pressures to reduce effluent nitrogen loadings to both the Upper East River and Jamaica Bay; and
- Sludge treatment limitations associated with WPCP construction activities.

Table 3.8 below shows the movement of sludge that was shipped via vessel and how it was moved from one WPCP to another during 2006. This table only represents the portion of the sludge that was shipped and is not meant to show the destination of all of the sludge. For example, even though the Bowery Bay WPCP has the ability to dewater its own sludge, some sludge was exported from Bowery Bay in 2006; this is typically done if the Bowery Bay WPCP's dewatering system is down for maintenance. Of the quantity shipped from the Bowery Bay WPCP, almost 80 percent was shipped to the Hunts Point WPCP and the remaining 20 percent was shipped to the Wards Island WPCP.

The table shows that in 2006, the 26th Ward WPCP received sludge from the Newtown Creek, North River, Owls Head, Port Richmond and Rockaway WPCPs via vessel shipment, totaling just under 10% of the total centrate processed at the 26th Ward WPCP that originated from outside Jamaica Bay.

TABLE 3.8 . Destination of the Vessel-Shipped Sludge

		Hunts Point	26th Ward	Wards Island
Shipments of Sludge via Vessels from WPCPs*	*Bowery Bay*	79.8%		20.2%
	Newtown Creek	54.0%	0.7%	45.3%
	North River	50.6%	0.6%	48.7%
	Owl's Head	57.4%	5.5%	37.1%
	Port Richmond	55.4%	3.1%	41.5%
	Red Hook	56.4%		43.6%
	Rockaway	3.2%	94.8%	2.0%
	Tallman Island	63.5%		36.5%
	Wards Island	100%		

* This percentage only represents the amount of sludge that was shipped *from* the WPCP in 2006.

However, during the period from 2004-2006, there was a slightly different configuration. On average during that period, 14 percent of the sludge treated at the 26th Ward WPCP was received by vessels that came from WPCPs outside Jamaica Bay. However, as shown in the graphic below, the vast majority (85 percent) came from WPCPs within Jamaica Bay (see Figure 3.7 below).

During the 2004 to 2006 period NYCDEP made efforts to reduce the amount of sludge shipped into Jamaica Bay, from the Owls Head WPCP in particular. As a result of construction restrictions at the 26th Ward WPCP, the percentage of sludge transported by vessel (from WPCPs outside of the Bay) has dropped from 23 percent in 2004 to 7 percent in 2006 (see Figure 3.8).

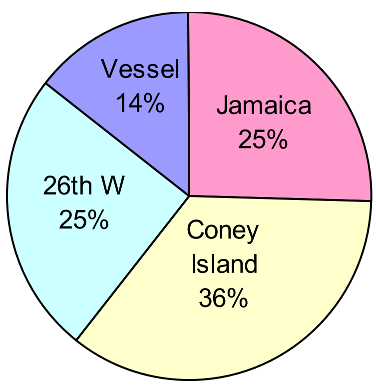


FIGURE 3.7 26th Ward Sludge Breakdown (2004-2006); Source: NYCDEP

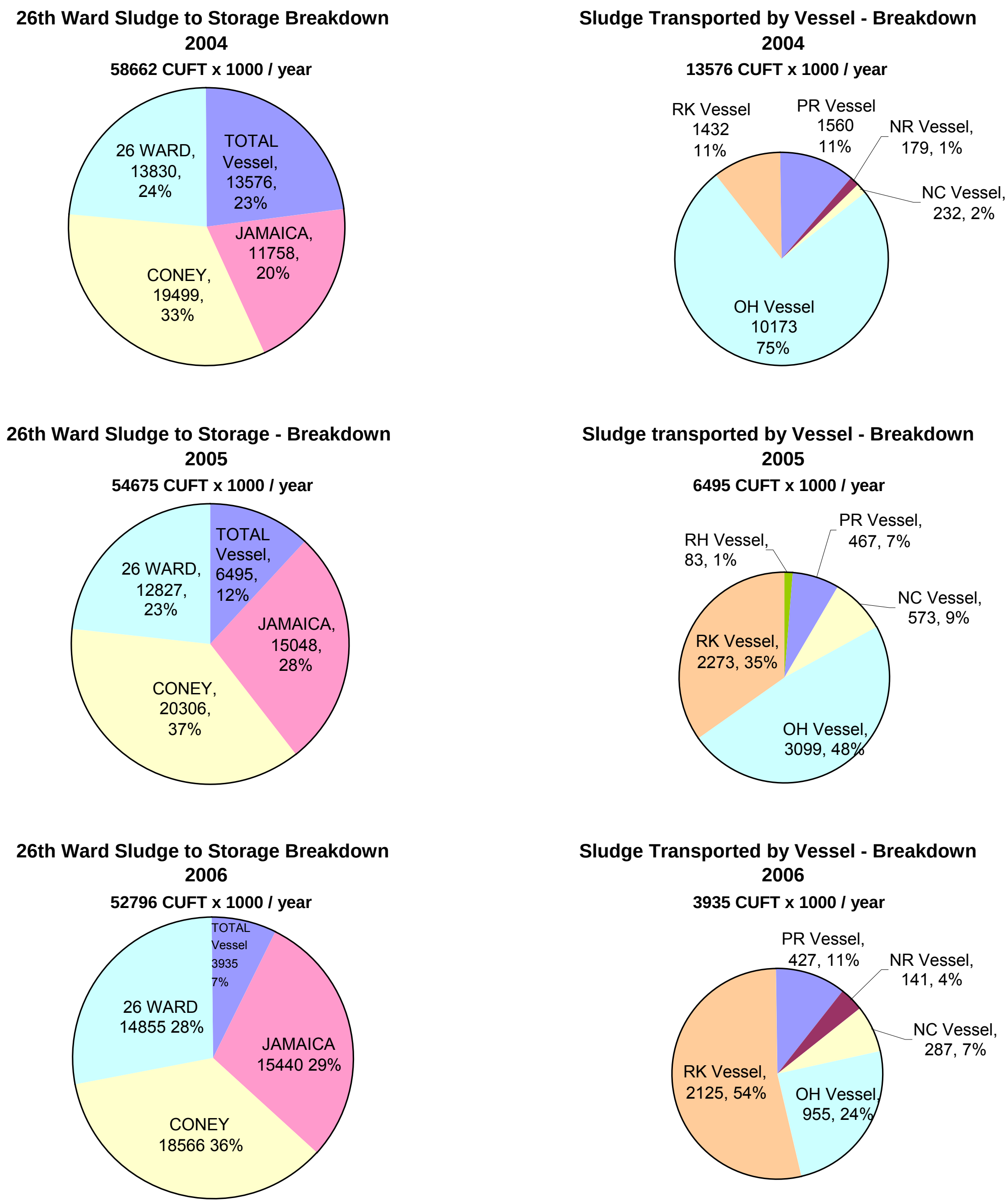


FIGURE 3.8 Sludge to Dewatering Facility at 26th Ward – Breakdown; Source: NYCDEP

NYCDEP has attempted to limit the shipment of sludge from WPCPs outside of Jamaica Bay for processing at the 26th Ward WPCP. However, due to operational concerns, routine plant maintenance, or other unforeseen events at the other wastewater treatment facilities, NYCDEP needs to keep this treatment option "open" for potential future use through at least mid 2009. However, best efforts will be made to limit, to the greatest extent possible, centrate from outside of Jamaica Bay.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

In 2006, approximately 10,800 lb TN/day arrived at the 26th Ward WPCP as influent from sanitary sewage. An additional 6,800 lb/day of TN arrived in the form of nitrogen from sludge dewatering centrate, for a total of 17,600 lb/day. Modeling was performed to determine whether reducing centrate treatment at 26th Ward WPCP would impact nitrogen loading in the Bay. Preliminary BioWin modeling has indicated that some centrate load at the 26th Ward and Jamaica WPCPs has a seeding affect that benefits the overall Nitrogen removal process. Data review of this work is ongoing and will be shared with NYSDEC in the coming months as negotiations continue on the CJBWQP.

The sludge delivered from WPCPs outside of Jamaica Bay has a relatively small impact on the concentration of total nitrogen within Jamaica Bay. The analyses indicate that no discernable benefit is obtained by changing practices relative to sludge dewatering processing and centrate treatment within Jamaica Bay.

Legal

Consistent with the Nitrogen Consent Order, NYCDEP must make best efforts not to ship sludge from the Owls Head WPCP to the 26th Ward WPCP. Sludge from the Bowery Bay and Tallman Island WPCPs is mandated to be transshipped to a visitor WPCP effective July 1, 2009 through the end of Phase I construction at each facility. Phase I construction is scheduled to conclude on December 31, 2010 at Tallman Island and December 31, 2011 at Bowery Bay. There are no apparent legal restrictions on the destination of Tallman Island and Bowery Bay sludge, and the NYCDEP may choose to restart dewatering operations at these facilities after Phase I construction has concluded.

RECOMMENDATION

NYCDEP will continue to minimize trans-shipment of centrate into Jamaica Bay. See *Implementation Strategies* below.

IMPLEMENTATION STRATEGIES

Continue to Minimize Transshipment of Sludge to Jamaica Bay

NYCDEP will continue its efforts to minimize trans-shipment of centrate to Jamaica Bay. In addition, it will make best efforts not to ship centrate from Bowery Bay and Tallman Island to Jamaica Bay. However, due to operational considerations and construction upgrades at other WPCPs, NYCDEP will need to have the option to ship sludge to the 26th Ward WPCP for dewatering so long as the effect on the TN loading to Jamaica Bay is minimal. NYCDEP requires this flexibility because there are limited options and facilities where sludge can be treated. Furthermore, NYCDEP has invested substantially in sludge dewatering equipment. NYCDEP will continue to evaluate where it can ship its sludge, consistent with its commitments to NYSDEC to not ship Bowery Bay and Tallman Island sludge into Jamaica Bay.

Schedule: Ongoing.

Cost: Not Applicable.

OBJECTIVE 1B: REDUCE CSO AND OTHER DISCHARGES INTO THE TRIBUTARY BASINS TO IMPROVE PATHOGEN AND DO LEVELS.

Current Programs

Addressing CSO discharges is a high priority for NYCDEP with ongoing Long Term Control Plan (LTCP) efforts in Fresh, Hendrix, and Spring Creeks as well as Bergen and Thurston Basins. (See Volume I, Chapter 3, "Water Quality" for a discussion of the LTCP.) In 1972, a facility at Spring Creek (Spring Creek Auxiliary WPCP (AWPCP)) was constructed to store 12 to 20 million gallons of CSO discharges and redirects it to the 26th Ward WPCP for treatment. This facility recently completed a stabilization and modernization upgrade to ensure that it will continue to operate as designed for many years into the future. Also in the 26th Ward WPCP drainage area, NYCDEP plans to clean selected sewers, dredge Hendrix Creek to remove accumulated sediment, and expand the 26th Ward WPCP to capture an additional 50 MGD.

In the Jamaica WPCP drainage area, NYCDEP is developing a drainage plan to separate storm and sanitary sewers in southeast Queens. NYCDEP will be moving forward with the design of a high level storm sewer system (HLSS) in the Laurelton section of the Thurston Basin drainage area once the Southeast Drainage Plan is completed. Further, NYCDEP will construct a new 48-inch inverted siphon under the Belt Parkway, enlarge the orifice at Regulator #3, and automate Regulator #2 to address hydraulic limitations that constrict wet weather flow to the Jamaica treatment facility, thereby capturing more wet weather flow for treatment.

NYCDEP is constructing a CSO retention facility for Paerdegat Basin in the Coney Island WPCP drainage area, to capture the first 50 million gallons of CSO from each rainfall event and to treat the overflow from larger events for floatables and settleable solids removal. In the Rockaway WPCP drainage area, NYCDEP is continuing to address flooding issues and sanitary connections in the Jamaica Bay watershed through construction of new storm sewers and correcting improper sewer connections, respectively.

NYCDEP is actively addressing the few remaining neighborhoods around Jamaica Bay that do not have public sewer service and therefore must use septic systems that often under-perform, storage tanks that require frequent pump-out, or illegal outfall pipes that discharge directly into surface waters. NYCDEP is currently constructing sewers in the Warnerville and Meadowmere sections of eastern Queens and is undertaking a storm sewer and sanitary sewer project along the Jewel Streets in Howard Beach.

While investing in new infrastructure, it is equally critical to maintain the existing system NYCDEP programmatically inspects its catch basins and regulators and responds to complaints related to sewer back-ups and maintenance. NYCDEP is investigating the expansion of its scheduled maintenance program to include sewers and interceptors.

The below initiatives to reduce CSO discharges are discussed in detail below under three management strategies:

- Maximize the existing sewer system through maintenance (Strategy 1c1);
- Reduce CSO discharges through sewer and treatment facility infrastructure improvements (Strategy 1c2); and
- Provide sanitary sewage treatment service to the remaining un-sewered neighborhoods along margins of the Bay (Strategy 1c3).

Strategy 1b1: Maximize the existing sewer system through maintenance.

STRATEGY DESCRIPTION

The historical development of the sewer system in New York City shows that the initial primary objectives were to alleviate street flooding, prevent sewer "back-ups," and transport wastes from properties. As knowledge was gained on the effects of waste products on water quality and human health, the City built "intercepting sewers" at the outfalls of the "combined" sewers to convey dry weather flow, as illustrated in Figure 3.11, to "new" sewage treatment plants. These intercepting sewers and the new treatment plants are designed to convey and treat up to two times design dry weather flow (DDWF). During wet weather, flow in the combined sewers that exceeds two times DDWF is diverted at regulators to the receiving waters via CSO.

Along with recommending construction solutions to reduce CSO discharges, this strategy encourages optimizing capacity of the existing sewer system to deliver wet weather flows to WPCPs. This will be accomplished through enhancements to NYCDEP's cleaning and maintenance program. With respect to controlling CSOs, maintenance of regulators and interceptors are most critical because they determine how much flow is directed to the WPCP as opposed to the CSO outfall.

Catch Basin Maintenance

Stormwater enters the system through catch basins along roadways. Catch basins are designed to maximize floatables capture, prevent them from entering the sewer system, and potentially leaving through a CSO. Maintaining optimal catch basin performance includes hood installation (see Figure 3.9) and programmatic catch basin cleaning. in addition to keeping floatables away from the sewer system, hooding catch basins and cleaning them regularly with a hydraulic scoop that removes the sediments, allows the maximum use of storage space before the rain flows into the sewer and helps to reduce downstream interceptor sedimentation.

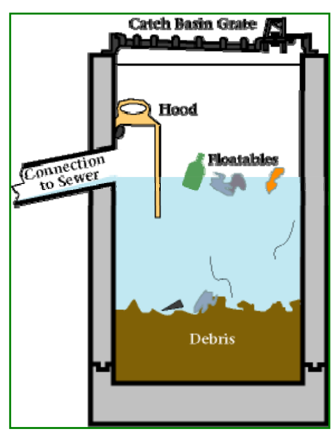


FIGURE 3.9 NYCDEP Catch Basin with Hood; Source: NYCDEP

During the course of the recent catch basin hooding program, over 4,000 catch basins were reconstructed in Jamaica Bay to allow them to be hooded. As of the April 2007, all catch basins that needed to be reconstructed in order to accommodate hooding have been either reconstructed or submitted to New York City Department of Design and Construction (NYCDDC) for reconstruction and will be completed by 2010.

As part of NYCDEP's regular maintenance program as required by the SPDES permit, crews inspect each catch basin once every three years and clean or repair catch basins based on inspection results. Along with the programmatic inspecting and cleaning, NYCDEP also responds to 311 complaints and cleans any clogged basins. 311 is New York City's phone number to contact NYCDEP and all other government agencies for information and non-emergency services.

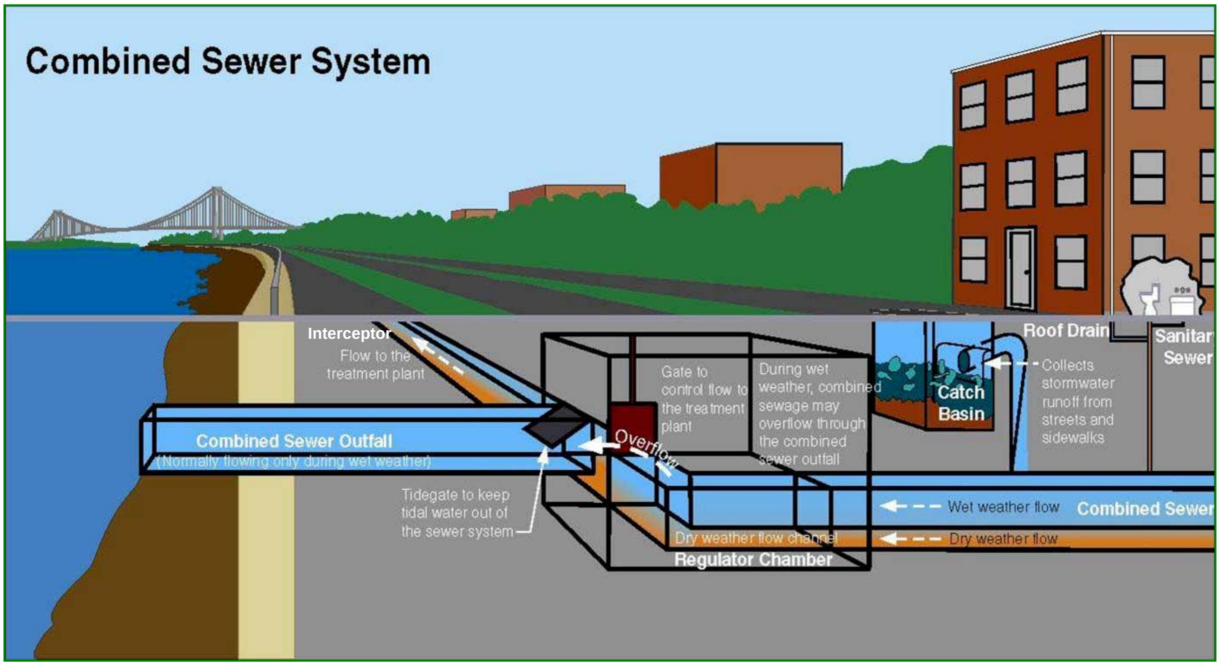


FIGURE 3.10 NYCDEP Combined Sewer System Diagram; Source: NYCDEP

Throughout Brooklyn and Queens, 24,446 were cleaned in 2006 out of the 36,682 catch basins that were cleaned citywide. Of the 48,542 catch basins in Jamaica Bay watershed, all were inspected, and 35,406 were cleaned at least once between January 2002 and June 2007. Of those that were cleaned during this period, 20 catch basins received 10 or more cleanings; past reasons include proximity to an under-performing seepage basin and excessive litter from hydrant flow, street sweeping or bus stops. However, NYCDEP's current program quickly addresses complaints and cleans all necessary catch basins as determined by the programmatic inspection.

Sewer Maintenance

Sewers are rodded and flushed periodically based on complaints as well as direct observation of excessive solids accumulation during Closed Circuit Television (CCTV) inspection. *Rodding* uses a flexible metal rod to dislodge material blocking the sewer; *flushing* injects high pressure water upstream of the problem area to dislodge the blockage. When a sewer is inspected, NYCDEP will first clean the sewer and then inspect the sewer for structural integrity through CCTV. Roughly 2% of the system is inspected each year via the current televising method. Repair, cleaning and maintenance of the sewer system is required in the SPDES permit requirements under the CSO Maintenance and Inspection Program and the Maximum Use of Collection System for Storage.

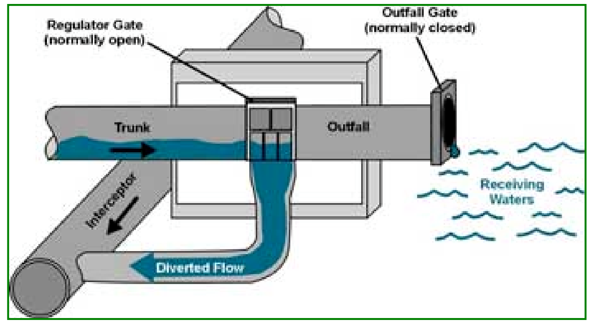


FIGURE 3.11 Regulator Image from King County, WA, Source: King County Wastewater Treatment Division

Sewer back up data were analyzed from January 2002 to May 2007. Sewer backups are reported to NYCDEP by 311 complaints and could be caused by a number of different factors including excess sediment that has settled within the sewer, an invasion of tree roots into the sewer, a physical obstruction such as a large piece of debris becoming lodged in the sewer, or other similar circumstances. The analysis found that the sewers needing repeated rodding or flushing were inland within the Jamaica WPCP drainage area. This area is separately sewered and blockages would not impact combined sewer overflows. Nevertheless, preventative maintenance for sewers will remove sediment and maximize the storage and transmission capacity of the current infrastructure.

Regulators

Regulators direct stormwater and wastewater to interceptors and then to CSOs once the system reaches its capacity during wet weather events. Interceptors are large sewers that connect the system via regulators to treatment plants and are built to deliver at least two times design dry weather flow. Regulators throughout the city have been designated as either high priority or normal priority. High priority regulators convey at least five million gallons per day and/or inherently require high maintenance. Regulators that pose a threat to beaches ("beach-sensitive") are also high priority and fall under the Enhanced Beach Protection Program, as described below. NYCDEP's regular inspection and maintenance program for regulators is part of the Nine Minimum Controls (NMCs) as defined by the U.S. Environmental Protection Agency's (USEPA's) National CSO Control Policy and included in the SPDES permit for all WPCPs.

Of the 490 regulators in New York City, 49 regulators are within the Jamaica Bay watershed, including seven beach-sensitive high priority, four high priority and 38 normal priority regulators. NYCDEP inspects high priority regulators four times a month and normal regulators once a month. Between the months of May and September, all beach sensitive regulators and pumping stations are monitored daily under the Enhanced Beach Protection Program. To further reduce dry weather bypasses, NYCDEP has installed automated monitoring systems in 100 regulators and all pumping stations. Every high priority regulator in the Jamaica Bay watershed has a telemetry system installed.

Field crews inspect the entire regulator and fill out an inspection report for each visit. Crews are required to fix any problems they encounter that would affect the regulator's operation. If a problem occurs that is beyond the crew's capabilities, an emergency contractor is called; the contractor is required to respond within 24 hours.

Pumping Stations

Pumping stations direct combined and separate flow to downstream locations in the City's sewer infrastructure when gravity cannot direct the flow. Along with regulators and interceptors, pumping stations control the amount of flow a WPCP will receive and how much will be discharged through a CSO. The Jamaica Bay watershed has nine pumping stations: two in the Coney Island WPCP drainage area, three in the Jamaica drainage area, four in the Rockaway drainage area, and none in the 26th Ward drainage area.

Interceptors

Interceptors are large sewers that connect the collection system to treatment plants, and are typically sized to deliver two times design dry weather flow to treatment plants. Currently, NYCDEP removes debris and sediments from interceptors on an as-needed basis. Interceptors are particularly critical for reducing CSOs because they dictate how much flow gets to the WPCP. If they are constricted with debris, they may trigger an earlier than necessary CSO event.

Between 1999 and 2000, the interceptor beneath JFK Airport was cleaned to increase the wet weather flow captured by the Jamaica WPCP. During the cleaning, 3,500-3,600 cubic yards of grit were removed. In 2005 segments of the west interceptor were also cleaned for the same reason. Although the cleaning maximized flow within the interceptor, the average wet weather flow that reaches the plant is still below the design of 200 MGD. Hydraulic modeling was used to isolate the cause of this diminished flow and two regulators along with segments of the west interceptor were identified as limiting the amount of wet weather flow reaching the plant. The strategies for upgrading the regulators to address this conveyance issue are discussed in Management Strategy 1c2.

STRATEGY EVALUATION

Maximizing the capture rates and storage capacity within the existing sewer infrastructure will have a positive environmental benefit as more combined sewage will be directed to and be treated by the WPCP. With respect to minimizing CSOs, interceptors and regulators are most significant as they dictate how much of the combined sewage can be conveyed to the plant and how much will be discharged to surrounding waters. Keeping catch basins and sewers clean will reduce back-ups and concomitant flooding; this sediment reduction would likely have a positive effect on CSOs as well. There are no significant technical or legal obstacles to the implementation of this strategy. Resource constraints are the primary obstacle to expanding NYCDEP's current programs. Costs for program elements are discussed below under specific *Implementation Strategies*.

RECOMMENDATION

It is recommended that the City continue its current maintenance program for catch basins and regulators and develop an enhanced program for maintaining sewers and interceptors, pending additional funding. This would be done through the *Implementation Strategies* listed below.

IMPLEMENTATION STRATEGIES

NYCDEP is developing a more proactive approach to the maintenance and cleaning of the sewer infrastructure to ensure that sewer infrastructure reaches its maximum capacity during wet weather. Programs, such as cleaning sewers in the 26th Ward drainage area, and pilot studies for preventative maintenance for sewers and interceptors and the catch basin maintenance program, show NYCDEP's commitment to keeping its infrastructure working at optimum capacity.

Expanded Sewer Cleaning Program

A programmatic sewer inspection and cleaning program is in development and would increase the current inspection rate from approximately 2% to 7-10% annually. At this increased rate, the entire sewer system would be inspected every 10 to 14 years. This would create a preventative program rather than the current one that largely responds to complaints. The proposed inspection program follows guidance from a potential USEPA regulation that would extend the Capacity Management Operation and Maintenance (CMOM) program required for sanitary sewer overflows to combined sewer overflows as well.

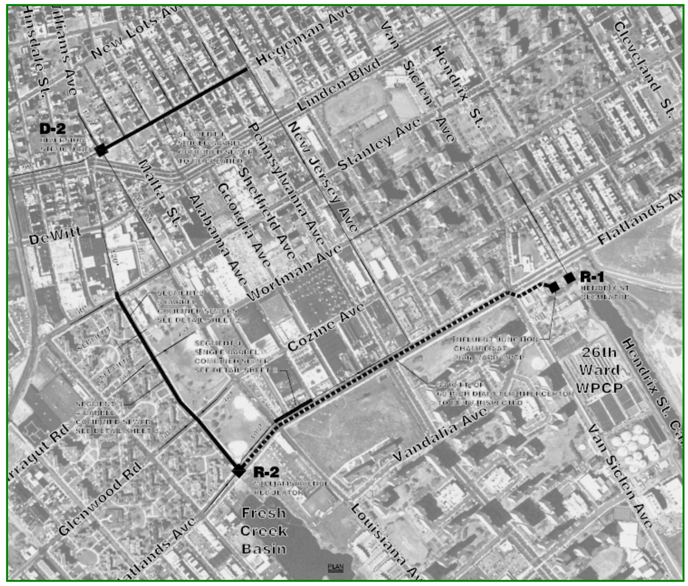


FIGURE 3.12 26th Ward Sewer Cleaning Plan, June 2007; Source: NYCDEP

Cost: Inspecting 7% of the sewers annually would cost approximately $2.5 million per year. The program has been funded until 2009.

Schedule: A pilot study will be initiated in 2008. One year of the full scale program will be completed in 2009.

26th Ward Sewer Cleaning Project

As part of the 2005 CSO Consent Order, NYCDEP will be undertaking a sewer cleaning project in the 26th Ward WPCP drainage area. NYCDEP will remove sediments from sewers that have been identified as bottlenecks in the system along Williams Street, Hegeman Avenue and Flatlands Avenue (see Figure 3.12 26th Ward Sewer Cleaning Plan).

The cleaning project will have the effect of redirecting the dry and wet weather flow from the Williams Avenue regulator (that discharges to Fresh Creek) to the Hendrix Street regulator (that discharges to Hendrix Street Canal). The sewer cleaning will allow the regulators to handle more wet weather flow.

An evaluation of the effectiveness of sewer cleaning to affect the dry and wet weather flows as predicted will be undertaken by NYCDEP and will inform the broader sewer cleaning program discussed above.

Cost: The 26th Ward Sewer Cleaning Project will cost approximately $4 million.

Schedule: This project has been designed and bid. Cleaning is scheduled to begin on or before June 2008 and completed on or before June 2010.

Expanded Interceptor Inspection and Maintenance

NYCDEP is undertaking an assessment of the entire intercepting sewer system to determine the structural integrity and operational conditions such as sedimentation and grease buildup. Sonar will be utilized to profile the bottom of each interceptor while simultaneously CCTV will be used to evaluate the structural condition of the surface above the water level. Repair, rehabilitation, and cleaning programs will be developed based on the assessment results.

The assessment program will be piloted in the Rockaway WPCP drainage area this year as well as in the Oakwood Beach WPCP drainage area. In the Rockaways, the pilot will inspect the entire east interceptor of the Rockaway WPCP. Once the pilot has been completed, a citywide inspection will be undertaken. Programmatic maintenance of interceptors is a key component to ensuring that the existing sewer system reaches its maximum storage and conveyance capabilities during wet weather, thereby potentially reducing CSO quantity and frequency.

Schedule: The pilot studies will be completed in 2008 and the citywide inspection is expected to be completed by 2010. Once the inspection is complete, a cleaning program and scheduled maintenance plan will be devised.

Cost: Approximately $300,000 for the pilot projects and $4 to 5 million to complete the citywide inspection program. The cleaning and maintenance program costs will be determined once the inspection program is complete.

Management Strategy 1b2: Reduce CSO discharges through sewer and treatment facility infrastructure improvements.

STRATEGY DESCRIPTION

The strategy includes projects mandated under the CSO consent order and/or proposed under the *Jamaica Bay and CSO Tributaries Waterbody/Watershed Facility Plan (WB/WS Plan)* submitted to the NYSDEC in June 2007 as part of the CSO LTCP. Also included in this section is the Paerdegat Basin LTCP that was developed in the *Paerdegat Basin LTCP* submitted to the NYSDEC in November 2005 and revised in June 2006. The projects focus on reducing CSO discharges and abating pathogen loading through off-line storage, WPCP facility enhancement, and high-level storm sewer design. The WB/WS Plan also considered in-line storage as a potential future option to achieve higher CSO capture levels.

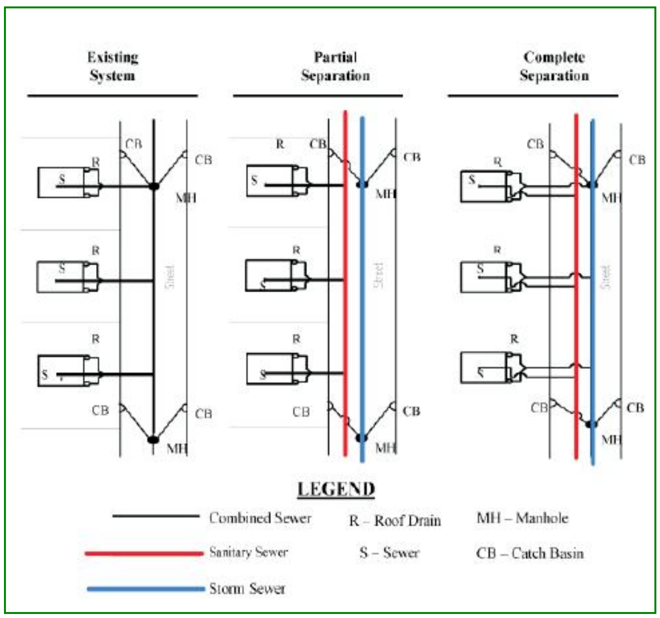


FIGURE 3.13 Sewer Separation Alternatives; Source: NYCDEP

Off-line storage is accomplished through storage facilities that are located outside the sewer conveyance system and WPCPs. Off-line storage reduces overflows by capturing combined sewage that WPCPs cannot handle during wet weather. After the storm event, the combined sewage is directed for controlled release back to the WPCPs.

In-line storage, or in-system storage, uses excess sewer capacity by containing combined sewage within a sewer and releasing it to the WPCP after a storm event. In-line storage includes storage tunnels, mechanical gates, and increased weir elevations.

WPCP Enhancement includes expanding or upgrading the facility to increase wet weather capture and treatment.

High Level Storm Sewers (HLSS) are created by removing the catch basin connection from the combined sewer combined sewers under streets or in the public right-of-way and connecting to a new storm sewer. This type of separation is also called *partial separation*. *Complete separation*, on the other hand, involves separation of stormwater runoff from private residences or buildings (*i.e.,* rooftops and parking lots) in addition to separation of sewers in the streets. Figure 3-13 illustrates these two types of sewer separation. Complete separation is very difficult to attain in New York City since it requires redesigning the plumbing within all properties where roof drains are interconnected to the sanitary plumbing inside the building.

The following sections discuss these strategies by WPCP drainage area. For additional information on these projects, please refer to the *Jamaica Bay and CSO Tributaries Waterbody/Watershed Facility Plan* and the *Paerdegat Basin LTCP*.

26th Ward WPCP Drainage Area

NYCDEP is currently proposing the following elements to reduce CSOs and improve water quality in the 26th Ward WPCP drainage area:

- **50 MGD Wet Weather Expansion for 26th Ward WPCP** – Increasing the treatment plant's wet weather capacity from 170 MGD to 220 MGD involves the construction of new primary settling tanks, a new chlorine contact chamber, and other related items (additional pumps, expansion of headworks building, and electrical work).

- **Spring Creek AWPCP Upgrade –** The AWPCP upgrade, which serves portions of the 26th Ward and Jamaica WPCP drainage areas, was completed in April 2007. The upgrade involved increasing floatable control and combined sewage treatment as well as providing a minimum of 20 MG of CSO storage. The Spring Creek AWPCP captures CSO at the Spring Creek outfall and provides settling and floatables removal from the influent. Once a storm event passes, stored flow is redirected to the Coney Island WPCP for treatment.

- **In-line Storage in Hendrix Creek –** As part of the LTCP, NYCDEP will further evaluate adding a bendable weir to the Hendrix Creek outfall for CSO abatement.

- **In-stream Aeration** – Discussed in Management Strategy 1c2.

- **Sewer Cleaning Project** – Discussed in Management Strategy 1b1.

- **Hendrix Creek Dredging** – Discussed in Management Strategy 1c1.

The WB/WS Plan also includes evaluations of other measures to reduce CSOs including complete separation of the combined sewers in the 26th Ward WPCP collection system, storage tunnels near Fresh Creek, and in-stream aeration in Fresh Creek. While many of these projects are still under evaluation for potential incorporation into future plans, most show minimal improvement for DO levels although, as discussed in Management Strategy 1c2, NYCDEP is actively pursing in-stream aeration to attain DO water quality standards.

Jamaica WPCP Drainage Area

- **Southeast Queens Drainage Plan –** NYCDEP is developing the drainage plan for the Laurelton and Springfield Boulevard areas of southeast Queens (Southeast Queens Drainage Plan). This area, as shown in Figure 3.15, includes Drainage Districts 41 SWB, 42 SW and 42, and involves sewer system modifications that are necessary to convert the existing system to one that is basically separated. Specifically, the Laurelton area (Drainage District 42) will be converted from a combined system to one that is serviced by HLSSs as well as other elements that would maximize separate sewers and minimize combined sewers. This plan will summarize the required work to construct the sewer system in accordance with the City's Drainage Plan, correct sewer and street flooding problems, and minimize combined sewer overflows.

  Another item being addressed in the drainage plan is whether NYCDEP can prevent stormwater generated in the 5,550 acre separately sewered drainage area upstream of Laurelton (42 SW) from mixing with the remaining portion of the HLSS via a new diversion storm sewer on Hollis Avenue. By constructing the Laurelton HLSS system and the Hollis Avenue stormwater diversion piping, the existing combined and storm sewer interceptors that run southerly under Springfield Boulevard (towards Thurston Basin) would convey stormwater flow only and, therefore, minimize CSOs.

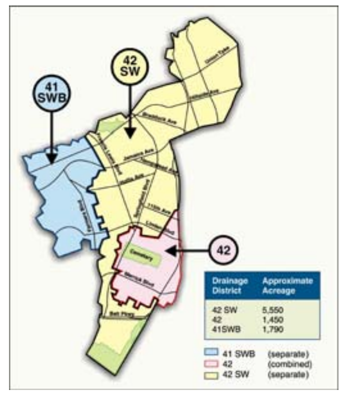


FIGURE 3.14 Portion of SE Queens Drainage Plan; Source: NYCDEP

- **Regulator Improvements at Bergen Basin –** As mentioned in the previous strategy, hydraulic limitations constrict wet weather flow to the Jamaica treatment facility. To address these limitations, NYCDEP will construct a new 48-inch inverted siphon, enlarge the orifice at Regulator #3, and automate Regulator #2. The new siphon will complement the existing dual 36 inch inverted siphon under the Belt Parkway. Regulator #3 orifice will be enlarged from 36 inch by 48 inch to 60 inch by 66 inch. This enlargement will address the back-up of wet weather flows in the interceptor and the resulting overflow of combined sewage at Regulators #3 and #14. Through an electro-hydraulic actuator, Regulator #2 will direct dry weather flow to Jamaica WPCP and a portion of wet weather flow to Spring Creek AWPCP.

- **In-stream Aeration for Bergin and Thurston Basins** – Discussed in Management Strategy 1e2

Coney Island WPCP Drainage Area

- **Paerdegat CSO Retention Facility –** NYCDEP is constructing a retention facility in Paerdegat Basin. The 50 MG facility will capture CSOs at the Paerdegat Basin outfall and provide settling and floatables removal from the influent. Once a storm event passes, the stored flow will be redirected to the Coney Island WPCP for treatment.

Rockaway WPCP Drainage Area

- **Complete sewer separation** – NYCDEP will reconstruct the sewers in the Rockaway WPCP drainage area. Many of the sewers in the western section of the drainage area have already been separated and NYCDEP intends to continue its current program to separate Rockaway sewers over time.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

As shown on Table 3.9, the strategies discussed above will reduce CSOs and improve water quality conditions within the Jamaica Bay Tributaries as discussed in more detail in the WB/WS Report.

TABLE 3.9. Annual Water Quality Benefits*

Tributary	Dissolved Oxygen *Baseline*	Dissolved Oxygen *Future*	Total Coliform *Baseline*	Total Coliform *Future*	Fecal Coliform *Baseline*	Fecal Coliform *Future*
Fresh Creek	60%	72%; 100%	58%	100%	33%	83%
Hendrix Creek	78%	78%	100%	100%	100%	100%
Spring Creek	82%	81%	100%	100%	92%	92%
Bergen Basin	50%	50%; 100%	67%	83%	58%	75%
Thurston Basin	60%	60% 100%	92%	100%	92%	100%
Paerdegat Basin	80%	89%	83%	100%	25%	75%

* At head of waterbody.

With these projects:

- Fresh Creek: CSO volume would be reduced by 61%. Total coliform criteria are projected to be 100% compliant and fecal coliform criteria are projected to be in attainment 83% of the time.

- Hendrix Creek: While CSOs to Hendrix Creek would increase, compliance with water quality standards would remain the same with 100% attainment for both total coliform and fecal coliforms.

- Spring Creek: Flows to Spring Creek will increase, but will be treated at the Spring Creek AWPCP, which removes floatables and solids. One hundred percent of total suspended solids and BOD are captured from flows that do not escape the facility. Thus total and fecal coliform criteria are projected to remain at 100% and 92% attainment, respectively.

- Bergen Basin: CSO volume would be reduced by 40%. With the CSO reduction in Bergin Basin, total coliform criteria are projected to be 83% compliant and fecal coliform criteria are projected to be in attainment 75% of the time. Total and fecal coliform standards would be achieved 100% of the time in the middle and mouth even though the head end does not achieve 100% attainment.

- Thurston Basin: CSO volume would be reduced by 87%. With the CSO reduction in Thurston Basin, total and fecal coliform criteria are projected to be met 100% of the time.

- Paerdegat Basin: With the construction of the CSO Retention Facility, 62% of potential CSOs would be directed to the WPCP for full treatment, while 35% would receive primary treatment at the facility. With this facility, total coliform should be in compliance 100% of the time and fecal coliforms would be in compliance 75% of the time.

Technical

These projects are technically feasible and, in fact, Spring Creek AWPCP has already been upgraded while Paerdegat is under construction. HLSS and sewer separation are difficult because they involve extensive sewer reconstruction within streets over large areas. During the drainage plan development for Southeast Queens, NYCDEP discovered deficiencies in the conveyance system that would compromise the HLSS if constructed without additional sewering. In-system overflows were detected that interconnect upstream storm sewers with combined sewers in Laurelton. The Southeast Queens Drainage Plan will address these technical issues and keep stormwater generated upstream of Laurelton isolated until it reaches Thurston Basin.

Cost

Costs for each of the projects are provided below under *Implementation Strategies*.

Legal

The projects discussed under this strategy are mandated under the CSO Consent Order and/or are part of the Waterbody/Watershed Plans submitted to NYSDEC pursuant to that order. For more information on the CSO Consent Order, please see Volume I, Chapter 3 (see Section 3.6), and "Water Quality."

RECOMMENDATION

NYCDEP will move forward with implementing measures under the CSO Consent Order and/or the WB/WS Plans. NYCDEP will also continue to evaluate other in-line and off-line infrastructure projects for potential inclusion in future plans as more data become available.

IMPLEMENTATION STRATEGIES

The implementation strategies listed here provide schedule and cost information for the programs discussed above. The Spring Creek AWPCP Upgrade was completed in April 2007 at a cost of $104.9 million. For additional information on these projects, please refer to the *Jamaica Bay and CSO Tributaries Waterbody/Watershed facility Plan and Paerdegat Basin LTCP*.

26th Ward 50 MGD Expansion

Increasing the treatment plant's wet weather capacity from 170 MGD to 220 MGD involves the construction of new primary settling tanks, larger pumps, a new chlorine contact chamber, and other related items.

Cost: $468 million.

Schedule: Final Design was initiated in 2006 and design completion is anticipated in June 2010. Construction will begin in June 2011 and be completed in December 2015.

Hendrix Creek – Evaluating In-line Storage

As part of the LTCP development, further evaluation will be performed for a bending weir that would be placed on top of the existing concrete weir to increase in-line capture of CSO discharges. A hydraulic analysis will be performed to determine if there is a risk of flooding. The cost will be part of the LTCP analysis and will be available when the final plan is released in August 2012.

Paerdegat CSO Retention Facility

NYCDEP is constructing a retention facility in Paerdegat Basin. The 50 MGD facility will capture CSOs at the Paerdegat Basin outfall and provide settling and floatables removal from the influent. Once a storm event passes, the stored flow will be redirected to the Coney Island WPCP for treatment.

Cost: $318 million.

Schedule: The facility is currently under construction and will be completed in 2012.

Laurelton High Level Storm Sewers

Following development of the Southeast Queens Drainage Plan in January 2008, NYCDEP will develop an implementation plan for designing and constructing HLSS and other improvements in the Laurelton area. The steps that generally follow drainage plan development include assessment of priority sewer system construction needs in the area, design of sewers for the priority areas, and finally construction of these sewers.

Cost: Cost estimates have not been developed as of yet since the drainage plan is not complete.

Schedule: No time frames have yet been established for reconstruction of the sewers in this area. Once the drainage plan is completed in January 2008, construction time frames will be developed.

Inflow/Infiltration Study with Corrective Measures

An Inflow and Infiltration Study with corrective follow-up would identify and resolve sewer system anomalies from illegal connections and interim measures that could allow sanitary flow to enter a stormwater pipe or stormwater to enter a sanitary pipe. Identifying and correcting these anomalies will improve the integrity of the separate sewer system and improve end-of-pipe water quality.

Cost: $2 million/year for engineering and $5 million/year for corrective measures.

Schedule: No time frames have yet been established for a start date or the required length of time to complete the study and corrective measures.

Regulators in Bergen Basin

NYCDEP will construct a new 48-inch inverted siphon under the Belt Parkway, enlarge the orifice at Regulator #3, and automate Regulator #2 to address hydraulic limitations that constrict wet weather flow to the Jamaica treatment facility.

Cost: $14 million.

Schedule: Final Design was initiated in February 2005 and completed in November 2006. Construction will begin in late 2007 and completion is estimated for June 2010.

Complete Sewer Separation in the Rockaways

The sewers are largely separated, but approximately 2,500 acres of storm sewers remain to be built.

Cost: The total cost to install separate sewers throughout the Rockaways is anticipated to be approximately $500 million.

Schedule: To be determined.

Management Strategy 1b3: Provide sanitary sewage treatment service to the remaining un-sewered neighborhoods along margins of the Bay.

STRATEGY DESCRIPTION

NYCDEP is actively addressing the few remaining neighborhoods around Jamaica Bay that do not have public sewer service and use one of the following: under-performing septic systems, storage tanks that require frequent pump-out, or illegal discharge into surface waters. NYCDEP is currently constructing stormwater and sanitary sewers in the Warnerville and Meadowmere sections of eastern Queens as well as undertaking a storm sewer and sanitary sewer project along the Jewel Streets in Howard Beach.

Warnerville / Meadowmere Sewer Project

This project will connect these neighborhoods to the Jamaica WPCP through a network of sanitary and storm sewers (see Figure 3.15). This project will connect these neighborhoods to the Jamaica WPCP through a network of sanitary and storm sewers (see Figure 3.15). Gravity sewers will bring flow from Meadowmere to the Warnerville pumping station that will direct the sanitary sewage to an existing sewer on 149th Avenue. Also included in this project is the creating and restoration of wetlands along Brookville Boulevard.

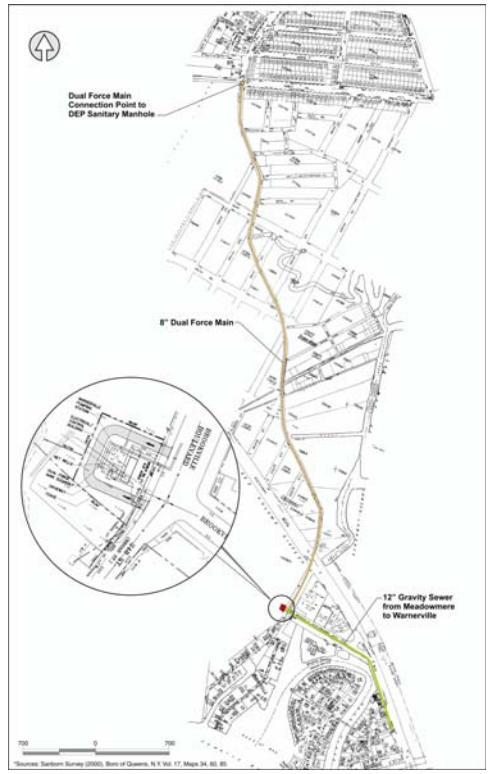


FIGURE 3.15 Meadowmere/Warneville Plan; Source: NYCDEP

Jewel Streets Sewer Project

NYCDEP is also undertaking a storm sewer and sanitary sewer project along the Jewel Streets (Ruby, Sapphire and Amber Streets) that straddle Brooklyn and Queens. The area has been plagued by flooding and failing septic systems respectively due to a lack of sanitary sewers and its topographical location in a low-lying "bowl" that can be eight feet lower than the surrounding community. The streets will be re-graded to allow adequate space for conveyance. This project also entails separating storm and sanitary sewers to prevent more CSO events. Stormwater will be treated using constructed wetlands with stilling basins as has been done in the Bluebelt Project in Staten Island. Other possible sites for constructing these stormwater treatment wetlands are Springfield Lake and Baisley Pond (see Management Strategy 3b4 for more information).

EVALUATION OF MANAGEMENT STRATEGY

This strategy would have a positive environmental impact by eliminating dry weather discharges to Mill Creek and Creek near Thurston Basin. There are no significant technical or legal obstacles to its implementation. While technically feasible, sewer construction involves extensive street work over large areas and is resource intensive. Costs are discussed below under the specific Implementation Strategies.

RECOMMENDATION

NYCDEP will continue to complete its planned projects to bring sanitary and storm sewers to currently unsewered areas**.**

IMPLEMENATION STRATEGIES

Warnerville / Meadowmere Sewer Project

NYCDEP has completed the design of sanitary sewers, a pump station, and a force main to collect this sanitary sewage and deliver it to the Jamaica WPCP for treatment. Much of the piping has already been laid and the construction of the pumping station has begun.

Cost: $30 million.

Schedule: This project is currently in construction with a construction completion date of March 2009.

Jewel Streets Sewer Project

NYCDEP will construct sanitary and storm sewers along with improved water mains for the Jewel Streets. The project would connect storm sewers to a stilling basin before discharging to a Jamaica Bay tributary. Along with sewer work, New York City Department of Transportation (NYCDOT) will reconstruct and re-grade the streets to create better drainage. Figure 3.16 illustrates the area around the Jewel Streets where construction would create a stilling basin at the top of a tidal creek and an existing siphon to treat stormwater.

Cost: $26 million from NYCDEP and $15 million from NYCDOT.

Schedule: This project is currently in design with a construction slated to begin in 2011.

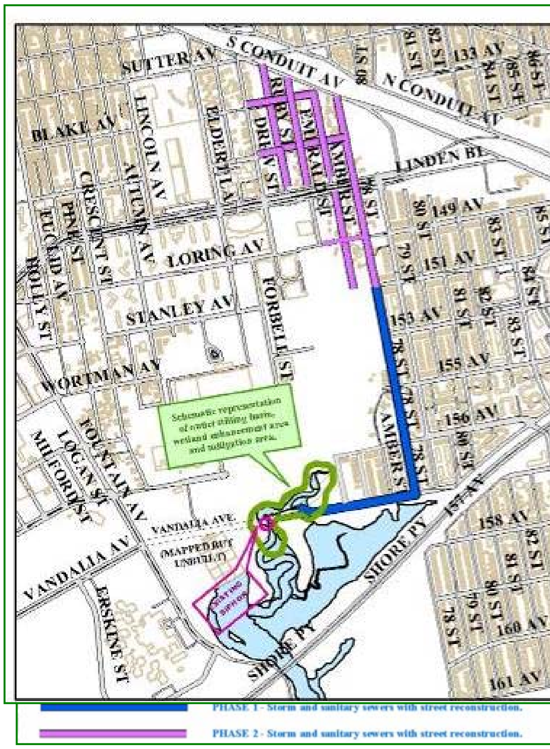


FIGURE 3.16 NYCDEP Jewel Streets Plan; Source: NYCDEP

Management Strategy 1b4: Expand boat pumpout program in Jamaica Bay.

STRATEGY DESCRIPTION

Under the Clean Vessel Act of 1992, the U.S. Department of Interior, Fish and Wildlife Service (USFWS), began a program to assist in reducing marine vessel waste in United States waterbodies. New York State's Clean Vessel Assistance Program (CVAP) was established to protect and improve water quality in New York's navigable waterways. The program provides federally funded grants of up to 75% of eligible project costs with a current maximum of $35,000 per project. The grants are to assist marinas, municipalities, and not-for-profit organizations install pump-out stations.

Paerdegat Basin Pump-Out.
Source: NYCDEP

To help improve water quality and provide an important free service to local area boaters, using matching funds from this program, NYCDEP has installed two pump-out facilities on Jamaica Bay. A boat pump-out unit installed in 2000 is located at the Coney Island WPCP, and a unit installed in 2005 is located at the Hudson River Yacht Club (Paerdegat Basin).

Paerdegat Basin Boat Pump-Out 1.
Source: NYCDEP

NYCDEP is currently developing the designs for a third facility at the Rockaway WPCP and obtaining required NYSDEC permits. NYCDEP expects to have this facility in operation for the 2008 boating season. Around the New York Harbor region, NYCDEP has installed seven pump-out facilities to help improve water quality in other waterbodies.

In addition to NYCDEP's free boat pump-out services, since 1994, the New York/New Jersey Baykeeper has operated a pump-out boat which travels to Jamaica Bay and offers free wastewater disposal to private boat owners. The pump-out boat discharges the wastewater at the Coney Island WPCP pump-out facility for treatment. Expansion of this type of program would encourage greater public use and reduce the amount of pathogens discharged from boat wastewater into Jamaica Bay. Funding from the CVAP is open to all marinas and environmental organizations, and NYCDEP encourages the wider use of this program by local marinas. Other municipalities, such as in Nassau and Suffolk Counties on Long Island, require pump-out units at marinas or facilities selling or dispensing gasoline. A similar effort within New York City would provide greater geographic coverage and use of boat pump-out facilities. Table 3.10 shows the location information for Boat Pump-outs in Jamaica Bay.

TABLE 3.10. Location Information For Boat Pump-Outs

Location	Longitude	Latitude
Hudson River Yacht Club	40.37.33	73.54.21
Coney Island WPCP	40.35.44	73.55.87

No Discharge Zone

As per existing legislation, before a waterbody can be considered eligible for a "no discharge zone" designation from the USEPA, a sufficient number (> 4) of pump-out units must be available for public use and they must be geographically spaced to service approximately 300 to 600 boats per boat pump-out unit (USEPA). It is estimated that approximately 1,200 boats are registered with marinas along Jamaica Bay (CVAP, 1996). Currently, within the City, the only waterway designated as a "no discharge zone" is the Hudson River from the Battery up to the Westchester County line. Along this stretch of the Hudson River, it is illegal for boaters to discharge sewage into local waterbodies. Therefore, additional sites for pump-outs beyond those already installed by NYCDEP will greatly assist in meeting these minimum requirements for a "no discharge zone" for Jamaica Bay.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

The installation of additional boat pump-out facilities is a necessary component of a comprehensive program to reduce pathogens and other pollutants from entering Jamaica Bay and its tributaries.

.

Technical

A key factor in determining locations for additional pump-out facilities is proximity to a sanitary sewage line not located within a combined sewer area. In combined areas, underground storage tanks must be installed. The installation of these tanks significantly raises operation and maintenance costs through the regular emptying of the tanks. To avoid these additional costs, the Coney Island WPCP facility is directly fed to the wastewater stream at the plant and provides the most efficient operation. The other facility within Jamaica Bay and others located around the harbor have underground storage tanks that NYCDEP maintains on a regular basis. Depending on weather and boating traffic, these tanks need to be emptied up to three times a week from Memorial Day through Labor Day, the official operating time of the boat pump-out facilities. This significantly raises O&M costs of the boat pump-out units, particularly for smaller marinas. To help with these additional costs, mariana operators can obtain assistance is through the CVAP to pay for O&M costs (see below).

Legal

In addition to the boat pump-out unit, all facilities will require the installation of floating docks. The installation of floating docks does require NYSDEC and USACE review and permits. In situations where the existing pier fendering system does not allow a safe connection of the floating dock, several piles will need to be driven. This requires a more detailed review and permitting process.

Cost

Boat pump-out units:	$10,000
Installation:	$3,500
Purchase and installation of floating dock with piles:	$8,000

The Clean Vessel Act will reimburse 75% of the purchase and construction of the project for a maximum of $35,000. In addition to construction reimbursement costs, “an O&M Grant Program is available to provide recipients of CVAP grants with funding to assist in the annual costs of upkeep of the pump out. The CVAP O&M is intended for routine replacement items and costs incurred annually and not for major repairs. Funding is available for up to 75% of eligible costs with a maximum annual grant amount of $2,000 for pump out facilities” (CVAP 2007).

RECOMMENDATION

NYCDEP will install a third boat pump-out at the Rockaway WPCP and pursue additional locations for future pump-out units in Jamaica Bay. As noted above, a minimum of four boat pump-out units is necessary to begin the process of designating Jamaica Bay as a “no discharge zone.” See *Implementation Strategies* below.

IMPLEMENTATION STRATEGIES

Install a Third Boat Pump out Facility at the Rockaway WPCP

NYCDEP is currently developing the designs for a third facility at the Rockaway WPCP and obtaining required NYSDEC permits.

Schedule: NYCDEP expects to have this facility in operation for the 2008 boating season.

Cost: Approximately $21,500.

Pursue Adding Additional Boat Pump-outs in Jamaica Bay and Obtaining a No Discharge Designation for the Bay

NYCDEP will continue to explore potential additional locations for future boat pump-out locations and encourages existing marinas to apply for CVAP grants to off-set construction costs of the facilities. There are a number of private marinas in Jamaica Bay that have the potential to install and operate a boat pump-out facility. NYCDEP will coordinate with these marinas and with Going Coastal, a nonprofit, educational and publishing organization focused on raising awareness of the coast's value and the importance of stewardship, to promote additional boat pump-out facilities. Interested marinas should contact:

CLEAN VESSEL ACT PUMPOUT GRANT PROGRAM
NYS Environmental Facilities Corporation
Technical Advisory Services
625 Broadway
Albany, New York 11207-2997
Attn: CVAP

Once the necessary pump-out facilities have been installed, NYCDEP will initiate the No Discharge Zone process. Under this process, NYSDEC must make a request to the USEPA that a particular area would like to be designated a “no discharge zone.” If designated, it will be illegal for boaters to discharge sewage to Jamaica Bay.

Schedule: To be determined.

Cost: Approximately $21,500. The Clean Vessel Act will reimburse 75% of the purchase and construction of the project for a maximum of $35,000. In addition to construction reimbursement costs, an O&M Grant Program is available to provide recipients of CVAP grants with funding to assist in the annual costs of upkeep of the pumpout.

OBJECTIVE 1C: INCREASE DISSOLVED OXYGEN LEVELS IN TRIBUTARY BASIN AREAS OF CHRONIC HYPOXIA TO IMPROVE ECOLOGICAL PRODUCTIVITY

INTRODUCTION AND ISSUES IDENTIFICATION

Deep areas in the tributaries of Jamaica Bay can lead to low DO concentrations in the water column. In deeper and wider areas of tributaries, current velocities slow down. These slower velocities allow particulate matter to settle and accumulate in the sediment where they can exert an sediment oxygen demand (SOD). In the deepest areas, due to temperature differences, density stratification can occur that reduces the vertical mixing of the water column. Due to this stratification, surface water that has higher DO concentrations cannot easily mix downward to bottom waters to replenish oxygen that has been lost due to SOD and the decomposition of organic matter in the water column.

To address these issues, the following two Management Strategies are discussed:

- Removal of CSO sediment mounds and/or re-contouring of tributaries to enhance drainage and eliminate borrow pits and deep trenches (Management Strategy 1c1)

- Determine hypoxic areas in the tributary basins that may benefit from mechanical aeration to increase DO concentrations (Management Strategy 1c2).

Current Programs

The Jamaica Bay WB/WS Plan recommends that that Hendrix Creek be dredged and recontoured. It also recommends that Fresh Creek, Bergen Basin, and Thurston Basin be dredged and recontoured and provided with aeration systems. The Paerdegat Basin LTCP recommended dredging but not aeration because the LTCP indicated that Paerdegat Basin might achieve the NYSDEC Class I DO standard of 4 mg/L; post-construction monitoring will confirm the attainment. These projects are discussed in more detail below. In addition, Shellbank Basin is currently implementing a pilot destratification system.

Management Strategy 1c1: Removal of CSO sediment mounds and/or re-contouring of tributaries to enhance drainage and eliminate borrow pits and deep trenches.

STRATEGY DESCRIPTION

CSO discharges include a combination of sanitary and stormwater flow and can contain high concentrations of solids. These solids over time have the potential to form large sediment mounds at the discharge point. The sediment mounds contain materials that increase BOD and have contaminants associated with sanitary flow and stormwater runoff that result in low DO levels in the water column, potential odor problems, and sediment that is toxic to aquatic life.

Some tributary basins in Jamaica Bay have deep pits from dredging and CSO scouring, along their lengths and at the head (away from Jamaica Bay) end of the basins; however, these become very shallow where the channel connects to Jamaica Bay. For example, Shellbank Basin has a depth of 52 feet at the head end, while the depth where it discharges to Jamaica Bay is only 7 feet. Mill and East Mill Basins, and Norton Basin, have similar bathymetric features. This atypical and unnatural bottom topography results in poor tidal circulation and the development of hypoxic or anoxic waters which can be transported into the near shore areas of Jamaica Bay during large storm events, when tidal surges greatly increase the circulation of waters in and out of these basins.

Different modeling analyses have indicated that re-contouring the non-CSO basins to a shallower depth, on the order of 6.0 to 10.0 ft, could eliminate the hypoxic conditions and improve DO concentrations.

CSO Impacted Tributaries

Sediment mounds are found in each of the CSO tributaries. These mounds contain settled CSO solids and in some basins settled stormwater solids. The CSO tributaries include Paerdegat Basin, Fresh Creek, Hendrix Creek, Spring Creek, Bergen Basin and Thurston Basin, although technically Spring Creek does not have a CSO because the flow passes through an auxiliary WPCP first for removal of the heaviest settleable solids. CSO mounds develop as particulate matter contained in the CSO flow settles down to the tributary sediment and accumulates over time. CSO mounds are a problem because they accumulate contaminants and result in a poor ecological habitat. They also exert a SOD that contributes to lower DO levels in the water column at the head ends of these CSO–impacted tributaries. If a CSO mound is removed, the tendency for the mound to reform will occur if the CSO discharge is not entirely eliminated. Therefore, the removal of a CSO mound can be viewed as an interim measure that needs to be performed on an as-needed basis. Reducing the quantity and improving the quality of the CSO flow will result in a decrease of CSO sediment building mounds and may have lower concentrations than the original mound. Proposed stormwater best management practices, WPCP upgrades and sewer cleaning improvements will also assist in reducing CSO volumes.

NYCDEP has made the commitment to dredge the CSO mounds in Paerdegat Basin, Fresh Creek, Hendrix Creek, Bergen Basin and Thurston Basin. These CSO mounds will be dredged to 5 feet below mean lower low water (MLLW) and then capped with 2 feet of clean material to bring the re-contoured bottom up to 3 feet below MLLW.

Under the Jamaica Bay Ecosystem Restoration Project (JBERP), of which NYCDEP is a local cost-share partner, the USACE developed plans to modify two of the tributaries, Paerdegat Basin and Fresh Creek, in order to improve DO levels and restore tidal marshes. To ensure that the removal of the CSO mounds provide the most ecological improvements, NYCDEP to the greatest extent possible, will coordinate and work with the regulatory agencies to form partnerships as appropriate so that the dredging of the CSO mounds can be combined with the ecological restoration plans proposed by the USACE and NYCDEP. For example, NYCDEP's recontouring projects will only be near the head ends of the basins over a distance of approximately 1,000 to 1,500 feet, and the recontouring of the remaining portions of the basins to depths of 6 feet below MLW would need to be coordinated with the USACE. Recontouring Paerdegat Basin and Fresh Creek to total depths on the order of 6 ft below mean lowwater (MLW) would improve water quality by enhancing vertical mixing and by enhancing the flushing of the basins with cleaner water from Jamaica Bay. The amount of water that would remain in the basin for long periods of time would be reduced. This would increase the tidal exchange between low water and high water for a much more effective flushing mechanism.

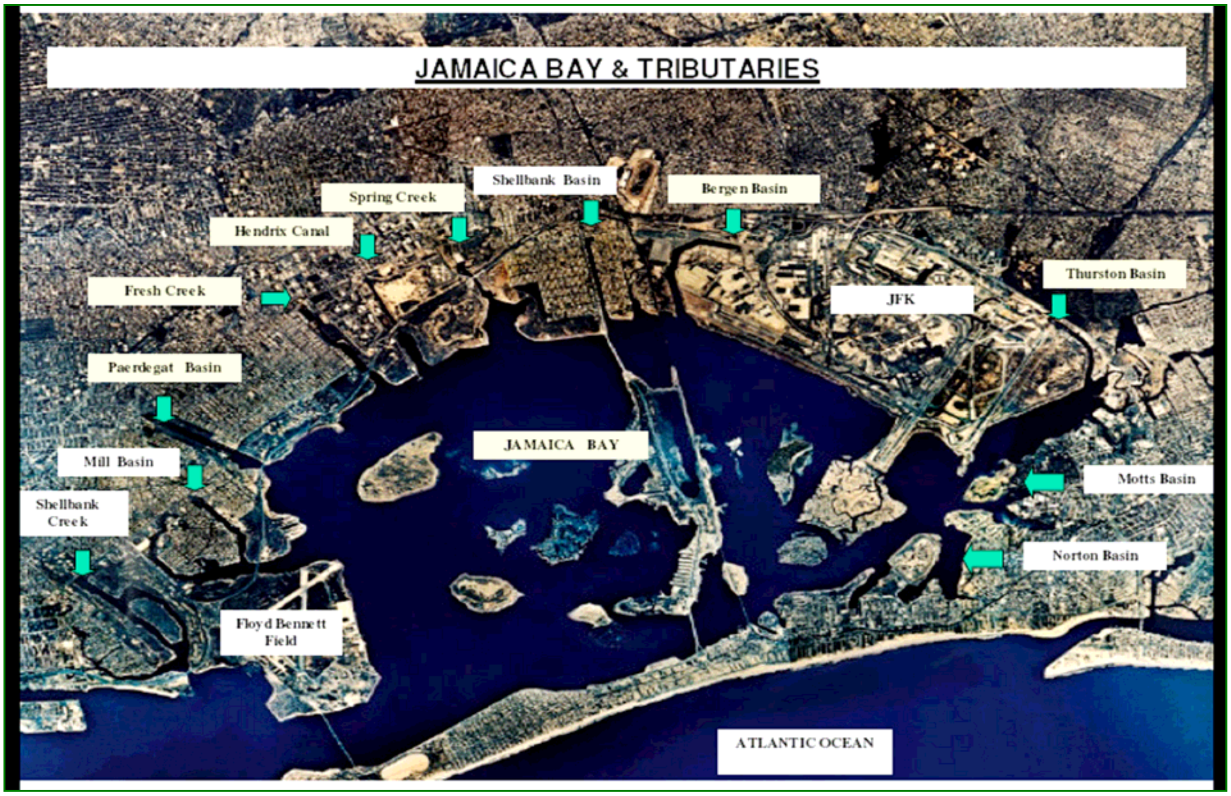


FIGURE 3.18 Tributaries of Jamaica Bay; Source: NYCDEP

NYCDEP is in the process of soliciting a consultant to develop the dredging designs and complete permit applications. It is anticipated that this dredging contract will be in-place in early 2009 so that dredging can be initiated in Paerdegat Basin as soon as the retention facility comes into service in 2011. NYCDEP through an existing contract has already developed a design for dredging of Hendrix Creek and will solicit a contractor to perform these dredging operations in early 2008.

Non-CSO Impacted Tributaries

Other areas that are known to have artificially deep basins that result in density stratification include Norton Basin, Shellbank Basin, and Mill Basin. The area of Norton Basin known as Little Bay has depths greater than 60 ft and experiences anoxia during much of the year. The USACE has proposed plans to re-contour the basin to a shallower depth, which have yet to be approved. Shellbank Basin is more than 50 ft deep at the head end and also experiences anoxia. A low energy diffuser destratification system is being used to mix the water column. The destratification increases the DO from 0.0 to 1.0 mg/L and prevents the system from stratifying (see Management Strategy 1c2 below). The increase in DO prevents the production of hydrogen sulfide to reduce odors, but it does little to improve aquatic habitat or meet water quality standards. Mill Basin is approximately 40 ft deep and experiences hypoxia and anoxia. The low DO concentration in Mill Basin is primarily due to SOD resulting from the deposition of organic matter from other sources such as stormwater and algal growth.

Some of the tributaries do not have sufficient data to determine if they suffer from poor water quality, or to assess whether they could benefit from re-contouring. For example, data from the Arverne

Environmental Impact Statement indicate that areas in Vernam, Sommerville and Barbadoes Basins experience at least occasional hypoxia (DO < 3.0 mg/L) (HPD 2003). Areas in Sommerville Basin are greater than 40 ft deep and Vernam Basin has areas that are greater than 30 ft deep. While Barbadoes Basin is only 10 to 15 ft deep, the entrance channel to the basin is constricted, based on the U.S. National Oceanic and Atmospheric Administration (NOAA) nautical chart for Jamaica Bay, and this may affect overall water quality. Currently, none of these basins have plans for water quality or habitat improvements.

However, if information from the other tributaries with data can be extrapolated, it appears likely that most of the tributaries could have periods with low DO levels. All of these tributaries could have improved bottom DO concentrations if they were made shallower. In general, the deeper the tributary the more likely it would benefit from re-contouring.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

The removal and recontouring of the CSO mounds in affected tributary basins will improve water quality, reduce noxious odors, provide for more diverse and healthier benthic habitats and remove contaminated sediments (polynuclear aromatic hydrocarbons (PAHs), pesticides, etc.) that have been discharged from the CSO outfalls through the years. Different modeling analyses have indicated that re-contouring the tributary basins to a shallower depth could eliminate or reduce the hypoxic conditions and improve DO concentrations.

Technical

Dredging will need to be done in a manner that minimizes disturbance and potential environmental effects. Dredging can be done in colder months to minimize potential for odors.

Legal

Dredging and the recontouring of tributaries within Jamaica Bay will require dredging and tidal wetland construction permits from NYSDEC in coordination with the USACE. Permits or authorizations would be required from NYSDEC, USACE, National Marine Fisheries Service (NMFS), and perhaps others, including:

- 33 CFR 225 – USACE Dredged Material Permit
- 33 CFR 323 – Compliance with definition of “Fill Material” under Section 404 of Clean Water Act.
- Section 401 of the Clean Water Act (Water Quality Certification)

Costs

See *Implementation Strategies* below for cost information.

RECOMMENDATION

NYCDEP will pursue the dredging and recontouring of Hendrix Creek and in the future, Paerdegat Basin, Fresh Creek, Bergen Basin and Thurston Basin. See *Implementation Strategies* below.

IMPLEMENTATION STRATEGIES

Dredge and Recontour Hendrix Creek

Improving the water quality and reducing the noxious odors from CSO buildup, the dredging will remove approximately 20,000 cubic yards of accumulated sediment and include capping the bottom with a mixture of clean sand and gravel.

Schedule: Final design was initiated in January 207 and was completed in June 2007. Construction schedule is being developed.

Cost: To be determined.

Pursue Dredging of Paerdegat Basin, Fresh Creek, Bergen Basin and Thurston Basin

Implementation schedules for dredging and recontouring of Paerdegat Basin, Fresh Creek, Bergen Basin and Thurston Basin have been developed and submitted to NYSDEC for approval in the *Paerdegat Basin LTCP* report and the *Jamaica Bay and Tributaries Waterbody/Watershed Plan* report.

Schedule: To be determined.

Cost: To be determined.

Support JBERP in Paerdegat Basin and Fresh Creek

The JBERP program proposed by the USACE with the NYCDEP as the local cost-sharing partner for Paerdegat Basin and Fresh Creek would provide comprehensive habitat and ecological benefits. NYCDEP strongly recommends that the USACE secure funding to continue with these proposed restoration activities in Paerdegat Basin and Fresh Creek as well as other CSO and non-CSO tributaries in Jamaica Bay.

Schedule: To be determined.

Cost: To be determined.

Management Strategy 1c2: Determine hypoxic area in the tributary basins that may benefit from mechanical aeration to increase dissolved oxygen concentrations.

STRATEGY DESCRIPTION

Aeration of water is the supply of air to a water body. Coarse bubble diffuser aeration utilizes compressors to supply air and a network of pipes and diffusers located beneath the water surface to distribute the air. A standard coarse bubble diffuser system might consist of an air intake structure, compressors to transport the pressurized air through supply piping, the mains and headers to convey the air to its point of delivery and a network of diffusers. At the diffusers, the compressed air is released to the water column in the form of coarse bubbles. These bubbles rise to the water surface, transferring oxygen to the water as they rise.

Multistage centrifugal compressors, or rotary positive displacement units, are often used to achieve the airflow and pressure required. The compressors are designed to develop sufficient pressure to overcome static head and friction losses of the supply piping, while delivering air at the required flow rate to the diffuser network.

The projects recommended under the WB/WS Plan, as discussed in Management Strategy 1b2, does not bring Fresh Creek to 100 percent attainment of DO standards. A number of alternatives were considered, yet only in-stream aeration was shown to affect DO compliance. NYCDEP is currently constructing an aeration pilot in Newtown Creek to analyze the effects of aeration in the New York Harbor. Results from this pilot will inform decisions made in Jamaica Bay. Aeration strategies used in other locations have also been evaluated according to their ability to improve DO and minimize ecological impacts associated with the installation and operation of aeration systems.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

The major factors affecting the dissolved oxygen levels in Jamaica Bay tributaries include the existing bathymetry of the tributary; whether there are discharges of stormwater, CSO, or WPCPs; the existing organic layer on the bottom of the tributary; and the interface of the substrate (bottom materials) with the waters of respective tributaries. It is important that these factors be taken into consideration in the determination of the oxygen input required to maintain a minimum dissolved oxygen level that meets the current NYSDEC dissolved oxygen water quality standard. Weather, temperature, tidal activity and a number of other variables also play an important part in the DO levels.

Over the years, significant sampling, analysis and water quality modeling have been performed on Jamaica Bay. However, there is less data on the condition of the tributaries. The WB/WS Plan provided water quality modeling for the CSO tributaries as shown in Table 3.11[1], based on 1988 data. Fresh Creek would meet DO levels 72% of the time with the WB/WS Plan and 100% if aeration is implemented. In Bergen Basin, DO levels would be met 100% of the time if aeration is implemented and only 50% without aeration. Similarly, Thurston Basin would also meet DO compliance levels 100% of the time with aeration, but only 60% without aeration.

TABLE 3.11. Annual DO Compliance Levels

Tributary	*Baseline*	*Future without Aeration*	*Future with Aeration*
Fresh Creek	60%	72%	100%
Bergen Basin	50%	50%	100%
Thurston Basin	60%	60%	100%
*At head of waterbody			

[1] The CSO tributaries of Jamaica Bay are: Fresh Creek, Hendrix Creek, Spring Creek, Bergen Basin, and Thurston Basin.

Further, the results of the North Channel Model, a subset of the peer-reviewed JEM model, and used for the WB/WS Plan, may be indicative of locations of hypoxia in the tributaries. This, taken together with citizen odor complaints, is helpful to refine the selection of tributaries to receive treatment. Sampling and analysis would confirm hypoxic locations.

Technical

A coarse bubble diffused aeration system for Jamaica Bay tributaries has advantages as well as disadvantages. The advantage of coarse bubble diffusion aeration is that it is a proven aeration system used in many wastewater treatment systems and has been used in the Cardiff Bay Project to improve dissolved oxygen within the fabricated escarpment. The Cardiff Bay project required the use of supplemental oxygen injected by spargers mounted on a barge with liquid oxygen tank (LOX) storage tank. This may not be the case in the Jamaica Bay tributaries as they are much shallower then Cardiff Bay. Typically, these systems are relatively easy to operate once installed, with all mechanical parts located on shore for ease of repair and maintenance. The disadvantages of coarse bubble diffusers are the difficulty of installation as well as inspection and maintenance of the system.

If the tributary does not have at least six feet of freeboard (distance from bottom to MLW, the aeration system is not efficient at transferring oxygen, and the tributary needs to be dredged to minus six feet below MLW. Dredging removes the settled CSO solids from the bottom of waterbodies. This restricts the area where the solids settle out and allows the waterbody to retain readily settleable solids that are carried by CSO discharges. The settled solids would be dredged from the receiving waterbody as needed to prevent use impairments such as nuisance odor conditions. Monitoring the need for dredging periodically to prevent the use impairment/nuisance conditions from occurring is essential. Dredging would be conducted as an alternative to structural CSO controls such as storage. Bottom water conditions between dredging operations would likely not comply with dissolved oxygen standards and bottom habitat would degrade following each dredging. In this case, dredging is needed to bring the bottom to minus six feet below MLW to increase the effectiveness of the aeration system. If the material to be dredged form each tributary is a Class C material, as defined within NYSDEC Technical & Operational Guidance Series (TOGS) 5.1.9, it would need to be removed and a clean sand cap provided. Dredging would be to eight feet below MLW and then capped with two feet of clean sand.

Two other technical issues include:

- Costs and effectiveness of DO transfer – The size of the system would be decided based on water quality modeling of the respective tributaries. Modeling the DO requirements of a tidal basin or creek is difficult with the possibility that an installed system may be undersized for the need. This happened to a system installed in Cardiff, Bay, Wales, UK. During periods of low flow, high temperatures and low wind velocity, the DO concentration was not in attainment with the water quality standard. The Environmental Agency required Cardiff Bay authorities to inject liquid oxygen through a side stream so that the DO water quality standard could be achieved.

- Effect on the environment – Hypersaturation of air in the waters of the tributaries may be harmful to aquatic organisms. The diffusers must be correctly spaced to prevent suspension of benthic material and appropriate mixing of the diffused air to occur.

Legal

Aeration and potential dredging for aeration of tributaries within Jamaica Bay will require dredging and tidal wetlands construction permits from the NYSDEC in coordination with the USACE. Permits or authorizations would be required from NYSDEC, USACE, NMFS, and perhaps others, including:

- 33 CFR 225 – USACE Dredged Material Permit
- 33 CFR 323 – Compliance with definition of "Fill Material" under Section 404 of Clean Water Act.
- Section 401 of the Clean Water Act (Water Quality Certification).

Costs

For initial cost estimates for Fresh Creek, Bergin and Thurston Basins, see Implementation Strategies below. Costs cannot be determined for those tributaries that have limited water quality and sediment data. The dredging and aeration costs would be site specific to each tributary.

RECOMMENDATION

NYCDEP will pursue the dredging and aeration of Fresh Creek, Bergen Basin and Thurston Basin. See *Implementation Strategies* below.

IMPLEMENTATION STRATEGIES

Pursue In-stream Aeration for Bergen and Thurston Basins

Increasing the DO levels in Bergen and Thurston Basins can be attained by adding in-stream aeration. Dredging each waterbody will be part of in-stream aeration to create a water column deep enough to achieve adequate oxygen transfer through the full range of tidal exchange.

Cost: Approximately $112 million.

Schedule: Installation of in-stream aeration would be subject to successful completion of the Newtown Creek demonstration project and permitting at the facilities. Final Design is estimated to begin in 2015 and finish in 2017. Construction is slated to begin in 2018 and completion is estimated for 2021.

Pursue In-stream Aeration for Fresh Creek

Increasing the DO levels in Fresh Creek can be attained by adding in-stream aeration. Dredging Fresh Creek will be part of in-stream aeration to create a water column deep enough to achieve adequate oxygen transfer through the full range of tidal exchange.

Cost: $82 million.

Schedule: Installation of in-stream aeration would be subject to successful completion of the Newtown Creek demonstration project and permitting at the facilities. Final Design is estimated to begin in 2015 and finish in 2017. Construction is slated to begin in 2018 and completion is estimated for 2021.

Investigate Potential for Future Aeration in Other CSO and Non-CSO Tributaries

For the other CSO and non-CSO tributaries, the following are the needs to be estimated, and steps in the process:

- Review literature and studies to evaluate potential tributaries that may be hypoxic.
- Water quality modeling performed for both the CJBWQP and the WB/WS Plan indicate that the following tributaries may be hypoxic and were preliminarily ranked with the most likely to be stratified first:
    - East Mill Basin
    - Mill Basin
    - Sheepshead Bay
    - Hawtree Basin.
- Review citizen complaints related to odor at specific tributaries.
- Collect data in tributaries where data are lacking to verify hypoxia.
- Perform water quality modeling data plots to determine ranking of creeks/basins.
- Determine if aeration for the basin/creek is for destratification or attaining WQS.
- Select a DO goal for each basin/creek selected.
- Determine if creek/basin needs dredging for the aeration system to perform.
- Select Basins and a schedule to implement.

Schedule: To be determined.

Cost: To be determined.

OBJECTIVE 1D: DEVELOP A ROBUST AND COORDINATE SCIENTIFIC PROGRAM

Current Programs

New York Harbor waters are cleaner now than at any time in the last 50 years. The water quality within Jamaica Bay has significantly improved and the continued improvements by NYCDEP to the wastewater treatment handling and treatment are chiefly responsible for continued improvements to water quality, which have led to increased recreational opportunities. New York City was one of the first metropolitan areas in the United States to design, construct and operate a modern sewage treatment facility. Portions of the Harbor Waters have been monitored for water quality since 1909 nearly 100 years of data collection. Research by NYCDEP has clearly shown that the waters around the City and Jamaica Bay are healthier than they have been since the beginning of the 20^{th} century.

In order to develop an effective scientific monitoring program, the goals of the program must first be defined. For example, the NYCDEP water quality sampling program for Jamaica Bay grew from one of the oldest and continuous monitoring programs in the United States, the Harbor Survey Program. The goal of this program is to monitor the general health of the harbor waters to determine the quality of the waters through the effectiveness of the WPCP upgrades and other environmental measures implemented by NYCDEP. As such, the City's current monitoring program for Jamaica Bay focuses on monitoring the general trends in water quality over time.

Jamaica Bay has been extensively studied over a range of many disciplines and by a wide range of entities including the efforts of NYCDEP, the NPS, NYSDEC, the USACE, and various academic programs. These studies have included a review of important vegetation communities, wildlife use, sediment deposition rates, sea level rise, wetland losses, nitrogen discharges, atmospheric deposition rates and sediment toxicity. This list of topics is not meant to imply an exhaustive list of research efforts but rather to illustrate that the Bay has had extensive study over the years covering many topics, but not necessarily in a coordinated effort that informs other studies with critical information.

To date, the monitoring efforts of water quality improvements within Jamaica Bay have primarily focused on tracking the following areas:

- Reduction of nitrogen loadings to the Bay;
- Reduction of CSO pathogen loadings to the Bay; and
- Improvement of the Bay ecosystem.

CURRENT NYCDEP MONITORING

NYCDEP Harbor Water Quality Survey In Jamaica Bay

There are currently eight open water sampling stations in Jamaica Bay and one located in Sheepshead Bay (see Figure 3.18, Active Harbor Survey Stations, below). The stations generally provide good spatial coverage of the Bay. However, one area that is not currently sampled is the center of the Bay within the intertidal marshes where shallow water depth makes sampling logistically difficult. The tributaries are sampled on a non-structured rotating basis.

Several parameters (salinity, temperature, pH, and DO) are sampled at both the surface and bottom. The nutrient series, chlorophyll, fecal coliforms and enterococci are sampled at the surface. The majority of the Bay is well mixed vertically, and additional bottom sampling is likely not to be warranted.

The majority of the sampling completed by NYCDEP is discrete sampling on a weekly to monthly basis at one particular location. These samples provide snapshots of water quality and can miss short-term or localized events. Continuous monitors can provide information on a more frequent basis, which allows the observation of short-term events, such as meteorological events, and tide cycles. Currently, NYCDEP has two continuous monitors in Jamaica Bay. One is located at Kingsborough College in Sheepshead Bay and the other is located on Broad Channel. These locations were chosen because they are in accessible, secure locations. The meters measure water level, temperature, salinity, dissolved oxygen, and chlorophyll, as well as meteorological information. However, the information from these monitoring stations is somewhat limited because they do not represent the open waters of the Bay.

As part of the CJBWQP, a series of short duration but multiple year ecosystem studies have been conducted. The study includes two moorings that have near surface and near bottom continuous monitors, and were deployed in North Channel and Grassy Bay. These monitors include temperature, salinity, and DO sensors

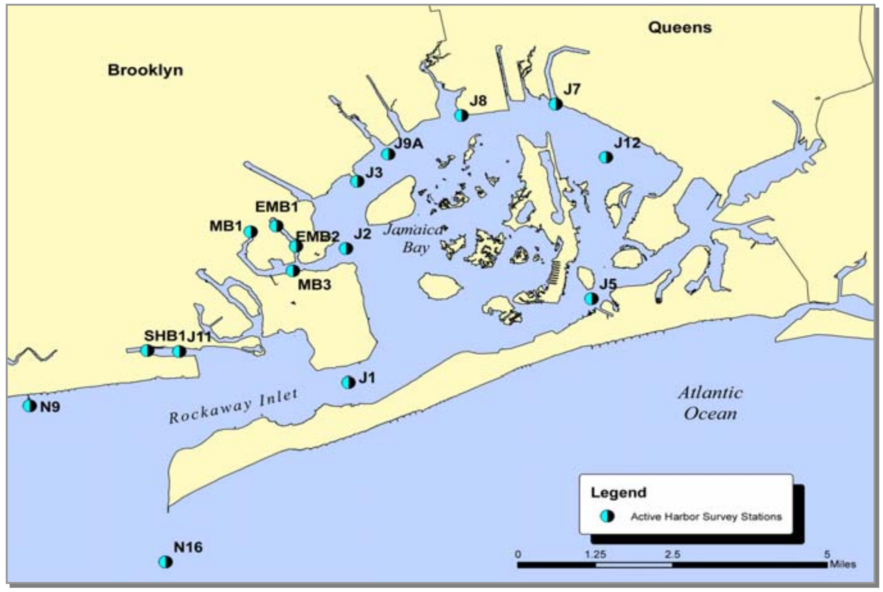


FIGURE 3.18 Active Harbor Water Survey Stations: HydroQual

BIOLOGICAL MONITORING

As part of the Jamaica Bay ecosystem studies being conducted under the CJBWQP project, short term biological monitoring is also being conducted. This sampling enhances the understanding of the relationship between dissolved oxygen and unionized ammonia concentrations and the health of the ecosystem. As part of the studies, sediment profile imaging (SPI) is being used to assess the quality of the benthic community. The images allow the observation of benthic organisms, the depth of the aerobic sediment layer, and the existence of hydrogen sulfide bubbles in the sediment. Benthic sampling was also conducted to complete species identification and enumeration. In the water column, trawls were conducted to collect fish eggs and larvae. Species identification and enumeration was conducted on these samples. Some samples were tested for RNA:DNA ratios to determine if there was evidence of stress on the growth of the organisms. This monitoring is part of a short term study over several years and is expected to continue through June 2008.

WPCP EFFLUENT SAMPLING

NYCDEP, as part of the SPDES permit monitoring, conducts extensive sampling of the effluent discharges (flow and pollutants) from the four WPCPs discharging to Jamaica Bay. The results of these sampling activities are reported to the NYSDEC monthly.

CSO AND STORMWATER SAMPLING

Samples of combined sewer overflows and stormwater collected from outfalls to Jamaica Bay and its tributaries have all been associated with CSO planning projects. For example, between 1985 and 2005 thousands of samples of CSO and stormwater quality samples have been collected by the NYCDEP. Further some limited flow monitoring has been conducted as part of these projects. There are currently no programs to monitor CSO or stormwater flow or quality in a way similar to the SPDES-required WPCP effluent monitoring. However, with the completion of the Waterbody/Watershed planning portion of the Long Term Control Plan, NYCDEP will be receiving modifications from NYSDEC to SPDES permits for the Coney Island WPCP and the 26th Ward WPCP for CSO facilities that now discharge or in the future will discharge to Jamaica Bay tributaries (Paerdegat Basin CSO Retention facility and the Spring Creek CSO Retention facility). These permits will require sampling and reporting of the treated effluent (flow and quality). NYCDEP will be required at that point to initiate a sampling program for those CSO facilities.

Management Strategy 1d1: Identify potential additional monitoring needs and develop an enhanced monitoring program.

STRATEGY DESCRIPTION

NYCDEP reviewed its current monitoring programs as well as programs in place in other harbor estuary areas to identify potential additional monitoring needs. The goal of any enhanced monitoring of Jamaica Bay would be to evaluate on a scientific basis the effectiveness of strategies and measures implemented under the Jamaica Bay Watershed Protection Plan and other efforts.

In addition to identifying additional monitoring, a coordinated collaborative effort between academic and public agency research efforts is necessary to develop a comprehensive sampling program and identify data gaps and issues that require further analysis. A central clearinghouse for data is essential to keep other research informed; much research has been done, but the data is located in diffuse locations and not easily coordinated to determine possible linkages between research efforts or findings.

Table 3.12 presents a comparison of the NYCDEP Harbor Water Quality Survey to other monitoring programs around the country. The programs include monitoring programs for Chesapeake Bay, Massachusetts Bay (Massachusetts Water Resources Authority (MWRA)), Chicago (Lake Michigan), South Florida (Southeast Environmental Research Center), Port of San Diego, Port of Los Angeles, and the National Estuarine Research Reserve System (NERR) of NOAA. The size of the programs depends on the goals and available funding. The California ports have small sampling programs. Chicago's program is concerned with the use of Lake Michigan as drinking water. The MWRA program is monitoring the impact of a newly relocated treatment plant effluent outfall on a large ecosystem. The Chesapeake Bay program attempts to look at the entire ecosystem. Each of these programs bring a unique perspective on monitoring efforts. In general, the NYCDEP Harbor Survey Program falls somewhere in the middle of these other programs for water quality and sediment monitoring. The water quality sampling is among the most comprehensive of those reviewed, but falls a little short of the MWRA and Chesapeake Bay programs.

TABLE 3.11. Comparison of NYCDEP Harbor Water Quality Survey to Other Programs

Water Column	Parameter	Jamaica Bay	Chesapeake Bay, VA	Chesapeake Bay, MD	Massachusetts Bay	Lake Michigan	South Florida, SERC	Port of San Diego	Port of Los Angeles	NERR, NOAA
	Stations	9	32	93	27	80	100+	5	31	
	Frequency per year	24	12 – 16	12 – 20	6 – 12	5	4 – 12	Buoys	12	12
	Depth	S/B			S/BV	S				B
	Temperature	X	X	X	X		X	X	X	X
	Salinity	X	X		X		X	X		X
	Dissolved Oxygen	X	X	X	X		X	X	X	X
	BOD								X	
	Specific conductance		X	X				X		
	pH	X	X	X						X
	Secchi Depth	X	X	X			X			
	Light Attenuation/PAR		X	X	X					
	Turbidity						X	X		
	Orthophosphate	X	X	X	X		X			X
	Total Dissolved Phosphate		X	X	X					X
	Particulate phosphate		X	X	X					
	Total Phosphorus	X					X			
	Nitrite		X	X						
	Nitrite+nitrate	X	X	X	X		X			X
	Ammonium	X	X	X	X		X			X
	Total dissolved nitrogen		X	X	X					
	Particulate nitrogen		X	X	X					

TABLE 3.11. Comparison of NYCDEP Harbor Water Quality Survey to Other Programs

Water Column	Parameter	Jamaica Bay	Chesapeake Bay, VA	Chesapeake Bay, MD	Massachusetts Bay	Lake Michigan	South Florida, SERC	Port of San Diego	Port of Los Angeles	NERR, NOAA
	Total organic nitrogen						X			
	Total Kjeldahl nitrogen	X								
	Total nitrogen						X			
	Dissolved organic carbon	X								
	Dissolved inorganic carbon				X					
	Particulate carbon		X	X						
	Total organic carbon						X			
	Dissolved silica	X	X	X	X		X			
	Biogenic silica				X					
	Total suspended solids	X	X		X					
	Volatile suspended solids		X	X						
	Chlorophyll-a	X	X	X		X	X			X
	Pheophytin		X	X						
	Fluorescence			X	X					
	Colored dissolved organic matter		X							
	Alkaline Phosphates Activity						X			
	Odor and color							X		
	Oil and grease							X		
	Floating solids				X			X		
	Cyanide					X				

TABLE 3.11. Comparison of NYCDEP Harbor Water Quality Survey to Other Programs

Water Column	Parameter	Jamaica Bay	Chesapeake Bay, VA	Chesapeake Bay, MD	Massachusetts Bay	Lake Michigan	South Florida, SERC	Port of San Diego	Port of Los Angeles	NERR, NOAA
	Metals					X				
	Pesticides					X				
	Total coliforms					X				
	Fecal coliforms	X				X				
	Enterococcus	X								
Sediment	Stations				8+					
	Frequency		4	4	1					
	Sediment analysis		X	X						
	Percent dry weight				X					
	Total organic carbon				X					
	Metals				X					
	PCBs				X					
	PAHs				X					
	Pesticides				X					
	Grain size				X					
Sediment	*Clostridium perfringens*				X					
	SPI		X		X					
Plankton	Stations									
	Frequency									
	Phytoplankton identification		X	X	X					
	Phytoplankton abundance		X	X	X					
	Picoplankton		X							

TABLE 3.11. Comparison of NYCDEP Harbor Water Quality Survey to Other Programs										
Water Column	**Parameter**	**Jamaica Bay**	**Chesapeake Bay, VA**	**Chesapeake Bay, MD**	**Massachusetts Bay**	**Lake Michigan**	**South Florida, SERC**	**Port of San Diego**	**Port of Los Angeles**	**NERR, NOAA**
	Mesozooplankton		X	X	X					
	Microzooplankton		X	X	X					
	Primary Production		X	X	X					
Benthos	Stations									
	Frequency									
	Benthic fauna identification		X	X						
	Benthic fauna counts		X	X						
	Benthic fauna biomass		X	X						
Fisheries	Stations									
	Frequency			1						
	Trawl and seine			X						
	Fish samples				X	X				
SAV				X						
Remote Sensing				X	X					

Based on this review, the addition of more water quality parameters, sediment sampling, and the sampling of aquatic and benthic biota similar to those of other estuary programs is required to better assess the holistic health of the Jamaica Bay ecosystem. The addition of more frequent water/sediment quality sampling and locations within the Bay, as well as monitoring efforts within the upland portions of the watershed would be required. For many areas and in particular the upland portions of the watershed, multiple entities forming collaborative partnerships to collect and process monitoring data would need to be part of a comprehensive plan.

To begin to collect additional data, the following potential water quality parameter monitoring enhancements could be added to NYCDEP's current sampling efforts.

Potential Water Quality Parameters

The following parameters could be part of an enhanced program:

- particulate organic carbon
- particulate organic nitrogen
- particulate organic phosphorus
- biogenic silica
- dissolved organic carbon
- dissolved organic nitrogen
- dissolved organic phosphorus.

These constituents provide additional information on phytoplankton in the Bay, which is very useful in assessing the eutrophic nature of the system. Additionally, phytoplankton enumeration and species identification would provide useful information on the Jamaica Bay ecosystem. Samples for these parameters could be collected from within the Bay at the same frequency as NYCDEP's routine monitoring is conducted.

As discussed above, under the Comprehensive Jamaica Bay Water Quality Plan, two moorings with near surface and near bottom continuous monitors were deployed in North Channel and Grassy Bay. These monitors include temperature, salinity, and DO sensors. A recommendation has been made to add an additional mooring station in Broad Channel.

Another monitoring need is an area not currently sampled - the center of the Bay within the intertidal marshes where shallow water depth makes sampling logistically difficult. An additional water quality sampling station within the center of the Bay and more regular sampling at select tributary locations will give a better indication of the ecological integrity and function of the system.

To date, NYCDEP has avoided deploying monitoring buoys in the open waters for several reasons. The buoys required for this monitoring are large, too large for NYCDEP to deploy using its current boats. When buoys such as these are deployed, there is a tendency for boaters to dock off the buoys, which can cause damage to the monitoring equipment. Theft of equipment is also a concern. Further, Jamaica Bay is very productive in terms of algae growth, so monitoring equipment can become biofouled within weeks, and require considerable maintenance.

As noted above, NYCDEP will conduct additional water quality monitoring of the CSO tributaries as part of its Long Term Control Plan. A sampling plan will be developed and approved by the

NYSDEC prior to the initiation of routine monitoring of the CSO impacted tributaries. CSO facility discharges – including the Paerdegat CSO retention facility, which is under construction, and the Spring Creek AWPCP CSO retention facility – will also be monitored.

As discussed under Chapter 5, Stormwater Best Management Practices, CSO volumes and discharges will also be monitored to assess the effectiveness of stormwater BMPs and other land use strategies as they are implemented over time.

ADDITIONAL ENHANCED MONITORING (would need to be in collaboration with other agencies)

Potential Sediment Sampling

A significant modification to the current sampling program could be the inclusion of sediment sampling. Sediment nutrient flux measurements, sediment oxygen demand, pore water and solid phase measurements will be added to the program on a limited basis. Both the Chesapeake Bay and Massachusetts Bay (MWRA) programs include limited sediment sampling. This type of sampling and analysis is highly specialized and would have to be completed by laboratories and researchers outside of NYCDEP, potentially in partnership with other agencies and academic institutions.

Potential Biological Sampling

The aforementioned sampling focuses on water quality indicators, which does not necessarily present a clear picture of the health of the ecosystem. Biological sampling will be conducted to provide this information. NYCDEP could institute biological sampling to include parameters such as algae enumeration and identification, SAV, as well as biological indicators such as benthic diversity.

Salt Marsh Island Monitoring

In addition, salt marsh island monitoring needs to be continued and expanded to include continued monitoring of wetland biomass production; extent of marsh coverage from year to year; wetland elevation monitoring; and sediment sampling within marsh

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Increasing the diversity and scope of the environmental sampling parameters will provide a better understanding of how the ecosystem of Jamaica Bay is functioning and the potential effects from changing environmental variables (*e.g.*, nutrient loading, temperature, wind, etc.). Additional water quality constituents within a comprehensive sampling program will assist in the further understanding of the health of the Bay as it relates to eutrophic conditions. In order to provide effective and useful data, water quality and ecosystem monitoring must be done in a coordinated fashion and be capable of informing other research efforts.

The JBWPP strategies target improvements in various aspects of the water quality of Jamaica Bay. An enhanced sampling program should be tailored to tracking the effectiveness of these changes as they are implemented over time. With this understanding, these measures can be refined and improved through adaptive management or other measures developed for further enhancements to the environmental quality of Jamaica Bay.

Technical

In order to be most effective, monitoring programs should be coordinated among the various entities. In order for the data collected by different entities to be useful in aggregate, the various entities must use similar protocols and collection methods. To achieve this, it is important that the various existing monitoring programs be coordinated through a central clearinghouse.

Cost

TABLE 3.13 Water Quality Sampling Costs

Sampling Type	Cost	Measurement Unit	Sampling Frequency
Sediment Profile Imagery	$43,000	50 stations	2x/year
Pore Water	$36,000	12 stations	2x/year
Benthic Habitat	$66,000	42 stations	2x/year
Moored Water Quality Sensors	$21,000	3 sensors/month	continuous
Mobile WQ Sampling	$24,000	30 samples/day	1x or 2x/year
Discrete WQ Monitoring	$7,000	14 stations in situ	
Ichthyoplankton	$26,000	14 stations	Bimonthly (Apr-Sep) and Monthly (Oct-Mar)
Finfish Sampling	$21,000	14 stations	Bimonthly (Apr-Sep) and Monthly (Oct-Mar)
Epibenthic Egg Sampling	$21,000	14 stations	Monthly (Jan-Mar)

Note: Other testing parameters and costs will need to be determined in partnerships with multiple agencies and environmental groups.

Legal

Additional sampling will require consultation with regulatory agencies and permission from property owners (*e.g.*, NPS). It will be important to clearly distinguish between monitoring performed to meet permitting requirements and other monitoring efforts.

RECOMMENDATION

Water quality constituents that are currently sampled by the NYCDEP as part of the ongoing Harbor Survey Program are fairly extensive. After reviewing the sampling programs of other harbor estuaries and the goals of the JBWPP, NYCDEP in the short term will review the potential to expand its current monitoring program to include Sediment Profile Imagery, Pore Water Analysis, Benthic Habitat Analysis, Moored Water Quality Sensors, Mobile Water Quality Sampling, Discrete Water Quality Monitoring, Ichthyoplankton Sampling, Finfish Sampling and Epibenthic Sampling in a number of areas. Additional monitoring needs to be a collaborative effort among multiple entities, with appropriate funding identified and information sharing of research and monitoring data collection. See *Implementation Strategies* below for a description of these efforts.

IMPLEMENTATION STRATEGIES

Enhanced Monitoring Plan

NYCDEP based on this review, will develop an enhanced holistic water quality and ecosystem monitoring program to include some of the items listed below. The monitoring program will be coordinated with other entities conducting sampling within the Bay (see *Development of Partnerships and Funding Sources* below). Enhancements will include the following as detailed above:

1. **Potential Additional Water Quality Sampling**: the following parameters will be part of an enhanced program:

    - particulate organic carbon;
    - particulate organic nitrogen;
    - particulate organic phosphorus;
    - biogenic silica;
    - dissolved organic carbon;
    - dissolved organic nitrogen; and
    - dissolved organic phosphorus.

2. **Potential Sediment Sampling:** This type of sampling and analysis is highly specialized and would have to be completed and funded in partnership with other agencies and entities.

3. **Potential Biological and Ecosystem Monitoring:** Parameters such as algae enumeration and identification, SAV, as well as benthic biological indicators will be added.

4. **Salt Marsh Island Monitoring**: This effort is outside of NYCDEP's control and the monitoring of wetland biomass production; extent of marsh coverage from year to year; wetland elevation monitoring; and sediment sampling within marsh islands would need to continue by others. However, NYCDEP will assist in some of the data collection andgeographic information systems (GIS) analysis as appropriate and as feasible. Further coordination with multiple agencies and environmental groups is necessary before finalizing extent of effort.

Schedule: Enhancement program will be developed by October 2008.

Cost: To be determined based on proposed enhancements.

Other Potential Ecosystem Monitoring

Additional research and monitoring efforts are needed to adequately detail the environmental conditions of the Bay, its watershed and to provide feedback mechanisms that give an indication of how well current and past remediation efforts are functioning to improve ecological conditions and at what level and what factors may be limiting its ability to function properly. Research needs should be identified in collaboration with academic institutions, the public sector, and environmental organizations. The program should incorporate research on water quality issues, sediment, and upland vegetation (perimeter of the Bay and watershed) salt marsh islands, aquatic and benthic biota. Develop a list of research needs within the following categories:

1. Aquatic ecology
2. Coastal geomorphology
3. Plant ecology
4. Wildlife ecology
5. Natural resources management
6. Resource protection, planning and maintenance; and
7. Watershed-wide ecosystem monitoring.

Development of Partnerships and Funding Sources

A collaborative effort between local academic institutions and government agencies is essential to adequately address the enormous scope and complexity of the interacting ecosystems of the Bay and watershed and NYCDEP strongly encourages the development of such a program.

The Jamaica Bay Institute (JBI) maintains a database inventory of known studies performed on the Bay over the last 25 years or so. Some of the studies are outdated and could be updated by taking advantage of the great refinements in technology. Other studies could have benefited from better access to previous studies had they been inventoried. To help close this gap, the JBI has contracted with Queens College to develop a Research Opportunities Catalog that is modeled after a similar undertaking at the Cape Cod National Seashore. The document, "Research Opportunities in the Natural and Social Sciences at Cape Cod National Seashore," is being reviewed by Queens College to develop a report that would highlight the specific research and data gap needs within the boundaries of Jamaica Bay.

The following quote from this report sums up the need for collaboration rather nicely:

> ***"The diversity, complexity and sheer magnitude of wildlife, vegetation and natural processes occurring within the boundaries of Cape Cod National Seashore dictate a collaborative approach to research and resource monitoring at the park. The National Park Service simply cannot meet all of its research needs alone and thus we seek to expand our research partnerships with individuals, universities, public agencies and non-governmental organizations"*** **(NPS 2002).**

This is not only true for the NPS resources at Cape Cod, but can be said of all agencies and groups that have jurisdiction or regulation over Jamaica Bay. The task at hand is simply too large for any one entity to manage alone. A comprehensive and coordinated team effort is required.

In addition, as discussed in Chapter 7, "Implementation and Coordination," it is recommended that a steering committee be established to guide the implementation of Water Quality and Ecological Restoration strategies. A key role of this committee could be to coordinate monitoring efforts, track monitoring results, and identify additional data needs.

In addition, extensive work with academic institutions to develop a watershed based curriculum and direct research opportunities of faculty and students to help fill existing data gaps will provide valuable information that could potentially guide future restoration efforts and research needs.

Track Endocrine Disrupter Issues

Endocrine-disrupting compounds (EDCs), pharmaceutical and personal care products (PPCPs), and pharmaceutically active compounds (PhACs) are included under this broader category of chemicals and compounds called microconstituents. Microconstituents can make their way into the environment through a variety of routes, such as industrial discharges, wastewater treatment plant (WWTP) effluent, runoff from agricultural and feedlot operations, and other nonpoint sources that are more difficult to quantify. Compounds that have most often been implicated in endocrine disruption in aquatic organisms are the natural estrogens estrone (E1) and estradiol (E2), which are excreted by all humans; the synthetic estrogen ethinylestradiol (EE2), which is the active ingredient in birth control pills; and nonylphenol and octylphenol. The Stony Brook University work within Jamaica Bay has primarily focused on nonylphenol ethoxylates (NPEO). NPEOs are high production volume surfactants which have been used as detergents, wetting agents and emulsifiers in commercial and industrial products for more than 50 years. The issue of NPEO persistence and availability has been controversial and sparked considerable research.

Using the procedures of the federal advisory committee, developed by the Endocrine Disruptor Screening and Testing Authority (EDSTAC), one study placed the cost range to screen and test for many compounds to be approximately $200,000 and $1,000,000. Developing a screening and testing program that is designed to test for potentially thousands of compounds is extremely challenging. In addition, once screened and tested for, the removal methods for each compound are so varied that a separate program for removal may be required for each compound or groups of compounds.

The USEPA recently released its draft list of chemicals for initial Tier 2 screening. While this list was developed with pesticides in mind, NYCDEP will closely monitor USEPA's guidance on this issue.

References

Adey, W.H., and J.M. Hackney. 1989. The composition and production of tropical marine algal turf in laboratory and field experiments. In: W.H. Adey (Ed.), *The Biology, Ecology, and Mariculture of Mithrax spinosissimus Utilizing Cultural Algal Turfs*. The Mariculture Institute, Washington, D.C.

Adey, W.H., and K. Loveland. 1991. *Dynamic Aquaria: Building Living Ecosystems*. Academic Press, New York, NY.

Adey, W.H., C. Luckett, and K. Jenson. 1993. Phosphorus removal from natural waters using controlled algal production. Restoration Ecology 1:29-39.

Adey, W.H. C. Luckett, and M. Smith. 1996. Purification of industrially contaminated groundwaters using controlled ecosystems. Ecological Engineering. 7:191-212.

Bain, M., J. Lodge, D.J. Suszkowski, D. Botkin, A. Brash, C. Craft, R. Diaz, K. Farley, Y. Gelb, J.S. Levinton, W. Matuszeski, F. Steimle and P. Wilber. 2007. Target Ecosystem Characteristics for the Hudson Raritan Estuary: Technical Guidance for Developing a Comprehensive Ecosystem Restoration Plan. A report to the Port Authority of NY/NJ. Hudson River Foundation, New York, NY. 106 p.

Blanchard, P. 1992. Buffer the Bay Revisited: An updated report on Jamaica Bay's open shorelines and uplands. The Trust for Public Land, New York, New York.

Blankenship, K. 1997. Algae crops up in nutrient removal system. Alliance for the Chesapeake Bay, Bay Journal, Vol. 7(8):1-6.

Briggs, M. 2004. Widescale biodiesel production from algae. Michael Briggs, University of New Hampshire, Physics Department. Unpublished Report of the UNH Biodiesel Group. msbriggs@unh.edu

Cardiff Harbour Authority. 2007. Available at:
http://www.cardiffharbour.com/environment/w_aeration.htm

Chesapeake Bay Program, Aquatic Reef Restoration.
Available at: www.chesapeakebay.net/reefrest

City of New York. 2007. PLANYC, A Greener, Greater New York. New York, NY.

Clean Vessel Assistance Program (CVAP). Available at:
http://www.nysefc.org/home/index.asp?page=21

Craggs, R.J., W.H. Adey, B.K. Jessup, and W.J. Oswald. 1996. A controlled stream mesocosm for tertiary treatment of sewage. Ecological Engineering 6: 149-169.

Fitzpatrick, J. 2006. HydroQual, Inc. Personal communication.

Hartig, E. K., et al. 2002. Anthropogenic and climate change impacts on salt marshes of Jamaica Bay, New York City. Wetlands 22:1.

Hicks, R.L. 2004. Recreational fishing and the benefits of oyster reef restoration in the Chesapeake Bay. Working Paper Number 1, Department of Economics, College of William and Mary, Williamsburg, VA.

Howarth, R.W., Swaney, D.P., Butler, T.J., and R. Marino. 2000 Climatic control on eutrophication of the Hudson River Estuary. Ecosystems, 3: 210-215.

HydroMentia, Water Treatment Technologies. 2007. Available at:
http://www.scc.rutgers.edu/coastweb/NYCDEPHarbor_survey/docs/biological/chlo.htm
http://www.hydromentia.com/

Jamaica Bay's Disappearing Marshes, Highlighting ongoing research, local and international perspectives and future restoration plans, March 3, 2004.

Jones, A.B., and N.P. Preston. 1999. Sydney rock oyster, *Saccostrea commercialis* (Iredale & Roughley), filtration of shrimp farm effluent: the effects on water quality. Aquaculture Research 30(1):51.

Kebede-Westhead, E., C. Pizarro, W. W. Mulbry, and A.C. Wilkie. 2003. Production and nutrient removal by periphyton grown under different loading rates of anaerobically digested dairy manure. J. Phycology. 39:1275-1282.

Libby, P.S., Geyer, W.R., Keller, A.A., Mansfield, A.D., Turner, J.T., Anderson, D.M., Borkman, D.G., Rust, S., Hyde, K., and C.A. Oviatt. 2006. 2005. Annual Water Column Monitoring Report. Massachusetts Water Resources Authority. Report 2006-20. Boston, MA. 182 p.

Long Island Sound Study Phase III Actions for Hypoxia Management, July 1998.
http://www.popularmechanics.com/science/earth/4213775.html

http://www.ldeo.columbia.edu/res/fac/physocean/Jambay/nitro.pdf

Mack, L. and J. M. Feller. 1990. Salt Marshes of New York City. New York City Department of Parks and Recreation (NYCDPR) & Natural Resource Group. New York, NY.

Maryland Department of Natural Resources. 2006. Draft Quality Assurance Project Plan for the Maryland Department of Natural Resources Chesapeake Bay Water Quality Monitoring Program – Chemical and Physical Properties Component for the period July 1, 2006 – June 30, 2007. Annapolis, MD. 146p.

Metcalf & Eddy, Inc. 1991. Wastewater Engineering, Treatment, Disposal, and Reuse, Third Edition. New York, McGraw-Hill.

Mockler, A. 1991. Freshwater wetlands of New York City. New York City Department of Parks and Recreation (NYCDPR) & Natural Resource Group. New York, NY.

Mulbry, W.W., and A.C. Wilkie. 2001. Growth of benthic freshwater algae on dairy manures. J. Appl. Phycology. 13:301-306.

New York City Department of Environmental Protection (NYCDEP). 2003. Jamaica Bay Eutrophication Model, Jamaica Bay Eutrophication Study Project, Vols. 1 and 2. New York, NY.

New York City Department of Environmental Protection (NYCDEP). 2006a. Comprehensive Jamaica Bay Water Quality Plan. New York, NY.

New York City Department of Environmental Protection (NYCDEP). 2006b. Cit-Wide Long Term CSO Control Planning, Paerdegat Basin LTCP, November 2005, Revised June 2006. New York, NY.

New York City Department of Environmental Protection (NYCDEP). 2007. Jamaica Bay and CSO Tributaries Waterbody/watershed Facility Plan - Draft, June 2007. New York, NY.

New York - New Jersey Harbor Estuary Program (HEP). 2006 Priority Acquisition and Restoration Sites (Revised February 8, 2006). New York, NY.

New York State Department of Environmental Conservation (NYSDEC). 2006. New York State Open Space Conservation Plan. Albany, NY.

New York State Department of Environmental Conservation (NYSDEC), Division of Fish, Wildlife, and Marine Resources, Restoration of Natural Resources through the Jamaica Bay Damages Account, 2007 Update. Albany, NY.

New York State Department of Environmental Conservation (NYSDEC). Jamaica Bay Wetland Loss Analysis, 2007. Available at: http://www.dec.ny.gov/lands/5489.html

New York State Department of State, Division of Coastal Resources and Waterfront Revitalization. 1992. Significant coastal fish and wildlife habitats program, Jamaica Bay habitat narrative, Breezy Point habitat narrative. Albany, NY.

Paine, R. T. 1966. Food web complexity and species diversity. American Naturalist 100:65-75.

Pietros, J.M., and M.A. Rice. 2003. The impacts of aquacultured oysters, *Crassostrea virginica* (Gmelin, 1791) on water column nitrogen and sedimentation: results of a mesocosm study. Aquaculture 220:407-422.

Pizarro, C., W. Mulbry, D. Blersch, and P. Kangas. 2006. An economic assessment of algal turf scrubber technology for treatment of dairy manure effluent. Ecological Engineering 26(4): 321-327.

Randall, C.W., D. Waltrip, and M.V. Wable, 1990. Upgrading a municipal activated sludge plant for high-rate biological nutrient removal. Water Sci. Tech., 22:21-33.

Riepe, D., J. Ingraham and G. Tudor. 1989. Butterflies of the Jamaica Bay Wildlife Refuge. Pamphlet for Gateway National Recreation Area, National Park Service. New York, NY.

Simpson H.J., Williams, S.C., Olsen C.R., Hammond, D.E. (1997) Nutrient and particulate matter budgets in urban estuaries. *Estuaries, Geophysics and the Environment*, National Academy of Sciences, Washington D.C., pp. 94-103.

South Carolina Oyster Restoration and Enhancement, 2007 http://score.dnr.sc.gov/index.php

Stalter, R. Undated. Rare plants of Gateway National Recreation Area, New York, New Jersey: a report for the National Park Service. Unpublished report. New York, NY.

Trust for Public Land and the New York City Audubon Society. 1987. Buffer the Bay: a survey of Jamaica Bay's unprotected open shoreline and uplands. The Trust for Public Land, New York, N.Y. 34pp.

Tucker J., Kelsey, S., Giblin, A.E., and C.S. Hopkinson, Jr. 2007. 2006 Annual Benthic Nutrient Flux Monitoring Report. Report 2007-07. Massachusetts Water Resources Authority (MWRA). Boston, MA. 65 p.

U.S. Army Corps of Engineers (USACE). 2005. Draft integrated ecosystem restoration report and environmental assessment. Jamaica Bay marsh islands, Jamaica Bay, New York. US Army Corps of Engineers, New York District. New York, NY.

U.S. Army Corps of Engineers (USACE). 2002. JBERRT –Jamaica Bay Ecosystem Research and Restoration Team. Final Report. New York, NY.

Tanacredi, John T., Martin P . Schreibman, and George W. Frame, eds. Staten Island, New York: National Park Service Division of Natural Resources.

U.S. Army Corps of Engineers (USACE), New York District. 2004. Hudson-Raritan Estuary Environmental Restoration Feasibility Study: Jamaica Bay Study Area Report. New York, NY.

U.S. Army Corps of Engineers (USACE), New York District. 2005. Jamaica Bay Marsh Islands, Jamaica Bay, New York. DRAFT Integrated Ecosystem Restoration Report and Environmental Assessment. New York, NY.

U.S. Department of the Interior. 1979. Final environmental statement, general management plan. Gateway National Recreation Area - New York/New Jersey. p. 256.

U.S. Department of the Interior. 1989. Mammals. Pamphlet for Gateway National Recreation Area, National Park Service.

U.S. Department of the Interior. 1991. Jamaica Bay fisheries survey, 1985-1989. National Park Service, Gateway National Recreation Area. Brooklyn, NY.

U.S. Department of the Interior. 1992. Water quality survey report 1992. Gateway National Recreation Area Division of Natural Resources and Compliance.

U.S. Department of the Interior. 1992. Amphibians and reptiles. Pamphlet for Gateway National Recreation Area, National Park Service.

U.S. Department of the Interior. 2002. Research Opportunities in the Natural and Social Sciences at Cape Cod National Seashore.

U.S. Department of the Interior. 2003. The Evolving Legacy of Jamaica Bay, Gateway National Recreation Area - New York/New Jersey.

U.S. Department of the Interior, National Park Service (NPS) Gateway National Recreation Area (GNRA) and Jamaica Bay Watershed Protection Plan Advisory Committee. 2007. An update on the disappearing salt marshes of Jamaica Bay, New York.

U.S. Fish and Wildlife Service. 1995. Piping plover (*Charadrius melodus*) Atlantic coast population revised recovery plan, technical/agency draft. Region 5, Hadley, MA.

U.S. Fish and Wildlife Service (USFWS). 1997. Significant habitats and habitat complexes of the New York Bight watershed. Southern New England – New York Bight Coastal Ecosystems Program. Charlestown, Rhode Island.

Wall & Associates, Inc. 2003. Final Environmental Impact Statement for the Arverne Urban Renewal Area. Prepared for the NYC Department of Housing Preservation and Development. CEQR#: 02 HPD 004 Q.

Werme, C., and C.D. Hunt. 2006. 2005 Outfall Monitoring Overview. Report 2006-18. Massachusetts Water Resources Authority (MWRA), Boston, MA. 105p.

Wilson Bay Water Quality Initiative, www.cvm.ncsu.edu/wb/bivalves

Wyllie-Echeverria1, S., and M. Fonseca. 2003 Eelgrass (Zostera marina L.) Research in San Francisco Bay, California from 1920 to the present, February 2003

C H A P T E R   F O U R

CATEGORY 2, RESTORATION ECOLOGY: OBJECTIVES, CURRENT PROGRAMS, AND POTENTIAL MANAGEMENT STRATEGIES

INTRODUCTION AND ISSUES IDENTIFICATION

There are two wetland assemblages in the Jamaica Bay watershed, salt marshes and freshwater wetlands. Freshwater non-tidal wetlands are typically found in depressions where surface runoff or over bank flooding from streams or rivers collects for extended periods of time, or where ground water intersects the land surface. Historically, several types of freshwater wetlands occurred throughout the watershed, including deep marsh, shallow marsh, shrub swamps, lowland swamp forest, upland swamp forest, and wet meadow (Mockler, 1991).

Prior to Euro-American settlement, it is estimated that there were about 16,000 acres of salt marsh in Jamaica Bay (USFWS, 1997, see Volume 1 of the JBWPP, Figure 4.3.1). At first, salt marshes were used by the settlers as pasturelands for livestock. Later, as farming was replaced by manufacturing in the New York City region, salt marshes were filled with debris and then later developed. Large areas of salt marsh were filled with garbage and converted to landfills, which were subsequently converted to parks and commercial and other private uses. As of 1971, only about 4,000 acres of salt marsh remained in the Bay (National Academy of Sciences and National Board of Engineering, 1971).

From a habitat standpoint, as well as an economic perspective, the Jamaica Bay salt marshes are critical for three groups of animals: shellfish, finfish, and waterfowl. Several species of invertebrates including fiddler crabs and ribbed mussels spend essentially all of their lives in the salt marsh. Numerous fish species spend all or part of their lives in or around the salt marsh. Mullet and menhaden feed and mature in shallow waters at high tide. Striped bass and shad pass by salt marshes from the ocean on their way to rivers to spawn. Large numbers of waterfowl and other birds use the salt marsh during their spring and fall migrations, and some stay for the summer to nest.

Over the years, a significant amount of effort has been taken to identify potential ecological restoration locations around Jamaica Bay. To further enhance existing open spaces, a Jamaica Bay restoration and conservation project inventory was undertaken. This inventory is summarized in Volume 1, Chapter 4.11 of the Watershed Protection Plan and shown in Volume 2, Figure 4.6 later in this document. Substantial ground verification efforts and outreach to the many responsible groups will be required to determine the present status of the previously identified restoration or conservation projects. Figure 4.6 highlights the project locations within the watershed, the implementing authority, and the current status of development based on literature searches. As observed, there are numerous land protection and restoration projects spanning the perimeter and interior of the Jamaica Bay estuary, with multiple entities engaged in ecosystem restoration and land protection. The inventory was developed based on a review of available publications and the input of key stakeholders in the watershed, but has recognized data gaps. Thus, it is still considered to be in "Draft" format, but is potentially a key starting point to begin to prioritize past inventory restoration exercises. Substantial ground verification efforts and outreach to the many responsible groups will be required to determine the present status of identified restoration or conservation projects. The JBWPP encourages the use of this map to assess the current potential for restoration. The status of funding for the various projects should also be evaluated. The refinement of the Jamaica Bay Conservation and Restoration Project Inventory will allow effective coordination between the entities involved in ecosystem conservation and restoration in Jamaica Bay, and the prioritization of remaining sites to occur.

Federal, state, and city agencies, as well as local environmental groups, have been very active in restoring and preserving open spaces along the shoreline of Jamaica Bay and, to a lesser degree, portions of the upland watershed. However, the upland portion of any watershed plays a key role in its ability to help buffer and protect the health and ecological functions of receiving waterbodies by controlling runoff and filtering upland pollutants before they are dispersed downstream. To address these issues, typical watershed management plans include measures to protect stream corridors, riparian forest buffers, freshwater wetlands and other types of open space designed to preserve the ecological health of the watershed and the receiving waterbodies. In the case of Jamaica Bay's watershed, many of these natural features have been developed and a very small percentage of those original protective natural processes that function at a high rate of attenuation remain within the watershed. Significant habitat complexes have been fragmented and displaced; measures must then be developed to accommodate the highly developed and populated watershed of Jamaica Bay in an environmentally-sustainable manner.

Significant steps have been taken by the NYCDEP to address some of these important watershed issues. Over the last five years, projects have been implemented that provide significant ecological benefits today and for future generations. Additional projects by NYCDEP are currently in the design phase and are expected to be implemented within the next two years. NYCDEP is actively designing and restoring complex environmental restoration projects along the perimeter of Jamaica Bay that will provide access to public open spaces, create additional wildlife habitat and in some cases provide stormwater management elements to improve water quality. The substantial and varied ecological benefits provided by each of these projects will further remediate the harmful effects of past land use activities.

This chapter addresses the following two major objectives:

1. Restore salt marsh islands in the Bay, and
2. Preserve and enhance natural areas along periphery of the Bay and watershed.

OBJECTIVE 2A: RESTORE THE SALT MARSH ISLANDS IN JAMAICA BAY

Current Programs

A pilot restoration project was initiated by NPS in 2003 on the two acre Big Egg Marsh. Using an innovative technique known as "thin-layer" sediment spraying to raise the salt marsh elevation, the project has been deemed successful as the initial restoration area has been substantially enhanced through additional plant recruitment. Elevation monitoring and data collection by the NPS will continue for at least several more years at the site.

A larger salt marsh restoration effort (70 acres) that was funded by multiple agencies, including NYCDEP, was completed at Elders Point East in 2006. This restoration will provide additional information on appropriate salt marsh restoration techniques and viability for application to other sites as monitoring data is compiled and analyzed. Additional restoration of Elder's Point West and potentially Yellow Bar, which is also expected to be funded by a multi-agency partnership, is scheduled to begin during the summer of 2008. In addition, a cost-sharing program (75/25) between NYSDEC and local sponsors is currently being considered, which will include the identification of additional salt marsh islands for potential future restoration.

Management Strategy 2a1: Prioritize the restoration of additional salt marsh islands (Black Wall, Ruler's Bar, Duck Point, etc.).

STRATEGY DESCRIPTION

It has been estimated that at the time of European settlement, Jamaica Bay originally contained approximately 16,000 acres of perimeter and interior wetlands of smooth cordgrass (*Spartina alterniflora*), a primary flora of vegetated tidal wetlands. Along the perimeter, an estimated 12,000 acres have been lost to dredging and fill placement, mostly within the last century. However, in recent years, observations have indicated that the interior salt marsh islands have been disappearing at an increasing rate.

The following information taken from the Jamaica Bay Improvement Commission Report (1907) provides a snapshot of some of the conditions of Jamaica Bay in 1907:

- 4,200 acres of salt marsh islands within the Bay;
- Rockaway Peninsula was primarily low sand dunes with potential for over-wash from ocean;
- Rockaway Inlet was deep (~50');
- 450,000 tons of oysters harvested annually;
- Tidal exchange of nearly 24 billion gallons two times a day;
- Rockaway Peninsula was 16,250 ft (>3 miles) shorter and grew at a rate of 232 ft per year from 1835 through 1905; and
- Population within watershed less than 350,000.

The ecological restoration and enhancement of salt marsh island wetland complexes within Jamaica Bay is important in sustaining and supporting the many varied ecosystems that exist within the Bay. A principle determining factor in the development of a watershed protection plan for Jamaica Bay has been the unexplained loss of the interior salt marsh islands. There is consensus among all parties that the salt marsh islands within Jamaica Bay are disappearing and that the loss has accelerated over the years. However, despite an active ongoing research effort, the exact mechanism of salt marsh island disappearance has not yet been identified; many theories have been put forth, no single cause has been identified that can adequately explain the loss. While additional research efforts are required to identify the exact causes of salt marsh loss a prioritization of the potential restoration efforts of remaining wetland islands is essential. Defining these priorities is not only critical to their long term success but is also important in allocating scarce resources in the most cost-effective manner to achieve the goal of establishing stable wetland complexes.

Future restoration actions must continue to minimize these losses while recognizing that the reasons for wetland loss are varied and evolving, and that the prioritization of restoration projects must be able to adapt and incorporate new information as it becomes available. Therefore, to help with the prioritization of future salt marsh island restoration efforts, an analysis of the current state of each salt marsh island and the potential for successful restoration efforts at each location is necessary. This analysis provides the framework to begin the "triage" of the islands to determine where best to focus efforts given the limited resources within the region, and to provide the most ecological benefit.

The salt marsh islands are an integral part of the Jamaica Bay environment, providing valuable fish and wildlife habitat, water quality, hydrologic, and ecological benefits, as well as protection from coastal storm events. The evaluation and prioritization of the salt marsh island restoration efforts needs to be accomplished through a review of past studies and restoration efforts and how these are applicable in balancing potential immediate opportunities with the desire to provide the greatest restoration efficiency and sustainable benefit.

ANALYSIS OF WETLAND LOSSES

At least two attempts to quantify the wetland loss within the Bay have been completed. One study was undertaken by the NYSDEC in 2001 and another more recent study was completed by the Jamaica Bay Advisory Committee in 2007. While both studies concluded that wetland loss is occurring at an accelerated rate, the reference material (*e.g.*, high resolution aerial imagery), analysis tools and methods and the years evaluated to calculate wetland loss for each study are different. Therefore, a direct comparison of the conclusions from these separate studies is not possible and is not inferred by this report. They are provided below for reference purposes only. To place Jamaica Bay in context of other regional wetland issues, the analysis below begins with a discussion of wetland losses found in other areas of New York State.

Wetland Losses in Other Locations

The NYSDEC has been researching and monitoring wetland loss in other locations of New York State, including estuaries in Nassau and Suffolk Counties, Long Island. These monitoring efforts were developed by the NYSDEC to evaluate the effectiveness of the existing wetland regulations. The areas evaluated include the following:

- Manhassett Bay
- Nissequogue River
- Stony Brook Harbor
- Flax Pond
- Mount Sinai Harbor.

While there have been smaller total observed losses of wetland acreage in these areas, the rate of loss has ranged from 0.091 acres per year to a high of 1.86 acres per year, with an average loss of 0.650 acres per acre of wetland complexes, slightly less than that of Jamaica Bay. The data collected for these sites is incomplete in terms of the measurements taken in 1994 and 1999. That is, a measurement was not always recorded for each site in each of the assessed years. Therefore, an uninterrupted analysis of the actual rate of loss for the referenced period is difficult to ascertain. While the total loss over the 25-year period is less than that of Jamaica Bay, it is worth noting that these wetlands are disappearing in a non-eutrophic system. It is also worth noting that other wetland systems in the region have been expanding inland over the last 20 years. For example, Shinnecock Bay and Moriches Bay on the eastern end of Long Island have gained 161 acres and 100 acres of tidal wetlands, respectively, from 1974 to 1995 as a result of landward movement of the tidal wetland systems. This inland migration of wetland systems is severely constrained within the Jamaica Bay environment and this is not a viable option for potential wetland expansion

In the wetland systems that have sustained losses, according to the NYSDEC, the reasons for the loss are speculative in many cases, but the leading causes include, *"wave energy, erosion, sand accretion, sediment budget disruption, subsidence, dredging and sea level rise. The loss of wetlands to permitted and unpermitted human activities was too small to be detected. The main cause of wetlands destruction has shifted from human caused factors such as filling to natural factors such as storms and flow restrictions."* In addition, in many of these locations, direct disturbance (*e.g.*, dredging) or other alterations are not apparent and loss continues to occur.

NYSDEC Wetland Analysis of Jamaica Bay

Unlike the previous sites, NYSDEC and others have observed significant wetland loss within Jamaica Bay. NYSDEC's analysis revealed that between 1867 and 1924 *Spartina alterniflora* (smooth cordgrass) coverage within the Bay varied slightly (±10 acres per year) but there was no overall observed trend (*i.e.*, no long term loss or accretion) during this time. Nor'easters and the occasional hurricanes would destroy portions of the wetlands but these areas would eventually recover during less active meteorological periods. According to the NYSDEC study, more significant changes to the wetland ecosystem appear to have occurred during the period from 1924 to 1974 (Figure 4.1). During this time, 780 acres of wetlands were lost to direct filling and another 510 acres were lost due to unknown reasons, for a loss rate of slightly more than 10 acres per year. The study also showed that between 1974 and 1994 a total of 526 acres were lost to unknown reasons, for a loss rate of slightly more than 26 acres per year. The final assessment period was from 1994 and 1999 where the observed losses were a total of 220 acres, for a loss rate of 44 acres per year. The NYSDEC analysis stated that additional research was required to explain the significant wetland losses, but did include sediment budget disruption, sea level rise, dredging, wave energy, erosion, inlet stabilization, mussel dams and eutrophication as potential contributing factors. Since the writing of that report, the importance of mussel dams as a contributing factor in wetland loss has diminished.

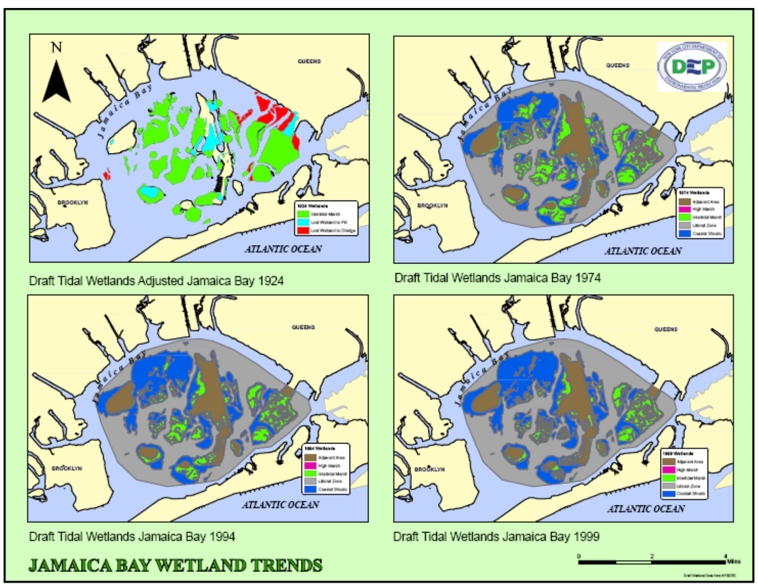


FIGURE 4.1 Trends in Jamaica Bay wetlands losses, 1924-1999

Using GIS data obtained from NYSDEC for the 2001 wetland analysis, a summary of the wetland loss for each salt marsh island complex is shown below.

TABLE 4.1. Wetland Losses in Jamaica Bay Between 1974 and 1994 (Data Source: NYSDEC)					
Wetland Complex	**1974 GIS Analysis (ACRES)**	**1994 GIS Analysis (ACRES)**	**Wetland Loss (ACRES)**	**Percent Of Wetland Loss**	**Orientation of Most Loss**
Elder's Point	98	29	69	-70.4%	North and southwest
Duck Point	112.8	42.2	70.6	-62.5%	North
Pumpkin Patch	50.3	18.3	32	-63.6%	Northeast
Nestepol	8.8	0.63	8.17	-92.84%	Gone
Stony Creek	83.8	46.03	37.77	-45.07%	North and west
Yellow Bar	180.2	146.4	33.8	-18.76%	No trend
Black Wall	41.8	35.4	6.4	-15.31%	Slight north
Rulers Bar	17.9	7.8	10.1	-56.42%	Slight north and east
Black Bank	158.5	107.5	51	-32.18%	West
Little Egg	122.5	81.2	41.3	-33.71%	Southwest and northeast
Big Egg	78.4	60.0	18.4	-23.47%	North
Jack's Hole	125.1	50.8	74.3	-59.39%	North
East High	136.02	73.8	62.22	-45.74%	North and southeast
Joco Marsh	361.03	212.7	148.33	-41.09%	Slight north (center)
Silver Hole	112.7	60.0	60.0	-46.76%	Slight north (center)
Winhole Hassock	6.43	1.6	4.83	-75.12%	North
East Island (Perimeter)	23.4	19.54	3.86	-16.50%	Northeast
Canarsie Pol (Perimeter)	48.1	22.6	25.5	-53.01%	North and southwest
Ruffle Bar (Perimeter)	55.3	26.0	29.3	-52.98%	North (slight center)
Total	1,821.08	1,050.5	770.58	-42.3%	

A review of these data indicates that there is substantial variability among the wetland complexes with respect to their average yearly relative rate of loss. Joco Marsh appears to have the highest rate of loss at 5.93 acres per year and Black Wall having the lowest among the salt marsh island complexes at 0.256 acres per year. Black Wall also has one of the lowest percentages of total loss over the referenced 25-year period, at 15.31% and a total loss of 6.4 acres, while Joco Marsh has lost 41% of total wetlands at nearly 149 acres.

TABLE 4.2. Average Wetland Loss Rate (Data Source: NYSDEC)		
Wetland Complex	**Avg. Loss Rate per year**	**Orientation**
East Island (Perimeter)	0.154	North and South west
Winhole Hassock	0.193	North
Black Wall	0.256	Northeast
Nestepol	0.327	Gone
Rulers Bar	0.404	North and west
Big Egg	0.736	No trend
Canarsie Pol (Perimeter)	1.020	Slight north
Ruffle Bar (Perimeter)	1.172	Slight north and east
Pumpkin Patch	1.280	West

TABLE 4.2. Average Wetland Loss Rate (Data Source: NYSDEC)		
Wetland Complex	**Avg. Loss Rate per year**	**Orientation**
Yellow Bar	1.352	Southwest and northeast
Stony Creek	1.511	North
Little Egg	1.652	North
Black Bank	2.040	North and southeast
Silver Hole	2.108	Slight north (center)
East High	2.489	Slight north (center)
Elder's Point	2.760	North
Duck Point	2.824	Northeast
Jack's Hole	2.972	North and southwest
Joco Marsh	5.933	North (slight center)

Jamaica Bay Advisory Committee Wetland Analysis of Jamaica Bay

Like the NYSDEC evaluation of wetland losses within Jamaica Bay, The Jamaica Bay Advisory Committee Wetland Analysis of Jamaica Bay lists sediment deprivation, hardening of shorelines, eutrophication, the extension of Rockaway Peninsula, stabilization of Rockaway Inlet, bathymetry and tidal circulation as potential contributing factors to wetland losses within the Bay. The main difference between this report and the previous NYSDEC study is the review of more recent higher resolution (post-2003) aerial photography and satellite imagery to determine the actual total salt marsh island acreage and the actual salt marsh island loss within the Bay The Jamaica Bay Advisory Committee Wetland Analysis of Jamaica Bay provides an updated and accurate representation of salt marsh island losses within the Bay.

TABLE 4.3. Jamaica Bay Wetlands Acres (Data Source: JBAC, 2007)					
	East High	**Yellow Bar**	**Black Wall**	**Elders Point**	**Pumpkin Patch**
1951 Analysis (Acres)	155	184	46	142	88
1974 Analysis (Acres)	125	131	37	50	24
1989 Analysis (Acres)	90	117	29	20	19
2003 Analysis (Acres)	57	93	25	11	12
2005 Analysis (Acres)	34	80	12	11	7

The average rate of loss during the period from 1951 through 2003 ranged from a low of 0.33 acres per year in 1989 at Pumpkin Patch to a high of 4 acres per year in 1974 at Elder's Point (Table 4.4). Generally, the average loss rate per year of these wetland complexes has declined since 1974, with the exception of East High which has seen nearly a two-fold increase in loss rate. As indicated above, the period from 2003 to 2005 is shown as having substantial losses far greater than in previously referenced periods.

Prior to the summer 2006 restoration of Elder's Point, 131 acres of the original 142 acres had been lost through 2005 and 34 acres of the original 46 acres of Black Wall had been lost.

TABLE 4.4. Jamaica Bay Wetland Losses (accrual/year), 1974-2005

Wetland Complex	Avg. Loss Rate Per Year				
	Baseline	1974	1989	2003	2005
East High	155	1.30	2.33	2.36	11.50
Yellow Bar	184	2.30	0.93	1.71	6.50
Black Wall	46	0.39	0.53	0.29	6.50
Elder's Point	142	4.00	2.00	0.64	0.00
Pumpkin Patch	88	2.78	0.33	0.50	2.50

Challenges in the data interpretation include the various yearly natural and anthropogenic fluctuations that are not readily observed. Major changes within the watershed, the Bay (*e.g.* dredging channels) and significant meteorological events have likely played a significant role in earlier marsh building and marsh destruction. During quiet meteorological years, wetland systems are able to gain acreage, and in years of above normal events the wetland acreage is usually lost to wave and wind erosion. To accurately detect the likely variable yearly changes and develop potential correlations to significant events within the watershed (*e.g.*, eutrophication and development) and meteorological events prior to 1974 and 1951, an annual review of aerial images dating back to the earliest year available would provide a better sense of the annual fluctuations and possible correlations to observed gains or losses. Without this extremely expensive (perhaps cost-prohibitive) and time consuming analysis, the losses are viewed mostly in the context of eutrophication, and in the absence of recognizing significant alterations to the natural features of the watershed, including but not limited to, altered tidal circulations, bathymetry and the westward extension of the Rockaway Peninsula (Figure 4.2) have likely played significant roles in contributing to wetland losses. At a minimum, it is recommended that a detailed annual review of wetland losses within an agreed upon reference time take place to develop a greater understanding of the anthropogenic and natural causes of wetland loss fluctuation.

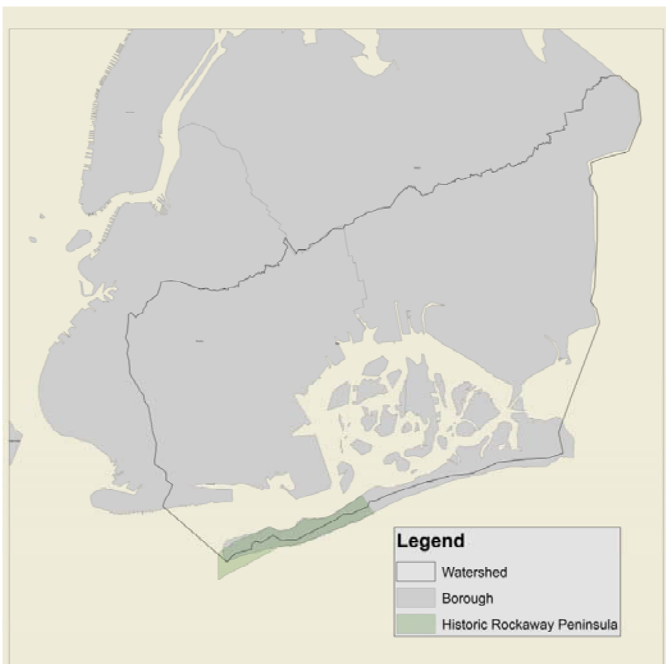


FIGURE 4.2, Rockaway Peninsula Extention

These two studies have raised important issues and demonstrated that wetland loss within Jamaica Bay is significant and, despite differences in loss rate values of the two studies, both show a serious decline in total wetland acreage.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

As described numerous times in this document, Jamaica Bay's ecologically-rich, providing food and habitat for migratory and resident bird populations, serving as an important home for coastal plant species, wetlands, resident animal species, providing natural pollutant filtering capabilities and protection from storm surges. The ecological integrity of the wetland systems within the Bay is vital to the many varied species and ecosystems that comprise the Bay. The wetland complexes are an important component of the ecological puzzle of Jamaica Bay, and restoration efforts by many varied partners is essential in maintaining their presence.

Technical

One of the most challenging obstacles to restoring the salt marsh island complexes within Jamaica Bay will be securing the vast amounts of appropriate substrate material for the rebuilding of marsh elevation. While a detailed topographic survey of each salt marsh island within the Bay is required to determine the exact amount required, assuming 1951 total acreages and a minimum two foot depth of material at each of the wetland complexes analyzed by the Jamaica Bay Advisory Committee, is approximately 1.5 million cubic yards. Considering that dredged sand from Rockaway Inlet represents approximately 250,000 cubic yards of material every 2 to 3 years, this leaves a substantial shortfall in required material (USACE, 2005). A combination of restoration efforts with alternative wetland perimeter protection measures is potentially a more attractive option. Shoreline protection measures that can be designed to reduce wave velocities and induce sediment accretion along the margins of salt marsh islands would provide for the natural "rebuilding" of wetlands. See the wave attenuator pilot study under Strategy 2a2 for further information).

Cost

In addition to securing the vast amounts of suitable substrate for rebuilding the marsh elevations, the cost to do so will also presents a significant challenge that needs to be addressed. Using the restoration costs for the recently completed Elder's Point project of approximately $500,000/per acre as a guide, Table 4.5 presents the projected salt marsh island restoration costs.

TABLE 4.5. Projected Salt Marsh Restoration Costs (5 Locations)

Wetland Complex	Cubic yards of material	Restoration Costs
East High	390,427	$60,500,000
Yellow Bar	335,573	$52,000,000
Black Wall	109,707	$17,000,000
Elder's Point	422,693	$65,500,000
Pumpkin Patch	261,360	$40,500,000
TOTALS:	**1,519,760**	**$235,500,000**

Restoration of five selected islands of 2007 JBAC update of wetland losses: $235,000,000.

RECOMMENDATION

Some salt marsh islands are more stable in terms of their size and relative losses and may provide a more effective restoration opportunity than those that are smaller in size and have high loss rates. A preliminary analysis (more research and uninterrupted monitoring is required to further inform the decision making processes) reveals that the complexity involved in prioritizing wetland restoration sites is exceedingly challenging. Many factors must be considered including, but not limited to, access to the islands, securing clean material, and evaluating probabilities for long-term stability.

IMPLEMENTATION STRATEGIES

Establish Salt Marsh Islands Wetlands Priority Restoration Review Board

NYCDEP will continue to be a local sponsor with the USACE for future salt marsh island restorations within Jamaica Bay. As a local sponsor, NYCDEP has recently committed $4.1 million to restore sections of Elder's Point and possibly Yellow Bar. NYCDEP encourages the participation and coordination of other local sponsors to better leverage limited existing resources.

To help expedite this process, it is recommended that within six months of the final JBWPP that a Salt Marsh Islands Wetlands Priority Restoration Review Board, coordinated by NYCDEP, of multi-agency and local environmental group representation, possibly developed under the proposed Jamaica Bay sub-workgroup of the HEP, would review restoration logistics and begin to establish a priority list of wetland restoration sites and potential funding sources. It is recommended that those wetland complexes that appear relatively stable based on the data analysis reviewed to date, be given higher consideration for potential restoration efforts as these likely have the greatest potential for buffering capacity and a reasonable expectation of long term stability than those identified with the most loss as these may have a high likelihood for failure in the short term.

Schedule: Prioritization process will determine restoration schedule.

Cost: Prioritization process will determine restoration costs. Costs for different restoration scenarios are provided above under the *Evaluation of Management Strategy*.

Complete the Restoration of the Jamaica Bay Marsh Islands Ecosystem Project (Elders Point and Yellow Bar) and the 8 JBERRT sites

The eight Jamaica Bay Ecosystem Research and Restoration Team (JBERRT) sites (including Dead Horse Bay, Paerdegat Basin, Fresh Creek, Spring Creek South, Hawtree Point, Bayswater State Park, Dubos Point, and Brant Point) have been identified as high priority restoration sites around Jamaica Bay. These sites have gone through an extensive review process and have excellent potential for restoration and providing environmental benefits. Conceptual plans and costs have already been developed for these projects. The Jamaica Bay Marsh Islands Ecosystem Project at Elders Point has been initiated. The Elders Point East marsh restoration was completed in Summer 2006 and the Elders Point West and Yellow Bar are currently seeking funding. Should funding become available, Elders Point West and Yellow Bar, and possibly other marsh islands could undergo restoration. The JBWPP strongly recommends that the funding for the eight JBERRT Projects and for Yellow Bar Hassock be secured and that the restoration efforts move forward.

Cost: The recommended efforts are currently unfunded.

Schedule: These efforts involve entities outside of NYCDEP; no time frames have been established.

Management Strategy 2a2: ***Using information from Elders Point, existing literature and other salt marsh island restorations, examine various technologies of "non-hardened" wave attenuators to protect the windward and ice flow sides of salt marsh islands from wind and water erosion forces.***

STRATEGY DESCRIPTION

Recently restored salt marsh islands are extremely vulnerable to the damaging effects of wind and wave energies due to their limited vegetative cover and the limited benefits of sediment anchoring from an under developed root system. These areas are also vulnerable to erosive forces from ice flows during the winter months. The use of geotextile fabrics, temporary floating breakwater systems or other biodegradable materials may be effectively used to armor the vulnerable windward fringe of these marshes, allowing sufficient protection while *Spartina alterniflora* (Smooth Cordgrass) becomes fully established. Used in combination with other salt marsh island restoration efforts, these treatments may help to reduce the rate of loss of existing marsh islands and increase the protective benefits of previous restoration efforts. These systems have the potential to increase the capture of marsh building sediments and may allow the outward expansion of the wetland system.

Wave Attenuator. Source: Elemental Innovation, Inc.

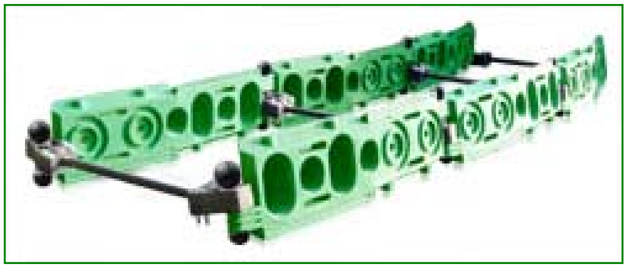
The use of wave and wind energy reducing devices for the protection of tidal vegetation has been limited. However, using the wave energy protective methods utilized for the Elders Point restoration as a measure of their relative success over the long term will help inform future protective measures in salt marsh island restoration efforts. An analysis of existing research in alternative wave attenuating/shoreline protection technologies used in other locations will also provide useful techniques that may be appropriate for use in Jamaica Bay. Those techniques that show the most promise for actual conditions within Jamaica Bay will be further vetted by NYCDEP.

A pilot project will be developed to test the recommended alternatives on an existing marsh island; success criteria will depend on the ability to attenuate salt marsh island loss and/or increase the capture of sufficient sediment for the natural colonization of *Spartina alterniflora*. To maximize the effectiveness of this pilot, the specific location chosen for the study will be coordinated with the NPS, USACE, NYSDEC and local environmental groups. The identification of potential funding mechanisms and a substantial multi-agency collaborative cost-sharing effort beyond the pilot study will be required to implement a broader meaningful protection program throughout Jamaica Bay. If determined to be beneficial and feasible from the results of the pilot study, implementation strategies to broaden the scope of this approach will be explored and discussed with relevant agencies and local environmental groups.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Wetland loss within Jamaica Bay over the last 100 years has been extensive and, based on several studies, the rate of loss has accelerated over the last few years. The loss of these salt marsh islands would diminish the ecological function of Jamaica Bay considerably, especially in regards to fisheries-nursery habitat and foraging habitat for shoreline birds. While physically restoring the salt marsh islands is the ideal solution, the time required to develop designs and issue construction contracts, the volume of suitable substrate needed, the enormous cost, and a coordination of collaborative partners does not make this a viable short-term option. A viable interim method is to evaluate alternative protection measures that have the potential to slow the current wetland loss rate, capture valuable marsh building sediments and potentially allow the natural expansion of the wetlands. When used in combination with restoration efforts, the use of the wave attenuators may provide important insight into the development of alternative short-term cost-effective protection measures.



Temporary floating wave attenuator.
Source: Elemental Innovation, Inc.

Technical

Floating breakwaters are typically designed to protect marinas from boat wakes but could possibly be modified to work in protecting wetland systems. It is expected that these would only be temporary until the edges of the marshes were stabilized and able to withstand some wave energy impacts. Shoreline areas susceptible to high wave energy typically require structural erosion controls to minimize the impact from wave action. In the case of Jamaica Bay where the salt marsh islands are already in a weakened condition, this potentially becomes even more important. Best Management Practices (BMPs) developed for the Chesapeake Bay Program (CBP) proposed "hardening" the shoreline with barrier-like structures, installing offshore breakwaters to dissipate incoming waves and/or creating headland control systems to allow adjacent embayments the opportunity to stabilize (CBP, 2006). Other structures, such as sea walls, revetments, groins and jetties could be installed to decrease the impacts of high-energy waves (Northcutt, 2001). NYCDEP does not believe that that these types of "hard-engineered" systems are appropriate for Jamaica Bay and believes that a softer, less structural method for salt marsh island protection is the preferred alternative.

More environmentally compatible erosion controls are suited in areas where the shoreline experiences low to moderate wave energy (CBF, 2007a). Depending on the slope and soil type of the shoreline, and associated labor and material costs, utilizing "softer" erosion and sediment control techniques can provide a temporary or permanent method to stabilize areas without significantly altering the natural composition and landscape.

The following provides a summary of the different types of environmentally-friendly erosion control techniques that could be applied within Jamaica Bay.

Coir Fabric Logs and Mats

Rolled erosion control products (RECOs), which includes erosion control blankets (ECBs) and turf reinforcement mats (TRMs), are becoming a cost-effective management tool to stabilize eroding shorelines (Dallaire, 2001). Made from natural, degradable fibers the RECOs can be used as the sole erosion control method or in conjunction with a planting regime (Allen and Leech 1997).

Coir is a coarse fiber obtained from the tissues surrounding the seed of the coconut palm (*Cocos nucifera*) (Royal Botanical Gardens, 2003). Mature brown coir fibers contain more lignin and less cellulose than flax and cotton, resulting in a stronger but less flexible material. Coir fibers are relatively waterproof and the only natural fiber resistant to saltwater damage.

While these have been mainly utilized in freshwater systems with primarily a one dimensional flow, tidal systems potentially represent a challenge with multi-dimensional flows (*e.g.*, ebb and flooding tides). Restoration efforts of eroded sections along water bodies such as the Yellowstone River in Montana (Tice, 2005), the Peachtree Creek in Georgia (Baxter, 2003) and the Whiskeytown Reservoir in northern California (Sloan, 2001) used coir logs and matting to stabilize banks and shorelines, minimize erosion and enhance vegetative growth. Coir logs supported by rock foots stabilized an area along College Creek in Maryland susceptible to low to medium wave energy (CBF, 2007b). Structural integrity of coir mats ranges between two to five years, sometimes more, depending on sunlight exposure and overall weathering (Dallaire, 2001).

A study of the efficacy of coir logs was conducted by the USACE during the restoration efforts for Elders Point Marsh in Jamaica Bay. The USACE surveyed the exposed coir logs in March and May of 2007. In general, the USACE reported it found that once the coir logs became exposed, they lacked the tensile strength to stay together for any great length of time in the Jamaica Bay wind and wave climate. The constant wetting/drying and sun exposure deteriorated them quickly also. Once the data from its bimonthly surveys become available, it will be evident whether the coir logs mitigated erosion at the island marsh. The USACE reported that the utility of coir logs was mostly during sand placement, as an initial berm for the pump-out settling area. The USACE reports that it does not plan to use them at Elders West.

It is likely that the failure of the coir logs at Elders Point Marsh was due more to the wetting and drying, as well as the sun exposure, than to the shear stresses exerted by the current and wave velocities within Jamaica Bay. It has been reported (Fischenich and Allen, 2000) that coir geotextile roll with coir rope mesh (staked only without rock bolster) can withstand a shear stress of 0.2 to 0.8 lb/ft^2. While somewhat coarse for this application, the hydrodynamic sub-model of the JBE Model seldom calculates shear stresses greater than 0.1 lb/ft^2. The use of coir geotextile roll may be more applicable for streambank erosion control than for a tidal system such as Jamaica Bay.

Jute Fabric Mesh and Mats

Jute is the common name given to the fiber extracted from the stems of plants belonging to the genus *Corchorus* (Rowel and Stout, 1998). Two commercially viable species, *C. capsularis* and *C. olitorius*, provide the raw plant fiber used to create the erosion control mats. The fibers develop in the phloem, or bast, region of the plant stem. Exposure to sunlight for approximately 350 hours causes a 50% reduction in strength of jute, but jute fibers typically last upwards of two years (Dallaire, 2001).

Commonly used as the mesh or netting for mats and logs made from other fiber materials, jute fabric could be used alone to protect shorelines from erosive forces. Krenitsky *et al.* (1998) compared erosion control materials in a rainfall-simulated study on two sites with different soil types and slopes of 8 and 14 to 21 percent. The authors found that only jute reduced runoff and sediment loss at both sites.

Because of the limited observed application of wave and wind energy reducing methods for the protection of vegetation in a tidal system, an alternative approach is necessary. At this point, no one protection method to slow salt marsh island and sediment loss can be considered too small for evaluation and will likely require a multi-faceted approach of using several erosion control techniques in combination with one another.

Other Natural Fiber Materials

Straw and excelsior constitute the remainder of the natural fibers used to manufacture ECBs. The Pennsylvania Department of Transportation uses light- to heavy-duty straw blankets to protect freshly graded and seeded slopes ranging from 25 to 50 percent, which typically last from three to four months (Dallaire, 2001). The manufacturing of excelsior blankets stitching together aspen wood shavings in a manner that eliminates the need for netting, favorable for areas that require rapid germination and frequent maintenance (Tice, 2005). The blankets typically last between two and four years (Dallaire, 2001). However, their use within a saline environment like that of Jamaica Bay has not been evaluated.

Shellfish

While ribbed mussels were identified as a potential contributing factor in wetland loss by not permitting the marshes to fully drain at low tide, other alternative bioengineering techniques could be employed to stabilize shorelines and minimize erosion that could include oyster restoration. Bushek and Kreeger (2007) observed mussel colonies stabilizing *Spartina alternifora* patches along eroded shorelines in Gandy's Beach, New Jersey in 2006. Marsh shoreline restoration efforts in South Carolina included installing concrete-coated wooden stakes for oyster recruitment and growth, a by-product of which was a natural breakwater for the incoming waves. Two oyster reefs developed by the NRCS in Texas decreased erosion rates by half, permitting grass planting immediately after reef establishment (Kaspersen, 2000). NYCDEP will implement a pilot oyster reef restoration near the mouth of one of the tributaries; however, in consultation with others, a modification or supplement to this pilot could include developing a protective oyster reef along an edge of an eroding marsh. However, as the oyster restoration is considered a long term effort, alternative short term wave attenuators will still need to be put in place for salt marsh island protection.

Cost

See *Implementation Strategies* below for cost information for a pilot study. Costs for a broader effort will be based on information gathered from the pilot.

Legal

Installation of any type of erosion control devices in Jamaica Bay for marsh protection would require permits from various regulatory authorities potentially including the following:

- NYSDEC;
- USACE;

- US Coast Guard; and
- NPS.

RECOMMENDATIONS

It is recommended that the City install a pilot wave attenuator at a selected salt marsh island to be determined in consultation with appropriate agencies and environmental groups. This would be done through the *Implementation Strategies* listed below.

IMPLEMENTATION STRATEGIES

Salt Marsh Island Wave Attenuator Pilot Study

Develop and implement a pilot study to determine if the installation of a wave attenuator around a section of a salt marsh island would be a cost-effective method to slow the rate of wetland loss and accrete marsh building sediments. NYCDEP will implement this pilot study and consult with other local resource management agencies to determine the selection of a specific salt marsh island and to evaluate the effectiveness of the wave attenuator.

Schedule: Pilot study will be developed through a proposed contract. A contractor is anticipated to be retained by mid-2008. Pilot to be initiated in Fall 2008.

Cost: $576,000.

FIGURE 4.3. Conceptual placement of wave attenuators, Yellow Bar; Source: NYCDEP

References

Allen, H. H., and J. R. Leech. 1997. Bioengineering for streambank erosion control. Technical Report EL-97-8. Waterways Experiment Station. U. S. Army Corps of Engineers. Available at: http://el.erdc.usace.army.mil/elpubs/pdf/trel97-8.pdf

Baxter, R. 2003. RECP, TRM: An alphabet of control. Erosion Control. Vol. 10 (May/June). Available at: http://www.forester.net/ecm_0305_recp.html

Bushek, D. and D. Kreeger. Some alternative strategies and applications for shellfish restoration and enhancement in Delaware estuary. Partnership for the Delaware Estuary, Inc. Wilmington, DE. Available at: http://www.delawareestuary.org/scienceandresearch/Science_Conf/Conference_Presentations/DESC07_No48_Bushek.pdf

Chesapeake Bay Program. 2006. Best management practices for sediment control and water clarity enhancement. Available at: http://www.chesapeakebay.net/pubs/subcommittee/nsc/sedwg/Best% 20 Management%20Practices%20Report.pdf

Chesapeake Bay Foundation (CBF). 2007a. Living shorelines. Available at:

http://www.cbf.org/site/Doc Server /Living_Shorelines.pdf?docID=8924

Chesapeake Bay Foundation (CBF). 2007b. Bay-friendly shoreline solutions. Available at: http://www.cbf.org/site/DocServer/Bay-Friendly_Shoreline_Solutions.pdf?docID=1102

Dallaire, Gene. 2002. Cost-effective erosion control with blankets and mats. Erosion Control. Vol. 2 (May/June). http://www.forester.net/ec_0205_cost.html

Fischenich, J.C., and H. Allen. 2000. Stream Management. U.S. Army Corps of Engineers, Waterways Experimental Station.

Franti, Thomas G. 2006. Bioengineering for hillslope, streambank and lakeshore erosion control. Publication G1307. Soil Resource Management Conservation. Division of the Institute of Agriculture and Natural Resources. University of Nebraska–Lincoln.
Available at: http://elkhorn.unl.edu /epublic/live/g1307/build/#target3

Kaspersen, Janice. 2000. Beachfront reinforcement. Erosion Control. (6) July/August. Available at: http://www.forester.net/ec_0007_beachfront.html

Knapp, Leslie H. 1997. Use of manufactured materials in shoreline restoration projects. Restoration and Reclamation Review. Vol. 2: Spring.
Available at: http://horticulture.coafes.umn.edu/vd /h5015/97papers/knapp.html

Krenitsky, E. C., M. J. Carroll, R. L. Hill, and J. M. Krouse. 1998. Runoff and sediment losses from natural and man-made erosion control materials. Crop Science. Vol 38 (4): 1042-1046.

Northcutt, Greg. 2001. Defending the coast from attack. Erosion Control. Vol. 8: Nov/Dec. Available at: http://www.forester.net/ecm_0111_defending.html.

Royal Botanical Gardens, Kew. 2003. Information Sheet: Coir. Available at: http://www.kew.org/ ksheets/coir.html

Rowel, R. M., and H. P. Stout. 1998. Chapter 7: Jute and Kenaf. Handbook of fiber chemistry (2nd ed.). M. Lewin and E. M. Pearce (eds). Marcel Dekker, Inc. New York, New York. Pgs. 465-504.

Sasser, C. E., M. D. Materne, J. M. Visser, G. O. Holm, and E. Evers. 2007. Restoring freshwater floating marsh in coastal Louisiana. Louisiana Agriculture. 50 (2): 14-17. Available at: http://www.lsuagcenter.com/NR/rdonlyres/D9116462-6C50-48C5-9E37-B2E3C19418C4/36738/La Agspring2007.pdf.

Sloan, Rose. 2001. Coir rolls with brushlayering for successful streambank and shoreline stabilization. Erosion Control. 8: March/April.
Available at: http://www.forester.net/ ec_0103_biotech.html

Tice, Bill. 2005. Blankets and mats. Erosion Control. 12: March/April.
Available at: http://www.forester.net/ecm_0503_blankets.html

OBJECTIVE 2B: PRESERVE AND ENHANCE NATURAL AREAS ALONG PERIPHERY OF BAY AND WATERSHED

Current Programs

Pennsylvania and Fountain Landfills

NYCDEP is responsible for the remediation and closure of two inactive hazardous waste sites, the Pennsylvania Avenue and Fountain Avenue Landfills, both situated abutting Jamaica Bay. Although restoration of these sites is not required as part of the remediation, due to the location of these landfills within a sensitive environmental area NYCDEP took a pro-active lead stewardship role in developing an innovative and comprehensive ecological restoration plan for these properties that is consistent with and will enhance the existing natural features of Jamaica Bay. In addition, the ecologically sound end-use design plan, with input from local community groups, also considered future passive public uses in the post-landfill remediation phase.

FIGURE 4.4 Pennsylvania Landfill Restoration; Source: NYCDEP

This project represents the largest ecological restoration effort ever undertaken in New York City and will provide significant habitat and environmental improvements for Jamaica Bay. The planting plan includes over 40 native tree and shrub species and over 30 forb (wildflowers) and graminoid (grasses) species. To ensure that a sufficient number of plants would be available for the planting phase of the project, NYCDEP initiated a three year contract growing program at several area nurseries for the approximately 35,000 trees and shrubs that will be required. The contract growing of these plants enabled NYCDEP to use local provenance plant material that is best acclimated to our soil and climate conditions and ensures the dissemination of local genotypes. In addition, this plan also enabled the use of plants that are not readily available in the nursery trade. The use of seed-grown plants has been maximized to the greatest extent possible to increase the genetic diversity of the plant community. Genetically diverse and locally adapted plants provide increased disease resistance and drought tolerance. NYCDEP also provided detailed soil specifications, requiring a soil that was high in sand content. Sandy soils, common to coastal regions, are typically low in nutrients. The low nutrient status of these

Wildflowers and warm seasonal grasses provide habitat for rare grassland birds; Source: NYCDEP sandy soils allows the growth of coastal plants and also tends to limit the invasion by undesirable non-native and nuisance plant species.

The first planting began at the Pennsylvania Landfill in Spring 2006 and the first planting at Fountain Landfill began in Spring 2007. Because of the large size of the total restoration area and the vast number of plants, in time the landfills will become a regional seed source to disseminate the reintroduced native species to other parts of the New York City metropolitan area. Migratory birds will be attracted to this green space and during resting and feeding will move plant propagules into and out of the site. The actual restoration limits have the potential to extend far beyond the physical restoration due to the size and geographic location of the landfills.

As with all NYCDEP ecological restoration projects, unique specifications and designs for each project are developed that incorporate appropriate environmental information for the desired ecosystems with the goal of providing the maximum ecological benefit and function. In addition, the species selection for these projects are based on their ecological plant community associations and environmental setting to provide much greater ecological value, sustainability and biodiversity than placing individual and "out of context" specimens that do little for long-term environmental sustainability. The use of extirpated indigenous coastal flora that have been absent from much of the New York City ecological landscape since the early 20th Century is an integral component of the designs for each of these projects. Their reintroduction allows the dissemination of these species propagules beyond the actual physical restoration boundaries, thus enhancing their ecological significance.

The development of soil specifications that favor the growth of coastal communities is a key element in the design of ecological restoration projects and will aid in their long-term sustainability. This ecosystem restoration approach provides the greatest habitat function and ensures the long-term stability of the sites by enhancing the natural buffering capacities of the restored habitats; increasing resilience to natural environmental variations. Each of these restoration sites significantly contributes to improving the ecology of the Bay by restoring degraded lands to productive wildlife habitats, increasing plant biodiversity and providing natural attenuation of stormwater through nutrient uptake, contaminant sequestration, plant evapotranspiration and groundwater infiltration. In addition, because of their size and spatial connectivity within the landscape, the positive cumulative effects from each of these restorations are further enhanced.

The following concepts used for the Pennsylvanian and Fountain Landfill restoration projects should serve as the model for developing future coastal upland restoration projects around the perimeter of the Bay:

- Initiate contract growing of most plant material
  - Maximize the use of seed-grown plants
  - Limit the use of cuttings when seed germination is difficult or slow

- Develop a soil sample collection program for analysis from existing plant communities targeted for restoration to closely "mimic" natural soil conditions of proposed plant communities:
  - higher sand content soils
  - low organic matterlow nutrients
  - low pH

- Use smaller plant material – will acclimate faster to site and grow healthier

- Use varying sizes of same species to "mimic" a natural and uneven aged stand

- Use high wildlife value and low maintenance warm season grasses over conventional low wildlife value and high maintenance cool season "erosion control" grasses

- Select appropriate plant material for site and existing environmental conditions (aesthetics should be considered least)

- Specify seasonal planting schedules for the various plant species

- Limit provenance of plant material to within a 150-mile radius of the planting site

Idlewild Restoration Planting

- Specify mycorrhizal (symbiotic association between fungus and plant roots) soil inoculants to help restore soil biological diversity and activity (not necessary in intact natural systems).

Idlewild Park

Idlewild Park is situated within the critically important headwaters of Jamaica Bay. NYCDEP in coordination with New York City Department of Parks and Recreation (NYCDPR) completed a significant restoration effort in 1997, resulting in the restoration of 16 acres of indigenous coastal grasslands and woodlands, five acres of tidal wetlands and 2.5 acres of freshwater wetland. The NYCDEP continues to maintain an active presence in restoring additional sections of the park through its association with the Eastern Queens Alliance (EQA) and the NYCDPR Natural Resources Group (NRG).

NYCDEP has participated in student planting projects organized by the EQA and is assisting with EQA's Master Plan efforts for the continued environmental restoration of the 110-acre park and for expanded community use of this valuable local natural resource. The NYCDEP continues to issue vegetation management contracts to control invasive plants and to restore additional areas. When feasible, restoration requirements resulting from other projects that are not possible at the site of disturbance are directed to Idlewild Park to help expedite the restoration process.

Aerial view of Idlewild Park;
Source: NYCDEP

Paerdegat Basin

The ecological restoration of Paerdegat Basin is associated with the NYCDEP's current efforts to treat and capture CSOs to improve water quality within the basin and ultimately within Jamaica Bay. The construction of a 50 million gallon CSO storage facility will capture sanitary wastewater and stormwater during rain events for subsequent processing and treatment at the Coney Island WPCP after the rain event has ceased (see Management Strategy 1c2 for additional information on this project). The ecological restoration component of this project is currently in the design stage and has an expected construction start date of mid to late 2009. Highlights of this project include the restoration of 15 to 20 acres of tidal wetland, creation of 40 to 50 acres of an indigenous coastal grassland/shrubland and a six acre Ecology Park. Stormwater from surrounding streets will be directed into the restoration area to create freshwater wetlands and attenuate pollutants from upland sources. NYCDEP is also collaborating with NYCDPR to develop an extensive "Greenstreet" planting along a long stretch of Bergen Avenue (see Management Strategy 3b1). These elements have the potential to capture significant volumes of stormwater runoff from surrounding streets. The Paerdegat Basin project site was also evaluated for restoration under the JBERP.

The six-acre Ecology Park will be designed to showcase many of the ecosystems present within New York City and will enable a close-up view of these communities. The NYCDEP expects the Ecology

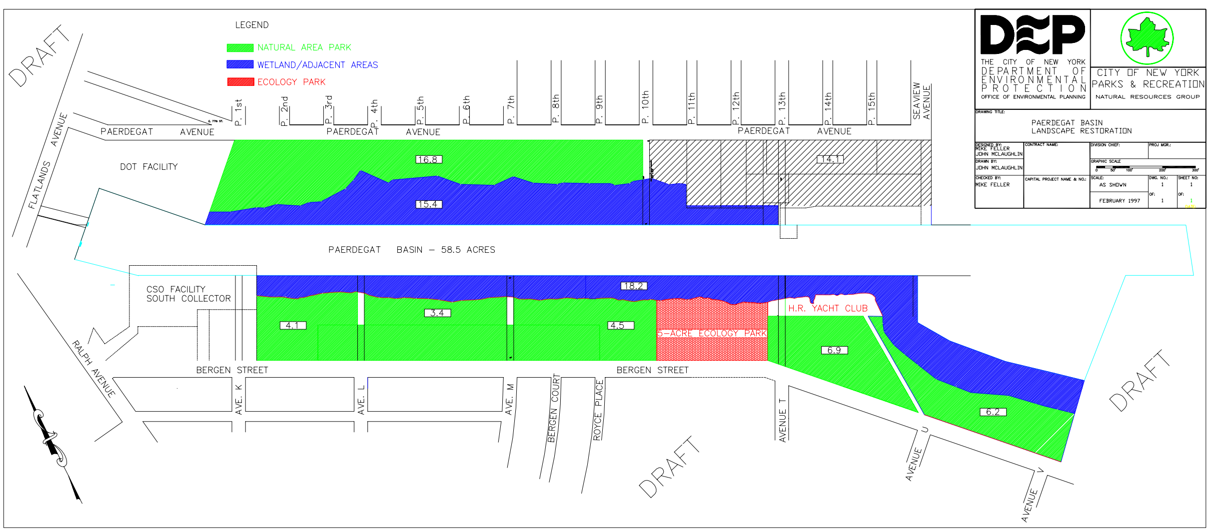


FIGURE 4.5 Paerdegat Basin Restoration Plan; Source: NYCDEP

Park to be an important environmental tool in helping area residents and students to gain an understanding of the many ecosystem types found within New York City and the important stewardship role that they have in helping to maintain the delicate ecosystem. It also provides the opportunity to create additional research topics within an array of closely located and varied ecosystems.

Springfield Gardens

As with the Idlewild project, this restoration project is associated with NYCDEP's current efforts to alleviate flooding in southeast Queens (see Management Strategy 1b2 for additional information on the Southeast Queens Drainage Plan). Some of the restoration areas overlap with the Idlewild restoration and provide a large contiguous restoration area. Creating connectivity is an important consideration when designing restoration efforts within the watershed. The project has restored two acres of tidal wetland and two acres of indigenous coastal woodlands. An additional two acres of tidal wetland and coastal grasslands will be restored during 2007.

Springfield Gardens Tidal Wetland; Source: NYCDEP

Innovative "Bluebelt" type designs are currently being developed to improve the habitat and water quality of Springfield Lake (see Management Strategy 3b3) and the downstream tidal channel that is connected to Thurston Basin. The re-grading of the lake shoreline, invasive plant removal and the planting of freshwater wetland plants will help to restore much of the lost ecological function of this important community resource. The restoration of the tidal channel will allow greater tidal flushing for improved water quality to the backwaters of Jamaica Bay. The design of this project is consistent with the goals of the Master Plan for Idlewild Park currently being developed by the EQA.

Management Strategy 2b1: Review existing recommendations for the acquisition and restoration of tidal wetlands and upland buffer areas around the Bay's periphery and evaluate the potential for additional acquisition and restoration opportunities.

STRATEGY DESCRIPTION

Over the last 25 years, surveys of Jamaica Bay's open shoreline areas have identified adjacent upland buffers that could be restored and/or acquired for potential restoration and enhancement of vegetation communities and wildlife habitat. The identification of open natural areas for potential restoration and acquisition opportunities were included in the following reports:

- *Buffer the Bay (Trust for Public Land and NYC Audubon, 1987)*
- *Buffer the Bay, Revisited (Trust for Public Land and NYC Audubon, 1992)*
- *Restoration of Natural Resources Through the Jamaica Bay Damages Account: Reconnaissance Phase Report (NYSDEC, 1993)*
- *Jamaica Bay Draft Comprehensive Management Plan (NYCDEP, 1994)*

- *Navigation Channels and Shoreline Environmental Survey (USACE, 1997)*
- *Harbor Estuary Program Priority Acquisition and Restoration Site List (HEP)*
- *NY/NJ Harbor Estuary Program, 2004 revised list*
- *Needs and Opportunities for Environmental Restoration in the Harbor Estuary Regional Planning Association (May, 2003)*
- *Jamaica Bay Study Area Report (USACE, 2004)*
- *New York State Open Space Plan (NYSDEC, 2007)*

A review of these reports indicates that many of the sites that were identified and considered to be valuable habitat have been protected and transferred to the NYCDPR, New York State Office of Parks, Recreation and Historic Preservation (NYSOPRHP) and the NPS. According to the Regional Plan Association (RPA) (2003), "Land preservation in Jamaica Bay, with a few exceptions such as some Arverne/Edgemere watershed sites, is virtually complete…" The recommended larger sensitive natural area properties within Jamaica Bay, that have been successfully protected, include the following locations:

Paerdegat Basin	*Fresh Creek Basin*
Spring Creek	*Bayswater State Park*
Brant Point	*Vernam Barbadoes Peninsula*
Dubos Point	*Edgemere Landfill*
Pennsylvania Landfill	*Fountain Landfill*
Four Sparrow Marsh	

However, a review of these reports also indicates that some of the recommended properties were eventually developed (*i.e.*, Vandalia Dunes), and the full acquisition status of other recommended properties has not been fully realized (*e.g.*, Four Sparrow Marsh). In the case of the Arverne Urban Renewal location, although a large section has been developed, an area of approximately 30 acres was set aside for natural area protection and wildlife habitat through the efforts of local environmental groups and discussions with NYCDPR.

In many of these reports, similar criteria were established to prioritize available sites. In no order of relative importance, the following criteria were used to determine site priorities for Buffer the Bay, Revisited:

- Biotic diversity: the variety of plant and animal species;
- Habitat diversity: variety of the landscape considering factors such as relief and topography;
- Size: parcels of greater acreage generally have greater potential as plant and animal habitat;
- Integrity: degree of alteration of the landscape and flora and fauna by past or present human activity;
- Proximity to other protected areas, leading to larger and less fragmented habitat suitable for reclamation; and
- Degree of present threat of change or development.

When larger vacant parcels were more abundant within the watershed and along the shoreline, this approach of prioritizing and selecting properties for acquisition was fairly simple to apply. However, now that many of the remaining vacant parcels are small in comparison to the previously identified properties, and discontinuous from larger parcels and from one another, the approach to prioritization becomes more challenging. Therefore, the approach used to assess the remaining vacant land for potential acquisition and restoration within the Jamaica Bay watershed was to focus on an area extending out approximately one mile inland from the shoreline of Jamaica Bay, and apply similar criteria as that used for identifying the priority vacant parcels under "Buffer the Bay" and other property inventory reports. With a few exceptions, a GIS analysis of potential properties within the watershed indicates that the majority of the vacant land within this one mile range and in most other portions of the watershed consists of small parcels (*e.g.*, 77% < 10,000 sq ft in size). As such, the selection of priority parcels should have multiple objectives in terms of their habitat and restoration opportunities, as well as their ability to function as potential stormwater management properties, and additional public open space and additional urban habitat. Because the remaining properties are small and in many cases discontinuous, the approach also used "clustering" assemblages of properties to maximize their potential for habitat improvements, open space and stormwater management opportunities.

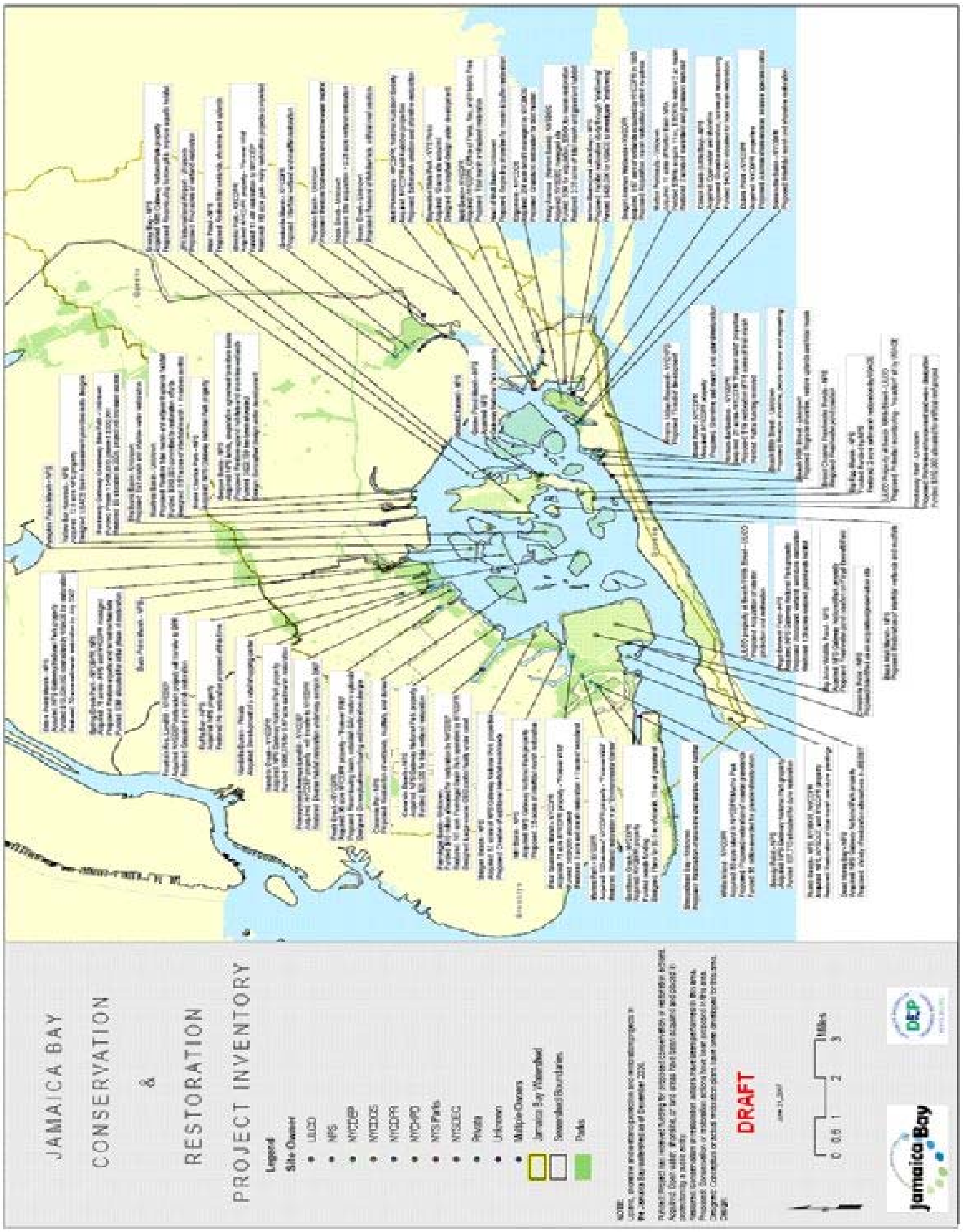


FIGURE 4.6. Jamaica Bay Conservation & Restoration Project Inventory; Source: NYCDEP

Edgemere Acquisitions

Approximately six acres of land in the Edgemere section of Queens, currently under the jurisdiction of the HPD, have been identified for potential transfer to the NYCDPR. While initial discussions with NYCDEP, HPD and NYCDPR have identified potential properties, issues with adjacent landowner encroachment, and securing the sites to prevent illegal dumping and site assessments still need to be finalized. Additional private sites in this area may also be available to enhance ecological connectivity.

TABLE. 4.6. POTENTIAL EDGEMERE AQUISITION PARCELS

BLOCK	LOT	SIZE (sq ft)
15961	61	3,200
15961	63	11,000
15961	83	4,000
15961	85	4,000
15961	87	2,500
15961	97	3,000
15961	100	4,000
15961	110	62,700
15962	19	17,237
15962	28	3,823
15962	30	5,704
15962	33	8,187
15962	54	5,305
15963	1	30,492
15963	21	8,967
15963	30	3,831
15963	32	1,915
15963	36	1,915
15963	38	1,915
15963	39	1,915
15963	40	1,915
15963	41	1,915
15963	42	1,915
15963	43	1,915
15963	44	1,915
15963	45	1,915
15963	47	1,600
15963	48	1,600
15963	54	2,000
15963	55	1,915
15964	55	10,659
15964	58	8,000
15964	62	1,600
15964	63	1,600
15964	64	1,600

FIGURE 4.7 Edgemere Properties: Source: NYCDEP

TABLE. 4.6. POTENTIAL EDGEMERE AQUISITION PARCELS		
BLOCK	LOT	SIZE (sq ft)
15964	65	1,600
15971	16	4,459
15971	21	9,071
	TOTAL:	248,013 sq ft (6 acres)

Other Sites

In addition to the properties listed above, additional properties were identified within a one mile radius of the Bay for potential land conservation and restoration opportunities. This was done through a GIS analysis of **PLUTO**™ map data. (© 2003-2007, NYCDCP). Both public and private properties were reviewed. Each parcel was evaluated for habitat and open space potential, using environmental criteria such as parcel size, the proximity of the parcel to existing open space, parkland, and potential for restoration and stormwater management opportunities.

The analysis identifies vacant publicly and privately-owned properties within the one mile radius zone, and shown as the "cluster areas" on the map below, as having the greatest potential for environmental benefits. Cluster areas were reviewed to be consistent with previous selection criteria (*e.g.*, size, proximity to the shoreline, other properties that increase their cumulative value, and to existing parks and open space) from other parcel inventory surveys. However, unlike the previous parcel inventory studies, this analysis evaluated the numerous smaller parcels to make the best determination of what would make the most ecological sense and provide ancillary benefits such as stormwater management, when considered cumulatively. Although there are additional public and private properties within the watershed, both within the one mile radius and beyond, the "cluster area" properties (in addition to those previously listed from HPD) represent those that closely match the criteria of other surveys and are expected to provide the most benefits. These cluster areas will require "ground-truthing" to verify their current status.

A summary of the public parcels indicates that they range in size from 30 sq ft to nearly 16 acres and include a total of 214 properties with a combined total of 208 acres. A total of 166 (approximately 77%) of the parcels are 10,000 sq ft or less, 33 (approximately 17%) are between 10,001 and 35,000 sq. ft. and 13 (approximately 6%) are greater than 35,001 sq ft. in size. The recommendation for the public properties within these "cluster areas" is to place a "study hold" until each property can be fully assessed for potential environmental benefits and stormwater management

If public properties within "cluster areas" were determined to be available and beneficial for acquisition based on field verification and research into status, they could be proposed to be transferred to NYCDPR and NPS. If acquired, these parcels would be set aside for future restoration and stormwater management.

Private parcels comprise a smaller total area, approximately 120 acres within the "cluster areas," but are represented by a much larger total of 942 individual parcels. The parcels range in size from as small as 15 sq ft to as large as almost 10 acres in size. Private parcels are not actively being considered for purchase, as negotiations with each land owner is required and significant funding would be needed from sources (*e.g.*, Trust for Public Land) other than NYCDEP to secure these parcels (see "Costs" below).

Approximately 0.67 acres of Seagirt Avenue wetlands, located in Far Rockaway, Queens, were acquired by the NYCDPR in September, 1995. However, this Plan supports the recommendation for the acquisition of additional Seagirt Avenue properties by others (*e.g.*, Trust for Public Land). The Seagirt site is considered a high-priority acquisition site by the New York/New Jersey Harbor Estuary Program and is also identified on the New York State Open Space list for acquisition. The site contains a tidal creek and is located adjacent to NYCDPR property and has the potential for restoration enhancement and stormwater management options.

In addition to identifying new acquisitions for restoration projects at this time, it is recommended that the existing restoration projects within Jamaica Bay should be prioritized and implemented. In particular, restoration and funding should focus on the completion of the USACE's Jamaica Bay Marsh Islands Ecosystem Restoration Project (Elders Point East and West and Yellow Bar) and the eight JBERRT sites for which conceptual designs have been prepared. These project sites are identified as Dead Horse Bay, Paerdegat Basin, Fresh Creek, Spring Creek South, Hawtree Point, Bayswater State Park, Dubos Point, and Brant Point. These projects are significant because they have evolved from the myriad of proposed projects, are large scale projects, and are based on existing needs. These are projects that have been identified by the many experts who are familiar with the detailed research that has been performed and the ongoing physical and biological processes within the Bay. In addition, significant studies have already been performed at these sites which will streamline the implementation process. This baseline data provides the necessary information needed for preparing permit applications and construction specifications.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

The intent of the parcel review was to identify those properties closest to the Bay, as these are the most sensitive properties and would likely provide the greatest potential for upland buffering protection and additional habitat in close proximity to Jamaica Bay. The potential exists for some of these locations to provide additional tidal wetland perimeter restoration and the opportunity to restore adjacent coastal upland systems with a greater plant species diversity than under existing conditions. In some cases the areas would provide an important connection to some of the fragmented natural areas around the Bay. Enhancing connectivity with these larger adjacent properties can also create wildlife corridors. Preservation ensures that development, with its associated stormwater runoff issues, soil changes and the potential for introducing invasive plant species, does not occur in sensitive areas along the Bay.

The restored areas would provide additional "green" open space in one of the most densely developed watersheds in the country. With careful planning and coordination, it is possible that some of these locations could provide additional public access to the Bay. Lastly, any vacant parcels could be restored utilizing BMPs to treat stormwater runoff resulting in improvements to the water quality of the Bay.

Technical issues

While the acquisitions themselves do not face significant "technical" hurdles, restoring the ecological functions of the sites do. Ensuring that future restoration work has the greatest potential to be self-sustaining involves detailed design and ecological landscape planning. In addition, parcels will need to be assessed for historic, cultural or contamination related issues before site work can begin. Site work may require clean-up of contamination and removal of debris and structures prior to restoration.

Cost

The transfer of existing public properties to NYCDPR or NPS would entail minimal cost.

Legal

While any property transaction involves legal issues, if private property were to be purchased, it would need to be from a willing seller. The City is not proposing condemnation of private property in order to acquire open space.

High property values within New York City make private land purchase a very expensive proposition and substantial funding would be required. With the assumed current market real estate value of $55 per square foot for residentially-zoned areas and $100 per square foot for commercially-zoned areas within the Jamaica Bay watershed, the anticipated purchase cost for the 120 acres of privately-owned "cluster" properties, would be approximately $298 million (see Table 4.7). Aside from the acquisition costs for the private parcels, as previously mentioned there may also be a need to remove existing structures and to address contamination issues, significantly raising the final cost of restoration.

TABLE 4.7. Estimated Acquisition Costs		
Brooklyn and Queens		
Residential	Square Footage	4,600,000
	Acquisition Cost	$255 million
Commercial	Square Footage	265,452
	Acquisition Cost	$27 million
Industrial	Square Footage	376,730
	Acquisition Cost	$17 million
	Acreage Total	121
	Acquisition Cost Total	$298 million

Purchasing private properties and restoring public and private lands on this scale would require a significant collaborative effort to identify potential funding opportunities. Multiple entities would need to work together to fundraise and secure funding from a variety of government agencies, private organizations and other entities.

RECOMMENDATION

It is recommended that multiple entities work together to acquire and restore "cluster areas" along the periphery of the Bay and other key parcels such as the Seagirt Wetlands in Far Rockaway, Queens. In addition, sites previously identified for restoration should be actively pursued and completed. This would be accomplished through the *Implementation Strategies* listed below.

IMPLEMENTATION STRATEGIES

Transfer HPD Properties in the Edgemere Section of Queens to DPR

Continue the process to transfer the approximately six acres of HPD properties in the Edgemere section of Queens to the NYCDPR. Provide site assessments and secure the sites. Once acquired, restoration plans will need to be developed. Work with multiple entities to design and implement restoration plans for these sites.

Cost: Restoration costs have not been developed and these efforts are currently unfunded.

Schedule: No time frames have been established for the transfer.

Pursue Acquisition and Restoration Efforts in Cluster Areas

Work with the New York City Department of Citywide Administrative Services (DCAS) to determine the status of all subject properties and the ability to place a "study hold" on them. Field verify the areas to determine potential ecological benefits, prior to acquisition. Work with multiple entities to design and implement restoration plans for these sites.

Cost: Restoration costs have not been developed and are currently unfunded.

Schedule: NYCDEP will determine status, field verify the sites, and work to place study holds on applicable sites within six months.

Acquire Seagirt Avenue Wetland Properties, Far Rockaway, Queens

Multiple entities should leverage funds to acquire the Seagirt Avenue wetland properties located in Far Rockaway, Queens. This site is on the high priority acquisition list for the HEP and also a high priority on the New York State Open Space list.

Schedule: This effort involves entities outside of NYCDEP; no time frames have been established.

Track and Inventory Restoration Sites

NYCDEP will continue to develop and distribute the Jamaica Bay Conservation and Restoration Project Inventory as a tool for inter agency coordination and prioritization. The JBWPP encourages other entities to use this as the base map for developing and monitoring restoration efforts within Jamaica Bay. NYCDEP will engage other relevant agencies to refine and update this inventory to make it a more effective restoration tool. The creation of a portal such as a web-access database to allow the inventory to be viewed and updated by stakeholders as projects are developed and implemented is one option to allow the greatest access. Coordination of this portal will need to take place among the various stakeholders of the Bay.

Management Strategy 2b2: Prepare a GIS map of existing and /or potential locations that could benefit from grassland, woodland, and shrubland restoration and prioritize restoration sites.

STRATEGY DESCRIPTION

At the time of European settlement, the upper watershed and upland perimeter of Jamaica Bay was dominated by a contiguous expanse of forest and maritime scrubland, interspersed with early successional grassland habitat. Most of these habitats have been lost to development or have been degraded by invasive species and poor soil conditions; however, there are isolated fragments of these habitats still present in undeveloped areas. Historically, these areas supported a high diversity of plants and animals, and aided in the filtering and processing of nutrients and sediments that drained from the upper watershed. In particular, native grasslands are key habitats for numerous species of insects and birds that occur in Jamaica Bay, including upland sandpipers, grasshopper sparrows, meadowlarks, short-eared owls, northern harriers and the American kestrel. The restoration, protection, and creation of additional grassland, woodland, and shrubland habitats would provide benefits for plant and animal species, and could be integrated with urban stormwater runoff management practices. Active monitoring of restored upland habitats will aid in the effective management of these areas, and maximize the ecological benefits.

As part of the closure and remediation of the Pennsylvania and Fountain Avenue Landfills, native coastal grassland, woodland and shrubland habitats are being restored, providing some one of the largest expanses of contiguous high-quality upland habitat in the watershed. Approximately half of the 370 acres of the two landfills sites are reserved for coastal woodland and shrubland habitat; the remaining areas are being restored to native coastal grasslands. In addition, there are plans by NYCDPR and HPD to restore an additional 55 acres of grasslands on White Island, within Gerritsen Creek.

A previously restored Floyd Bennett Field grasslands site covers 140 acres. The site is located in the Gateway National Recreation Area (GNRA) and is managed by the NPS. It is the site of the former Grassland Research and Management Project (GRAMP), and is protected and actively managed for grassland breeding bird habitat by NPS and the New York City Audubon Society.

An inventory and assessment of upland habitat complexes in the watershed must be performed to better understand the current extent and condition of these areas. Woodland and shrubland restoration around the perimeter of the Bay should be coordinated as part of the larger Jamaica Bay acquisition and restoration efforts described in previous Objectives, but it is essential that woodland habitat be included as part of the restored upland buffer habitat mosaic. Opportunities for additional large-scale restoration of grassland habitat may be very limited within the upper sections of the Jamaica Bay watershed; however, some upland areas around the periphery of the Bay may afford opportunities to enhance ecologically unproductive areas to more productive and diverse grassland and woodland habitats. Active monitoring and management of these areas is necessary to determine the success of restored areas, and prevent infestation by invasive species.

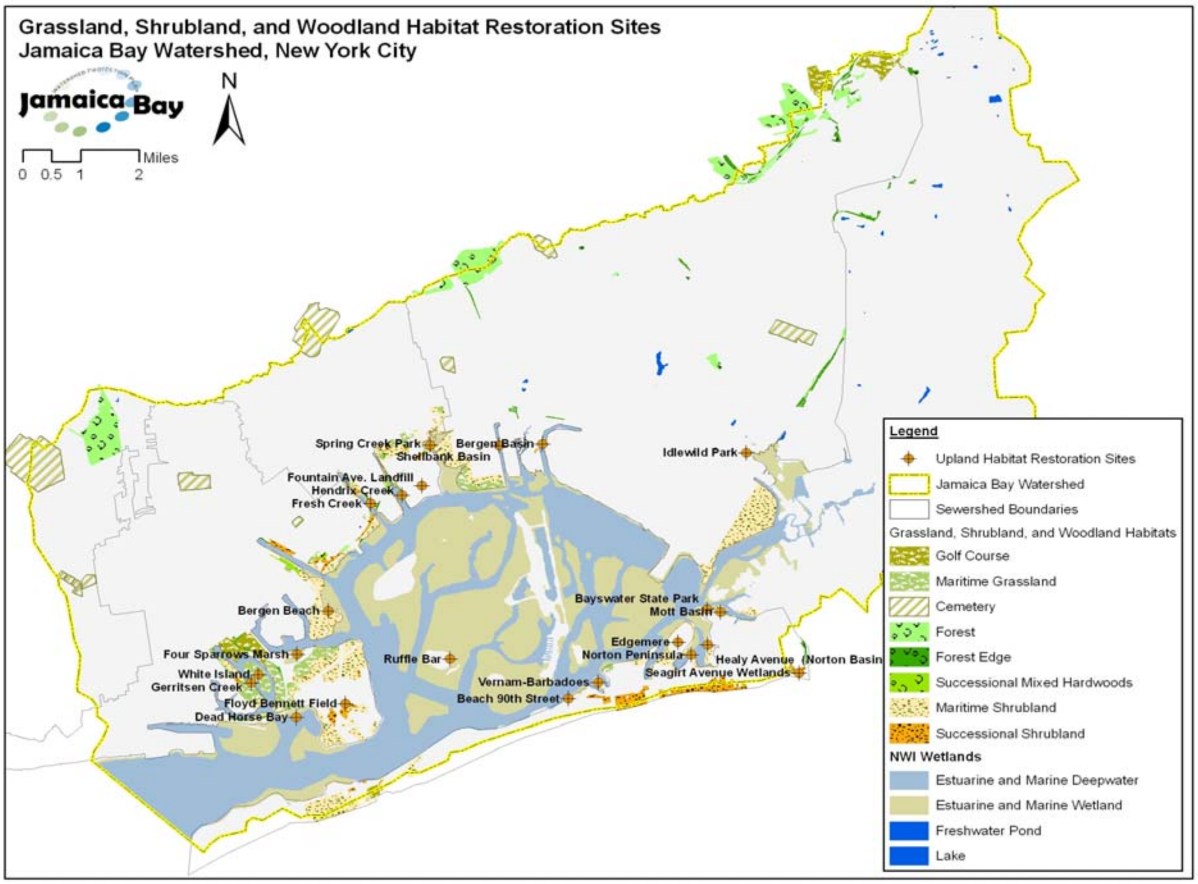


Figure 4.9 Grassland/Shrubland/Woodland Habitat Restoration Sites in Jamaica Bay Watershed; Source: NYCDEP

Grassland, woodland, and shrubland habitat complexes tend to occur around the perimeter of the Jamaica Bay estuary, comprising a natural buffer between the wetlands areas and the urbanized portions of the watershed. Major disturbances to these areas include fragmentation, removal for urban infrastructure, and invasive species. During the past couple of decades, numerous resource management agencies active in the Jamaica Bay watershed including NPS, USACE, USFWS, NYCDEP, NYCDPR, RPA, New York City Audubon Society and the HEP have performed natural resource assessments, and identified areas that could benefit from land protection or habitat restoration actions. Many of these acquisition and restoration sites are comprised of grassland, woodland, and shrubland habitats. The current status of the acquisition/restoration of these sites varies tremendously some areas have already experienced habitat restoration and protection; others have been identified as areas that would greatly benefit from these actions, but no actions have yet occurred.

Proposed Restorations and Potential Additional Restoration Enhancement Opportunities

Currently identified grassland, woodland, and shrubland habitat complexes in the watershed are displayed in Figure 4.9.

EVALUATION OF MANAGEMENT STRATEGY

Environmental
The combination of upland and wetland habitats within many of the sites supports diverse native vegetation assemblages, and provides essential habitat to an array of avian, insect, and mammal species that exist within the watershed. In addition, these complexes around the perimeter of the Bay function as a shoreline buffer, providing important protection from storm surges and helping to stabilize the shoreline. These buffer areas also provide water quality benefits, buffer sensitive wetlands and shallow water habitats from urban areas, and increase the diversity of habitat types along the shoreline. In addition to their wildlife habitat value, these areas provide aesthetic beauty and serve as potential passive and active recreational features for visitors and residents in the watershed.

Technical
Many of these sites have been previously identified for their potential restoration opportunities. Some of these restorations have occurred, while others may not have been funded, therefore, an assessment will need to be performed to determine their current status. In addition, many of these assessments are greater than 10-years old and will require updated restoration potential assessments and costs to determine current opportunities. See also Management Strategy 2b1 for additional technical issues associated with restoration efforts.

Legal
USACE and NYSDEC permits will be required for most restoration efforts occurring at these properties. Additional permits and permission will likely be required of NYCDPR and the NPS on areas under their jurisdiction.

Cost
Updated restoration costs have not been developed and the funding status for many of these restorations is unclear at this time, but it is highly likely that many of these proposals remain unfunded.

RECOMMENDATION

Because these sites have already been identified by multiple entities engaged in conservation and restoration of Jamaica Bay habitats, it is recommended that where applicable that these plans be updated to reflect current conditions. Additional grassland, woodland, and shrubland habitat restoration sites likely exist around the perimeter of the Bay and in the upland areas of the watershed, but these sites have yet to be identified by local resource management agencies.

IMPLEMENTATION STRATEGY

Create a Current Inventory and Prioritize Restoration Efforts

Complete updated inventory of all existing upland habitat locations and coverage to create a base GIS mapping and information data layer that can be used by restoration practitioners in developing and leveraging future ecological restoration designs. Develop, map and prioritize a list of potential sites for restoration of these habitat types.

Cost: $400,000 for existing conditions research, mapping, evaluation, threats assessment, prioritization of restoration opportunities and new site potential.

Schedule: Approximately one year to inventory existing sites, conditions and coverage, GIS mapping of sites, condition and coverage and cross referencing of all invasive species control actions. However, much of this effort involves entities outside of NYCDEP and multiple agency coordination and cooperation is required.

Management Strategy 2b3: Prepare a GIS map of existing and potential dune and beach habitats that could benefit from restoration and prioritize restoration sites.

STRATEGY DESCRIPTION

Beaches and dunes are important natural buffers against the forces of wave and wind erosion, and are dynamic landscape features that quickly change as a result of wind erosion and deposition. Large contiguous portions of the Jamaica Bay shoreline are covered in expanses of sandy beaches and dunes, especially on the northwestern and southwestern sides of the Rockaway Inlet (Breezy Point and Dead Horse Bay), where wave and tidal forces are strongest. These areas support several rare plant species including seabeach amaranth (*Amaranthus pumilus*), seabeach knotweed (*Polygonum glaucum*), and Schweinitz's flatsedge (*Cyperus schweinitzii*). Beaches and dunes serve as vital foraging and breeding habitat for selected birds and aquatic organisms, many of which are listed rare, threatened, or endangered species, including piping plover, least terns, diamondback terrapin turtles, and horseshoe crabs. Beach and dune ecosystems, and the plant and animal species they support, are delicate and easily damaged by disturbance. The hardening of shorelines for urban infrastructure along the periphery of the Bay has impacted historic beach and dune habitats, and potentially limits restoration opportunities in these areas. Invasive plant species such as *Phragmites australis* have displaced much of the indigenous vegetation in large areas of sandy upland habitat along the shoreline.

Breezy Point is the most ecologically important beach and dune habitat area within Jamaica Bay, and is actively managed and monitored by NPS and the USFWS to protect piping plover and colonial shorebird habitat. Plum Beach along the northwest shoreline of the Bay and portions of Far Rockaway also contain high quality beach and dune habitat complexes.

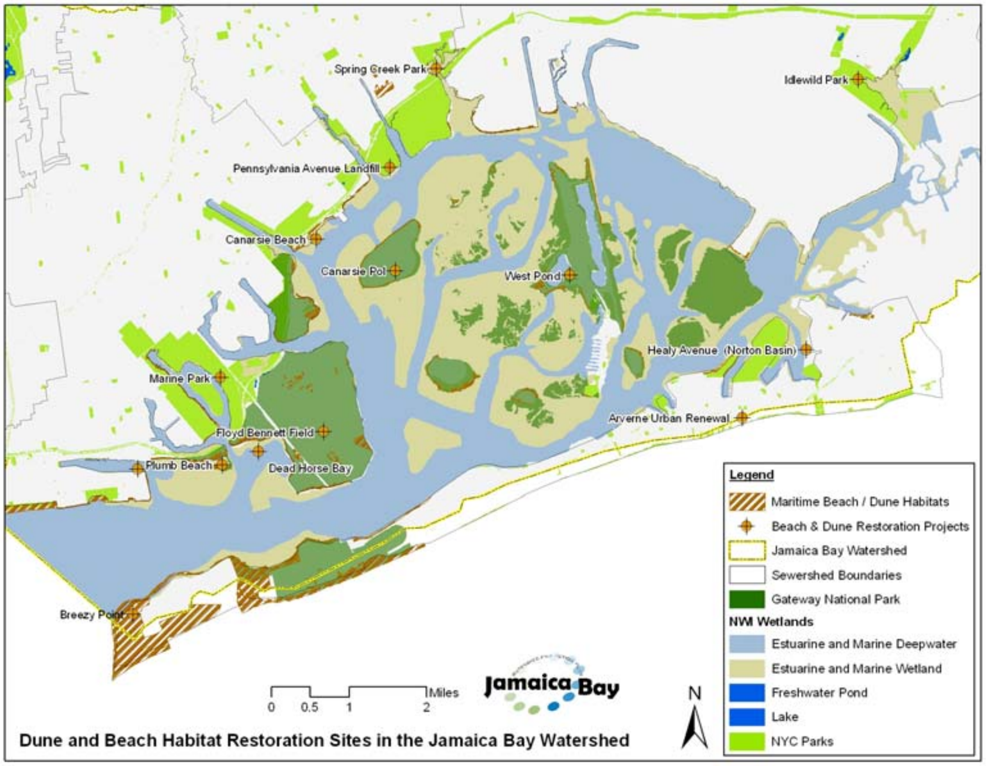


Figure 4.10 Maritime Dune/Beach Habitat Restoration Sites in Jamaica Bay Watershed; Source NYCDEP

The enhancement and restoration of additional beach habitats will increase biodiversity and improve existing wildlife habitats. The identification of existing dune and beach habitat in Jamaica Bay is an important first step in evaluating additional sites for restoration, either to augment / improve existing habitat, or to create or restore new areas to this habitat type. An inventory of their location and area coverage, physical characteristics and the plant and animal species that utilize them will help to inform and guide the potential restoration of new sites.

Previous and Current Dune and Beach Habitat Assessments

Over the last years, numerous resource management agencies active in the Jamaica Bay watershed, including the NPS, USACE, USFWS, NYCDEP, NYCDPR, RPA, Audubon Society and the HEP, have performed natural resource assessments, and identified areas that could benefit from land protection or habitat restoration actions. Many of these acquisition and restoration sites are comprised of maritime dune and beach habitats. However, ground-truthing is required to determine the current status and condition of the restoration of these sites; some areas have already experienced beach and dune habitat restoration and protection, others have been identified as areas that would greatly benefit from these actions, but no actions have yet occurred. Discussions with appropriate agencies and organizations is necessary to begin to develop a current inventory of potential locations.

The locations of currently identified maritime dune and beach habitats in the watershed are displayed in Figure 4.10.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Dune and beach habitats are home to many rare, threatened, and endangered animal species that utilize the Bay during the summer season and during spring and fall migratory runs. Several species of plants are found nowhere else in the area. These sand complexes also provide important protection from storm surges and when vegetated help to stabilize the shoreline with highly specific plant species well adapted for dynamic environmental conditions. The enhancement and restoration of additional dune and beach habitats will increase biodiversity and improve existing wildlife habitats.

Technical Issues

Depending on the location and remoteness of the dune restoration, equipment access to the site may be limited. Also, seasonal restrictions may be in place if working near existing dune beach habitat to prevent disturbance of protected wildlife populations. In other cases where land access is possible, the use of heavy equipment is likely prohibited due to the impacts to this fragile plant community. To minimize disturbance, additional measures will raise costs and time to the effort of restoring dune and beach habitat.

Legal

Depending on the location of the site and restoration activities to be performed, NYSDEC, USACE and USFWS permits may be required. If the restoration site occurs on NYCDPR or NPS administered lands, permits from those entities may also be required.

Cost

Updated restoration costs have not been developed and the funding status for many of these restorations is unclear at this time, but it is highly likely that many of these proposals remain unfunded.

RECOMMENDATION

Because these sites have already been identified by multiple entities engaged in conservation and restoration of Jamaica Bay habitats, it is recommended that further beach / dune habitat restoration be facilitated according to the following process:

- Update the current status of the beach/dune habitat restoration projects indicated in Figure 4.10 above.

- Coordinate with NYCDPR, HPD, NPS, USFWS, USACE, NYSDEC and local environmental groups in the restoration of these beach/dune habitat sites to leverage existing funding and maximize restoration efforts.

IMPLEMENTATION STRATEGY

In coordination and collaboration with multiple agencies and environmental groups, update inventory of all existing dune and beach habitats and coverage to create a base GIS map. This information can be then used by restoration practitioners in developing and leveraging future ecological restoration designs.

Cost: $400,000 for existing conditions research, mapping, evaluation, threats assessment, prioritization of restoration opportunities and new site potential. Note: *Cost to perform this work includes work suggested under Strategy 2b3 and does not represent an additional cost.*

Schedule: Will be developed through a proposed contract. A contractor is anticipated to be retained by mid-2008. Work to be initiated in Fall 2008.

References

Yozzo, D.J., Rhoads, J.M., Wilber, P., Nuckols, W., Hollen, L. and Will, R. 2001. Beneficial uses of dredged material for habitat creation, enhancement, and restoration in NY/NJ Harbor. U.S. Army Corps of Engineers, New York District, New York, N.Y.

Management Strategy 2b4: Identify habitats of listed species and suggest projects that would support the recovery of animals and plants that are listed as RTE.

STRATEGY DESCRIPTION

A number of species that occur in the Jamaica Bay watershed are listed by the federal or state government as rare, threatened, or endangered (RTE). The commonality between these RTE species is that the specific habitat conditions necessary for their survival have been severely degraded, leading to a decline in species health and population. The success of an RTE species requires effective management and an understanding of the specific habitat conditions necessary for the successful restoration of each species. As ecosystem restoration occurs throughout the watershed and Jamaica Bay, special attention should be made to identify RTE species in those areas, and to integrate the specific ecological requirements of those species into habitat restoration or enhancement plans. Some of these species will need to be "phased" into the landscape as specific habitat conditions necessary for the long-term survivability of the species will not have established immediately after the initial restoration.

Federal, state and local agencies maintain databases of RTE plant and animal species. These databases are regularly updated as the status of a particular species changes. Those RTE species are granted special protections by federal or state regulations, including the requirement that any project that may impact the health of those species must be evaluated. In addition, once a species has been designated as RTE, it receives varying degrees of active habitat protection and management.

Using the existing federal and state species that are listed as endangered, threatened, rare or vulnerable by the federal or state government, an inventory of RTE plant and animal species known to have occurred within Jamaica Bay and its watershed was developed. In addition, a preliminary review of the habitats necessary for the survival and propagation of those species was evaluated, identified, and assessed for their ability to provide the requisite ecological conditions. Consultation with other natural resource agencies and environmental stakeholder groups is necessary to further refine potential habitat locations. The integration of this information into ongoing and proposed restoration and enhancement plans will assist in the support and recovery of those RTE species, and may be additional criteria to consider in the prioritization of future habitat restoration efforts.

New York State Classification Codes

The following legal definitions and codes are used to describe rare, threatened, and endangered species in the State of New York and the United States (from the New York Natural Heritage Program (NYNHP) - http://www.acris.nynhp.org/ranks.php).

New York State Legal Status for Animals

Categories of Endangered and Threatened species are defined in New York State Environmental Conservation Law section 11-0535. Endangered, Threatened, and Special Concern species are listed in regulation 6 NYCRR Part 182.5.

E - Endangered Species: any species which meet one of the following criteria: Any native species in imminent danger of extirpation or extinction in New York. Any species listed as endangered by the United States Department of the Interior, as numerated in the Code of Federal Regulations, 50 CFR 17.11.

T - Threatened Species**:** any species which meet one of the following criteria: Any native species likely to become an endangered species within the foreseeable future in NY. Any species listed as threatened by the U.S. Department of the Interior, as enumerated in the 50 CFR 17.11.

SC - Special Concern Species: those species which are not yet recognized as endangered or threatened, but for which documented concern exists for their continued welfare in New York. Unlike the first two categories, species of special concern receive no additional legal protection under Environmental Conservation Law section 11-0535 (Endangered and Threatened Species).

P - Protected Wildlife (defined in Environmental Conservation Law section 11-0103): wild game, protected wild birds, and endangered species of wildlife.

U - Unprotected (defined in Environmental Conservation Law section 11-0103): the species may be taken at any time without limit; however a license to take may be required.

G - Game (defined in Environmental Conservation Law section 11-0103): any of a variety of big game or small game species as stated in the Environmental Conservation Law; many normally have an open season for at least part of the year, and are protected at other times.

New York State Legal Status for Plants

The following categories are defined in regulation 6 NYCRR Part 193.3 and apply to Environmental Conservation Law section 9-1503.

E - Endangered Species: listed species are those with: 5 or fewer extant sites, or fewer than 1,000 individuals, or restricted to fewer than 4 U.S.G.S. 7 ½ minute topographical maps, or species listed as endangered by U.S. Department of Interior, as enumerated in 50 CFR 17.11.

T - Threatened: listed species are those with: 6 to fewer than 20 extant sites, or 1,000 to fewer than 3,000 individuals, or restricted to not less than 4 or more than 7 U.S.G.S. 7 and ½ minute topographical maps, or listed as threatened by U.S. Department of Interior, as enumerated in 50 CFR 17.11.

R - Rare: listed species have: 20 to 35 extant sites, or 3,000 to 5,000 individuals statewide.

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

U - Unprotected: no state status.

Federal Classification Codes

Federal Legal Status for Plants and Animals
The categories of federal status are defined by the United States Department of the Interior as part of the 1974 Endangered Species Act (see 50 CFR 17). The species listed under this law are enumerated in the Federal Register vol. 50, no. 188, pp. 39526 - 39527.

LE: The element is formally listed as endangered.

LT: The element is formally listed as threatened.

PE: The element is proposed as endangered.

PT: The element is proposed as threatened.

C: The element is a candidate for listing.

LE,LT: The species is formally listed as endangered in part of its range, and as threatened in the other part; or, one or more subspecies or varieties is listed as endangered, and the others are listed as threatened.

LT,PDL: Populations of the species in New York are formally listed as threatened, and proposed for delisting.

(LE): If the element is a full species, all subspecies or varieties are listed as endangered; if the element is a subspecies, the full species is listed as endangered.

LT,T(S/A): One or more subspecies or populations of the species is formally listed as threatened, and the others are treated as threatened because of similarity of appearance to the listed threatened subspecies or populations.

PS: Partial status: the species is listed in parts of its range and not in others; or, one or more subspecies or varieties is listed, while the others are not listed.

Documents and databases from The USFWS, NMFS, Jamaica Bay Wildlife Refuge, NPS GNRA, and NYNHP were reviewed in an effort to determine the rare, threatened and endangered species within the Jamaica Bay Watershed. The final list of species includes those that are listed under the Federal Endangered Species Act of 1973, along with New York State listed species whose status in the Jamaica Bay Watershed were listed as rare, threatened or endangered (Table 4.8).

Habitat criteria for the relevant RTE species were defined according to documented habitat preferences by the relevant species (Table 4.9). Several species that are federally–listed are not likely to occur in Jamaica Bay, but were included to provide a complete range of potentially-viable RTE vegetation and wildlife.

Habitat Categories

The habitat requirements were categorized into general land cover types occurring in the Jamaica Bay watershed, to allow a determination of which RTE species may frequent those areas. These are:

- Bareground
- Coastal Rock
- Coastal Scrub
- Dune
- Grassland
- Landscape
- Landscape Corridor
- Shrubland
- Freshwater
- Woodland
- Woodland Edge
- High Salt Marsh
- Low Salt Marsh
- Low Salt Marsh Salt Panne
- Intertidal Mudflat
- Maritime Beach
- Maritime Dune

TABLE 4.8. Rare, Threatened, and Endangered Species in Jamaica Bay Watershed

Species		Listing		
Common Name	**Latin Name**	**Global**	**Federal**	**State**
American wigeon	Anas americana			R
gadwall	Anas stepera			R
short-eared owl	Asio flammeus			I/P/S/E
long-eared owl	Asio otus			P/P
red-shouldered hawk	Buteo lineatus			T/S
piping plover	Charadrius melodus	R	FT	I/E
Northern harrier*	Circus cvaneus			R/T/S
blackpoll warbier	Dendroica striata			R/P
snowy egret	Egretta thula			I/R/P
peregrine falcon*	Falco peregrinus	R	E	I/E

TABLE 4.8. Rare, Threatened, and Endangered Species in Jamaica Bay Watershed				
Species		**Listing**		
Common Name	**Latin Name**	**Global**	**Federal**	**State**
American coot	Fulica americana			R
common loon	Gavia immer			R/P/S
American oystercatcher	Haematopus palliatus			R/P
least bittern	Ixobrychus exillis			R/P/S/T
black crowned night heron	Nycticorax nycticorax			R/P
osprey	Pandion haliaetus			T/S
Northern parula	Parula americana			R/P
double-crested cormorant	Phalacrocorax auritus			R/P
pied-billed grebe*	Podylimbus podiceps			R/P/T
clapper rail	Rallus longirostrus			R/P
least tern	Sterna antillarum			R/E/T
Roseate tern	Sterna dougallii		FE	I/E
Foster's tern	Sterna forsteri			CI/P
common tern*	Sterna hirundo			R/T
common barn-owl	Tyto alba			R/P/S
FINFISH				
blueback herring	Alosa aestivalis			R/U
bay anchovy	Anchoa mitchilli			R/U
mummichog	Fundulus heteroclitus			R/U
naken goby	Gobiosoma bosci			I-R/U
seaboard goby	Gobiosoma ginsburgi	?		I-R/U
inland silverside	Menidia berylina			I-R/U
Atlantic tomcod	Microgadus tomcod			I-R/U
grubby sculpin	Myoxocephalus aenaeus	?		R/U
summer flounder	Paralichthys dentatus	?		I/R/U
Atlantic needlefish	Stongylura marina			I-R/U
Northern Pepefish	Syngnathus fuscus	?		R/U
hogchoker	Trinectes maculatus			R/U
REPTILES				
loggerhead	Caretta caretta	R	T	T/Z
green turtle	Chelonia mydas		T	
leatherback turtles	Dermochelys coriacea		T	
Kemp's ridley sea turtle	Lepidochelys kempii	CI	FE	CI/E
diamondback terrapin	Maclemys t. terrapin			SC/U
AMPHIBIANS				
eastern spadefoot	Scaphiopus h. holbrookii			R/U/S
MARINE MAMMALS				
humpback whale	Megaptera novaeangliae		E	
harbor seal	Phoca vitulina			R/P
sperm whale	Physeter catodon	I	FE	E
bottlenose dolphin	Tursiops truncates			R/U
BUTTERFLIES				
tawny emperor	Asterocampa clyton			R
Appalachian azure	Celastrina neglectamajor			R

TABLE 4.8. Rare, Threatened, and Endangered Species in Jamaica Bay Watershed				
Species		Listing		
Common Name	Latin Name	Global	Federal	State
TREES				
Virginia pine	Pinus virginiana			R/E
willow oak	Quercus phellos			CI/E
SHRUBS				
Houghton's umbrella-sedge	Cyperus houghtonii			R
Schweinitz's flatsedge	Cyperus schweinitzii			I/R
HERBACEOUS				
field-dodder	Cuscuta pentagonia			I/R
smartweed dodder	Cuscuta polygonorum			CI/R
seabeach knotweed	Polygonum glaucum	R		R/RU
silverweed	Potentilla anserina ssp. pacifica			I/R
heart-winged sorrell	Rumex hastatulus			CI/T
WILDFLOWERS				
smooth bur-marigold	Bidens laevis			I/R
seabeach knotweed	Polygonum glaucum	R		R/U
heart-winged sorrell	Rumex hastatulus			RI/T

TABLE 4.9. Rare, Threatened, and Endangered Species Habitat Preferences	
Species	
Common Name	**Notes on Habitat Preferences**
BIRDS	
American wigeon	Prefers deeper lakes or wide, slow-moving sections of river surrounded by grass/forb or shrub-covered lands
gadwall	Grasslands and marshes.
short-eared owl	Broad expanses of open land with low vegetation, such as grasslands or low-structured open shrublands.
long-eared owl	Trees/grass-forbs; riparian habitat nearby.
red-shouldered hawk	Extensive, mature to old-growth woodlands, especially bottom hardwoods, riparian areas, and flooded deciduous swamps feed along the wooded margins of marshes, often close to cultivated fields and natural openings
piping plover	Large expanses of short, sparse grasslands for nesting and foraging, and wetland complexes for foraging.
Northern harrier*	Grasslands and open habitats characterized by tall, dense vegetation, and abundant residual vegetation, wet or dry grasslands, fresh to alkali wetlands, lightly grazed pastures, croplands, fallow fields, oldfields, and brushy areas
blackpoll warbier	
snowy egret	Freshwater sites, dry fields, but most frequently in brackish and sheltered saltwater areas.
peregrine falcon*	Usually nest on cliffs, typically 45 m (150 ft) or more in height. They will also nest on off-shore islands and ledges on vegetated slopes
American coot	grassland to woodland ponds, lakes, slow-moving streams, or rivers.
common loon	Deeply indented shorelines having multiple bays and numerous islands surrounded by boreal or mixed forest.
American oystercatcher	Coastal salt marshes and sand beaches.
least bittern	Coastal zone. Freshwater emergent marsh is used, especially if cattail is present. In addition, pond and lake margins with emergent vegetation.
black crowned night heron	In annual grasslands, riparian deciduous types, medium/large woodlands. Ponds, lakes, marshes, slow streams with pools, or rivers.

TABLE 4.9. Rare, Threatened, and Endangered Species Habitat Preferences	
Species	
Common Name	**Notes on Habitat Preferences**
osprey	Near water, primarily lakes, rivers, and coastal waters with adequate supplies of fish.
Northern parula	Associated with bottomlands and swamps, where they inhabit mature coniferous and deciduous forests in which Spanish moss is an important component of the nesting habitat.
double-crested cormorant	Rocky cliffs and islands.
pied-billed grebe*	Marshes, sluggish streams, ponds 18 acres or less, and some emergent vegetation.
clapper rail	79% smooth cordgrass (*Spartina alterniflora*), 20% black rush (Juncus roemerianus), and 1% salt flats or salt meadows (Hon *et al.,* 1977)
least tern	Favor islands or sandbars along large rivers for nesting.
Roseate tern	Rocky coastal islands, outer beaches or salt marsh islands.
Foster's tern	Large saltwater and freshwater marshes; also found on marshy bays, marshy edges of streams and lakes, sloughs, dikes in evaporation ponds, estuarine islands, marshes adjacent to barrier beaches, and dredge-spoil islets.
common tern*	Mainly near water, often on islets, and usually in areas with little or no vegetation. Inhabits sparsely vegetated sandy islands, barrier beaches, marshy islands, small island in salt marshes, or low, small, rocky islands in lakes and rivers. After nesting, typically found along shorelines, on exposed rocks and old pilings, and inshore over shallow coastal waters.
common barn-owl	Grasslands, marsh, lightly grazed pasture.
FINFISH	
blueback herring	Migrate from ocean waters to spawn in freshwater rivers and streams when water temperatures reach between 10.5 degrees C and 14 degrees C
bay anchovy	Shallow water estuarine and inshore coastal water species (can exploit a larger range).
mummichog	Benthopelagic, euryhaline species. They are commonly found in salt water marshes, tidal creeks and in sheltered shores. The fish's upper salinity limit is reported to be 106 to 120.3 parts per thousand (ppt).
naken goby	Shallow estuarine habitats like patches of oysters, oyster reef, salt marsh and bare sand/mud substrate, but it is most abundant in tide pools and subtidal areas with oyster shell.
seaboard goby	
inland silverside	
Atlantic tomcod	Generally occurring in brackish water but occasionally in freshwater.
grubby sculpin	
summer flounder	
Atlantic needlefish	
Northern Pepefish	
hogchoker	
REPTILES	
loggerhead	Nest on ocean beaches, generally preferring high energy, relatively narrow, steeply sloped, coarse-grained beaches.
green turtle	Shallow, protected areas, nesting on high energy, southern, sand beaches.
leatherback turtles	
Kemp's ridley sea turtle	Nearshore and inshore waters extensive swamps or large bodies of open water having seasonal narrow ocean connections.
diamondback terrapin	Unpolluted saltwater emerge to mate, nest, and bask in the sun on coastal dunes or narrow sandy beaches.

TABLE 4.9. Rare, Threatened, and Endangered Species Habitat Preferences	
Species	
Common Name	**Notes on Habitat Preferences**
AMPHIBIANS	
eastern spadefoot	Fields, farmland, dunes and woodlands with sandy or loose soils. Breed in temporary bodies of water (*e.g.*, vernal pools), flooded fields and forested wetlands.
MARINE MAMMALS	
humpback mammals	
harbor seal	Shallow areas where sandbars, rocks and beaches are uncovered during low tides.
sperm whale	Deep waters.
bottlenose dolphin	
BUTTERFLIES	
tawny emperor	Woodlands near Hacklberry sites, densely wooded areas, dry woods, fence rows, open woods, parks.
Appalachian azure	
TREES	
Virginia pine	Forested rocky ridges & ravines, it is often seen growing on abandoned farmlands, roadsides, and other disturbed areas.
willow oak	Transitional communities between swamps and upland mesic forests.
SHRUBS	
Houghton's umbrella-sedge	Dry, open, rocky summits; the exposed fine sand of a large esker with heavily eroded sand gullies; and a broad, gently sloping sandplain.
Schweinitz's flatsedge	Swamp, edge of swamp riverside cove, calcareous border of a seepy creek on marsh edge.
HERBACEOUS	
field –dodder	Lowland grassland and grassy woodland, riparian vegetation, freshwater wetland (seasonal) and saline and subsaline wetland
smartweed dodder	Open areas and partial shade
seabeach knotweed	Exposed sandflats above high tide line to dunes, but occasionally submerged during storms or exceptionally high tide.
silverweed	Wetlands, generally below 500 ft, coastal areas.
heart-winged sorrell	
WILDFLOWERS	
smooth bur-marigold	Swamps, shores.
seabeach knotweed	Maritime beaches.
heart-winged sorrell	Old fields

TABLE 4.10. Rare, Threatened, and Endangered Species Habitat Communities in the Jamaica Bay Watershed																			
Species		**Habitat Requirements**																	
Common Name	**Latin Name**	Bareground	Coastal Rock	Coastal sand	Coastal Shrub	Dune	Grassland	Landscape	Landscape Corridor	Shrubland	Freshwater	Woodland	Woodland Edge	High Salt Marsh	Low Salt Marsh	Low Salt Marsh Salt Panne	Marsh Intertidal Mudflat	Maritime Beach	Maritime Dune
BIRDS																			
American wigeon	Anas americana				x		x			x	x								
gadwall	Anas stepera						x							x	x	x	x		

TABLE 4.10. Rare, Threatened, and Endangered Species Habitat Communities in the Jamaica Bay Watershed

Species		Habitat Requirements																	
Common Name	**Latin Name**	Bareground	Coastal Rock	Coastal sand	Coastal Shrub	Dune	Grassland	Landscape	Landscape Corridor	Shrubland	Freshwater	Woodland	Woodland Edge	High Salt Marsh	Low Salt Marsh	Low Salt Marsh Salt Panne	Marsh Intertidal Mudflat	Maritime Beach	Maritime Dune
short-eared owl	Asio flammeus				X		X			X					X				
long-eared owl	Asio otus				X		X			X	X	X	X						
red-shouldered hawk	Buteo lineatus						X					X	X						
willet	Catoptrophorus semipalmatus						X							X	X	X	X	X	X
piping plover	Charadrius melodus			X	X						X			X					
Northern harrier*	Circus cvaneus						X							X	X	X	X	X	
blackpoll warbier	Dendroica striata																		
snowy egret	Egretta thula						X				X			X	X	X			
peregrine falcon*	Falco peregrinus		X																
American coot	Fulica americana						X				X	X							
common loon	Gavia immer				X													X	
American oystercatcher	Haematopus palliatus			X		X								X	X	X	X	X	X
least bittern	Ixobrychus exillis		X	X	X						X			X	X	X	X	X	X
black crowned night heron	Nycticorax nycticorax						X				X	X		X	X	X	X	X	X
osprey	Pandion haliaetus										X			X	X	X	X	X	X
Northern parula	Parula americana										X	X							
double-crested cormorant	Phalacrocorax auritus		X																
pied-billed grebe*	Podylimbus podiceps										X			X	X	X	X	X	X
clapper rail	Rallus longirostrus													X	X				
least tern	Sterna antillarum			X		X												X	X
Roseate tern	Sterna dougallii		X											X	X	X	X		
Foster's tern	Sterna forsteri			X							X			X	X	X	X	X	
common tern*	Sterna hirundo		X								X			X	X	X	X	X	X
common barn-owl	Tyto alba						X				X			X	X	X	X	X	X
FINFISH																			
blueback herring	Alosa aestivalis										X								
bay anchovy	Anchoa mitchilli													X	X				
mummichog	Fundulus heteroclitus													X	X	X	X	X	X
naken goby	Gobiosoma bosci													X	X	X	X	X	X
seaboard goby	Gobiosoma ginsburgi																		
inland silverside	Menidia berylina																		
Atlantic tomcod	Microgadus tomcod													X	X	X	X	X	X
grubby sculpin	Myoxocephalus aenaeus																		
summer flounder	Paralichthys dentatus																		
Atlantic needlefish	Stongylura marina																		
Northern Pepefish	Syngnathus fuscus																		
hogchoker	Trinectes maculatus																		
REPTILES																			
loggerhead	Caretta caretta		X	X														X	
green turtle	Chelonia mydas																		
leatherback turtles	Dermochelys coriacea																		
Kemp's ridley sea turtle	Lepidochelys kempii		X	X		X					X			X	X	X	X	X	X

TABLE 4.10. Rare, Threatened, and Endangered Species Habitat Communities in the Jamaica Bay Watershed

Species		Habitat Requirements																	
Common Name	**Latin Name**	Bareground	Coastal Rock	Coastal sand	Coastal Shrub	Dune	Grassland	Landscape	Landscape Corridor	Shrubland	Freshwater	Woodland	Woodland Edge	High Salt Marsh	Low Salt Marsh	Low Salt Marsh Salt Panne	Marsh Intertidal Mudflat	Maritime Beach	Maritime Dune
diamondback terrapin	Maclemys t. terrapin					X								X	X	X	X	X	X
AMPHIBIANS																			
eastern spadefoot	Scaphiopus h. holbrookii				X	X	X			X		X	X						
MARINE MAMMALS																			
humpback whale	Megaptera novaeangliae																		
harbor seal	Phoca vitulina		X	X	X													X	X
sperm whale	Physeter catodon																		
bottlenose dolphin	Tursiops truncates																		
BUTTERFLIES																			
tawny emperor	Asterocampa clyton									X		X	X						
Appalachian azure	Celastrina neglectamajor																		
TREES																			
Virgina pine	Pinus virginiana		X				X		X				X						
willow oak	Quercus phellos										X		X						
SHRUBS																			
Houghton's umbrella-sedge	Cyperus houghtonii		X	X														X	X
Schweinitz's flatsedge	Cyperus schweinitzii										X			X	X	X	X	X	X
HERBACEOOUS																			
field-dodder	Cuscuta pentagonia						X				X	X	X	X	X	X	X	X	X
smartweed dodder	Cuscuta polygonorum						X												
seabeach knotweed	Polygonum glaucum			X		X												X	X
silverweed	Potentilla anserina ssp. pacifica													X	X	X	X	X	X
heart-winged sorrell	Rumex hastatulus																		
WILDFLOWERS																			
smooth bur-marigold	Bidens laevis													X	X	X	X	X	X
seabeach knotweed	Polygonum glaucum																	X	
heart-winged sorrell	Rumex hastatulus						X												

EVALUATION OF MANAGEMENT STRATEGY

Environmental

The identification and potential locations of RTE species allows restoration projects to integrate these species in the design phase, establish realistic restoration targets, and may help in establishing prioritization criteria in moving forward with restoration projects in the Bay. The restoration of RTE habitats will also aid in their long term recovery, improve wildlife habitat features and increase ecological diversity.

Technical

As with all ecological restoration projects, it is important to use those RTE plants that are suitable for the current environmental conditions of the site. Some physical alterations can be made, but if too much of the original system has been lost and appropriate environmental conditions can not be readily duplicated, the restoration of some species may not be practical. In addition, careful attention to the genetic origin of the plant material is critical in maintaining the ecological integrity of the restoration. Establishing criteria limiting the provenance of the source material is an important factor. Provenance restrictions are required on all NYCDEP restoration projects.

In areas where the potential for RTE species exists, the installation of non local provenance species should generally not be planted; importing species from elsewhere could potentially lead to damaging alteration of the gene pool of the remaining population (USFWS, 2004). Therefore, to the greatest extent possible the propagation of existing plant populations (seed preferred) of RTE species is desired and the limiting of provenance distance when existing populations are not sufficient for propagation purposes.

Cost

While there is not expected to be any additional cost to a restoration project to specify the use of RTE species, additional coordination of the design schedule to accommodate the propagation source and growing the material may be necessary.

Legal

Permits from relevant regulatory agencies may be required for the collection of seed and/or propagation of certain RTE species. In addition, the installation of these species may require special permission or notification of relevant government agencies.

RECOMMENDATION

It is recommended that government agencies and environmental stakeholders actively involved in restoration projects recognize the potential for RTE species for use in their projects. NYCDEP strongly supports and encourages the prioritization of restoration and conservation projects that incorporate RTE habitat criteria into their designs.

IMPLEMENTATION STRATEGY

Determine RTE Restoration Priorities and Targets

Ecological assessments of Jamaica Bay should continue to refine the Jamaica Bay habitat potential to provide an accurate identification of where current RTE critical habitat areas exist. In coordination and consultation with multiple agencies and other relevant stakeholder groups, determine realistic RTE restoration priorities and targets (*e.g.,* which species populations are the most desirable and practical to restore).

Cost: Costs have not been developed but are considered to be minimal and inclusive of existing site assessment and restoration efforts.

Schedule: In coordination with multiple agencies, by October 2008 establish the priority species that should be targeted for restoration and develop potential restoration locations.

REFERENCES

Falt, D., and P. Sabalis. 2005. Gerritsen Creek – Creating a Sustainable Environment in the Port of New York and New Jersey. Land and Water.

Nagy, C. 2005. Harbor Herons Monitoring Program. New York City Audubon Society. New York, NY.

National Park Service (NPS). 1979. General Management Plan for Gateway National Recreation Area. New York, NY.

National Park Service (NPS). 2002. Proceedings "Jamaica Bay's Disappearing Marshes – Highlighting ongoing research, local and international perspectives and future restoration plans." Scientific Symposium and Public Forum. March 3, 2004. New York, NY.

NY/NJ Harbor Estuary Program (HEP). 2001. NY/NJ Harbor Estuary Program Habitat Workgroup 2001 Status Report. New York, NY.

National Park Service (NPS). 2004. The National Park Service's Big Egg Marsh Experimental Restoration Project, Gateway National Recreation Area, NY: Progress Report, May 2004. New York, NY.

New York City Department of Environmental Protection (NYCDEP). 1994. Jamaica Bay Draft Comprehensive Management Plan. New York, NY.

New York City OASIS (OASISNYC.net.) 2006. http://www.oasisnyc.net/OASISmap.asp. New York, NY.

New York City Department of Parks and Recreation (NYCDPR). 2006. http://www.nyc.govparks.org/ sub_about/parks_divisions/nrg/foreverwild/site.php

New York State Department of Environmental Conservation (NYSDEC). 1993. Restoration of Natural Resources through the Jamaica Bay Damages Account: Reconnaissance Phase Report. Albany, NY.

New York State Department of Environmental Conservation (NYSDEC). 2006. New York State Open Space Conservation Plan. Prepared by the New York State Department of Environmental Conservation, The Department of State, and the Office of Parks, Recreation and Historic Preservation, Albany, NY.

Niedowski, N. 2000. New York State Salt Marsh Restoration and Monitoring Guidelines. Prepared for the New York State Department of State, Div. of Coastal Resources and the New York State Department of Environmental Conservation. Albany, NY.

Regional Planning Association (RPA). 2003. Needs and Opportunities for Environmental Restoration in the Hudson-Raritan Estuary – A Report Prepared for the US Army Corps of Engineers – Based on

Recommendations of the Harbor Estuary Program Habitat Working Group and Estuary Stakeholders. USACE, New York, NY.

Trust for Public Land and the New York City Audubon Society. 1987. Buffer the Bay: a survey of Jamaica Bay's unprotected open shoreline and uplands. The Trust for Public Land, New York, N.Y. 34 pp.

Trust for Public Land (TPL). 1992. Buffer the Bay revisited – An Updated Report on Jamaica Bay's Open Shoreline and Uplands. TPL, New York, NY.

US Army Corps of Engineers (USACE). 1997. Jamaica Bay Navigation Channels and Shoreline Environmental Surveys – Final Report. USACE, NY District, New York, NY.

US Army Corps of Engineers (USACE). 2001 Beneficial Uses of Dredged Material for Habitat Creation, Enhancement, and Restoration in New York-New Jersey Harbor. USACE, NY District. New York, NY.

US Army Corps of Engineers (USACE). 2002 Jamaica Bay Ecosystem Restoration Project: Existing Conditions, Future Without Project Conditions, Goals and Objectives Report, USACE, NY District, New York, NY.

US Army Corps of Engineers (USACE). 2002. JBERRT-Jamaica Bay Ecosystem Research and Restoration Team. Final Report. Tanacredi, John T., Martin P. Schreibman, and George W. Frame, eds. Staten Island, New York: National Park Service Division of Natural Resources.

United States Army Corps of Engineers (USACE). 2005. "Draft Integrated Ecosystem Restoration Report and Environmental Assessment for Jamaica Bay Marsh Islands, Jamaica Bay, New York." USACE, NY District USACE, New York, NY.

United States Fish and Wildlife Service (USFWS) 1981. National Wetland Inventory Maps. Washington, D.C.

Management Strategy 2b5: Expand litter removal and reduction programs including beach clean-ups and request that DPR and NPS maintain trash receptacles on beaches and parks through the end of October.

STRATEGY DESCRIPTION

Source: Don Riepe (American Littoral Society)

The shorelines of Jamaica Bay and the beaches of Rockaway and Coney Island attract millions of visitors every year to take advantage of the cool waters, breathtaking views and the unique assemblages of the varied ecosystems. Unfortunately, the great use of these natural resources also comes with a price, the litter and debris that are generated by public use. To address this issue, the NYCDPR and the NPS maintain the trash receptacles at these areas during the traditional summer beach use, from Memorial Day through Labor Day. However, while the weather beyond Labor Day is suitable for recreational use of these areas, the regular trash collection for these areas ends on Labor Day. With limited options for disposing of the waste, litter can be deposited along shorelines through wind and/or tides. Upland litter within the watershed has been identified as a primary source of floatable debris via discharge through CSO and storm drain outfalls. In this situation, the primary mechanism of floatables and debris entering the waterbodies and depositing along the shorelines is the through the direct discharge from these open recreational areas.

Source: Don Riepe (American Littoral Society)

To begin to address this issue and determine the extent of the debris along the shorelines, NYCDEP, in coordination with the American Littoral Society, has initiated a global positioning system (GPS) mapping effort of the debris piles around the perimeter of the Bay. In addition to the aesthetic issues, it has been asserted that these piles may be partly responsible for the suppression of the natural succession in some locations along the shoreline. With each tide cycle or storm event, the debris movement along the shoreline inhibits the growth of wetland and adjacent upland plants. It is also possible that the historic "rotating" debris piles from dilapidated piers and other near shore neglected structures (*e.g.*, floating docks) deposited years ago may also serve as the source for much of the debris that is reintroduced into the Bay by each spring and storm tide. Once the areas of debris along the shoreline of Jamaica Bay are inventoried and mapped, then a "master plan" can be developed that begins to prioritize the removal of these piles of debris.

Source: Jeanne Dupont (Rockaway Waterfront Alliance)

To help expedite this process and begin to tackle this large geographic issue within the Jamaica Bay, over the last 15-months NYCDEP has assisted in several beach clean-ups with several environmental groups, including the American Littoral Society and the Rockaway Waterfront Alliance and will continue to expand upon these efforts in the future. Hundreds of volunteers and thousands of hours of time have been devoted to cleaning up the shoreline areas of Plumb Beach and along the beaches of Far Rockaway. These volunteer efforts have removed over 300-cubic

Source: Jeanne Dupont (Rockaway Waterfront Alliance) yards of debris from the shoreline, have prevented their re-entry into the waterways, and have allowed adjacent areas to naturally regenerate. They have also raised the awareness of the issues surrounding the damage that can be caused to the marine environment by floatables and other debris.

In addition to the debris removal, these volunteer efforts have also planted over 4,000 indigenous trees, shrubs, native grasses and wildflowers. The addition of these plantings will help to stabilize these areas, improve the ecological diversity of plant species and help in the future recruitment of additional coastal species. While the main focus of these efforts is to help to restore and improve the ecology and species diversity with Jamaica Bay, these volunteer efforts also begin to open up these areas for passive recreational use and enjoyment. A sense of stewardship is instilled in those who help out and this fosters further protection of these areas.

Community volunteer groups and other non-governmental organizations can play a large role in cleaning up and preventing litter and other debris along shorelines and in upland areas. NYCDEP, with continued support and collaboration with non-governmental partners, will continue these efforts to help reduce the presence of floatables and shoreline debris.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

As the weather typically remains warm for several weeks beyond Labor Day, these public areas continue to be used and generate waste. Trash can overflow and eventually spill out onto the adjacent ground surfaces, becoming a source of debris that can end up in Bay waters. Extending the maintenance schedule of these trash receptacles would help to reduce the amount of potential floatables during this time period.

FIGURE 4.11 Beach Clean Up Efforts. Source: NYCDEP.

The intent of the beach clean-ups and plantings is to help restore and improve degraded areas near the shoreline of the Bay that have a direct and immediate influence on the ecology of the Bay. The removal of the debris along the shoreline not only improves the aesthetic qualities of the Bay but also provides the opportunity to allow the natural colonization and stability of indigenous vegetation types that greatly improves the ecological health and diversity of the Bay.

Technical

Depending on the location of the clean up, the access to the site may be limited by water entry only. In other cases where land access is possible, the use of heavy equipment is prohibited due to wetland regulatory issues. To minimize disturbance, additional measures will likely add additional cost and time to the effort of removing shoreline debris.

Costs

See *Implementation Strategies* below for cost information.

Legal

For many of the beach clean up efforts and plantings, wetland permits may not be required. However, for those efforts that require the use of heavy equipment and/or access to the waters edge will require permits from NYSDEC and USACE. Also, depending on the location within the Jamaica Bay watershed, permits from NYCDPR and NPS may also be required.

RECOMMENDATION

A potential correctable source of floatable debris and litter is to extend the seasonal collection of trash receptacles in public parks and along near shore areas beyond the current collection end period of Labor Day.

IMPLEMENTATION STRATEGY

Continue Beach Clean Up Efforts

NYCDEP will work with NYCDPR to determine whether trash collection along the beaches and parks can be extended beyond Labor Day. In addition, NYCDEP will continue to work with local groups with future shoreline clean ups and restoration plantings. NYCDEP encourages participation from other agencies and organizations in these efforts. Figure 4.12 provides a list of some of the organizations within the watershed that can be contacted regarding volunteer opportunities to promote stewardship and environmental programs.

Schedule: NYCDEP will continue to *c*ollaborate with government agencies and environmental organizations in shoreline clean up and plant restoration efforts throughout Jamaica Bay and the watershed. No schedule has been established for the possible extension of litter collection along shoreline beaches and parks.

Cost: Shoreline Clean Ups and Restoration: Use of existing NYCDEP staff and resources is minimal, however, to expand the program additional resources from multiple agencies and organizations will be required.

Trash Receptacle Collection: approximately $125,000 for NYCDPR and $80,000 for NPS staff is required each year to maintain trash receptacles beyond Labor Day to October 31 along public beaches, parks and shoreline areas. Funding is not yet available.

Organizations Offering Volunteer Opportunities in the Jamaica Bay Watershed

American Littoral Society
- Beach Cleanups
- Wildlife Census

Contact: Don Riepe
Phone: 718-318-9344
Email: driepe@nyc.rr.com
http://www.alsnyc.org/

Jamaica Bay Eco Watchers
- Beach Cleanup
- Community Plantings
- Stewardship

Contact: Dan Mundy
Email: DMundy5032@aol.com
http://deepcreekyachtclub.com/WebPage/jamaicabayecowatchers.html

Eastern Queens Alliance
- Stewardship
- Advocacy

Contact: Barbara Brown
Phone: 866-372-4255
www.easternqueensalliance.org

Rockaway Waterfront Alliance
- Environmental Workshops
- Advocacy
- Shoreline Cleanup and Plantings

Contact: Jeanne DuPont
Phone: 718-327-5919
Email: rockaway@rwalliance.org

Bay Improvement Group
- Beach Cleanups
- Community Gardening

Contact: Steve Bardson
Phone: 212-750-5560
Email: whwsailboat@optonline.net
http://members.aol.com/baytmpgrp/

Friends of Gateway
- Beach Cleanups
- Community Planting

Contact: Dave Lutz
Phone: 212-228-3126
Email: dave.lutz@treebranch.com
http://www.treebranch.com/friends_of_gateway.htm

Jamaica Bay Watershed Alliance
- Litter Cleanups
- Tree Planting

Contact: Mike Steffens
Phone: 646-256-1941
Email: ecocreek@aol.com

Salt Marsh Nature Center Urban Park Rangers
- Community Cleanups
- Tree plantings

Contact: Kristy DiCarlo
Phone: 718-421-2021
http://www.saltmarshalliance.org/

New York City Department of Environmental Protection
- Beach cleanups
- Street cleanup (with coordination from New York City Department of Sanitation)

Contact: Ana Ma
Phone: 718-595-6686
Email: ama2@dep.nyc.gov
Website: http://www.nyc.gov/html/dep/

New York City Department of Parks and Recreation
- Tree Census
- Gardening

http://www.nycgovparks.org/

FIGURE 4.12 Organizations Offering Volunteer Opportunities in the Jamaica Bay Watershed; Source: NYCDEP.

Management Strategy 2b6: Reduce the extent of invasive vegetation to create wetlands and/or upland buffers and develop a GIS layer displaying the extent of invasive vegetation within the watershed.

STRATEGY DESCRIPTION

Many of the proposed restoration efforts occurring around the perimeter of the Bay have an important goal of removing invasive exotic vegetation. However, due to numerous past disturbances, including the degradation or removal of indigenous soils and replacement with anthropogenic soils, a number of exotic and invasive plant species have colonized wetlands and upland areas within Jamaica Bay and the watershed. The dominant invasive plant species along the periphery of the Bay is the common reed (*Phragmites australis*), which now occupies large areas of wetland and upland buffer areas. *Phragmites* monocultures provide limited wildlife benefit and out-compete most native species, resulting in reduced biodiversity and the loss and degradation of wildlife habitat function and value. The goal of improving biodiversity of Jamaica Bay requires the eradication and future control of these lower quality opportunistic vegetation types.

Existing Vegetation Analysis

The 2002 JBERRT Report includes a vegetation analysis at 12 study sites within Jamaica Bay, from the waters edge to several hundred meters inland. A draft vegetation analysis has also been prepared by the NPS that shows the limits and acreages of various plant community types along the perimeter of the Bay. In addition, NPS is developing a draft invasive species management plan that identifies target species and recommends control practices.

An inventory of invasive species in the Jamaica Bay watershed was compiled from numerous sources, including documents and databases from the New York State Invasive Species Task Force; NPS GNRA, Jamaica Bay Unit; and NYCDEP. The 2002 JBERRT Report provided resources for identifying selected invasive species, and restoration plans associated with those species. The Draft Invasive Plant Management Plan for the GNRA Jamaica Bay Unit developed by the NPS provides specific invasive species targets and control strategies for areas within the Park. Table 4.11 presents a list of invasive species that are known to occur in the watershed.

The inventory is focused on vegetation and does not identify aquatic or macro-invertebrate species. This stems from the lack of sound information regarding the presence of invasive species other than plants in the Jamaica Bay watershed. Additional research within Jamaica Bay is required to determine the presence of additional problematic species.

TABLE 4.11. Invasive Species Known to Occur in the Jamaica Bay Watershed

Species		Confirmed Location in Watershed														
Common Name	**Latin Name**	Floyd Bennett Field (Barren Island)	North-forty	Canarsie Pier	Plumb Beach	Bergen Beach	Fort Tilden	Breezy Point	Jacob Riis Park	North Garden	Dead Horse Bay	Fresh Creek	Willolake	Elder Point	Yellow Bar	**Jamaica Bay**
BIRDS																
house finch	Carpodacuas mexicanus															X
monk parakeet	Myiopsitta monachus															X
house sparrow	Passer domesticus															X
European starling	Sturnus vulgaris															X
Mute Swan	Cygnus olor													X	X	X
REPTILES																
red-eared slider	Trachemys scripta															X
MAMMALS																
feral dog	Canis familiaris															X
feral cat	Felis silvestris															X
house mouse	Mus musculus															X
Norway rat	Rattus norvegicus															X
black rat	Rattus rattus															X
TREES																
Norway maple	Acer pseudoplatanus															X
tree-of-heaven	Ailianthus altisima											X		X		X
SHRUBS																
autumn olive	Elzeagnus umbellata		X													X
European buckthorn	Rhamnus cathartica									X						X
VEGETATION-GRASS																
mugwort	Artemisia vulgaris											X				X
Curly grass	Carex kobomugli															X
spotted knapweed	Centaurea maculosa	X														X
mouse-eared chickweed	Cerastium fontanum															X
cypress spurge	Chamaesyche (Euphorbia) cyperasias															X
leafy spurge	Chamaesyche (Euphorbia) esula															X
lovegrass	Eragrostis sp.															X
purple loosestrife	Lythrum salicarai												X			X
Japanese stilt grass	Microstegium vimineum															X
Eurasian watermilfoil	Myriophyllum spicatum															X
common reed	Phragmites australis	X	X						X		X	X		X		X
Japanese knotweed	Polygonum cuspidatum	X														X
Mile-a-minute vine	Polygonum perfoliatum															X
cattail	Typha latifolia															X
EXOTIC VINES																
Japanese barberry	Berberis thunbergii															X
garlic mustard	Aliaria petiolata															X
multiflora rose	Rosa multiflora	X	X	X	X	X										X
porcelain berry	Ampelopsis breviligulata															X
VINES																
oriental bittersweet	Celastrus orbiculatus		X							X						X
Japanese honeysuckle	Lonicera japonica															X
wisteria	Wisteria sinensis															X
Poison Ivy	Toxicodendron radicans								X							X

Regionally, there are many invasive species that are likely to also occur in the Jamaica Bay watershed (Table 4.12).

The primary landowners of natural, open spaces in the Jamaica Bay watershed are the NPS and the NYCDPR. Additionally, NYCDOT and NYCDEP control significant areas of undeveloped lands in some part of the watershed. Finally, there are some private landholdings that are significant.

These open spaces are the areas that are susceptible to invasion by invasive species. Because there is such a wide distribution of land ownership, invasive species control responsibilities must be engaged individually by each land authority. The NPS is underway with an invasive species inventory and management plan within the GNRA Jamaica Bay Unit. NYCDPR has done some spot treatments for invasives species on some properties in Jamaica Bay, including Four Sparrows Marsh, but many NYCDPR properties still contain large stands of invasive vegetation, including: Brant Point, Dubos Point, Four Sparrows Marsh, Fresh Creek, and White Island.

The first step in invasive species control is understanding where invasive communities are located by performing an invasive species survey and an understanding of the biological and physical changes to a particular location that encourage these vegetation types (*e.g.*, anthropogenic soil changes). Once the invasive species have been identified and located, an invasive species management plan can be created to provide appropriate control measures for each area. Funding and implementing the plan requires a multi-year ongoing effort; invasive species control is difficult, and is best performed in conjunction with the restoration of native communities in the areas where invasive species control occurs, to prevent the recolonization of the area by other invasive communities. While this has occurred in some areas of the Bay, the extent of the invasive vegetation and the potential for the recolonization of other locations remains high.

TABLE 4.12. Invasive Species Know to Occur Regionally	
privet	Ligustrum vulgare
mimosa	Albizia julibrisin
catalpa	Catalpa bignonioides
Swallow-wort	Synanchum sp.
Chinese bush clover	Lespedeza cuneata
Scotch broom	Cytisus scoparius
Bell’s honeysuckle	Lonicera x bella
Morrow’s honeysuckle	Lonicera morrowii
ox-eye daisy, margarite	Leucanthemum vulgare
Tatarian honeysuckle	Lonicera tatarica
European fly honeysuckle	Lonicera xylostreum
white mulberry	Morus alba
Eurasian watermilfoil	Myriophyllum spicatum
reed canary grass	Phalaris arundinacea
Amur cork tree	Phellodendron amurense
Scotch pine	Pinus sylvestris
curly-leaf pondweed	Potamogeton crispus
common buckthorn	Rhamnus cathartica
black jetbead	Rhodotypos scandens
black locust	Robinia pseudoacacia

TABLE 4.12. Invasive Species Know to Occur Regionally	
eglantine; sweetbrier	Rosa eglanteria
red sorrel	Rumex acetosella
water chestnut	Trapa natans
siebold viburnum	Viburnum sieboldii
Chinese wisteria	Wisteria sinensis

The control of invasive species in the Jamaica Bay watershed will require each jurisdiction which manages natural open spaces in the watershed to perform an inventory and create an invasive species management plan.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Invasive species control increases the biodiversity and resilience of native communities, attracts desirable native wildlife and beneficial insect populations for greater pest management. The control of invasive species in the watershed and around Jamaica Bay is multiple agency effort and needs to coordinated and distributed among many partners, some of which are already engaging in these efforts.

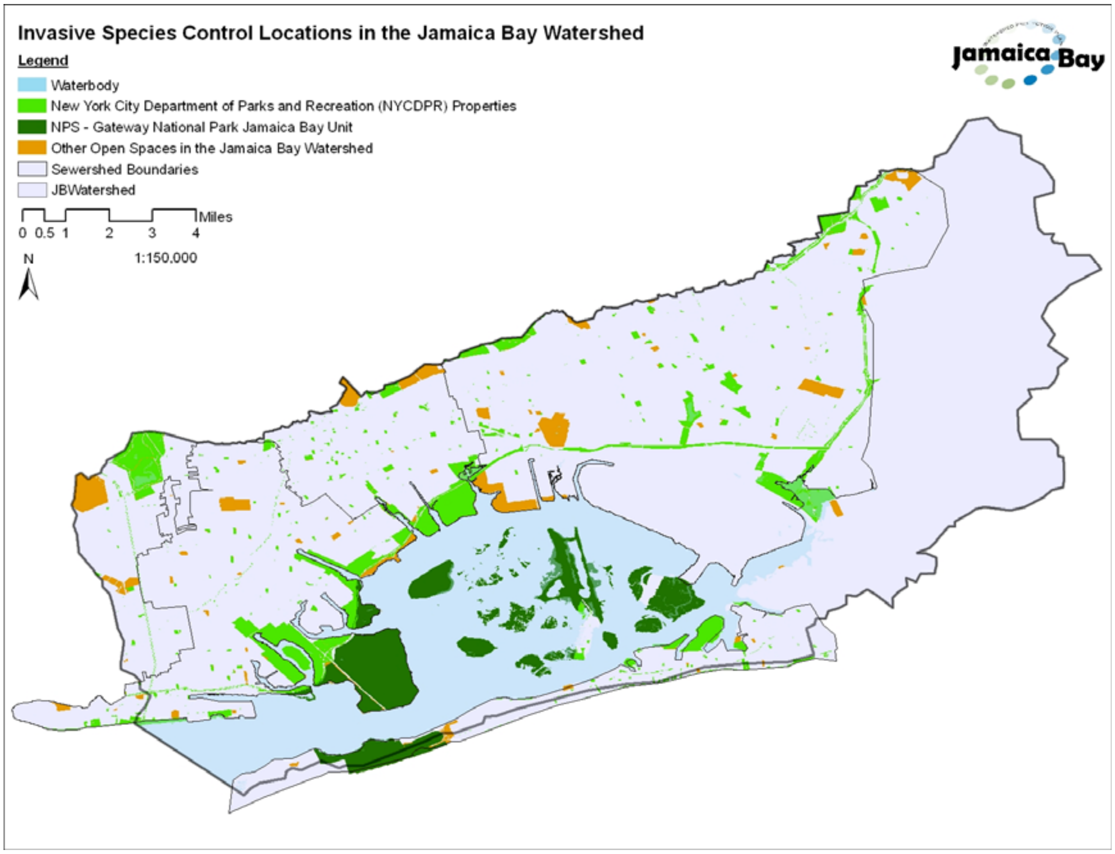


FIGURE 4.13 Open spaces in Jamaica Bay watershed – areas for invasive species control.
Source: NYCDEP

Technical

Invasive species control is expensive and laborious; it requires a dedicated effort and repeated application of control measures to be successful. Invasive species management efforts by a variety of land management entities will result in varied approach to invasives management, and may be applied more successfully in some location than in others. To avoid the duplication of non-effective treatment methods, the coordination of previous successful eradication methods is critical.

Legal

Depending on the location and control methods utilized, NYSDEC, USACE and USFWS permits and licenses (*i.e.*, certified herbicide applicator) may be required. Also, depending on the location within the Jamaica Bay watershed, permits from NYCDPR and NPS may also be required.

Cost

Cost: The cost for invasive species management is highly variable depending on the target species, level of infestation, amount of area infested, and diversity of environmental features. Costs per acre can range from $1,500 to $2,500 per acre for spray application only and does not include physical removal of invasive vegetation off-site or other restoration efforts.

RECOMMENDATION

NYCDEP in collaboration with multiple agencies and partners will initiate invasive species inventories on appropriate sensitive areas of the Jamaica Bay watershed, and subsequently formulate in partnership with other agencies and organizations an invasive species management plans for each area.

IMPLEMENTATION STRATEGY

NYCDEP will work with other government agencies and environmental organizations to promote the importance of invasive species management to the overall health and ecological function of the Jamaica Bay watershed Invasive species management plans that each land managing entity can implement will be developed in partnership with other agencies and organizations. Funding for invasive plant removal is not available.

Schedule: To be determined.

C H A P T E R   F I V E

CATEGORY 3, STORMWATER MANAGEMENT THROUGH SOUND LAND USE

INTRODUCTION AND ISSUES IDENTIFICATION

The vision of the *Jamaica Bay Watershed Protection Plan* describes the future watershed as an urban environment that harbors healthy estuarine and land-based habitats in which "*New Yorkers and visitors co-exist with natural areas and clean water*." The attainment of this vision is dependent upon the human uses and management of land within the watershed, which has a direct impact on the water quality of the Bay and the natural resources in and around the Bay. Sound, environmentally-sensitive land use initiatives, ranging from the modification of an individual's landscaping practices to comprehensive planning and management measures, will enable human populations in the Jamaica Bay watershed to live in a more environmentally sustainable manner, and can offset the added stressors of future population growth on the ecological integrity of the Bay.

The transport of pollutants from developed land to water starts with an increase in volume and rate of stormwater runoff from a watershed's impervious areas, which enters the combined sewer system and triggers CSO events when the wastewater treatment plants cannot handle the excess water. Much of the urban landscape is impervious including building rooftops, parking lots, and roads. Instead of infiltrating water to the ground, these hard surfaces direct stormwater into the nearest storm drain or combined sewer system. They are so efficient at moving water that the time for stormwater to arrive at any given point in the watershed is very short, translating into a large volume of runoff occurring in a short amount of time in the combined sewer or storm drain network. CSO events in New York City can occur during rainfall events as small as 0.05 to 0.1 inches per hour.

Stormwater BMPs effectively reduce stormwater runoff volumes entering the storm drain and combined sewer system, thereby reducing the pollutant load and the volume of water that discharges directly to Jamaica Bay through storm sewers, CSOs or the WPCPs during a rainfall event. Stormwater BMPs are designed to improve infiltration, retention, and detention of stormwater runoff. In addition, reducing the amount of impervious surface, increasing interception of rainfall, and promoting the development of pervious media (including landscaped areas) can help to reduce the impact of urban stormwater on water quality in Jamaica Bay. BMPs have the potential to reduce the volume of stormwater runoff that makes its way into the sewer system, thus reducing the quantity of pollutants that occur on the streets or sidewalks to be directed into the tributaries and the Bay. Furthermore, by reducing the volume of stormwater runoff, more sewage in the combined sewer system can be treated in the WPCPs.

In dense urban environments, controlling stormwater at the source before it enters the sewer system is appealing because end of pipe controls can be very expensive and land availability for off-site BMPs can be scarce. Control of stormwater runoff at the parcel level may under certain instances lead to some reduced public costs for larger, more expensive stormwater management facilities. These source controls are gaining wider acceptance and play a role in stormwater management in municipalities around the country including Portland, Chicago, Seattle, Philadelphia, and Washington, DC.

The passage of LL 71 requires the NYCDEP to create a *Jamaica Bay Watershed Protection Plan* to address the long-term ecological sustainability of the Jamaica Bay watershed. With respect to land use practices, the law requires NYCDEP to assess the feasibility of a variety of land use and development practices including, but not limited to, stormwater BMPs, the minimization of impervious surfaces and creation of natural systems to control and minimize stormwater runoff; incentives for environmentally beneficial development, and disincentives, such as stricter development guidelines, for development that may adversely impact Jamaica Bay.

The Mayor issued PLANYC 2030 to meet the challenges faced by the City and its anticipated one million new residents over the next three decades. PLANYC 2030 includes ten goals as drivers in the development of citywide sustainability initiatives; one of these goals is to open 90% of the City's waterbodies for recreation. In order to achieve this goal, the Mayor's Office is specifically considering strategies for implementing a comprehensive stormwater BMP approach using information and strategies generated as part NYCDEP's watershed protection planning process for Jamaica Bay and long-term control planning for CSOs citywide. According to PLANYC 2030:

> "We cannot rely solely on hard and centralized infrastructure upgrades to improve the quality of our waterways. In addition to working to capture more CSOs at the "end of the pipe," after it has already entered our system, we have also begun pursuing a range of proven strategies to keep stormwater from entering our combined system at all."
>
> "…a range of emerging strategies that enhance the ecological environment while naturally cleansing our waterways have begun to be tested and installed across the United States. Cities from Seattle to Chicago have begun integrating these softer solutions on a broad scale into their planning and development, with exceptional results. Within New York City, financial, informational, and institutional barriers have hindered our ability to experiment with these best practices. Our dense environment has also made spaces difficult to identify. But the opportunities are there."

These efforts are discussed below. In addition, the Mayor's Office has created an interagency task force for BMP implementation to bring together all the relevant City agencies to analyze ways to incorporate BMPs into the design and construction of both public and private development projects. NYCDEP has been working with the Mayor's Office to develop BMP strategies and pilot projects specific to New York City's urban environment.

This *Jamaica Bay Watershed Protection Plan* addresses two different types of stormwater BMPs:

- "on-site" source control, at individual development parcels such as a residential lot whereby runoff would be captured, attenuated, and/or infiltrated at the source (see Objective 3A below); and
- "off-site" control, which typically involves capturing runoff from streets and sidewalks. It also includes use of vacant lands or open space to capture stormwater from multiple parcels (usually at a neighborhood or community scale) and store it in a stormwater pond, underground detention tank, or other structure (see Objective 3B below).

The Objectives and Management Strategies discussed in this chapter identify measures and programs that would change the way people develop and use watershed land with the goal of restoring and preserving Jamaica Bay's unique ecological resources. To be successful, these strategies will require widespread participation from watershed residents and businesses. They will require people to change old habits. They will require coordination between multiple New York City regulatory agencies, as well as the engagement of those who directly affect land use and whose actions are inextricable from environmental effects — the citizens who live within the watershed. When the relationships between human actions and ecosystem effects are addressed in a holistic and coordinated way, we will begin to reverse the current trend of environmental degradation.

OBJECTIVE 3A: PROMOTE THE USE OF ON-SITE BEST MANAGEMENT PRACTICES IN NEW AND EXISTING DEVELOPMENT

Current Programs

The current Administrative Code and City practices are directed to controlling the flow of stormwater away from lots and into sewers with the primary purpose of controlling flooding and standing water and protecting against public health concerns associated with these conditions. While they have ancillary benefits for control of CSOs, they do not specifically require or promote the use of stormwater detention or retention BMPs with the goal of minimizing CSOs.

Currently, both NYCDEP and the Mayor's interagency BMP Task Force are evaluating potential strategies for expanding the use of stormwater BMPs to reduce stormwater runoff throughout New York City. PLANYC 2030, using information generated by NYCDEP, recommends a number of different pilot projects and incentive programs to evaluate the uncertainties associated with BMPs and to promote their use including new parking lot design standards and a green roof incentive program (see *Implementation Strategies* below).

Other recent "green initiatives" include passage of Local Law 86 which requires all new public construction to be designed and constructed to comply with green building standards to achieve a Leadership in Energy and Environmental Design (LEED) silver or higher rating and, in many cases, to use energy and water more efficiently than current codes mandate; LEED is a program of the U.S. Green Building Council. Sustainability concepts have been incorporated into the policies and projects of different city agencies through the formation of specific offices such as the Office of Sustainable Design (OSD), a branch of the NYCDDC, which has established green-building principles for New York City. Two documents released by OSD, *High Performance Building Guidelines* (1999) and *High Performance Infrastructure Guidelines* (2005) introduce sustainable design guidance for New York City buildings. HPD and the New York City School Construction Authority (SCA) are also incorporating green design into their design guidelines. For recent projects, HPD has been adding a sustainability requirements checklist. The checklists have 30 prerequisites that are required for new construction projects, dependent on the size of the project, and 11 optional credits. The below list highlights the required and optional credits related to wastewater and stormwater:

- *Required:* Choosing an environmentally aware site plan that maximizes permeable space would offer an indirect benefit; required water conservation.

- *Optional:* On-site stormwater capture, use retained rainwater for irrigation and non-potable uses, increased permeable surfaces and water containment features, install an extensive green roof; additional water conservation.

SCA has created a NYC Green Schools Guide (SCA 2007) that adapts the LEED credit system to New York City Schools per Local Law 86. The list below highlights the required and optional credits related to wastewater and stormwater:

- *Required non-point credit:* Develop an Erosion and Sedimentation Control Plan for all projects that will include earth disturbance activities (*i.e*., excavation, trenching, etc).

- *Required with credit:* Avoid using undeveloped lands within 50 feet of a water body, 100 feet of wetlands and any land that was previously parkland; Promote biodiversity through conserving natural areas and restoring damaged areas; Maintain a high percentage of open space that is vegetated with adapted or native plants; Reduce or eliminate water pollution by reducing impervious cover, increasing on-site infiltration, eliminating contaminants and suspended solids from stormwater runoff.

- *Additional credit option with SCA approval:* Install a vegetated roof on at least 50% of the roof surface; Limit disruption of the site's natural hydrology by reducing impervious cover through either equalizing post-development stormwater volume and discharge rate to pre-development rates or by decreasing runoff volume by 25%.

- *Water Conservation:* three requirements for one credit each to conserve water.

In addition to these guidelines, the adoption of the *New York State Stormwater Management Design Manual* (CWP, 2003) marked a significant step in facilitating the design and implementation of stormwater BMPs.

NYCDEP is embarking on a new water conservation program to achieve a five percent reduction in water demand over a five year period. Such a program has the potential to free up capacity at the wastewater treatment plants to treat additional wet weather flow.

Three management strategies to reduce stormwater discharges and address them at the individual lot level are discussed below:

- Promote low impact development and BMPs for new and existing development (Strategy 3a1).
- Reduce the imperviousness of new and existing development (Strategy 3a2).
- Expand water conservation program to achieve a greater reduction in water use (Strategy 3a3).

Management Strategy 3a1: Promote low impact development and Best Management for new and existing development (residential and non-residential).

STRATEGY DESCRIPTION

On-site stormwater BMPs at the parcel or lot level can provide significant stormwater runoff volume and pollutant load reduction benefits for a wide range of land uses. BMPs control runoff at the source, intercepting, infiltrating, and/or storing runoff before it enters the combined or separate sewer system.

Treating stormwater on-site involves the integration of detention or retention measures onto a discrete parcel (Table 5.1). Typical detention measures include underground detention tanks or rooftop detention to detain certain storm intensities. Retention measures include a wide range of low impact development techniques, many of which infiltrate stormwater into the soils.

TABLE 5.1. Examples of Stormwater BMPs	
LOW DENSITY RESIDENTIAL	
Infiltration/Retention	**Detention**
Bioinfiltration Practices (Rain Gardens and Swales)	Rain Barrels/Cisterns
Porous Paving	
Trees	
Driveway Infiltration	
Rain Planters	
Infiltration Basin	
MEDIUM TO HIGH DENSITY RESIDENTIAL/COMMERCIAL/INDUSTRIAL	
Infiltration/Retention	**Detention**
Bioinfiltration Practices (Rain Gardens and Swales)	Rain Barrels/Cisterns
Porous Paving	Green Roofs
Trees	Rooftop Detention
Parking Lot Infiltration Islands	Subsurface Detention
Rain Planters	
Sand/Peat Filter	

Source: Milwaukee Metropolitan Sewer District

Low density residential developments, especially those that include some vegetation, can incorporate a wide range of BMPs including downspout disconnection, rain barrels, rain gardens, rain planters, bioinfiltration practices, and cisterns.

Stormwater BMPs can also be sited on high density residential, commercial, manufacturing, and industrial developments. These uses generally have little vegetation and often contain large rooftops. Under the existing Sewer Code, these developments are typically required to provide subsurface detention or rooftop detention when there is not adequate capacity in the sewer system.

Green roofs are another option for these high density urban land uses. A green roof can either be a tended roof garden that adds open space or a more low-maintenance rooftop feature. In addition to providing stormwater management benefits, a green roof reduces the urban heat island effect caused by a concentration of dark impervious rooftops and other hard surfaces and can provide carbon sequestration to mitigate greenhouse gases.

Rooftop Detention

Rooftop detention, also known as *Blue Roofs*, is a promising BMP for a densely developed urban landscape filled with flat roofs. By using already available rooftop area, smaller storms that cause CSOs can be detained at the source and more slowly released to the sewer system reducing peak surges, thus allowing more of the flows to be directed to the WPCP for treatment. Collars – as shown in the picture to the lower left – capture the smaller storms by detaining flow of about 1.5 inches. Rooftop detention, an acceptable option for controlling flows under the Sewer Code (the other being subsurface detention), is used on a number of developments in New York City, particularly where land is scarce. Subsurface detention cannot be designed to accommodate the smaller storms addressed by rooftop detention.

Not only is rooftop detention less expensive than subsurface detention, but it also is much less expensive, and likely just as effective in reducing CSOs, as green roofs. They also have fewer load bearing issues than green roofs. While effective at reducing CSOs, they have limited applicability in areas that discharge to storm sewers. They may also be somewhat useful in reducing localized flooding.

Despite its significantly lower costs, rooftop detention is only being implemented on a small number of developments. One reason is that developers may not be aware that it is an option until later in the process when their designs, including subsurface detention, are well underway. Another reason is that there are concerns that rooftop detention will result in leaks. However, rooftop detention has been successfully used in New York City and is expected to be used more frequently, especially in high density areas where use of subsurface detention is limited due to lack of available land. If designed properly, rooftop detention can be very reliable.

To make a real impact on CSOs, measures to incorporate into existing development should be investigated. Existing development would need to be evaluated to determine the structural integrity of buildings and may require some structural support and resurfacing to prevent leakage. Roofs are built to support snow pack, and therefore load bearing may not be a significant issue. NYCDEP will work to develop opportunities to promote the use of rooftop detention more widely as discussed below.

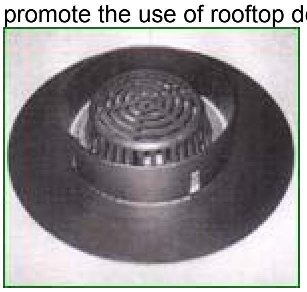


FIGURE 5.1 Rooftop Detection Collar; Source: Milwaukee Sewer District

In addition to the building footprint, parking lots found on many of these high density land uses are also a major source of stormwater runoff due to their large impervious areas. NYCDEP worked with New York City Department of City Planning (NYCDCP) to incorporate BMPs into proposed new parking lot design standards in the Zoning Resolution for commercial and community facility developments. The new standards would not only address aesthetic issues of vast expanses of pavement, but also increase permeability to mitigate stormwater runoff and increase tree canopy to reduce the heat island effect. The standards include adding street trees and perimeter and interior landscaping combined with BMPs that would provide infiltration to the soils.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Approach

Analyses were performed to estimate the stormwater runoff and CSO reductions associated with various stormwater BMPs applied to residential, commercial and manufacturing development. Six land use prototypes were identified to develop potential BMP conceptual site plans for what might be achievable on individual parcels:

- low density residential,
- medium density residential/commercial,
- high density residential/commercial,
- big box commercial and industrial (small)
- big box commercial and industrial (large)
- schools and other institutional uses

Attractive examples of residential BMPs including a rain garden on left and porous paver blocks on right. Source: Amy S. Greene Environmental Consultants

Land use prototypes were based on NYCDCP's Zoning Handbook, including specific zoning regulations (*e.g.*, lot area, floor area ratio (FAR), open space ratio, etc.) for the prevalent zoning district represented by each prototype.

For each prototype, BMP applications were developed to address existing development and new development. For existing development, "low capture," "medium capture," and "high capture" measures were developed, while for new development, "medium capture," and "high capture" measures were developed. Note that for new development, green roofs appear in both medium and high capture scenarios. The high capture scenario represents a more intensive green roof design for several of the prototypes.

FIGURE 5.2. High Capture for Existing Development: Single Family Residential Prototype w/Tree & Bioinfiltration, 120 sf. Source: Biohabitats, Inc.

The BMP applications provide a range of stormwater benefits as shown for each prototype on Table 5.2. As reflected in the capture rates, it is expected that it would be easier to install BMPs on new development and more difficult to retrofit existing development.

TABLE 5.2. Stormwater Capture Benefits By Land Use Prototype					
	Existing Development			New Development	
	Low Capture	Medium Capture	High Capture	Medium Capture	High Capture
LOW DENSITY RESIDENTIAL					
3,500 Square feet					
Zoning: R1					
Example BMPs	Rain barrels (4-55 gal), downspout disconnection	Porous paving (300 sf)	NA	NA	Infiltration basin (1140 gal) + porous paving (750 sf)
	Rain planter (60 sf)	Infiltration basin (450 gal)	NA	NA	Cistern (448 gal) + infiltration basin (510 gal) + porous pavement (750sf)
BMP Capture Volume (gal)	224	449	NA	NA	2304
Average rainfall event 0.4 inches	30%	60%	NA	NA	100%
90%ile rainfall 1.2 inches	10%	20%	NA	NA	100%
100%ile rainfall 2.5 inches	5%	10%	NA	NA	50%
MEDIUM DENSITY RESIDENTIAL/COMMERCIAL					
2,178 Square feet					
Zoning: R5, 6, 7, c1, 2, 4, 6					
Example BMPs	Rain barrels (4-55 gal), downspout disconnection	Plumbing retrofit, rain barrels (6-55 gal) or equiv cistern	Green roof (3 in. soil, 2178 sf)	Green roof (3 in. soil, 2178 sf)	Green roof (3 in. soil, 2178 sf)
	Rain planter (45 sf)	Infiltration basin (340 gal)	Rooftop Detention	Rooftop Detention	
BMP Capture Volume (gal)	170	340	1698	1698	1698
Average rainfall event 0.4 inches	31%	63%	100%	100%	100%
90%ile rainfall 1.2 inches	10%	21%	100%	100%	100%
100%ile rainfall 2.5 inches	5%	10%	50%	50%	50%
HIGH DENSITY RESIDENTIAL/COMMERCIAL					
17,000 Square feet					
Zoning: R8, 9, 10, C1, 2, 4, 5, 6					
Example BMPs	NA*	NA	Green Roof (3"' soil, 17000 sf)	Green Roof (3" soil, 17000 sf)	Green Roof (3"' soil, 17000 sf)
	NA	NA	Rooftop Detention	Rooftop Detention	
BMP Capture Volume (gal)	NA	NA	13246	13246	13246
Average rainfall event 0.4 inches	NA	NA	100%	100%	100%
90%ile rainfall 1.2 inches	NA	NA	100%	100%	100%
100%ile rainfall 2.5 inches	NA	NA	50%	50%	50%

TABLE 5.2. Stormwater Capture Benefits By Land Use Prototype					
	Existing Development			New Development	
	Low Capture	Medium Capture	High Capture	Medium Capture	High Capture
INDUSTRIAL AND BIG BOX COMMERCIAL (SMALL)					
0.5 Acres					
Zoning: M1					
	Bioinfiltration/trees	Bioinfiltration/trees	Green roof	Green roof	
	(390 sf)	(780 sf)	(3" soil, 12795 sf)	(3" soil, 12795 sf)	
Example BMPs*	Porous paving (1150 sf)	Porous paving (2300 sf)	Rooftop Detention	Rooftop Detention	Green roof 3" soil, 12,795 sf) + bioinfiltration/trees (1,560 sf)
BMP Capture Volume (gal)	1698	3396	9969	9969	16980
Average rainfall event 0.4 inches	31%	63%	100%	100%	100%
90%ile rainfall 1.2 inches	10%	21%	60%	60%	100%
100%ile rainfall 2.5 inches	5%	10%	29%	29%	50%
INDUSTRIAL AND BIG BOX COMMERCIAL (LARGE)					
1 Acre					
Zoning: M2, 3, C4					
	Bioinfiltration/trees	Bioinfiltration/trees	Green roof	Green roof	
	(780 sf)	(1560 sf)	(3" soil, 18150 sf)	(3" soil, 18150 sf)	
Example BMPs*	Porous paving (12300 sf)	Porous paving (4600 sf)	Rooftop Detention	Rooftop Detention	Green roof 3.1" soil, 18150 sf) +, bioinfiltration/trees (4440 sf)
BMP Capture Volume (gal)	3396	6792	14142	14142	33959
Average rainfall event 0.4 inches	31%	63%	100%	100%	100%
90%ile rainfall 1.2 inches	10%	21%	43%	43%	100%
100%ile rainfall 2.5 inches	5%	10%	21%	21%	50%
PUBLIC FACILITIES, SCHOOLS AND INSTITUTIONAL USES					
1.5 Acres					
Zoning: NA					
	Bioinfiltration/trees (1170 sf)	Bioinfiltration/trees	Green roof	Green roof	
		(2340 sf)	(3.1" soil, 19900 sf)	(3.1" soil, 19900 sf)	
Example BMPs*	Porous paving (3400 sf)	Porous paving (6800 sf)	Rooftop Detention	Rooftop Detention	Green roof +, bioinfiltration/trees (7906 sf)
BMP Capture Volume (gal)	9500	18999	15505	15505	47498
Average rainfall event 0.4 inches	31%	62%	95%	95%	100%
90%ile rainfall 1.2 inches	10%	21%	32%	32%	100%
100%ile rainfall 2.5 inches	5%	10%	15%	15%	50%
* "NA" = It was assumed that physical space is limited for several of the land use prototypes.					

Once it was determined what was achievable on an individual parcel, these benefits were evaluated on a watershed scale. A ten-year snapshot (2000-2010) of BMP implementation was developed to estimate the effects on CSO reductions if development that occurred or will occur during this period had installed BMPs. This ten-year snapshot could be carried into future years to estimate additional benefits with new development over time.

To develop the ten-year snapshot of the watershed, the following assumptions were made:

- Existing development: For the low and medium capture scenarios, it was assumed that 1% per year of existing development would install BMPs for a total of 10% over the ten year period. For the high capture scenario, it was assumed that large rooftops over 5,000 square feet would install BMPs.

- New Development: It was assumed that both new development and major alterations of existing development would install BMPs. All development that occurred in the watershed between 2000 and 2007 and all that is projected to occur through 2010 was estimated using the following sources of information (Figure 5.3):

  - New York City Department of Buildings (NYCDOB): new and major reconstruction permits (2000-2010)
  - NYCDCP: projected redevelopment sites - ten year period
  - Economic Development Corporation: recent and proposed development projects
  - HPD recent and proposed housing projects
  - SCA: recent and proposed school projects.

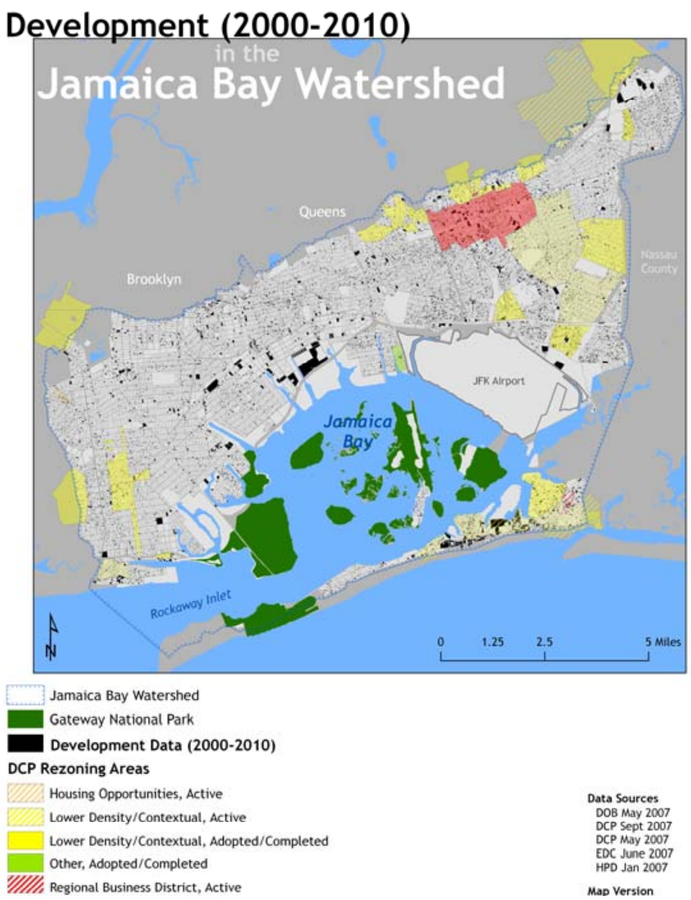


Figure 5.3 Development data used to model BMP penetration in the Jamaica Bay watershed; Source: NYCDEP

The total amount of runoff that could be captured through implementation of these BMPs throughout the watershed was calculated for each of the application scenarios, (existing low, medium, and high capture; and new medium and high capture) and the accumulated annual reduction of discharges to the Bay including CSOs, storm sewer discharges and direct runoff was modeled using the INFOWORKS model for each WPCP drainage area. Precipitation data were used for the year 1988, which represents a typical year.

The results were compared to baseline conditions which included 2020 dry weather flows (*i.e.*, 55 MGD at 26th Ward WPCP, 82 MGD at Jamaica WPCP, 21 MGD at Rockaway WPCP, and 90 MGD at Coney Island WPCP), and specific CSO-related infrastructure projects in progress or recently completed (*i.e.*, Paerdegat Basin storage tank, sewer cleaning within 26th Ward WPCP drainage area, and the Spring Creek AWPCP Upgrade).

As discussed above, for low and medium capture scenarios for existing development, it was assumed that 1% per year of existing development would install BMPs for a total of 10% over the ten year period. For the high capture scenario for existing development, it was assumed that large rooftops over 5,000 square feet would install BMPs including rooftop detention or green roofs. It was determined that within the watershed large roofs (over 5,000 square feet) account for 2.5% of the buildings, but 29% of the roof area, for a total of 109 million square feet of rooftop area. (See also *Existing Development* section under *Technical* below for more information on targeting large rooftops.)

Lastly, a separate analysis was performed to measure the effects of the proposed Zoning Resolution parking lot standards. The parking design regulations are expected to achieve the following benefits for different rainfall events:

- Average from a 2.5 inch rainfall (typically largest event in a year): 47% capture
- Average from a 1.2 inch rainfall (90th percentile event): 76% capture
- Average from a 0.4 inch rainfall (average event): 100% capture.

RESULTS

Results of the modeling for the ten-year period for new and existing development are shown on Table 5.3. The results are summarized to include reductions due to BMPs of untreated discharges to the Bay including CSOs, storm sewer, and direct runoff discharge volumes. The results also include reductions in treated overflows from Paerdegat CSO facility (for Coney Island WPCP drainage area) and Spring Creek AWPCP (for 26th Ward WPCP and Jamaica WPCP drainage areas).

TABLE 5.3. Stormwater Capture Benefits Of On-Site BMPs By Drainage Area						
Condition	**Baseline Conditions**	**Existing Development Low Capture BMPs**	**Existing Development Medium Capture BMPs**	**Existing Development High Capture BMPs (Large Roofs)**	**New Development Medium Capture BMPs**	**New Development High Capture BMPs**
Coney Island WPCP Drainage Area						
Portion of Drainage Area Impacted (%)	N.A.	3.4%	3.4%	5.4%	2.2%	3.8%
Total BMP Storage Volume (MG)	N.A.	2.5	5.1	22.1	9.2	14.9
Total CSO, treated CSO, storm sewer, and Direct (surface) Discharge (MG)	455.5	449.3	441.0	341.5	414.3	409.3
Reduction with BMPs (MG/yr)	0.0	6.2	14.5	114.0	41.2	46.2
Reduction with BMPs (%)		1.4%	3.2%	25.0%	9.0%	10.2%
26th Ward WPCP Drainage Area						
Portion of Drainage Area Impacted (%)	N.A.	5.4%	5.4%	9.3%	6.5%	7.7%
Total BMP Storage Volume (MG)	N.A.	1.4	2.8	19.1	13.5	15.7
Total CSO, treated CSO, storm sewer, and Direct (surface) Discharge (MG)	822.4	798.8	771.3	587.3	652.5	648.9
Reduction with BMPs (MG/yr)	0.0	23.7	51.1	235.1	169.9	173.5
Reduction with BMPs (%)		2.9%	6.2%	28.6%	20.7%	21.1%
Jamaica WPCP Drainage Area						
Portion of Drainage Area Impacted (%)	N.A.	4.1%	4.1%	4.4%	1.8%	5.7%
Total BMP Storage Volume (MG)	N.A.	5.8	11.6	39.2	15.8	46.7
Total CSO, treated CSO, storm sewer, and Direct (surface) Discharge (MG)	11,947.3	11,661.1	11,350.5	11,179.5	11,605.7	10,487.9
Reduction with BMPs (MG/yr)	0.0	286.2	596.8	767.8	341.6	1459.5
Reduction with BMPs (%)		2.4%	5.0%	6.4%	2.9%	12.2%
Rockaway WPCP Drainage Area						
Portion of Drainage Area Impacted (%)	N.A.	5.0%	5.0%	2.6%	4.0%	15.0%
Total BMP Storage Volume (MG)	N.A.	1.4	2.8	4.9	7.6	25.4
Total storm sewer and Direct (surface) Discharge (MG)	2,605.6	2,478.6	2,367.1	2,474.7	2,412.6	1,848.3
Reduction with BMPs (MG/yr)	0.0	127.0	238.5	130.9	193.0	757.3
Reduction with BMPs (%)		4.9%	9.2%	5.0%	7.4%	29.1%
Jamaica Bay Watershed Totals						
Portion of Drainage Area Impacted (%)	N.A.	4.2%	4.2%	5.0%	2.7%	6.5%
Total BMP Storage Volume (MG)	N.A.	11.1	22.3	85.3	46.1	102.7
Total CSO, treated CSO, storm sewer, and Direct (surface) Discharge (MG)	15,479.8	15,040.5	14,590.8	14,253.2	15,085.1	13,075.7
Reduction with BMPs (MG/yr) (of Untreated Discharges)	0.0	439.3	888.9	1,226.6	745.8	2,404.1
Reduction with BMPs (%) (of Untreated Discharges)		2.8%	5.7%	7.9%	4.8%	15.5%

Key findings are:

- Across the watershed, implementation of BMPs on new development would reduce *untreated discharges to the Bay* including CSO, partially treated CSO, storm sewer, and direct runoff volumes by 4.8% (medium capture) to 15.5% (high capture).
- Installing BMPs on 10% of existing development would reduce *untreated discharges to the Bay* including CSO, partially treated CSO, storm sewer, and direct runoff volumes by 2.8% (low capture) to 5.7% (medium capture).
- Installing BMPs on existing large rooftops would reduce *untreated discharges to the Bay* including CSO, partially treated CSO, storm sewer, and direct runoff volumes by 8% (high capture).
- Pollutant load reductions are comparable to volume reductions. For example, a high capture/new development BMP scenario could achieve a 15% reduction in *untreated discharge* volumes and a similar percent reduction in total nitrogen, BOD, fecal coliforms and toxins. A low capture BMP scenario for existing development could achieve a 6% reduction in volume and a similar pollutant load reduction.

The results provided above are presented as reductions with BMPs of *untreated discharges to the Bay.* Stormwater runoff from a site can travel many different pathways to reach a waterbody. And the Jamaica Bay watershed offers more pathways than are typically found in other parts of the City. A large percentage of the runoff in combined sewer areas makes its way directly to the WPCPs (the WPCPs accommodate wet weather flow at a capacity of approximately two times design dry weather flow) or it is sent to the WPCP indirectly – being first detained at the Spring Creek AWPCP wet weather retention facility or, soon to be completed, Paerdegat Basin CSO retention facility and then pumped back to the WPCP when capacity is freed up after the rain event. Some of the stormwater infiltrates into soils to groundwater, which slowly makes its way to the Bay. The remainder of the runoff is discharged to the Bay as CSOs, partially treated CSOs (overflows from Spring Creek and planned Paerdegat Basin CSO facilities), storm sewer discharges, and direct surface runoff, which are cumulatively summarized as *untreated discharges to the Bay*.

As shown in Table 5.4 below, in the Jamaica Bay watershed, the majority of untreated discharges to the Bay, as measured by volume, are storm sewer discharges (62%), as compared to CSOs which make up only 12% of the discharges. This balance is highly influenced by the amount of stormwater introduced into the eastern section of Jamaica Bay in the Jamaica WPCP sewershed. In most other areas of the City, CSOs make up the predominant source of untreated discharges.

TABLE 5.4 Baseline Untreated Discharges To Bay

Discharge	Volume (MG)	Volume (%)
CSO	1841	12%
Partially Treated CSO (overflows from CSO facilities)	514	3%
Storm Sewer	9572	62%
Direct Runoff	3615	23%
Total	15480	100%

So, for example, the 15.5 percent reduction in *untreated discharges to the Bay* with high capture BMPs (see Table 5.4) includes not only reductions in CSO discharges, but large reductions in storm sewer discharges. Watershed-wide, the percent reduction for each type of discharge is based on where the BMPs are located in the watershed (*e.g.* a combined sewered or separately sewered area). If the development where the BMPs are located is primarily in the combined sewer area of the watershed, then much of the reduction will be in CSOs.

However, most of the discharges that will be addressed by BMPs in the Jamaica Bay watershed are likely to be discharged from storm sewers as the storm sewered areas represent a large portion of the drainage area tributary to the Bay. While storm sewer discharges contain significantly lower levels of solids and pathogens than are present in CSOs, they still contain significant pollutant loads from street runoff (oil, grease), lawn areas (pesticides and fertilizers), and numerous other pollutants. For example, stormwater is estimated to contribute about 45 to 50 percent of the total nitrogen discharged to the Bay from wet weather sources while only contributing about 10 percent of the pathogen loads to the Bay. This clearly indicates that the effectiveness of any BMP program will depend on the location within the watershed where the BMPs are applied. Currently, a major focus of NYCDEP's wet weather flow reduction program is focused on CSOs. However, it is expected that storm sewer discharges will be receiving increasing attention as a source of pollution.

It should be noted that not all BMPs are applicable across all systems, thus a menu of options is offered. In a combined sewer area, rooftop detention and other detention BMPs could be very effective in detaining stormwater that would be slowly released and ultimately make its way to a WPCP for treatment. On the other hand, in a separately sewered area, rooftop detention and other detention BMPs would not be effective in reducing stormwater volumes or pollutants. They would merely detain the stormwater for release a few hours later, having no effect on discharges. However, with a large enough penetration rate, they could be effective in reducing some of the effects of flooding. In areas with storm sewers, infiltration BMPs or green roofs would be most effective; however, in many of these areas in the watershed, there are high groundwater tables that would preclude the use of infiltration BMPs.

It is also important to understand that the results presented are reductions with BMPs in *untreated* discharges to the Bay. This does not mean that BMPs reduce discharges to the Bay. All stormwater would ultimately discharge to the Bay, whether it be very slowly via infiltration and groundwater or more rapidly through WPCP discharges, thereby maintaining salinity levels similar to those there now. However, with BMPs, the stormwater is "treated" in some manner prior to discharge to reduce CSO and stormwater pollutants that negatively influence the Bay.

In addition to reducing untreated discharges to the Bay, including CSOs and other discharges, BMPs also provide aesthetic resources, open space, and other environmental benefits. See the *BMP Conclusions* section at the end of this Chapter for a discussion of these benefits.

Technical

There are a number of challenges to ensuring more widespread implementation of BMPs, particularly those that rely on infiltration as compared to detention. BMPs require substantial maintenance to ensure their effectiveness over time. In addition, in areas with high groundwater tables, infiltration practices could lead to more flooding. However, BMPs can provide effective stormwater management over a wide range of rainfall conditions. Specific BMPs such as green roofs and rain barrels also have their own set of technical concerns. Finally, it may be considerably more feasible to implement BMPs for new development than for existing development. These issues are discussed below.

Maintenance

Infiltration BMPs require maintenance to ensure that they function over time. A common problem is that they collect sediments and can clog. For example, dry wells are sometimes used in New York City where access to sewers is inadequate; they are susceptible to clogging, causing street flooding problems. Because infiltration devices would be located on private property, the property owner would be responsible for their ongoing maintenance.

Site Conditions

Stormwater infiltration measures require certain soil types; in general, sandier soils that drain well are preferable to clay soils. However, infiltration BMPs can be engineered with porous materials to allow for increased drainage.

In addition, depth to groundwater is an important factor to consider. In areas such as Southeast Queens with high groundwater tables, installation of infiltration BMPs are not recommended because they could exacerbate flooding problems.

Infiltration issues can also be addressed through installing overflow devices that would direct excess stormwater to the sewers. Site conditions that may best lend themselves to BMP implementation include:

a. The soil texture is primarily sand, loamy sand, sandy loam, loam, or silt loam and, therefore, in a class with an infiltration rate that will permit adequate percolation of collected water through the soil.

b. There is adequate depth to provide a vertical depth of five feet, minimum, between the infiltration bed and bedrock.

c. There is adequate depth to provide a vertical depth of five feet, minimum, between the infiltration bed and the seasonal high water table.

d. The site topography is mildly sloped (between 5-8 percent), appropriate to the proposed infiltration system and would not cause flooding to occur (NYCDEP, 2004).

Permeable gravel parking strip in residential neighborhood of the Jamaica Bay Watershed; Source: Biohabitats

e. The location of foundations, utilities, wells, subways, and similar features is appropriate to the proposed infiltration system and would not cause flooding to occur.

Climate Conditions
Climate conditions, particularly in areas that commonly experience intense rainfalls during short periods of time, cold temperatures, deep frost lines, short growing seasons, or significant snowfalls may impact the performance of BMPs, which should be selected or designed accordingly (CWP, 1997). Most BMPs rely on pipes for controlled releases of water or for overflows; in order to prevent pipes from freezing, pipes should be located at a depth of three feet or more below the surface where the ground is less likely to freeze. BMP inlets and outlets closer to the surface may freeze and result in flooding. Detention ponds and constructed wetlands could also freeze over creating increased impervious surface and reduced storage volumes. Detention facilities with shorter detention times are less likely to be problematic. Infiltration BMPs would become ineffective if the soil were to freeze and prevent stormwater runoff from percolating into the ground which would, in turn, increase the runoff rate. Despite this limitation, infiltration BMPs such as swales and filter strips can be used to store packed or melted snow for infiltration upon the warming of the ground cover and surface soils. BMPs can be effective throughout the year in climate conditions such as in New York City, if designed properly.

Specific BMPs
Green roofs have been extensively studied and are being installed at sites in New York City and other major metropolitan areas. While green roofs provide a number of stormwater and heat island effect benefits especially in urban environments, their application may be limited for existing developments. The saturated soils that make up green roofs are heavy and require rooftops with adequate internal structural support. Existing rooftops would need to be evaluated to determine if they can accommodate the load. New lighter-weight substrate materials are being produced that may make it easier to install green roofs on a wider range of existing rooftops. However, even with lighter weight substrates the weight of the saturated substrate needs to be balanced against the structural support system. Rooftop detention, while not having as significant load bearing issues as green roofs, would also require evaluations of a roof's structural integrity and upgrades with leakproof membranes.

Rain barrels are a far simpler and cheaper alternative. However, they depend on active attention by the homeowner. They require disconnecting the rain barrel from the roof leader in the fall/winter and reinstalling it in the spring/summer. Rain barrels also require the homeowner to empty them between rainfall events using the contents for watering gardens, lawns and houseplants. In New York City, the rain barrels need to be fitted with an overflow device that connects them to the sewer when the capacity of the rain barrel is reached. In addition, they are only appropriate for low density settings that contain vegetation requiring watering. Even for these applications, numerous rain barrels would be required and they would need to be emptied between rain events to achieve a substantial percentage of stormwater capture.

Rain barrels and downspout disconnection;
Source: Biohabitats

Existing Development
Incorporating BMPs on a built lot can mean expensive alterations. It may mean removing paved areas and replacing them with infiltration measures. Or installing additional plumbing, drainage controls, or waterproofing on an already built structure. To encourage the use of BMPs on existing lots, financial incentives will likely be needed. It may also be feasible to target existing developments that are undergoing substantial renovations (see *Implementation Strategies* below).

One way to achieve cost-effective implementation for existing development can be to target large roofs. This is an approach suggested in a USEPA-funded study; by targeting large roofs, a significant percentage of the total building footprint can be addressed with a smaller number of buildings involved (Casey Trees and LimnoTech, 2007). A similar assessment was undertaken for the Jamaica Bay watershed to determine the number of buildings with a rooftop area over 5,000 square feet. The assessment found that:

- 2.5% of the buildings in Jamaica Bay watershed have rooftops over 5,000 square feet. These buildings make up approximately 29% of the rooftop area in the watershed.

Therefore, targeting this smaller number of buildings, 7,116 of 285,937 in the Jamaica Bay watershed, for rooftop detention or green roofs could be beneficial (see *Implementation Strategies*" below).

Cost
Average construction costs for each of the low, medium and high capture prototypes are shown in Table 5.5. Operation and maintenance costs are under development.

As can be seen from the table, rooftop detention is shown as a no-cost alternative for new development. This is because under the Administrative Code, in areas such as the watershed where there is inadequate capacity of the sewer system, higher density new development is required to provide stormwater detention, either subsurface or rooftop, or sewer reconstruction. Rooftop detention is considerably less expensive than subsurface detention and can detain smaller flows that cause CSOs. Rooftop detention also compares very favorably to green roofs. Green roofs estimated for these prototypes cost approximately $30/square foot, depending on the depth and type of green roof system, compared to approximately $5/square foot for rooftop detention. These costs do not include structural upgrades; however, green roofs are more likely to require additional structural support than rooftop detention.

Because BMPs have not been widely used in New York City, these costs are based largely on estimates developed in other areas and adjusted to account for New York City construction costs, and there are uncertainties associated with them. More accurate costs will be developed as part of the proposed pilot projects (see *Implementation Strategies* below), which will also provide information needed to determine which BMPs provide the most cost-effective results under New York City conditions. In addition, BMP costs are expected to drop as they are more widely implemented and economies of scale are realized.

TABLE 5.5. Stormwater BMP Costs By Land Use Prototype					
	Existing Development			New Development	
	Low Capture	Medium Capture	High Capture	Medium Capture	High Capture
LOW DENSITY RESIDENTIAL 3,500 Square feet					
Zoning: R1					
Example BMPs	Rain barrels (4-55 gal), downspout disconnection	Porous paving (300 sf)	NA	NA	Infiltration basin (1140 gal) + porous paving (750 sf)
	Rain planter (60 sf)	Infiltration basin (450 gal)	NA	NA	Cistern (448 gal) + infiltration basin (510 gal) + porous pavement (750 sf)
BMP Capture Volume (gal)	224	449	NA	NA	2304
Average BMP Scenario Costs	$4,700	$7,250	NA	NA	$27,650
MEDIUM DENSITY RESIDENTIAL/COMMERCIAL 2,178 Square feet					
Zoning: R5, 6, 7, c1, 2, 4, 6					
Example BMPs	Rain barrels (3-55 gal), downspout disconnection	Plumbing retrofit, rain barrels (6-55 gal) or equiv cistern	Green roof (3 in. soil, 2178 sf)	Green roof (3 in. soil, 2178 sf)	Green roof (3 in. soil, 2178 sf)
	Rain planter (45 sf)	Infiltration basin (340 gal)	Rooftop Detention	Rooftop Detention	
BMP Capture Volume (gal)	170	340	1698	1698	1698
Average BMP Scenario Costs	$3,500	$6,350	$ 10,700 (rooftop detention)-$63,050 (green roofs)	$0 (rooftop detention)-$63,050 (green roofs)	$63,050
HIGH DENSITY RESIDENTIAL/COMMERCIAL 17,000 Square feet					
Zoning: R8, 9, 10, C1, 2, 4, 5, 6					
Example BMPs	NA	NA	Green Roof (3'" soil, 17000 sf)	Green Roof (3" soil, 17000 sf)	Green Roof (3 in. soil, 17000 sf)
	NA	NA	Rooftop Detention	Rooftop Detention	
BMP Capture Volume (gal)	NA	NA	13246	13246	13246
Average BMP Scenario Costs	NA	NA	$58,300 (rooftop detention)-$492,000 (green roofs)	$0 (rooftop detention)-$492,000 (green roofs)	$492,000

TABLE 5.5. Stormwater BMP Costs By Land Use Prototype					
	Existing Development			**New Development**	
INDUSTRIAL AND BIG BOX COMMERCIAL (SMALL) 0.5 Acres					
Zoning: M1					
Example BMPs	Bioinfiltration/trees (390 sf)	Bioinfiltration/trees (780 sf)	Green roof (3" soil, 12795 sf)	Green roof (3" soil, 12795 sf)	
	Porous paving (1150 sf)	Porous paving (2300 sf)	Rooftop Detention	Rooftop Detention	Green roof (3" soil, 12795 sf) +, bioinfiltration/trees (1560 sf)
BMP Capture Volume (gal)	1698	3396	9969	9969	16980
Average BMP Scenario Costs	$22,500	$36,000	$46,100 (rooftop detention)-$370,400 (green roofs)	$0 (rooftop detention)-$370,400 (green roofs)	$453,000
INDUSTRIAL AND BIG BOX COMMERCIAL (LARGE) 1 Acre					
Zoning: M2, 3, C4					
Example BMPs	Bioinfiltration/trees (780 sf)	Bioinfiltration/trees (1,560 sf)	Green roof (3" soil, 18,150 sf)	Green roof (3" soil, 18,150 sf)	
	Porous paving (2,300 sf)	Porous paving (4,600 sf)	Rooftop Detention	Rooftop Detention	Green roof 3" soil, 18150 sf) +, bioinfiltration/trees (4,440 sf)
BMP Capture Volume (gal)	3,396	6,792	14,142	14,142	33,959
Average BMP Scenario Costs	$36,000	$58,000	$61,500 (rooftop detention)-$525,417 (green roofs)	$0 (rooftop detention)-$525,417 (green roofs)	$677,900
PUBLIC FACILITIES, SCHOOLS AND INSTITUTIONAL USES 1.5 Acres					
Zoning: NA					
Example BMPs	Bioinfiltration/trees (1170 sf)	Bioinfiltration/trees (2340 sf)	Green roof (3" soil, 19900 sf)	Green roof (3" soil, 19900 sf)	
	Porous paving (3,400 sf)	Porous paving (6,800 sf)	Rooftop Detention	Rooftop Detention	Green roof (3 in. soil,19,900 sf) +bioinfiltration/trees (7,906 sf)
BMP Capture Volume (gal)	5,086	10,173	15,505	15,505	50,864
Average BMP Scenario Costs	$47,500	$76,500	$66,400 (rooftop detention)-$576,100 (green roofs)	$0 (rooftop detention)-$576,100 (green roofs)	$789,700

Table 5.6 summarizes costs for implementing BMPs across the watershed for each of the scenarios. Costs range from $231 million to $3 billion depending on the scale of implementation. For new development, these costs range from $0 (if rooftop detention is already required) to $2.4 billion.

TABLE 5.6. Watershed Wide Costs For Implementing BMP Scenarios

Existing Development Low Capture BMPs	Existing Development Medium Capture BMPs	Existing Development High Capture BMPs	New Development Medium Capture BMPs	New Development High Capture BMPs
$231 million	$346 million	$ 469 million (rooftop detention) - $3 billion (green roofs)	$0 (rooftop detention) - $1.7 billion (green roofs)	$2.4 billion

Legal

The authority for various functions to control drainage of stormwater from private and public lots, to City streets and sewers, and eventually to waterbodies is a shared responsibility that crosses five major City agencies (see Table 5.7 below). As such, implementation of stormwater control practices, whether to reduce stormwater runoff or to improve stormwater quality, is a multi-agency responsibility. The agencies that have the greatest ability to promote change are the NYCDEP, because of its role in permitting connections to the sewers, NYCDOB for its responsibility in enforcing the Building Code, and the NYCDCP, because of its control over zoning in the form of property development requirements.

TABLE 5.7. Regulatory Authority For Controlling Stormwater Runoff

NYC Agency	Authority as Related to Disposal of Stormwater	Legislative Authority
New York City Department of Environmental Protection (NYCDEP)	• Establish Drainage Plan - sets sewer sizes in relation to zoning • Assess the capacity of the sewer system to accept sanitary and stormwater from new development or altered development and certifies sewer connection applications • Issues permits and inspects for the connection of the building or house sewer to the sewer system	• Administrative Code, Title 24 (24-503) • Administrative Code, Title 24 (24-526) and Reference Standard 16 (P110.0) • Administrative Code, Title 24 (24-507)
New York City Department of Buildings (NYCDOB)	• Develops Building Code – sets standards for construction practices on individual lots in accordance with land uses and zoning • Reviews new building or alteration applications including associated plumbing. Can accept and may certify applications for connection of building or house sewer in conjunction with a permit for construction or alteration of a structure • Authority for Building Code which allows retention and recycling of stormwater	• Administrative Code, Title 27 (27-102) • Administrative Code, Title 27 (27-896, 27-901, 27-909, 27-916 and 27-2027) • Administrative Code, Title 28 (PC 28-1101.2, PC 1110.1, PC C101.1)

TABLE 5.7. Regulatory Authority For Controlling Stormwater Runoff (continued)		
New York City Department of City Planning (NYCDCP)	• Establish City Map – establishes land uses and population densities in districts (zones) around City • Develop Zoning Resolution - controls open space on lots and other factors such as floor area ratios that impact use of individual lots • Review and approve NYCDEP drainage plans	• City Charter (Section 198) • City Charter (Section 200)
New York City Department of Transportation (NYCDOT)	• Responsible for roadways and sidewalks and associated storm drainage • Can become involved with site grading	• Administrative Code, Title 17 • Administrative Code, Title 19 (19-137)
New York City Department of Health and Mental Hygiene	• Enforces drainage on property when poor drainage impacts public health • Review and approve NYCDEP drainage plans • Reviews and approves water reuse systems	• Administrative Code, Title 17 (17-119) • Administrative Code, Title 24 (24-143 and 24-145)

Currently, City codes and stormwater management regulations do not routinely require or promote the use of stormwater detention or retention BMPs for the purpose of minimizing CSOs. However, stormwater detention to address flooding and capacity limitations in the built infrastructure is routinely required. The current Administrative Codes, Building Codes and City practices are directed to controlling the flow of stormwater away from lots and into sewers with the primary purpose of avoiding flooding and standing water and the public health concerns associated with these conditions. They also are intended to prevent disputes between homeowners created by storm drainage being routed across property boundaries.

The Building Code requires that all stormwater falling on a property shall be discharged into a street storm or combined sewer by:

- a house connection where there is a street storm or combined sewer in front of the property; or
- construction of a new sewer to the storm or combined sewer located within 200 feet of the property (for residential exceeding 20,000 square feet impervious) to 500 feet of the property (for commercial lots), where feasible.

When a new or expanded development applies for a sewer connection permit, an assessment is performed to assess the capacity of the sewer to demonstrate whether the impervious surfaces on the property will generate stormwater runoff that can be accommodated by the existing street storm or combined sewer. That generally requires the developer to perform step-by-step calculations assessing the flow (sanitary and storm drainage) being added to every sewer pipe in the area as well as those draining from the immediate area of the project site. Typically one of the following three outcomes are identified:

- If the subject sewer has adequate capacity, then it is a matter of demonstrating capacity to NYCDEP for a site connection approval to the sewer.

- When the sewer does not have adequate capacity, the developer must work with NYCDEP to redesign the sewers and develop a modified drainage plan or provide for on-site detention of stormwater so the sewers can convey the storm drainage without adversely impacting the system.
- When no sewer exists within 200-500 feet of the property, the developer must design and construct on-site retention using a drywell sized in accordance with design standards.

If on-site detention is proposed, the developer can provide either a subsurface detention tank, rooftop detention, or can apply for an alternative method of control. The detention required is not intended, as a goal, to address CSOs. NYCDEP requirements for on-site detention primarily address large rainfall intensities, for example 3 or 5 year storms. However, smaller storms that can result in CSO events are also detained to some extent. Rooftop detention is more effective in controlling smaller storms than subsurface detention due to design limitations associated with subsurface detention systems.

Adequate design capacity is established in NYCDEP's current drainage plans and has been the practice for many years in development of the drainage plans for most areas of New York City. The current practice is to design storm or combined sewers to convey stormwater drainage from parcels based on rainfall intensities of 5.95 inches per hour, is about a 5-year return rainfall intensity. Older sewers in the City were designed to lesser levels of protection (1, 2 and 3 year intensities) and thus could incur flooding on a more frequent basis.

As discussed, the codes are quite specific in how stormwater from impervious surfaces needs to be controlled and where it should go. It does not appear that mandatory stormwater BMPs that allow for increased detention and retention to address CSOs could be implemented without changes to the Administrative Code and other regulations. However, there are a number of situations where they could be installed under the current Sewer Code and Building Code and the soon to be effective revised Building Code:

- If no street storm or street combined sewer is located within 200-500 feet, NYCDEP will determine the appropriate means by which stormwater is to be managed. On-site drywells (in accordance with Reference Standard (RS) P110.13) are specifically referenced as an alternative measure. According to Reference Standard RS-16 (P110.2) where there is no sewer within 200 feet (or 500 feet for commercial lots) the owner may provide for on-site disposal of stormwater using a dry well designed to contain and dispose of 2 inches of rainfall within a 24 hour period with approval from NYCDEP (RS-16, P110.13).
- Stormwater falling onto pervious surfaces can be disposed of on-site through surface infiltration providing that the stormwater does not drain to the street across a sidewalk or drain onto an adjacent property (27-901, 27-2027) and without ponding on the site.
- Stormwater falling onto areaways 25 square feet or less can be leached into the ground through pervious surfaces where groundwater is at least 2 feet below the ground surface (RS-16, P110.13 (a) and (b)). An areaway is a sunken space that affords below grade access, air, and light to the first basement or cellar story below grade. This regulation applies only to a very small and specific area immediately adjacent to a building.
- Disconnection of roof leaders from the sewers could be connected to a BMP if it is provided with a connection to the sewer for any overflow (27-2027, RS-16, P110.2). For example, downspouts could be directed into a rain planter, rain garden, or rain barrel as long as a means is provided

from the BMP to capture and divert flow back into the property storm sewer and then to the street sewer at an allowable rate before it overflows the BMP.

- Green roofs and rooftop gardens could be installed provided that the roof is designed to carry the load of the garden and the landscaped portions in accordance with Administrative Code 27-561, and a means is provided from the BMP to capture and divert flow back into the property storm sewer and then to the street sewer at an allowable rate before it overflows the BMP.
- Property could be recontoured to encourage rainwater to infiltrate if the re-contouring did not result in either ponding of the water on-site without rapid percolation into the ground or in water flow off the property across a sidewalk or onto an adjacent lot (27-901). By directing the runoff to a BMP technology such as bioinfiltration, it would be possible to manage stormwater on-site without ponding of the water on-site or water flow off the property across a sidewalk or onto an adjacent lot, provided an underdrain and a control structure to discharge at an allowable rate are connected to the sewer system.
- Other types of BMPs that reduce impervious surfaces are likely to be allowable under the current codes (see also Management Strategy 3a2 below). These include planting of additional trees or other landscaping practices, converting impervious areas to pervious areas or porous pavers, where groundwater is at least two feet below ground surface.
- The new plumbing code, soon to be effective under the revised Building Code, allows for approved systems for the beneficial collection for recycling of stormwater (Section PC 1101.2): "Where required. All roofs, paved areas, yards, courts and courtyards shall drain into a separate storm sewer system, or a combined sewer system, or to an approved place of disposal. In accordance with city department of environmental protection requirements, an approved system for beneficial collection and use of stormwater may be installed in which case overflow from such a system shall be discharged to street storm sewer or street combined sewer." Note that NYCDEP will be developing the requirements referenced above.

Possible changes to rules and regulations to encourage BMPs. As discussed above, the objectives of the current City Codes promote the removal of stormwater drainage away from public and private parcels of land to the sewer system. NYCDEP regularly requires detention, with the primary goal of addressing flooding due to large storms. These detention facilities do not specifically address the goal of reducing combined sewer or storm sewer flows and related pollution in waterbodies. However, rooftop detention and, to a lesser extent, subsurface detention are typically designed in a manner that would address CSOs due to smaller storms. To better encourage BMPs, changes to the City codes may be needed to balance the need for public health protection with the need to reduce environmental pollution from urban runoff and from CSOs.

Possible changes to existing codes to encourage BMPs, which appear to be implementable within the constructed New York City environment, are discussed below. Code changes related to detention and retention are addressed. Some of these concepts are based on practices currently permitted in other large cities. ***All potential revisions discussed below are not recommendations at this point in time, but rather preliminary concepts for further evaluation. As a next step, NYCDEP will undertake a study to identify specific provisions of the Sewer Code and other applicable codes that might be recommended for revision while meeting the goals of addressing flooding, ponding, and other potential health effects.***

Potential New Applicability Triggers for On-Site BMPs. The current practice is to require on-site detention when proposed zoning changes or impervious cover changes would cause the sewers to exceed their flow capacity based on large rainfall intensities. Where the street sewer does not have adequate capacity to convey intense rainfalls, the City can mandate on-site detention or retention and controlled release of the stormwater. When adequate capacity is available to handle large rainfall intensities, no detention measures are required.

Rather than requiring detention or retention when allowable flow capacity of the sewer is exceeded, alternative triggers for requiring on-site detention or retention could include:

1. require BMPs when additional CSOs beyond some selected baseline are created; OR
2. require all new construction or enlargements over a certain size (*e.g.*, ¼ acre impervious) to require on-site detention or retention sufficient to not increase the total volume or peak discharge rate of stormwater over that presently leaving the site. This would result in no increase in stormwater entering the sewer. However, since most development sites in the city are largely covered with impervious surfaces that may not be controlled, this would do little to reduce uncontrolled stormwater from the site; OR
3. require all new construction or enlargements over a certain size (*e.g.*, ¼ acre impervious) to require on-site detention or retention sufficient to not increase the total volume or peak discharge rate of stormwater over pre-development conditions. This would typically reduce the stormwater entering the sewer and would not allow the developer to take credit for existing impervious surfaces.

Temporary Storage of Stormwater on Lots (On-site Detention). The Code and Reference Standards could be revised to provide specific design guidelines and requirements to support higher levels of detention to address CSOs. Specifically, guidance to determine storage volumes and design overflow control structures that can detain on-site stormwater flows for smaller storms with intensities that cause or contribute to CSOs could be developed.

In addition, the rules can be modified to promote detention systems other than subsurface or rooftop detention. While the rules do not necessarily preclude diversion of roof leaders into a rain barrel or cistern with reconnection of the overflow from these detention devices at an allowable rate to the storm or combined sewer, the code could be revised to specifically permit these types of storage practices. Alternatively, they could be allowed to infiltrate without reconnection to a sewer (see below).

Infiltration of Stormwater on Lots (On-site Retention). While the rules do not preclude diversion of stormwater from impervious areas into a rain garden, rain planter, bioinfiltration basin, or other infiltration device, the device must include a reconnection of the overflow to discharge at an allowable rate through these devices to the storm or combined sewer. Changes to the code to better support infiltration practices could include:

- Removing the mandate of needing to make a direct connection of impervious surfaces to street storm or combined sewers in certain situations.
- Providing allowances for and conditions under which certain infiltration BMPs either could or must be employed.

- Discourage ponding of water on-site.

To ensure that infiltration practices continued to meet the objectives of avoiding flooding and ponding of water, the Codes and Reference Standards would need to be revised to provide specific design guidelines and requirements related to the following:

- Define soils that can be used for on-site retention.
- Infiltration or permeability testing requirements for acceptable on-site retention infiltration practices.
- Minimum depths to groundwater.
- Minimum depths to bedrock.
- Mandated overflow connections to discharge at an allowable rate to storm or combined sewers from certain subsurface drainage systems to protect against surface ponding during extreme rainfall events or when peak stormwater flows exceed infiltration rates.
- Provisions for freezing temperatures.
- Maintenance requirements and responsibilities to ensure the ongoing performance of the installed methods.

If any of the changes discussed in this section were to be proposed, they would require revisions to the Administrative Code by an action of the City Council. The City Council would need to pass a local law to introduce any changes to the Code or Reference Standards.

In addition, enforcement is an issue with allowing BMPs under sewer permits. Because they do not function well without regular maintenance, widespread use of BMPs would require an inspection program. NYCDEP does not inspect individual properties and this may be an effort that would require support from the NYCDOB.

RECOMMENDATION

It is recommended that the City further pursue and encourage the use of on-site stormwater BMPs in the Jamaica Bay watershed. This would be done through the Implementation Strategies listed below. Many of these Implementation Strategies address the uncertainties discussed above under environmental, technical, cost, and legal issues.

IMPLEMENTATION STRATEGIES

The integration of stormwater BMPs into new and existing development will occur over time. Currently, BMPs are the exception in New York City, and developing more widespread use will involve technical assistance and education for developers and building owners, economic incentives, and regulatory and design standard changes. BMP technologies have not been widely accepted by the development community, including engineers and architects, due to a lack of familiarity with the available technologies, maintenance issues, costs, and the fact that existing regulations do not encourage their use. Pilot projects and demonstration projects will be needed to determine the effectiveness and address uncertainties of the measures in conditions unique to New York City.

Monitoring programs will be needed to track their effectiveness over time. These *Implementation Strategies* are discussed below.

Pilot Projects and Demonstration Projects

To address uncertainties related to costs, benefits, public acceptance, maintenance requirements, and site conditions, NYCDEP will pursue several pilot studies. In addition, New York City government can be a leader by example in pursuing these technologies; there are potential opportunities to incorporate BMPs into the design of city government buildings and construction projects.

Green Roof/Blue Roof Pilot Study

One of Gaia Institute's green roof projects in the New York City area; Source: Gaia Institute

NYCDEP, working with the Gaia Institute, will design, construct and monitor a green roof and a blue roof (rooftop detention) on two existing commercial developments in the Jamaica Bay watershed. Although green roofs have been investigated in various cities, their widest applications have been in the Pacific Northwest and in Germany whose temperate climates are not similar to New York City's. In addition to comparing the stormwater benefits of the two approaches, addressing uncertainties with installation on existing development and costs will be the objectives of the study.

Schedule: Pilot to begin in late 2007. Nine months to select site, design and install. Monitoring over a three year period to evaluate the effectiveness over time and under various environmental conditions.

Cost: $352,500 for design and construction. Additional funding will be provided for monitoring and reporting over three years.

Rain Barrel Give-Away Pilot Study

Rain barrels have been installed in low density areas both in New York City and other American and European cities. Rain barrels have been shown to be effective particularly in the Pacific Northwest, whose milder weather and less intense rainfall patterns are more conducive to rain barrel use. One goal of the pilot study would be to test the effectiveness in climate patterns experienced in New York City.

In addition, to make a noticeable change in stormwater capture rates, rain barrels would require wide-scale market penetration and buy-in from homeowners. To function properly, they require dedicated involvement. They need to be emptied between rainfall events with the water being used for garden, lawn and houseplant watering. In addition, rain barrels need to be disconnected from the roof leader each fall and reinstalled each spring. Therefore, a second goal of the pilot study would be to gauge public acceptance and interest in using rain barrels and their willingness and ability to maintain them. Approximately 1,000 rain barrels would be distributed.

Schedule: Pilot study will be developed through a proposed contract that will implement CSO strategies. Pilot to be initiated in Summer 2008. Program to be monitored over two years. Depending on public participation, program can be expanded.

Cost: $138,000.

Parking Lot Pilot Study

To serve as a model for the proposed Zoning Resolution parking lot design requirements, NYCDEP will develop a model parking lot pilot study in the Jamaica Bay watershed. Two 1.5 acre parking lots will be retrofitted for stormwater capture with edging and median bioretention and storage systems in accordance with proposed design requirements under the Zoning Resolution.

Schedule: Pilot study to begin in late 2007. Nine months to select sites, design and install. Monitoring over a three year period to evaluate the effectiveness over time and under various environmental conditions.

Cost: $290,000 for design and construction. Additional funding will be provided for monitoring and reporting over three years.

NYCHA or HPD Pilot Study

NYCDEP will retrofit an existing affordable housing site under the jurisdiction of New York City Housing Authority (NYCHA) or HPD. The pilot study will include retrofitting the existing site with infiltration and detention BMPs and redirecting runoff to existing pervious areas. The study will examine the uncertainties involved in retrofitting existing development.

Schedule: Pilot study will be developed through a proposed contract that will implement CSO strategies. Pilot to be initiated in Summer 2009. Program to be monitored over two years.

Cost: $550,000 including design, construction and monitoring.

New York City Agency Demonstration Projects

Because BMPs do not have wide-scale application in New York City, City projects and lands can provide a testing ground that can highlight the benefits and work out the logistics to provide for wider scale implementation. Implementing BMPs on public properties would provide a real life evaluation of the performance of these BMPs and the costs for implementation. Such an approach by the City of "leading by example" would expand practice in the construction of BMPs within New York City, help to standardize BMP construction costs, and encourage private developers to pursue these options. Through an on-going monitoring program and campaign to determine accurate costs and benefits of BMPs on public properties, on-site BMP implementation could be scaled up to include more City-owned properties and extend to private developments.

Through the Mayor's interagency BMP Task Force, strategies for incorporating BMPs into the design and construction of City capital projects will be developed. The interagency task force includes HPD, New York City Economic Development Corporation (NYCEDC), SCA, NYCDDC and DCAS which are directly responsible for managing, designing, and constructing City housing projects, schools, courthouses, City-funded commercial development, and other City development projects as well as NYCDEP and NYCDOB which grant permits and approvals for these projects. (See "Off-site BMPs" below for NYCDPR and NYCDDC roles on the BMP Task Force). The Task Force members are evaluating their built and planned projects to determine where BMPs can be incorporated. Interagency communications and coordination is particularly helpful to share lessons learned about BMP implementation and provide case studies of information for both public and private developers.

In addition, NYCDEP has met with HPD, NYCDDC and SCA, to determine how BMPs can be incorporated into current design projects. These agencies are eager to work with NYCDEP to determine how to add BMP requirements to their Requests for Proposals and/or contracts with private developers. All of these agencies have developed green design standards for their projects.

In addition to measures encouraged by individual agencies, Local Law 86 can be expanded to more prominently encourage stormwater BMPs in addition to its current focus on reducing energy and water usage. Under Local Law 86, all new public construction is required to be designed and constructed to comply with green building standards to achieve a LEED silver or higher rating for the infrastructure.

Schedule: Mayor's Office Interagency BMP Task Force Plan to be delivered in Fall 2008.

Evaluate Rooftop Detention

Despite its considerably lower cost, as discussed above, only a small number of developers now choose rooftop detention over subsurface detention when required to provide detention as part of their projects. NYCDEP will work with the NYCDOB to better promote the advantages of rooftop detention earlier in the approval process. Information will be provided on costs as compared to subsurface detention and case studies of where it has been implemented will be highlighted.

In addition, NYCDEP will investigate a program to target the implementation of rooftop detention on existing large roofs in the Jamaica Bay watershed. As noted above, 2.5% of the rooftops are over 5,000 square feet representing approximately 29% of the rooftop area within the watershed. NYCDEP will identify the associated buildings and inventory the extent to which they already include detention or retention measures, and the ability of the rooftops to be retrofitted to accommodate rooftop detention. A pilot study comparing a green roof and blue roof will be undertaken (see "Pilot Projects and Demonstration Projects" above).

NYCDEP will work with the New York City Soil and Water Conservation District (NYCSWCD) (see *Economic Incentives* below) to investigate and incentive program to encourage the installation of rooftop detention and other BMPs on these buildings. In addition, as part of the Code Review, NYCDEP will explore whether rooftop detention can be included as an option for major roof renovations.

Schedule: To be initiated late 2007.

Cost: See Cost Sharing Programs below.

Economic Incentives

Economic incentives such as water and sewer rate discounts and public/private cost-sharing may be needed to encourage the implementation of BMPs, particularly for existing development. New York City already has engaged in several incentive-based initiatives, including a toilet rebate program, where residents can obtain a rebate if they have a new water-conserving toilet installed by a licensed plumbing company.

Stormwater Rates and Credits

Stormwater rates and water conservation rates are currently being used by municipalities across the country to achieve local and regional goals of reducing water demand and stormwater generation and addressing infrastructure needs to meet more stringent regulatory requirements. Rates to achieve higher levels of water conservation send price signals to encourage users to consume less water. Stormwater rates establish a separate pricing structure for stormwater discharges to reflect the stormwater generation characteristics of specific land uses. This revenue can then be applied to a large array of stormwater-related investments from infrastructure to BMPs.

In New York City, the New York City Water Board uses a metered and flat rate system to bill customers for water service and sewer service. The wastewater charge for any property is 159% of the charges for water supplied to that property. Rates for expenditures related to both wastewater and stormwater are incorporated into one wastewater rate.

New York City's rate schedule also provides limited incentives for buildings which meet the criteria for either "Blackwater Systems" or "Greywater/Recycled Water Systems." The building must demonstrate a 25% aggregate annual reduction in demand for potable water compared to other similar buildings. Reduction in potable water can be through water conservation, reuse, or stormwater reuse.

Under the current structure, ratepayers are charged for service in a manner that assigns stormwater costs to the quantity of water that is used. This structure does not reflect stormwater generation. For example, customers that do not use water (*e.g.,* parking lots) are receiving stormwater service but are not assessed a rate. On the other hand, high density housing developments can have high water usage and wastewater volumes, but from a stormwater perspective, they generate less stormwater per capita due to their compact land area.

NYCDEP will undertake a study to evaluate alternative water, sewer, and stormwater rate structures. Among other issues, the study will assess revenue and ratepayer impacts of different stormwater rate structures, as well as the costs to the City of new development on water, wastewater and stormwater infrastructure. There are both advantages and disadvantages associated with stormwater rate structures that will be explored as part of this study.

Stormwater rate structures can be defined by a number of variables such as imperviousness, land area, and property classifications. The study will assess the extent to which a variety of stormwater rate structures can provide additional revenue and equity, while encouraging BMPs. The study will evaluate impacts on ratepayers and revenues. Administrative, billing, and enforcement requirements associated with the different rate structures will also be explored.

Stormwater rate structures in and of themselves do not encourage the use of BMPs without a credit program. This is because administratively it is not possible to measure the imperviousness of each lot and charge based on actual imperviousness. If such a rate were possible, stormwater charges would be lower for those who install pervious areas. Instead, these rates are typically based on lot size and average impervious surface coverage for each land use such as residential, commercial, and industrial. Because consumers are paying an average rate, their rate is not reduced if they install BMPs. Therefore, the study will review appropriate credit programs that could be developed to encourage BMPs, without substantial loss of revenues. Seattle and Kings County, Washington have included a sophisticated credit program as part of their stormwater rate structure.

Schedule: The study is expected to begin in late 2007 and take 18 months, to be concluded in mid-2009.

Cost: To be determined.

Cost-Sharing Programs

As noted below, New York City provides rebates for installing low flow toilets citywide. Several other economic incentive programs are offered within the City for energy and other environmental initiatives for private developers. The Bronx Overall Economic Development Corporation (BOEDC), a federally designated agency for economic development in the county, offers several incentive programs as part of its Bronx Initiative for Energy and the Environment. The first is the Empowerment Zone Environmental Fund applicable for businesses located in the Empowerment Zone that receive an Empowerment Zone loan. The Environmental Fund funds up to $100,000 per grant to cover the incremental costs associated with the installation of a green roof or photovoltaic cells/solar panels.

To expedite the implementation of BMPs on existing development, particularly development with large rooftops and impervious areas, NYCDEP will investigate the establishment of an incentive program with the NYCSWCD. The program could be modeled after a program currently in place through Washington D.C.'s Department of the Environment. Under the program, the NRCS partners with the Washington D.C. Department of the Environment to offer design/build services instead of cash awards; BMPs are fully designed and installed by a list of pre-qualified contractors.

PLANYC 2030 includes an incentive program for green roofs. Under PLANYC 2030, the City has proposed providing incentives for green roofs beginning in 2007. A key role of the Mayor's Office Interagency BMP Task Force is to investigate incentives that can be used to encourage BMP implementation. These incentives will be included in the Task Force's Plan to be completed in late 2008.

Schedule: NYCDEP and NYCSWCD will investigate cost-sharing programs beginning in Fall 2007. The PLANYC 2030 green roof incentive program is awaiting approval from the state legislature and is scheduled to last five years upon state approval. The Mayor's Office Interagency BMP Task Force Plan will be completed in late 2008.

Cost: The NYCDEP/NYCSWCD program is currently funded for $40,000 to do exploratory work to investigate the establishment of a framework and identify funding sources for the incentive program. Monetary incentives are not included and funding would need to be identified.

Other Incentives

Streamlining development processes such as expediting or fast-tracking building permit applications could be implemented for developments that include green buildings and low impact development, or developers utilizing the NYCDDC high performance guidelines.

Potential Regulatory Code Changes

Zoning Resolution Parking Lot Design Requirements

As discussed above, NYCDEP worked with NYCDCP to develop proposed parking lot design standards in the Zoning Resolution. The standards apply to commercial and community facilities with parking lots that contain 18 or more parking stalls or are 6,000 sq ft or more in size. The standards include adding stormwater BMPs such as street trees and perimeter and interior landscaping that would provide infiltration to the soils. To be implemented, the standards require a zoning text change through a process similar to the City's Uniform Land Use Review Process (ULURP).

Schedule: The proposed text amendment approval and public review process began on June 18, 2007 and involves the City Planning Commission, Community Boards, Borough Presidents, and City Council. If approved, the requirements would take effect on the date it is approved by the City Council.

Code Review

Based on the above summary of potential legal issues associated with installing BMPs for new and existing development, the Sewer Code and Building Code may need to be revised to better facilitate installation of BMPs on a wider scale. NYCDEP will conduct a review and study of the Sewer Code and closely coordinate with NYCDOB and other agencies on related codes to evaluate whether code changes would be needed.

Schedule: The Sewer Code review will be developed through a contract that will implement CSO strategies. A contractor is anticipated to be retained by mid-2008. The review will be conducted in conjunction with the development of a BMP Design Manual (see below). The pilot studies will also be used to inform potential revisions. If revisions are proposed, they will be required to be adopted pursuant to the City's Administrative Procedures Act (CAPA) process.

Cost: $250,000 (includes BMP Design Manual below).

Technical Assistance

Companion BMP Design Manual

A BMP Design Manual will be developed as a companion to the Sewer Code. A number of existing manuals including the *New York State Stormwater Management Design Manual* (CWP 2003) currently provide a wealth of information related to the design of BMPs. However, a manual specific to New York City's unique conditions and urban environment would further facilitate the implementation of BMPs in New York City. The manual would specifically address high density development patterns, drainage issues, Sewer Code and permitting process interface, soil, bedrock and groundwater conditions, and climate conditions specific to New York City. The manual would include detailed design requirements for public and private development projects and would be developed with input from multiple city agencies.

Schedule: The BMP Design Manual will be developed through a contract that will implement CSO strategies. NYCDEP will issue a Request for Proposals for the study in early 2008 and a contractor is anticipated to be retained by mid-2008. Proposed revisions will take 18 months, to be concluded by late-2009, and will be done in conjunction with Sewer Code revisions (see above). The pilot studies will also be used to inform the manual.

Cost: See Code Review above.

<u>CEQR Technical Manual</u>

Revisions to the New York City Environmental Quality Review (CEQR) Technical Manual will be proposed to include a specific section addressing proposed developments in the Jamaica Bay watershed that are subject to CEQR. For example, applicable developments in the Jamaica Bay watershed that exceed certain size thresholds could trigger a detailed CEQR review. The applicant would need to document measures to capture, store, and/or treat stormwater from the site.

Schedule: Next CEQR Technical Manual revision is scheduled for Summer 2008.

Monitor Benefits

Currently, benefits provided by BMPs can only be predicted by modeling. To determine actual benefits, field indicators need to be developed to track the success of BMP implementation over time. The City will maintain a database of public and private projects that incorporate BMPs. Improvements at the CSO outfalls for the drainage areas where these BMPs are installed will also be tracked to assess the effectiveness in reducing CSOs.

In addition, the pilot studies, which include a substantial monitoring and evaluation component to track performance and effectiveness over time, will provide data to inform and improve BMPs and make them easier to implement in the future in a manner that is specific to conditions found on the ground in New York City.

Schedule: To be determined. The tracking program will be expanded as Implementation Strategies are undertaken.

Management Strategy 3a2: Reduce the imperviousness of new and existing development.

STRATEGY DESCRIPTION

Despite its low density land uses compared to other parts of the City, the Jamaica Bay watershed is densely developed and largely covered with impervious surfaces. Based on recently analyzed multi-spectral satellite imagery being performed by the Lamont Doherty Earth Observatory, the land area in the Jamaica Bay watershed is approximately 65-70% impervious surfaces. As indicated in Table 5.8, the 26th Ward sewershed has the greatest percent impervious cover (83%), while Rockaway has the least (59%).

TABLE 5.8. Impervious Cover By Sewershed

WPCP Sewershed	Impervious cover %
Coney Island (Paerdegat area)	66
26th Ward	83
Jamaica	68
Rockaway	59

A trend toward increased impervious cover is occurring. According to PLANYC 2030, over the last 25 years, the City has lost more than 9,000 acres of pervious surfaces. Another trend observed in low density areas is that homeowners are paving over front lawns to allow for additional parking.

Standard Pavement

Porous Pavement

FIGURE 5.4 Comparison of asphalt types; Source: University of New Hampshire Stormwater Center and Biohabitats, Inc.

Creating pervious areas on a site with adequate subsoil strata reduces runoff and allows for infiltration to the soils. Currently, there are no rules within New York City that limit the amount of impervious area or require that a portion of the lot remain pervious. The Zoning Resolution does have open space requirements for various zoning categories, but these areas are allowed to be paved. However, City

Planning is currently considering changes to the Zoning Resolution to require pervious areas on low density residential lots (see *Implementation Strategies* below for more information). In addition, implementing certain of the BMPs discussed above for on-site stormwater control, including trees and rain gardens would create both pervious areas and infiltration capabilities. Under the Zoning Resolution's new parking lot design standards, it is estimated that about 10% of the area of regulated parking lots will be pervious.

FIGURE 5.5 *Porous concrete* – Like porous asphalt, porous concrete is produced by substantially reducing the number of fines in the mix in order to establish voids for drainage. The pavement will support traffic and allow water to pass through to a gravel layer underneath. The strength of pervious concrete is about 85 percent of conventional concrete, making it suitable for sidewalks, driveways, alleys, parking lots and residential streets. In northern and mid-Atlantic climates, porous concrete should always be underlain by a stone subbase designed for stormwater management and should never be placed directly onto soil; *Source: Draft Pennsylvania Stormwater Management Manual. 2005*

FIGURE 5.6 *Porous bituminous asphalt* - consists of standard bituminous asphalt in which the fines have been screened and reduced, allowing water to pass through very small voids. Porous asphalt is suitable for use in any climate where standard asphalt is appropriate and its compressive strength is similar to conventional asphalt pavements; *Source: Draft Pennsylvania Stormwater Management Manual. 2005*

A second strategy for reducing imperviousness is the use of porous pavement for driveways, sidewalks, walkways, patios, parking lots, and playgrounds, among other uses. Porous paving, also known as permeable paving, allows the passage of water through voids within the pavement media. Porous paving materials include pervious concrete, porous asphalt, pervious interlocking concrete paving blocks, concrete grid pavers, perforated brick pavers, and compacted gravel

Porous pavement consists of a permeable surface underlain by a uniformly-graded stone bed with a void space of at least 40% which provides stormwater management. Stormwater drains through the surface, is temporarily held in the voids of the stone bed, and then slowly exfiltrates into the underlying, uncompacted soil substrate. The stone bed is designed with an overflow control structure so that during large storm events peak rates are controlled, and at no time does the water rise to the pavement level. A layer of nonwoven geotextile filter fabric separates the aggregate from the underlying soil, preventing the migration of fines into the bed.

EVALUATION OF MANAGEMENT STRATEGY

Keeping areas pervious allows stormwater to infiltrate, thus reducing stormwater runoff. It also provides attenuation of pollutant loading through the absorptive capacity of the soils. Porous pavement can also provide runoff volume and pollutant load reductions. Long-term studies show removal efficiencies of:

- 82-95% of sediments
- 65% total phosphorus
- 80-85% total nitrogen
- high removal rates are also reported for zinc, lead and chemical oxygen demand (COD) (Adams, 2003; USDOT, 2002; Stotz and Krauth, 1994).

FIGURE 5.7 ***Porous paver blocks*** - Porous paver blocks consist of interlocking units (often concrete) that provide some portion of surface area that may be filled with a pervious material such as gravel. These units are often very attractive and are especially well suited to plazas, patios, small parking areas, etc. The compressive strength of pavers varies depending on the product, but tends to be high (up to 8,000 psi); *Source: Draft Pennsylvania Stormwater Management Manual. 2005*

Porous pavements have not been found to effectively treat fuel leaks from automobiles.

Porous paving has other environmental benefits it can reduce thermal pollution; glare and automobile hydroplaning (skidding) accidents; pavement ice buildup; and tire noise (for asphaltic porous pavements). In playgrounds it also can reduce noise of bouncing balls. Porous pavement also benefits nearby trees which have greater access to water, since water infiltrates rather than running off.

Technical

A review of what is required or allowable within zoning districts such as maximum building coverage, FAR, open space ratio, driveways and parking areas was conducted. Based on this assessment, low density districts could most readily accommodate areas to be set aside as pervious.

While use of porous pavement cannot replace asphalt and concrete, there are many opportunities for its wider use in New York City. However, there are a number of technical issues to be addressed including maintenance issues, site and climate conditions, and determining the types of applications that would be most appropriate.

Maintenance

Porous pavements require regular maintenance to ensure that pavements remain free of fine materials which can clog the pores. Quarterly maintenance (four times per year) includes vacuum sweeping followed by high-pressure hosing. Potholes and cracks can be filled with patching mixes unless more than ten percent of the surface area needs repair. Spot-clogging may be fixed by drilling 1.3 centimeter (half-inch) holes through the porous pavement layer every few feet (USEPA, 1999). With the proper care, porous pavements can last 15-20 years or more with moderate to heavy use, equivalent to the lifetimes of most standard pavements. The property owner would be responsible for their ongoing maintenance; if not properly maintained they lose their effectiveness.

Site Conditions
As discussed above for BMPs, porous pavement which infiltrates stormwater requires soil types that drain well. However, porous pavement is typically underlain with a porous substrate to enhance infiltration and storage. In addition, as with any infiltration practice, depth to groundwater is an important factor that needs to be considered to avoid ponding and flooding.

Climate Conditions
As discussed above, the effectiveness of specific BMPs can be impacted by climate conditions including frost, snowfall and heavy, intense rainfall in a short period of time. The effectiveness of porous pavement may be limited in cold climate conditions. Besides limitations related to infiltration and frozen ground cover, sand or salts to deice pavement clog the porous pavement. However, new technologies for porous materials are in development and should undergo pilot studies to determine effectiveness in New York City.

Appropriate Applications
Porous pavement is well suited for parking lots, driveways, walking paths, sidewalks, playgrounds, plazas, tennis courts, and other similar uses. While it has been shown that porous pavements are more efficient than conventional materials at filtering out pollutants, it is recommended that they not be applied in heavy industrial use areas. Also, they may not meet specifications for traffic-bearing roadways. Table 5.9 below illustrates areas in New York City that would be optimal for porous pavement application and others where it would not be recommended.

TABLE 5.9. Appropriate Locations For Application Of Porous Pavement

Porous Pavement *Not* Recommended for Use on:	Porous Pavement Recommended for Use on:
Commercial nurseries	On-street parking lanes in residential neighborhoods
Auto recycle facilities	Sidewalks in residential neighborhoods
Vehicle service and maintenance areas	Patios and plazas
Vehicle and equipment washing/steam cleaning facilities	Residential driveways
Fueling stations	Residential and commercial parking lots
Industrial parking lots	Playing, basketball fields
Marinas (service and maintenance)	Parks and bicycle lanes
Hazardous material generators (if the containers are exposed to rainfall)	Cemeteries
Outdoor loading and unloading facilities	
Public works storage areas	

Cost
Materials costs are often higher for porous pavement applications that require underlying stone bed than for conventional pavement, but these added expenses can be somewhat offset when soil is favorable by the need for less piping and other materials that would otherwise be required for traditional stormwater management practices.

Maintenance involves vacuum sweeping followed by high-pressure hosing to be performed four times per year. Annual maintenance costs are in the process of being developed by NYCDEP. Potholes and cracks may on occasion need to be filled with patching mixes unless more than 10 percent of the surface area needs repair.

Legal

The Building Code does contain specifications for porous pavement on parking lots. However, the Building Code and potentially the Sewer Code may need to be revised to better facilitate installation of porous pavement.

In addition, the Zoning Resolution currently provides density, bulk, and setback requirements for development within each zoning district which contain maximum building and other coverage requirements per lot. Although not all of the area of a parcel is accounted for by structures, driveways, and other impervious surfaces, there is no impervious surfaces requirement that restricts paving the entire lot. NYCDCP is addressing this through proposed text changes (see *Implementation Strategies* below).

RECOMMENDATION

It is recommended that the City further pursue and encourage the use of porous pavement and setting aside areas as pervious surfaces for appropriate applications. This would be done through the *Implementation Strategies* listed below. Many of these Implementation Strategies address the uncertainties discussed above under environmental, technical, cost, and legal issues.

IMPLEMENTATION STRATEGIES

Porous pavement technologies have not been widely used in New York City due to a lack of familiarity with the available technologies, maintenance issues, and costs, and existing regulations do not provide for their use. Pilot projects will be conducted to determine their effectiveness and address uncertainties due to conditions unique to New York City. Code changes may be required to promote both setting aside pervious areas and the use of pervious technologies and to define appropriate areas for their use. As discussed above under BMP Implementation Strategies, financial incentives may also be needed to facilitate their acceptance.

Pilot Projects

To address uncertainties related to costs, benefits, maintenance requirements, and site conditions, NYCDEP will pursue several pilot studies. In addition, New York City government can be a leader by example in pursuing these technologies and incorporate them into the design of City buildings and construction projects.

<u>Parking Lot Pilot Study</u>

As discussed above under on-site BMP Implementation Strategies, NYCDEP is proposing a pilot study to serve as a model for the new Zoning Resolution parking lot design requirements. This pilot study can also be used to test the effectiveness and maintenance requirements for porous pavement technologies.

Porous Pavement on NYCDEP Property
NYCDEP will install and monitor the effectiveness of porous pavement on several of its properties.

Schedule: Pilot study will be developed through a proposed contract that will implement CSO strategies. Pilot study to be initiated in Summer 2008. Monitoring will be performed over two years.

Cost: $442,000.

Potential Regulatory Code Changes

Zoning Resolution Pervious Area Requirements

NYCDCP is developing front yard landscaping requirements for low density zoning districts (R1-R5), which will ensure that a certain portion of the lot remains pervious. The proposal calls for planting a minimum percentage of the area of a front yard ranging from 20% for narrow lots (less than 20 feet), to 50% for lots 60 feet wide or more. The proposal would apply to new and existing residential developments. To be implemented, the standards require a zoning text change through a process similar to ULURP.

NYCDCP is also planning a citywide text change to require that new developments and enlargements provide street trees except for certain light and heavy industrial uses. This would also provide more permeability (see Off-Site BMPs below for more information on this proposal.)

Revising the Zoning Resolution to require more pervious areas would begin to change the surfaces of New York City, thereby reducing the environmental impacts of stormwater runoff. Such a requirement would have aesthetic benefits in addition to reductions in stormwater runoff.

Schedule: The proposed text amendment approval and public review process began on September 17, 2007 and involves the City Planning Commission, Community Boards, Borough Presidents, and City Council. If approved, the requirements would take effect on the date it is approved by the City Council.

Code Review

The Building Code includes some specifications for porous paving materials. Currently, the American Society for Testing and Materials (ASTM) is developing standards for pervious concrete and asphalt. Many municipalities have developed their own specifications for the application of porous paving materials.

It is recommended that additional standards and specifications be developed for New York City to allow porous paving in qualified areas. As discussed above under BMPs Implementation Strategies, the BMP manual that will be developed could address specifications for porous pavements.

Schedule: To be determined.

Cost: To be determined.

Management Strategy 3a3: Expand water conservation program to achieve a greater reduction in water use.

STRATEGY DESCRIPTION

The City uses 1.1 billion gallons of water each day. Water use and wastewater flows have consistently declined over the last decade (see Figure 5.10) due to enormous strides the City has made in water conservation. In the 1990s, the City spent $290 million for a toilet rebate program that provided incentives to all property owners to replace older toilets and shower heads with modern, more efficient models. The program achieved 70-90 MGD of water conservation savings.

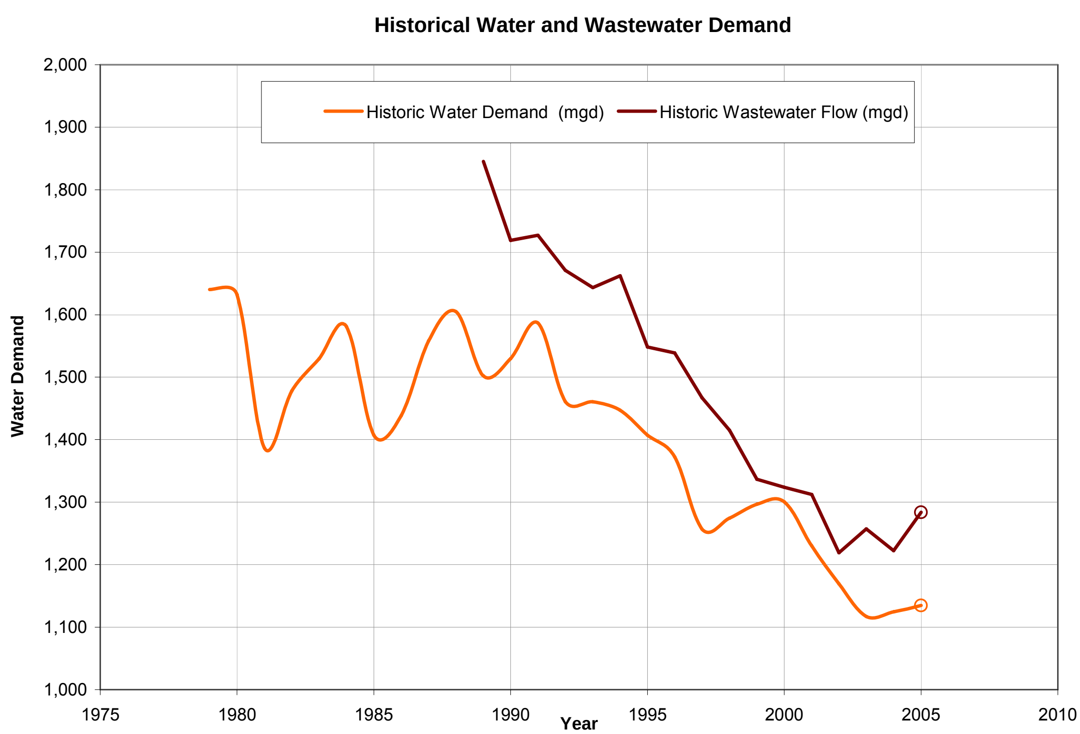


FIGURE 5.10 Historical water and wastewater demand; Source: NYCDEP

Starting in 2008, NYCDEP will launch additional rebate programs for toilets, urinals, and high-efficiency washing machines to lower water use in the City by 5%. This program will save approximately 60 MGD.

Water conservation not only reduces demands for potable water, but it also provides enormous benefits for reducing the flows to the wastewater treatment plants. As part of the Jamaica Bay planning effort, an assessment was performed to determine potential benefits from water conservation on reducing CSOs. By reducing sanitary flows, more room would be available at the plants to treat CSOs. This strategy examines the effects of the new 5% program. The effects of an additional 5%

water conservation savings within Jamaica Bay, for a total of 10% in water savings, was also analyzed.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Modeling, using INFOWORKS, was performed to estimate CSO reductions associated with 5 percent and 10 percent water conservation in Jamaica Bay.

Results of the modeling by sewersheds are shown on Table 5.10. Key findings are:

- The Coney Island WPCP drainage area has the largest reductions with 2.7% and 5.1% reductions in *untreated discharges to the Bay* of CSO, treated CSO, storm sewer, and direct runoff for the 5 and 10 percent water conservation scenarios, respectively. See On-Site BMPs (Management Strategy 3a1) above for a definition of *untreated discharges to the Bay.*

- Implementing the 5 and 10 percent water conservation scenarios in the 26th Ward Island WPCP drainage area would reduce *untreated discharges to the Bay* of CSO, treated CSO, storm sewer, and direct runoff by 1.7% and 3.3%, respectively.

- Water conservation programs in the Rockaway and Jamaica WPCP drainage areas would not result in significant reductions in *untreated discharges to the Bay* since both drainage areas are primarily separately sewered areas.

TABLE 5.10. Stormwater Benefits Of Water Conservation Savings By Drainage Area (Average Year 1988)

Condition	Baseline Conditions	10% Water Conservation	5% Water Conservation
Coney Island WPCP Drainage Area			
Reduction in dry weather flows in 2020 (MGD)	N.A.	9	4.5
Total CSO, treated CSO, storm sewer and Direct Discharge (MG)	455.5	432.4	443.3
Reduction with BMPs (MG/yr)	0.0	23.1	12.2
Reduction with BMPs (%)	0.0%	5.1%	2.7%
26th Ward WPCP Drainage Area			
Reduction in dry weather flows in 2020 (MGD)	N.A.	5.5	2.8
Total CSO, treated CSO, storm sewer, and Direct Discharge (MG)	822.4	795.1	808.8
Reduction with BMPs (MG/yr)	0.0	27.4	13.7
Reduction with BMPs (%)	0.0%	3.3%	1.7%

Technical

Water conservation is a proven program. However, it is more difficult to obtain conservation savings as higher goals for water savings are set (see *Costs* below).

Cost

The costs for the 60 MGD water conservation program are estimated to be $186 million over five years, amounting to $3.11/gallon of water savings. Additional conservation efforts would have higher costs of $10.35/gallon due to the increasing difficulty of identifying water saving opportunities.

Legal

There are no legal issues associated with the water conservation program.

RECOMMENDATION

It is recommended that the City further pursue and encourage water conservation. The current goal is to reduce water use by 5%. Once this level has been achieved, the City may pursue additional measures. The Implementation Strategies to achieve a 5% reduction are listed below.

IMPLEMENTATION STRATEGIES

Listed below are planned programs to achieve a 5%, or 60 MGD, reduction in citywide water use. In addition to these strategies, NYCDEP is planning to conduct a study of water conservation and stormwater rate structures to encourage water conservation (see BMP Implementation Strategies above).

Toilet, Urinal, and Clothes Washer Rebate Program

Preparations for a new series of conservation incentive programs are underway. An incentive program for toilets and possibly clothes washers for apartment building laundry rooms will be opened for high-density buildings currently on flat-rate billing during the first quarter of 2008. The program is scheduled to open citywide and be expanded to include urinals in 2009. The program is expected to result in water savings of 50 MGD.

Schedule: Five years - 2008-2012.

Cost: $154 million. Partially funded.

Fixture Replacements in Public Buildings

NYCDEP will be working with other city agencies to replace plumbing fixtures in public buildings. The program is expected to result in water savings of 5 MGD.

Schedule: Five years - 2008-2012.

Cost: $16 million. Partially funded.

Performance-Based Efficiency Projects to be Issued

Water efficiency opportunities exist well beyond fixture replacements. Replacement of once-through water-cooled equipment, steam condensate reuse, water reuse and irrigation-based measures are only a few examples. NYCDEP will be pursuing cost-sharing opportunities with the private sector for incentives for these water efficiency measures. The program is expected to result in water savings of 5 MGD.

Schedule: Five years - 2008-2012. NYCDEP issued a Request for Expressions of Interest to potential applicants as a first step in the process in June 2007.

Cost: $16 million. Funding not yet available.

OBJECTIVE 3B: PROMOTE THE USE OF OFF-SITE STORMWATER BEST MANAGEMENT PRACTICES

Current Programs

Off-site BMPs involve the capture and infiltration of runoff from roadways and sidewalks and use of vacant parcels and parks for stormwater management. With respect to roadways and streets, NYCDDC works closely with the NYCDOT and NYCDEP to construct or reconstruct streets and sewer lines within the street right-of-way. NYCDDC recently introduced sustainable design standards, entitled *High Performance Infrastructure Guidelines* (NYCDDC, 1999) which include stormwater BMPs for New York City infrastructure. This guidance document provides a road map for incorporating various types of BMPs into the City's right-of-way infrastructure capital program, including vegetated filter and buffer strips, catch basin inserts, detention structures, infiltration structures, bioretention and constructed wetlands among others. In addition, the NYCDPR will be responsible for planting and monitoring over one million street trees under the Mayor's PLANYC 2030 program.

Open space also provides opportunities for stormwater capture. The Council on the Environment of New York City (CENYC) utilizes stormwater BMPs for their citywide community gardens projects at certain sites. For example, using rain barrels and cisterns to retain stormwater during high rainfall events reduces runoff and provides water storage for use in community gardens during periods of water scarcity.

The Mayor's BMP Task Force is meeting regularly with NYCDEP, NYCDDC, and NYCDPR to coordinate the implementation of many of the strategies discussed in this section. Some of these strategies are highlighted in PLANYC 2030.

Three management strategies are discussed below:

- Promote the use of BMPs on highway rights-of-way and adjacent lands, streets, and sidewalks.
- Promote the use of vacant public lands for their potential conversion to stormwater parks.
- Promote the use of existing open space (such as parks, plazas, community gardens, etc.) for their potential to accommodate stormwater BMPs.

Management Strategy 3b1: Promote the use of BMPs along streets and sidewalks and highway rights-of-way.

STRATEGY DESCRIPTION

Impervious surface analyses of the watershed estimate that approximately 30% of the Jamaica Bay watershed is covered by streets and sidewalks alone. Locating off-site BMPs along roadways would help to capture runoff that contains high levels of pollutants that collect on the City's streets and sidewalks.

Several major and intermediate roadways and transportation corridors intersect the Jamaica Bay watershed throughout Brooklyn and Queens. The volume of stormwater runoff and pollutant loading from these surfaces could be reduced through the integration of stormwater BMPs. Specific BMPs suitable for roadways and sidewalks include use of infiltration swales in medians and along curbs, infiltration basins within streets and sidewalks, adjacent land areas for detention/retention or constructed wetlands, increased street-side planting, and enhanced tree pits which are larger than traditional tree pits and designed to store stormwater.

With these types of BMPs, there is a combined opportunity to increase habitat, green spaces, and tree plantings throughout the watershed. Vegetation and trees provide a myriad of ecological benefits, including shade, oxygen generation, temperature regulation, habitat for birds and insects, aesthetic benefits, and carbon sequestration. The key is to integrate these concepts into roadway construction, reconstruction, retrofit, and maintenance projects early in the design process.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Approach

Modeling was performed to estimate the stormwater runoff and CSO reductions associated with various stormwater BMPs applied to streets and sidewalks. To estimate the effects on individual streets and sidewalks, two street and sidewalk prototypes were developed based on street width since this is a major determinant of BMP type and size that can be feasibly constructed within a street right-of-way. For each street and sidewalk prototype, two sets of BMP applications were developed to address "low capture" and "high capture" measures that could be implemented as part of proposed infrastructure projects. The two applications provide a range of stormwater benefits and costs as shown on Table 5.11.

TABLE 5.11. Stormwater Capture Benefits Street And Sidewalk Prototype		
Land Use Prototypes	**Low Capture**	**High Capture**
STREETS AND SIDEWALK 25 TO 65 feet wide; 500 feet long		
Example BMPs	Sidewalk Reservoir (580 sf, 22 inch gravel)	Sidewalk Reservoir (1160 sf, 22 inch gravel)
	Bioinfiltration (1825 sf)/trees	Bioinfiltration (3650 sf)/trees
BMP Capture Volume (gal)	6,807	13,614
Average rainfall event 0.4 inches	100%	100%
90%ile rainfall 1.2 inches	52%	100%
100%ile rainfall 2.5 inches	25%	50%
STREETS AND SIDEWALK 65 feet wide and greater; 500 feet long		
Example BMPs	Sidewalk Reservoir (750 sf, 22) inch gravel)	Sidewalk Reservoir (1500 sf, 22 inch gravel)
	Bioinfiltration (2604 sf)/trees	Bioinfiltration (5208 sf)/trees
BMP Capture Volume (gal)	9,724	19,448
Average rainfall event 0.4 inches	100%	100%
90%ile rainfall 1.2 inches	52%	100%
100%ile rainfall 2.5 inches	25%	50%

Once it was determined what was achievable on an individual street level, a ten-year snapshot of road reconstruction projects based on NYCDDC's capital improvement program was used to determine what would be achievable at a watershed level. A total volume of runoff capture was calculated for each of the two application scenarios (low and high capture) and the accumulated annual storage volumes were modeled using the INFOWORKS model to calculate the decrease in annual CSO volumes and overflow events for each WPCP drainage area.

Results

Results of the modeling for the ten year period for streets and sidewalks reconstruction are shown on Table 5.12 for individual drainage areas. Key findings are:

- Across the watershed, implementation of BMPs would reduce *untreated discharges to the Bay* including CSO, treated CSO, storm sewer and direct runoff of 3.4% (low capture) to 5.8% (high capture). See On-Site BMPs (Management Strategy 3a1) above for a definition of *untreated discharges to the Bay.*

TABLE 5.12. Benefits Of Street And Sidewalk BMPs By Drainage Area			
Condition	**Baseline Conditions**	**Streets & Sidewalks Low**	**Streets & Sidewalks High**
Coney Island WPCP Drainage Area			
Portion of Drainage Area Impacted (%)	N.A.	0.6%	0.6%
Total BMP Storage Volume (MG)	N.A.	1.3	2.6
Total CSO, treated CSO, storm sewer, and Direct Runoff (MG)	455.5	433.5	404.1
Reduction with BMPs (MG/yr)	0.0	22.0	51.4
Reduction with BMPs (%)		4.8%	11.3%
26th Ward WPCP Drainage Area			
Portion of Drainage Area Impacted (%)	N.A.	1.1%	1.1%
Total BMP Storage Volume (MG)	N.A.	1.1	2.2
Total CSO, treated CSO, storm sewer, and Direct Runoff (MG)	822.4	801.8	779.7
Reduction with BMPs (MG/yr)	0.0	20.6	42.7
Reduction with BMPs (%)		2.5%	5.2%
Jamaica WPCP Drainage Area			
Portion of Drainage Area Impacted (%)	N.A.	2.0%	2.0%
Total BMP Storage Volume (MG)	N.A.	9.1	18.2
Total CSO, treated CSO, storm sewer, and Direct Runoff (MG)	11,947.3	11,539.4	11,246.8
Reduction with BMPs (MG/yr)	0.0	407.9	700.6
Reduction with BMPs (%)		3.4%	5.9%
Rockaway WPCP Drainage Area			
Portion of Drainage Area Impacted (%)	N.A.	2.5%	2.5%
Total BMP Storage Volume (MG)	N.A.	2.4	4.8
Total storm sewer and Direct (surface) Runoff (MG)	2,605.6	2,516.5	2,486.7
Reduction with BMPs (MG/yr)	0.0	89.1	118.9
Reduction with BMPs (%)		3.4%	4.6%
Jamaica Bay Watershed Totals			
Portion of Drainage Area Impacted (%)	N.A.	1.6%	1.6%
Total BMP Storage Volume (MG)	N.A.	13.9	27.8
Total CSO, treated CSO, storm sewer, and Direct Runoff (MG)	15,830.9	15,291.2	14,917.2
Reduction with BMPs (MG/yr) (of untreated discharges)	0.0	539.6	913.6
Reduction with BMPs (%) (of untreated discharges)		3.4%	5.8%

Similar to on-site BMPs, off-site BMPs provide significant pollutant removal benefits in addition to reductions of untreated discharges. BMPs along streets and sidewalks and highway right-of-ways can also be instrumental in the capture of what is commonly referred to as the "first flush," highly concentrated pollutant loading that occurs during the early stages of a storm due to the washing effect of runoff on pollutants that have accumulated on impervious areas. Generally, it is the stormwater runoff draining the streets and sidewalks that contains the highest pollutant load, carrying automobile byproducts, road salt and sediment, and urban litter and debris.

Trees provide multiple pathways that alter the patterns of stormwater runoff, through the processes of rainfall interception on the leaves, trunk and branches, and the combined processes of runoff attenuation, infiltration, and vegetative uptake. Thus, an increase in vegetation and the number of street trees in the watershed would positively influence runoff processes by decreasing the volume and pollutant load of stormwater runoff entering the storm drain or combined sewer system.

Technical

As with on-site BMPs, there are a number of challenges to ensuring more widespread implementation of off-site BMPs, including maintenance, site conditions, and climate. These challenges are generally described under the summary of technical issues associated with on-site BMPs (see Management Strategy 3a1).

Costs

According to NYCDPR, Mayor Bloomberg has dedicated $391 million over ten years for greening initiatives (*e.g.*, planting street trees in all possible locations, creating 800 new greenstreets, and reforesting 2,000 acres of parkland), with the first year's funding becoming available starting July 1, 2007. In addition, the Mayor has funded an additional 156 staff and $4.6 million in new forestry and horticulture maintenance funds to support these greening efforts.

Table 5.13 below illustrates the average costs associated with other street and sidewalk BMPs including bioinfiltration and sidewalk reservoirs.

TABLE 5.13. Stormwater Capture Benefits Street And Sidewalk Prototype

Land Use Prototypes	Low Capture	High Capture
STREETS AND SIDEWALK 25 TO 65 feet wide; 500 feet long		
Example BMPs	Sidewalk Reservoir (580 sf, 22 inch gravel)	Sidewalk Reservoir (1160 sf, 22 inch gravel)
	Bioinfiltration (1825 sf)/trees	Bioinfiltration (3650 sf)/trees
BMP Capture Volume (gal)	6,807	13,614
Average BMP Scenario Cost	$102,900	$183,000
STREETS AND SIDEWALK 65 feet wide and greater; 500 feet long		
Example BMPs	Sidewalk Reservoir (750 sf, 22 inch gravel)	Sidewalk Reservoir (1500 sf, 22 inch gravel)
	Bioinfiltration (2604 sf)/trees	Bioinfiltration (5208 sf)/trees
BMP Capture Volume (gal)	9,724	19,448
Average BMP Scenario Cost	$130,200	$232,400

Legal

As with on-site BMPS, the Sewer Codes and potentially other codes may need to be revised to better facilitate installation of BMPs on a wider scale.

RECOMMENDATION

It is recommended that the City further pursue and encourage the use of BMPs on streets and sidewalks and highway rights-of-way in the Jamaica Bay watershed. This would be done through the *Implementation Strategies* listed below. Many of these Implementation Strategies address the uncertainties discussed above under environmental, technical, cost, and legal issues.

IMPLEMENTATION STRATEGIES

The integration of stormwater BMPs into the City's roadways, streets and sidewalks will occur over time as the City replaces and reconstructs its infrastructure. Developing more widespread use will require pilot projects and demonstration projects to determine the effectiveness of some of the measures and conditions unique to New York City along with monitoring programs to track the effectiveness over time. These Implementation Strategies are discussed below. See also on-site BMPs above for information about possible Sewer Code revisions and a companion BMP Design Manual that would also be needed to further encourage the installation of BMPs along streets and sidewalks.

In addition to the initiatives outlined below, the NYCDOT will be embarking on a *Streetscape NYC: Materials and Designs for the 21st Century* project to review and update street materials being used in New York City to include more sustainable designs. They will be leading an interagency task force to review performance and costs and develop recommendations.

Pilot Projects and Demonstration Projects

Belt Parkway Bridges Demonstration Project

NYCDEP and NYCDOT in consultation with NYCDPR and the NPS have developed designs for stormwater BMPs for the reconstruction of the Fresh Creek, Paerdegat and Rockaway Bridges along the Belt Parkway. This roadway improvement project provides an opportunity to incorporate stormwater BMPs that concurrently treat roadway runoff, attenuate direct discharges and provide freshwater habitat in the watershed. These initial bridges and their BMPs will serve as demonstration projects that could be expanded to other bridges.

FIGURE 5.9 Location of BMPs for the reconstruction of Rockaway and Paerdegat Bridges adjacent to the Belt Parkway; Source: NYCDEP

Preliminary concepts including linear bioinfiltration and bioswales have already been created, and are in the process of being reviewed for two of the three bridge crossings, Paerdegat and Rockaway (see Figure 5.9 for locations of BMPs). Drainage areas were determined for each site location and design option. Each site location includes unique hydraulic conditions that needed to be considered during the design process related to slopes, groundwater, overflow and potential for erosion.

Schedule: Final designs to be completed in three months.

Cost: The BMP designs for both bridges cost $95,000. Construction of BMPs for the Rockaway Bridge will cost $1,200,000. The total BMP construction cost for the Paerdegat Bridge has yet to be determined.

Vegetated swale installed in road median;
Source: USDA Natural Resources
Conservation Service

Streetside Infiltration Swales Pilot Study

NYCDEP, working with the Gaia Institute, will pilot test different infiltration and detention BMPs along streets and sidewalks within the Jamaica Bay watershed. This pilot study is designed to demonstrate the cost-effectiveness of streetside infiltration swales for a four lane, 500 linear foot street. Three swales would be installed along the roadway.

Schedule: Pilot study to begin in late 2007. Nine months to select site, design and install. Monitoring over a three year period to evaluate the effectiveness over time and under different environmental conditions.

Cost: $510,000 for design and construction. Additional funding will be provided for monitoring and reporting over three years.

Constructed Wetlands Pilot Study

NYCDEP, working with the Gaia Institute, will pilot test a constructed wetland to detain stormwater runoff from a roadway. The constructed wetland would be designed to capture runoff from 1.5 acres of impervious surface.

Schedule: Pilot study to begin in late 2007. Nine months to select site, design and install. Monitoring will be performed over a three year period to evaluate the effectiveness over time and under different environmental conditions.

Cost: $510,000 for design and construction. Additional funding will be provided for monitoring and reporting over three years.

Tree Pit Pilot Study

A pilot test to study the effectiveness of enhanced tree pits will be performed. Five enhanced tree pits would be designed to incorporate infiltration, retention and water harvesting practices as well as larger spaces for trees (4 feet wide by 20 feet long) than traditional tree pits (4 feet by 4 feet) (see Figure 5.10). The enhanced tree pits will be installed along a street. The enhanced tree pits would be designed to store stormwater in a subsurface cistern that can hold approximately 1,200 gallons of stormwater. Capture rates for an enhanced tree pit over a 24-hour period could be as high as 7,800 gallons. Water captured in the cistern could be stored and released slowly via gravity feed to a subsurface irrigation system. This pilot project will monitor additional benefits potentially provided by enhanced tree pits including improved chances for tree survival given a larger pit size and ability of the cistern to irrigate plantings during periods of reduced precipitation. The pilot projects could also test the use of "structural soils." These manmade "soils" consist of angular stone with some clayey topsoil and organic matter mixed in to increase the rooting zone area beneath pavements and thereby improve tree longevity.

Schedule: Pilot to begin in late 2007. Nine months to select site, design and install. Monitoring over a three year period to evaluate the effectiveness over time and under different environmental conditions.

Cost: $112,500 for five enhanced tree pit retrofits. Additional funding will be provided for monitoring and reporting over three years.

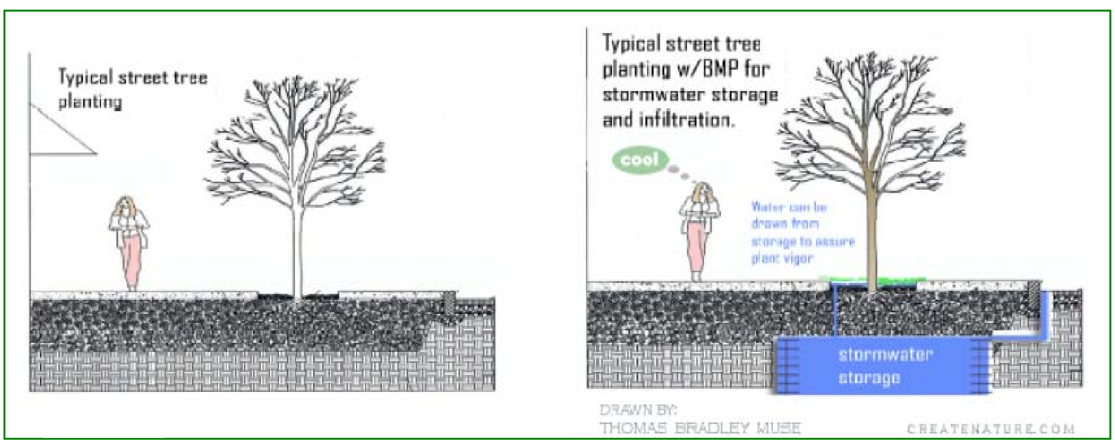


FIGURE 5.10 Comparison of typical street tree planting and street tree planting with BMP for stormwater storage and infiltration; Source: Gaia Institute

Greening Initiatives

PLANYC 2030 Street Tree Plantings

As discussed above, PLANYC 2030 has committed to planting one million street trees throughout the City. According to the NYCDPR 2000 Tree Census Survey, there are 74,138 street trees within the Brooklyn portion of the watershed and 105,931 street trees within the Queens portion of the watershed (Figure 5.11 provides street tree stocking levels within the Jamaica Bay watershed).. The Mayor's PLANYC 2030 includes an initiative to green the cityscape and specifically to increase the number of street trees in New York City by filling every available street tree opportunity in New York City. Current plantings citywide fill 74% of the existing space for street trees. The Mayor's goal is to raise the street stocking level to 100% as part of the overall goal of planting one million more trees by 2030. To achieve this, the City will plant approximately 23,000 additional trees annually citywide.

Schedule: 23,000 additional trees to be planted annually citywide.

Cost: $391 million including Greenstreets projects (see discussion below) over the next ten years.

PLANYC 2030 Greenstreets Initiative

PLANYC 2030 includes a strategy to undertake 40 new Greenstreets projects every planting season, bringing the total number of Greenstreets projects to 3,000 by 2017. The Jamaica Bay watershed is targeted for 14 new Greenstreets to be planted in Fall 2007 (see Figure 5.12). NYCDPR is interested in working with NYCDEP and NYCDDC to ensure that Greenstreets capture stormwater flows to the extent feasible.

Schedule: Fourteen new Greenstreets to be planted in the Jamaica Bay watershed in Fall 2007; 3,000 new Greenstreets citywide by 2017.

Cost: See Street Tree Plantings above.

East New York Community Forestry Management Plan

NYCDPR, together with community residents, developed a strategy for increasing the tree cover in East New York. The overall vision of the East New York Community Forestry Management Plan is to increase the health and extent of East New York's urban forest in order to improve the health and well-being of their residents. The primary goal of the plan is to increase the street tree stocking level of the East New York community from 52 to 100 percent in the next ten years. In addition, the plan seeks to establish a Friends of Trees Group. East New York was one of five City neighborhoods selected for the Trees for Public Health program based on two variables: street tree stocking level; and asthma hospitalization rates among children since trees are noted for their potential to improve air quality.

Cost: Implementation will be funded through PLANYC 2030 Street Tree Plantings (see above). An additional $425,000 in outside funding is needed each year to protect at least half of all new trees planted with tree guards (Figure 5.12).

Schedule: NYCDPR will plant 850 trees in East New York (Community Board 5) each year for the next ten years.

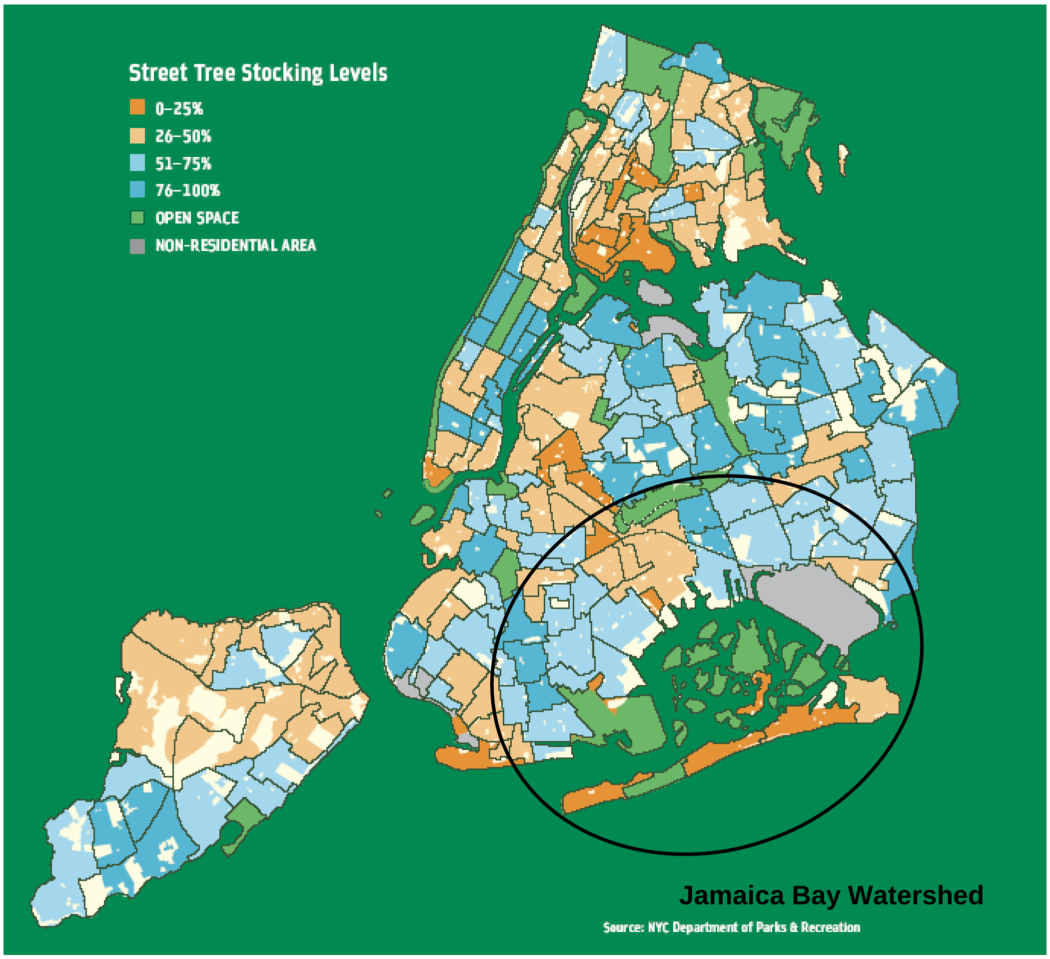


FIGURE 5.11 Street stocking levels in the Jamaica Bay Watershed;
Source: NYCDPR

Regulatory and Design Code Changes

Zoning Resolution Street Trees Requirements

NYCDCP is developing citywide street tree requirements for all zoning districts except for certain light and heavy industrial uses, to ensure that new developments and enlargements provide street trees (above a required baseline) and, as a result, increase permeability in the public right-of-way. The proposal calls for NYCDPR standards for tree pit design to be applied. To be implemented, the standards require a zoning text change through a process similar to ULURP.

Revising the Zoning Resolution to require more street trees would begin to change the surfaces of New York City, thereby reducing the environmental impacts of stormwater runoff. Such a requirement would have aesthetic benefits in addition to reductions in stormwater runoff.

Schedule: The proposed text amendment approval and public review process began on September 17, 2007 and involves the City Planning Commission, Community Boards, Borough Presidents, and City Council. If approved, the requirements would take effect on the date the proposed amendment is approved by the City Council.

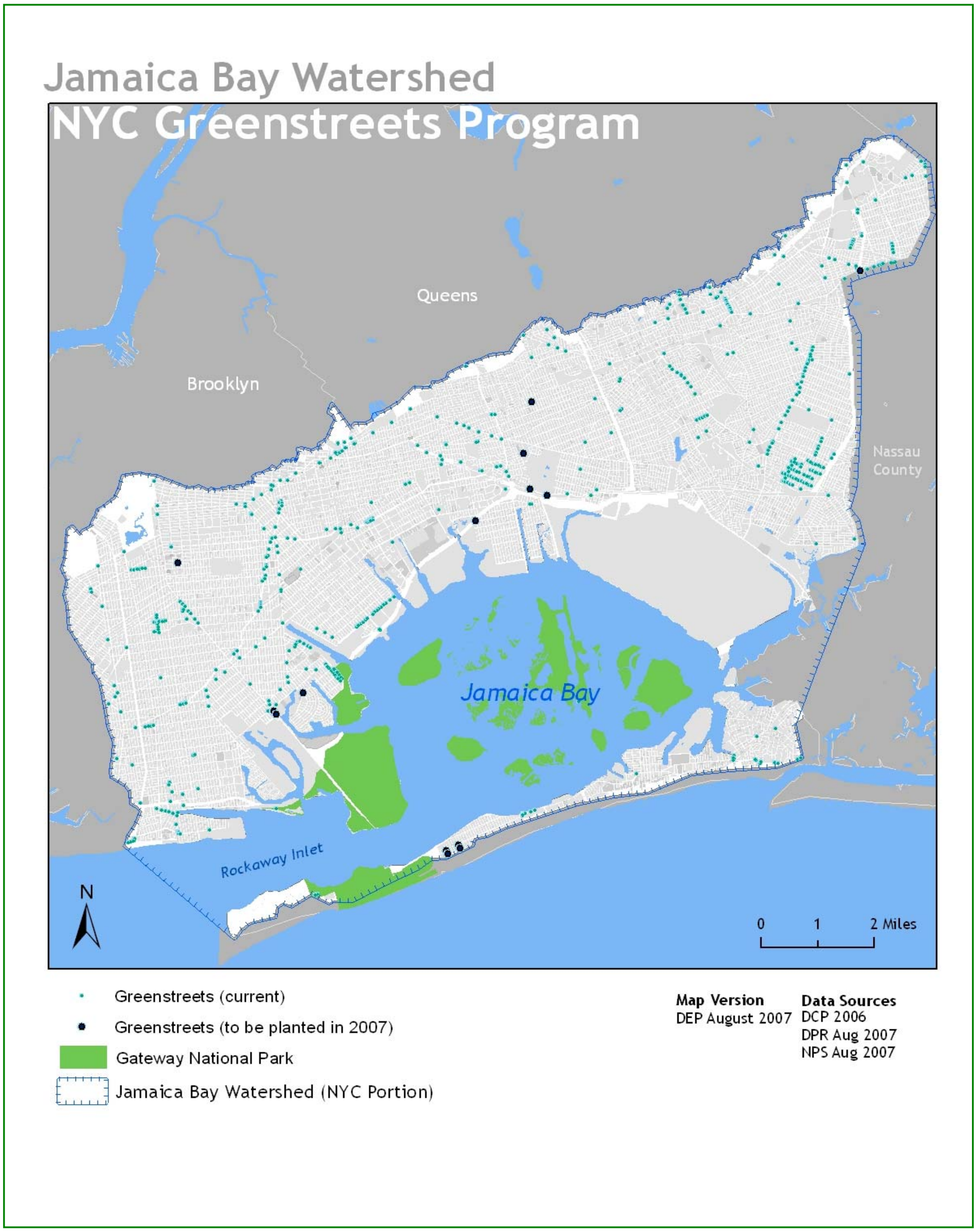


FIGURE 5.12 Jamaica Bay Watershed Greenstreets Program; Source: NYCDEP

Management Strategy 3b3: Promote the use of vacant public lands for their potential conversion to stormwater parks.

STRATEGY DESCRIPTION

Constructing off-site BMPs on existing publicly-owned vacant parcels and open spaces would allow BMPs to detain or infiltrate larger stormwater volumes from multiple adjacent parcels. This strategy would provide stormwater runoff benefits and establish "pocket parks" within the watershed. The design of these stormwater facilities can incorporate palustrine woodlands, gardens, vegetated swales, bio-infiltration areas, constructed wetlands, detention/retention ponds, and other stormwater capture and treatment features designed to attenuate urban stormwater runoff as well as provide some level of urban habitat and/or public use. The greatest opportunities lie in capturing runoff from adjacent developed lots by disconnecting roof leaders and rerouting the runoff from impervious surfaces into the off-site stormwater facility.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

Approach
Modeling was performed to estimate the potential for publicly-owned vacant parcels to be used to capture and infiltrate stormwater runoff from a specified area surrounding the parcel. An inventory of publicly-owned vacant parcels was completed to identify vacant parcels that could be available for use as "stormwater parks." Recognizing that small parcels would not be able to store sufficient volumes of runoff, only vacant, city-owned parcels or adjacent parcels totaling 5,000 square feet (0.11 acres) or greater were selected.

TABLE 5.14 Runoff And Capture Volumes	
RUNOFF STORAGE POTENTIAL	
Lot size:	10,000 sq ft
Usable area:	80%
Usable area:	8,000 sq ft
Average storage depth:	2 ft
Average storage volume:	16,000 cu ft
Average storage volume:	120,000 gallons
AVERAGE RUNOFF PER BLOCK	
Average block area:	150,000 sq ft
Assume 90% impervious area	
2.5 inch event:	281,125 cu ft <-~50% runoff captured
1.2 inch event:	13,500 cu ft <-all runoff captured
0.4 inch event	4,500 cu ft <-all runoff captured

The results from the above analysis illustrated that 607 vacant public sites totaling 306 acres could potentially be used to implement public stormwater parks. These sites were then used to model the potential effects of constructing BMPs such as constructed wetlands and detention ponds. Table 5.14 presents the information used for runoff and capture volumes for a prototypical lot size of 10,000 square feet. In the model, these volumes were scaled based on the actual size of the lot in which BMPs were applied. (The determination of existing public vacant lots for potential use as "stormwater parks" consisted of a GIS desktop analysis only; the data used were not field verified to determine whether the lots identified remain vacant and publicly-owned at the time of modeling or publication of this report.)

RESULTS

The results of the modeling for constructing BMPs on vacant parcels for individual drainage areas are shown on Table 5.15. Key findings are:

- Installing BMPs on 306 acres of vacant land across the Jamaica Bay watershed would reduce *untreated discharges to the Bay* including CSO, treated CSO, storm sewer, and direct runoff by 6.8%. See On-Site BMPs (Management Strategy 3a1) above for a definition of *untreated discharges to the Bay.*

TABLE 5.15. Benefits Of Vacant Parcel BMPs By Drainage Area

Condition	Baseline Conditions	Vacant Parcels – Off-site Scenario
Coney Island WPCP Drainage Area		
Portion of Drainage Area Impacted (%)	N.A.	0.3%
Total BMP Storage Volume (MG)	N.A.	16.6
Total CSO, treated CSO, storm sewer and Direct Runoff (MG)	455.5	443.1
Reduction with BMPs (MG/yr)	0.0	12.4
Reduction with BMPs (%)		2.7%
26th Ward WPCP Drainage Area		
Portion of Drainage Area Impacted (%)	N.A.	1.3%
Total BMP Storage Volume (MG)	N.A.	40.1
Total volume CSO, treated CSO, Direct Runoff (MG)	822.4	716.4
Reduction with BMPs (MG/yr)	0.0	106.1
Reduction with BMPs (%)		12.9%
Jamaica WPCP Drainage Area		
Portion of Drainage Area Impacted (%)	N.A.	0.3%
Total BMP Storage Volume (MG)	N.A.	48.1
Total CSO, storm sewer and Direct (surface) Runoff (MG)	11,947.3	11,258.4
Reduction with BMPs (MG/yr)	0.0	689.0
Reduction with BMPs (%)		5.8%
Rockaway WPCP Drainage Area		
Portion of Drainage Area Impacted (%)	N.A.	2.8%
Total BMP Storage Volume (MG)	N.A.	82.7
Total CSO, storm sewer and Direct (surface) Runoff (MG)	2,605.6	2,330.6
Reduction with BMPs (MG/yr)	0.0	275.0
Reduction with BMPs (%)		10.6%

TABLE 5.15. Benefits Of Vacant Parcel BMPs By Drainage Area		
Condition	**Baseline Conditions**	**Vacant Parcels – Off-site Scenario**
Jamaica Bay Watershed Totals		
Portion of Drainage Area Impacted (%)	N.A.	0.7%
Total BMP Storage Volume (MG)	N.A.	187.5
Total CSO, treated CSO, storm sewer and Direct (surface) Runoff (MG)	15,830.9	14,748.5
Reduction with BMPs (MG/yr)	0.0	1,082.4
Reduction with BMPs (%)		6.8%

Technical

Utilizing vacant parcels to construct BMPs designed to capture and infiltrate runoff presents similar maintenance issues as other BMPs previously described. Capture of roof runoff from adjacent parcels would require installing a "feeder pipe" from the roof leaders of each house to direct flow into stormwater parcel and could present potential conflicts with existing utilities or neighboring property uses. Finally, ponded water may be considered a health hazard that may require use of facilities that encourage infiltration or use sub-surface storage.

Cost

The cost of achieving the stormwater capture benefits above and installing BMPs on 607 vacant public sites within the Jamaica Bay watershed has not been estimated. It would depend on site specific conditions.

Legal

The Sewer Codes may need to be revised to better facilitate installation of off-site BMPs on a wider scale (see *Implementation Strategies* above for on-site BMPs). Currently, NYCDEP requires on-site detention storage when the capacity of the sewer is not adequate. However, the use of infiltration and retention measures is not typically encouraged under the current Administrative Codes. In addition, the Sewer Code does not permit stormwater to flow across property boundaries.

RECOMMENDATIONS

It is recommended that the City further pursue and encourage the use of vacant lots for off-site stormwater BMPs (stormwater parks) in the Jamaica Bay watershed. This would be done through the *Implementation Strategies* listed below. These Implementation Strategies address some of the uncertainties discussed above under environmental, technical, cost, and legal issues.

IMPLEMENTATION STRATEGIES

The development of stormwater parks will also require pilot projects and demonstration projects to determine the effectiveness of some of the measures and conditions unique to the drainage characteristics of the study area and the impacts on the existing sewer system. Similar to the other BMPs to be piloted, monitoring programs would be implemented to track the effectiveness related to stormwater runoff reductions over time as well as additional benefits provided such as opportunities for multi-use, pocket parks, green spaces, and urban habitat. These Implementation Strategies are further discussed below. See also on-site BMPs above for information about Sewer Code revisions and the companion BMP Design Manual that would be needed to further encourage the installation of BMPs on publicly-owned vacant parcels.

Pilot Projects and Demonstration Projects

Vacant Parcels Pilot Study

NYCDEP, working with the Gaia Institute, will implement a pilot project for a constructed wetland on a publicly-owned vacant parcel to capture runoff from a roadway (see the "Streetside Infiltration Swales Pilot Study" described above). The pilot project will be used to demonstrate the costs and benefits of BMP installation on publicly-owned vacant parcels. Based on these results, additional publicly-owned vacant parcels that show the most promise to reduce stormwater runoff entering the combined sewer system may be identified for future installation of BMPs. The inventory of city-owned vacant properties in the Jamaica Bay watershed, completed for the modeling exercise described above, and the sites identified for land acquisition in Chapter 4, *Ecological Restoration,* can be used to select parcels for the development of future stormwater park pilot projects. In addition, abandoned railroad corridors may provide a potential opportunity for implementing a BMP pilot.

Schedule: To be determined based on results of Streetside Infiltration Swales Pilot Study.

Cost: To be determined based on results of Streetside Infiltration Swales Pilot Study.

Management Strategy 3b4: Promote the use of existing open space (such as parks, plazas, community gardens, etc.) for their potential to accommodate stormwater BMPs.

STRATEGY DESCRIPTION

Existing open space can offer additional opportunities to attenuate, store, and infiltrate stormwater runoff in the Jamaica Bay watershed. Existing landscaped areas can be retrofitted to accommodate stormwater detention, retention, and infiltration capabilities, including bioretention, vegetated swales, rain gardens, etc., while improving the ecology of these same areas. An ancillary benefit associated with BMPs in active and passive open spaces is the educational information provided to park and open space users. Opportunities to provide interpretative or descriptive information about stormwater runoff and the benefits of BMPs for the City's surrounding waterbodies may increase awareness and encourage BMPs on private properties.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

While the environmental impacts of applying BMPs to existing open space within the Jamaica Bay watershed were not modeled, the information developed for the analysis of vacant parcels could be directly applied to existing open space.

Technical

Fencing may be needed to prohibit access to retention ponds or constructed wetlands and swales may need to be clearly marked to prevent accidents and injuries.

Cost

See individual *Implementation Strategies* below for cost information.

Legal

As with on-site BMPS, the Sewer Codes may need to be revised and the BMP Design Manual will be developed to facilitate installation of BMPs on a wider scale.

RECOMMENDATION

It is recommended that the City further pursue and encourage the evaluation of existing publicly-owned open space for off-site stormwater BMPs in the Jamaica Bay watershed. This would be done through the *Implementation Strategies* listed below.

IMPLEMENTATION STRATEGIES

<u>Baisley Pond Park Project</u>

Baisley Pond is a 30-acre pond within the 110-acre Baisley Pond Park, located north of the Belt Parkway and west of Baisley Boulevard in Queens (Figure 5.13). The neighborhood directly adjacent to the eastern side of Baisley Pond experiences periodic flooding due to the absence of storm sewers. NYCDEP has developed a plan to discharge the stormwater from this neighborhood into Baisley Pond. The project will involve connecting traditional sewers within the neighborhood to a non-traditional stilling basin to reduce the water's velocity and allow the release of suspended sediment to the bottom of the basin where it will be periodically removed by NYCDEP. The water will then continue on its normal path to Jamaica Bay. To increase the pond's filtering abilities, the outlet will be planted with vegetation that can further remove stormwater pollutants as well as improve the pond aesthetics.

FIGURE 5.13 Baisley Pond Project area map
Source: NYCDEP

Schedule: Since the Baisley Pond stormwater upgrade will require street reconstruction, this project will be constructed by NYCDDC in coordination with NYCDOT and is slated to begin construction in 2010.

Cost: The estimated cost of constructing the project is $3 million to $4 million dollars.

Springfield Park Project

NYCDEP is currently designing a project to implement non-traditional stormwater management into Springfield Gardens, which drains in Springfield Lake, located in Springfield Park in Southeast Queens just north of JFK Airport (Figure 5.14). This area has recurrent flooding from insufficient storm sewers and poor roadway conditions.

To alleviate the community's flooding issues and improve water quality of Springfield Lake, new storm and sanitary sewers are proposed for the neighborhood south of South Conduit Avenue, west of Springfield Boulevard, and north of 149th Avenue. The current design moves stormwater through a freshwater wetland, a tidal wetland with a low marsh and elevated wooded buffer, and a stream with a wetland buffer on its way to Jamaica Bay. The construction of fresh water and tidal wetlands with stilling basins by each outfall would allow stormwater to decrease its velocity, giving time for sediments to sink to the bottom. Removing sediments from the water in stilling basins would reduce algal blooms in the lake and improve water quality throughout the system as well as downstream in Jamaica Bay. The accumulated sediments will be removed periodically by NYCDEP with Vactor trucks.

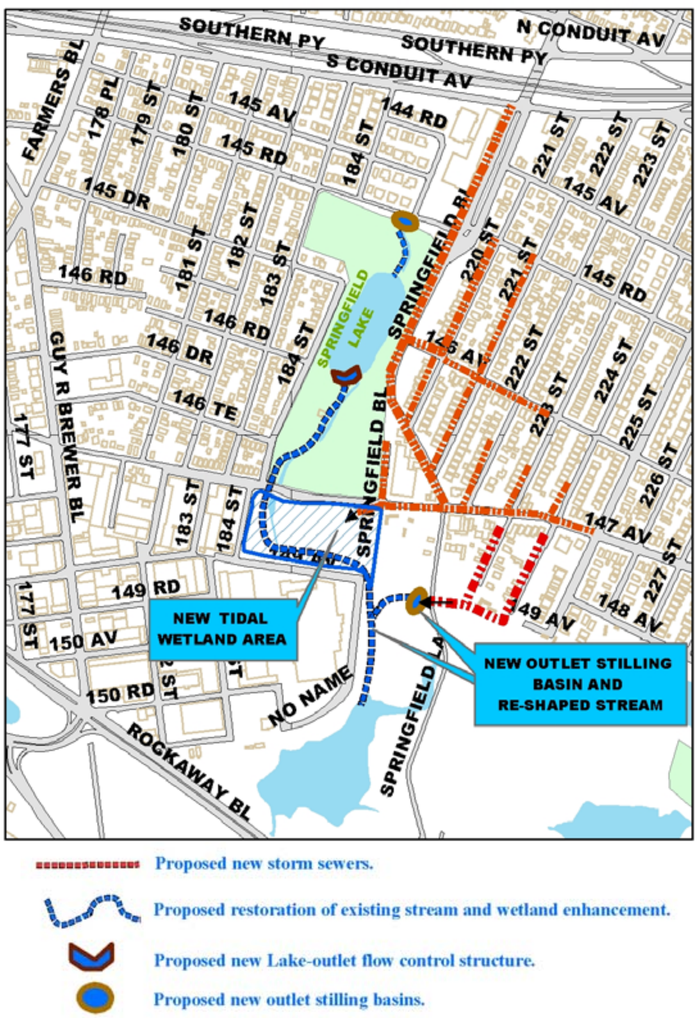


FIGURE 5.14 Proposed Springfield Gardens Stormwater Plan; Source: NYCDEP

The current design would include dredging the lake of accumulated sediments and re-grading the lake bottom to create a more hospitable environment for diverse native vegetation. Along with flooding relief and water quality improvement, NYCDEP plans to maintain the water elevation and return the lake to its historic footprint while improving its aesthetic value to the community.

Schedule: The sewer and roadway reconstruction for Springfield Gardens has been implemented in phases: Phase C has been completed, Phases A and B are in progress, and Phase D, which includes the work discussed above, is slated to begin construction in 2009.

Cost: The estimated cost to construct the project is $15 million.

BMP CONCLUSIONS

BMPs can effectively achieve substantial reductions in stormwater runoff generated by impervious surfaces. Table 5.16 presents four different scenarios that address new development, existing development, and streets and sidewalks. After a ten-year period, BMP implementation efforts in the Jamaica Bay watershed could yield:

- *Scenario 1*: Lower capture BMPs, such as rain barrels, rain gardens, and swales for existing development and streets and sidewalks, could reduce CSOs by 5% and achieve a 6% reduction in *untreated discharges to the Bay* including CSO, treated CSO, storm sewer, and direct runoff annually.

- *Scenario 2*: A scenario that includes rooftop detention or green roofs on new development and existing large rooftops could reduce CSOs by 17% and achieve a 13% reduction in *untreated discharges to the Bay* including CSO, treated CSO, storm sewer, and direct runoff annually.

- *Scenario 3:* A scenario that includes rooftop detention or green roofs on new development and existing large rooftops, and high capture BMPs on streets and sidewalks could reduce CSOs by 15% and achieve an 18% reduction in *untreated discharges to the Bay* including CSO, treated CSO, storm sewer, and direct runoff annually.

- *Scenario 4:* A scenario that includes medium capture BMPs on existing development and high capture BMPs on new development and streets and sidewalks could reduce CSOs by 25% and achieve a 24% reduction in *untreated discharges to the Bay* including CSO, treated CSO, storm sewer, and direct runoff annually.

Pollutant reductions from BMPs for the Jamaica Bay watershed include pathogens, nutrients and toxins. Pollutant load reductions are comparable to volume reductions. For example, an aggressive BMP implementation effort (Scenario 4) would achieve a 24% loadings reduction in total nitrogen, BOD, and fecal coliforms, while a low capture scenario (Scenario 1) would achieve a 6% loadings reduction in total nitrogen and BOD, and a 5% loading reduction in fecal coliforms.

As discussed in On-Site BMPs (Management Strategy 3a1) above, the results are presented as reductions with BMPs of *untreated discharges to the Bay.* Stormwater runoff from a site can travel many different pathways to reach a waterbody. And the Jamaica Bay watershed offers more pathways than are typically found in other parts of the City. Stormwater runoff that does not get treated by the WPCPs in CSO sewersheds (directly or indirectly passing first through CSO retention facilities) is discharged to the Bay as CSOs, partially treated CSOs (overflows from Spring Creek and planned Paerdegat Basin CSO facilities), storm sewer discharges, and direct surface runoff, which are cumulatively summarized as *untreated discharges to the Bay.* In the Jamaica Bay watershed, the majority of *untreated discharges to the Bay*, as measured by volume, are storm sewer discharges (62%), as compared to CSOs which make up only 12% of the discharges. This balance is highly influenced by the amount of stormwater introduced into the eastern section of Jamaica Bay in the Jamaica WPCP sewershed. In most other areas of the City, CSOs make up the predominant source of untreated discharges.

TABLE 5.16 Summary Of BMP Runoff Reductions and Costs					
Scenario #		1	2	3	4
Condition	Baseline Conditions	LOW CAPTURE BMPS (Existing Development, Streets/Sidewalks)	HIGH CAPTURE BMPS (Existing Development) PLUS MEDIUM CAPTURE BMPS (New Development)	HIGH CAPTURE BMPS (Existing Development, Streets/Sidewalks) PLUS MEDIUM CAPTURE BMPS (New Development)	MEDIUM CAPTURE BMPS (Existing Development) PLUS HIGH CAPTURE BMPS (New Development & Streets/Sidewalks)
Jamaica Bay Watershed Totals					
Portion of Drainage Area Impacted (%)	NA	6%	11%	12%	12%
Total BMP Storage Volume (MG)	NA	25	131	159	153
Total CSO, stormwater and direct (surface) Discharges (MG)	15,480	14,531	13,516	12,963	11,726
Reduction with BMPs (of untreated discharges) (MG)	NA	949	1,963	2,517	3,754
Reduction with BMPs (of untreated discharges) (%)	NA	6%	13%	18%	24%
Partially Treated CSO (MG)	514	497	285	357	402
Untreated CSO (MG)	1,841	1,752	1,529	1,572	1,381
Reduction with BMPs of CSO only (MG)	NA	106	541	426	572
Reduction with BMPs of CSO only (%)	NA	5%	17%	15%	25%
Cost ($)*	NA	$400 million	$470 million- $4.9 billion	$825 million - $5.2 billion	$3.2 billion
*Low end of cost ranges is for rooftop detention and high end is for green roofs.					

Example, the 25 percent reduction in *untreated discharges to the Bay* with high capture BMPs (see Table 5.16) includes not only reductions in CSO discharges, but large reductions in storm sewer discharges. Watershed-wide, the percent reduction for each type of discharge is based on where the BMPs are located in the watershed (*e.g.* a combined sewered or separately sewered area). If the development where the BMPs are located is primarily in the combined sewer area of the watershed, then much of the reduction will be in CSOs.

However, most of the discharges that will be addressed by BMPs in the Jamaica Bay watershed are likely to be discharges from storm sewers as the storm sewered areas represent a large portion of the drainage area tributary to the Bay. While storm sewer discharges contain significantly lower levels of solids and pathogens than are present in CSOs, they still contain significant pollutant loads from street runoff (oil, grease), lawn areas (pesticides and fertilizers), and numerous other pollutants. For example, stormwater is estimated to contribute about 45 to 50 percent of the total nitrogen discharged to the Bay from wet weather sources while only contributing about 10 percent of the pathogen loads to the Bay. This clearly indicates that the effectiveness of any BMP program will depend on the location within the watershed where the BMPs are applied. Currently, a major focus of NYCDEP's wet weather flow reduction program is focused on CSOs. However, it is expected that storm sewer discharges will be receiving increasing attention as a source of pollution.

It should be noted that not all BMPs are applicable across all systems, thus a menu of options is offered. In a combined sewer area, rooftop detention and other detention BMPs could be very effective in detaining stormwater that would be slowly released and ultimately make its way to a WPCP for treatment. On the other hand, in a separately sewered area, rooftop detention and other detention BMPs would not be effective in reducing stormwater volumes or pollutants. They would merely detain the stormwater for release a few hours later, having no effect on discharges. However, with a large enough penetration rate, they could be effective in reducing some of the effects of flooding. In areas with storm sewers, infiltration BMPs or green roofs would be most effective; however, in many of these areas in the watershed, there are high groundwater tables that would preclude the use of infiltration BMPs.

It is also important to understand that the results presented are reductions with BMPs in *untreated* discharges to the Bay. This does not mean that BMPs reduce discharges to the Bay. All stormwater would ultimately discharge to the Bay, whether it be very slowly via infiltration and groundwater or more rapidly through WPCP discharges, thereby maintaining salinity levels similar to those there now. However, with BMPs, the stormwater is "treated" in some manner prior to discharge to reduce CSO and stormwater pollutants that negatively influence the Bay.

These environmental benefits need to be understood in the context of what is achievable. For purposes of this Plan a number of what-if scenarios were developed. *What if* all new development and 10% of existing development were to implement BMPs? *What if* all existing large rooftops were to implement BMPs? While the Plan answers these questions to a certain degree, a much more difficult question is: "How much can be implemented?" The answer to this question will depend on the development of a comprehensive program that will potentially include regulatory measures, incentive programs, and public outreach. This effort, being orchestrated through the Mayor's Interagency BMP Task Force, will require the coordination of the resources of many City agencies, private interests, and other stakeholders.

As positive as the potential benefits are, they come at a hefty price. The scenarios outlined above for the Jamaica Bay watershed result in a wide range of costs:

- Scenario 1: $400 million for a program achieving a 6% reduction in untreated discharges to the Bay.
- Scenario 2: $470 million – $4.9 billion for a program achieving a 13% reduction in discharges to the Bay.
- Scenario 3: $825 million – $5.2 billion for a program achieving a 18% reduction in discharges to the Bay.
- Scenario 4: $3.1 billion for a program achieving a 24% reduction in discharges to the Bay.

Note that ranges are provided for Scenarios 2 and 3. The low end of the range assumes rooftop detention for new and existing development (no costs are assumed for rooftop detention for new development, since these new developments would likely require either subsurface or rooftop detention under the current provisions of the Administrative Code). The high end of the range assumes green roofs for new and existing development.

These cost estimates are substantially higher and would capture a significantly smaller percentage of CSOs than that which is currently proposed under NYCDEP's CSO Long Term Control Program. That program focuses on hard infrastructure including the installation of storage tanks, additional treatment capacity and the construction of high level storm sewers.

However, there is still much to be resolved on the costing side of BMPs. *The Jamaica Bay Watershed Protection Plan* utilizes the best available information on the cost of BMP installation in New York City. However, there is little information to draw from that is specific to New York City implementation, and there are many uncertainties associated with these costs. One of the key purposes of the pilot studies proposed in this Plan is to develop better cost estimates for both capital and maintenance costs and to determine which BMPs provide the most cost-effective results under New York City conditions.

The cost-benefit equation will also differ from area to area in the City. In Jamaica Bay, large CSO storage tanks are cost-effective because there is typically one CSO outfall per tributary basin and a storage facility can be located so as to capture CSOs in one location. In other areas of the City, CSOs are more diffuse. Either more smaller tanks would need to be built, or sewer construction would be needed to reroute and concentrate flows at a tank location. In addition, much of the Jamaica Bay watershed discharges to separate storm sewers, therefore effects of BMPs on CSOs in this watershed are not as significant as they would be in largely combined sewered areas.

Another key consideration is: *who pays*? While NYCDEP, and ultimately the City's water and sewer ratepayers, will bear the burden of expenditures for new CSO tanks and other hard infrastructure costs, the costs for BMPs can be allocated differently. One approach could be to mandate BMPs for new development, thereby placing greater responsibility on new development to offset the additional burdens it would place on the City's already taxed infrastructure. Credit programs could be offered to partially offset some of these costs.

In addition, large-scale infrastructure projects do not necessarily provide greater benefits than do low-impact small-scale technologies. When a large-scale infrastructure element has a problem or needs repair, large geographic areas can be affected. Diffusely located BMPs would not subject any area to large-scale disruptions.

Further, the benefits of BMPs should not be compared only to the NYCDEP's CSO program. In fact, BMPs are embraced by many municipalities around the country that do not have CSOs. By addressing stormwater generation at its source and fostering low-impact development, BMPs can provide many benefits that end-of-pipe treatments cannot.

In addition to controlling stormwater runoff and CSO volumes and pollutant loads, some of the many benefits BMPs and source controls provide include:

- Reducing urban heat island effect: Impervious surfaces, prevalent in urban areas, increase urban temperatures as compared to suburban and rural temperatures. Many BMPs that reduce impervious areas and increase vegetative and tree canopy reduce the urban heat island effect, thus reducing ambient temperatures and energy needs.

- Greenhouse gas reductions: Reductions due to reduced energy use and carbon sequestration, reducing carbon dioxide through plant uptake.

- Flood mitigation: Because BMPs reduce the rate and/or volume of stormwater runoff, they can alleviate localized street flooding by detaining water so it does not reach the street during peak stormwater generation. However, in areas that are prone to flooding due to high groundwater tables, infiltration BMPs cannot be used.

- Habitat: Trees and other BMPs provide habitat for wildlife.

- Erosion control: BMPs reduce sediment loadings from construction sites and other exposed areas.

- Aesthetic amenities: BMPs add greenery and, at times, open space to private properties and public areas. These amenities have been documented to increase property values. In fact, many tenants are attracted to, and willing to pay a premium for, apartments and office space in LEED-certified buildings.

While these benefits are difficult to quantify in dollars, Columbia University recently undertook a study for green roofs with assumptions specific to New York City (Acks, 2006). Columbia University modeled a green roof installation on a single building (green roof of 1,968 sq ft) and a wide-scale installation of 7,698 acres of green roofs (equivalent to 4% of the City total land area, or greening 50% of the City's flat roofs) (see Table 5.17 below for estimated benefits). The Columbia Study concludes that green roof infrastructure is cost-effective when all of these benefits are incorporated.

TABLE 5.17. Quantified Green Roof Benefits		
1 GREEN ROOF (1,968 SQ FT)		
Benefits and Costs	**Modeled Benefit**	**Additional Information**
Energy used for cooling	15% reduction	Difficult to estimate given that each building has different and cooling demands that depend on a variety of parameters associated with a building
Sound reduction	3 decibels	Figure used to estimate change in property value; based on data from German green roof company
Private aesthetic benefits	$10-50 per person benefiting	Based on willingness-to-pay for building amenity; based on Toronto study
7,698 ACRES OF GREEN ROOFS (4% of the City total land area)		
Benefits and Costs	**Modeled Benefit**	**Additional Information**
Urban heat island	$213 million (total savings resulting from energy reduction)	0.8˚F temperature reduction results in 5% reduction in energy demand for cooling
Stormwater runoff	1.9% reduction in capital expenditures	Resulting from retention of 50% of rainwater that falls directly on roof
Greenhouse gases	$0.18 per square foot in savings	Based on Toronto study
Air Pollution	$2.2 per pound	Assumed 20% reduction in airborne particulates; based on US Forest Service model
Health	Mean willingness to pay for longer/healthier life	Based on USEPA numbers
Public aesthetic	1.7 million people benefiting	Assumes 12 people per green roof would enjoy

As BMPs become more widely used and as contractors and developers incorporate more BMPs into their developments, lessons will be learned, cost efficiencies will be identified, and economies of scale will be accrued. Installing BMPs at City-owned facilities, an approach being pursued through the Mayor's Interagency BMP Task Force, will also set an example and help to establish the market. It is NYCDEP's hope that the implementation strategies suggested in this Plan, from the many pilot studies that will be conducted to the code reviews and the incentive programs that will be explored, will help lay the groundwork for more widespread acceptance of BMPs in New York City.

The future for BMPs is encouraging, but it will take time to see the benefits. It will involve harnessing the resources of many city agencies, private developers, homeowners and environmental organizations. End-of-pipe solutions also take long periods of time to become facts on the ground, involving very lengthy design and construction processes. The City has patiently awaited these facilities to be built and their effects to be made known; it is now time to pursue BMPs with the same patience and commitment.

REFERENCES

Acks, K. 2006. A framework for cost-benefit analysis: Initial estimates. In: Rosenzweig, C., S. Gaffin, and L. Parshall (Eds.) 2006. Green Roofs in the New York Metropolitan Region: Research Report. Columbia University Center for Climate Systems Research and NASA Goddard Institute for Space Studies. New York. 59 pages. pp 41-52.

Adams, Michelle C. 2003. Porous Asphalt Pavement with Recharge Beds: 20 Years & Still Working. Stormwater. May/June 2003. Vol. 4 Number 3.

Adey, W.H., and J.M. Hackney. 1989. The composition and production of tropical marine algal turf in laboratory and field experiments. In: W.H. Adey (Ed.), *The Biology, Ecology, and Mariculture of Mithrax spinosissimus Utilizing Cultural Algal Turfs*. The Mariculture Institute, Washington, D.C.

Adey, W.H., and K. Loveland. 1991. *Dynamic Aquaria: Building Living Ecosystems*. Academic Press, New York.

Adey, W.H., C. Luckett, and K. Jenson. 1993. Phosphorus removal from natural waters using controlled algal production. Restoration Ecology 1:29-39.

Adey, W.H. C. Luckett, and M. Smith. 1996. Purification of industrially contaminated groundwaters using controlled ecosystems. Ecological Engineering. 7:191-212.

Briggs, M. 2004. Widescale biodiesel production from algae (unpublished report of the UNH Biodiesel Group). Michael Briggs, University of New Hampshire, Physics Department. msbriggs@unh.edu

Casey Trees and LimnoTech. 2007. The Green Build-out Model: Quantifying the Stormwater Management Benefits of Trees and Green Roofs in Washington, DC. Funded by USEPA Cooperative Agreement CP-83282101-0, Washington, DC.

Center for Watershed Protection (CWP). 1997. Stormwater BMP Design Supplement for Cold Climates. Prepared for the USEPA Office of Wetlands, Oceans and Watersheds and USEPA Region 5. Ellicott City, MD.

Center for Watershed Protection (CWP). 1998. Rapid Watershed Planning Handbook. Ellicott City, MD. October 1998 (Reprinted 1999).

Center for Watershed Protection (CWP). 2003. New York State Stormwater Management Design Manual. New York State Department of Environmental Conservation, Albany, NY.

Kebede-Westhead, E., C. Pizarro, W. W. Mulbry, and A.C. Wilkie. 2003. Production and nutrient removal by periphyton grown under different loading rates of anaerobically digested dairy manure. J. Phycology. 39:1275-1282.

Metcalf & Eddy, Inc. 1991. Wastewater Engineering, Treatment, Disposal, and Reuse. Third Edition. McGraw-Hill, New York, NY.

Mulbry, W.W. and A.C. Wilkie. 2001. Growth of benthic freshwater algae on dairy manures. J. Appl. Phycology. 13:301-306.

New Jersey Department of Environmental Protection (NJDEP). 2004. New Jersey Stormwater Best Management Practices Manual. Trenton, NJ.

New York City Department of Design and Construction (NYCDDC). 1999. High Performance Building Guidelines. New York, NY.

New York City School Construction Authority (SCA). 2007. NYC Green Schools Guide. New York, NY.

Paine, R.T. 1966. Food web complexity and species diversity. American Naturalist 100:65-75.

Pennsylvania Department of Environmental Protection (PADEP). 2006. Pennsylvania Stormwater Best Management Practices Manual, Final Draft. Harrisburg, PA.

Pizarro, C., W. Mulbry, D. Blersch, and P. Kangas. 2006. An economic assessment of algal turf scrubber technology for treatment of dairy manure effluent. Ecological Engineering 26(4): 321-327.

Randall, C.W., D. Waltrip, and M.V. Wable, 1990. Upgrading a municipal activated sludge plant for high-rate biological nutrient removal. Water Sci. Tech. 22:21-33.

Schueler, T. 1994. The importance of imperviousness. Watershed Protection Techniques 1(3):100-111

Stotz, G., and K. Krauth. 1994. The Pollution of Effluents from Pervious Pavements of an Experimental Highway Section: First Results. The Science of the Total Environment (146/147):465-470.

United States Department of Transportation (USDOT). 2002. Stormwater Best Management Practices in an Ultra-Urban Setting: Selection and Monitoring: Fact Sheet - Porous Pavements. Federal Highway Administration. http://www.fhwa.dot.gov/environment/ultraurb/3fs15.htm.

United States Environmental Protection Agency (USEPA). 1999. Storm Water Technology Fact Sheet, Porous Pavement. Municipal Technology Branch, Washington, DC.

C H A P T E R S I X

CATEGORY 4, PUBLIC EDUCATION AND OUTREACH

INTRODUCTION AND ISSUES IDENTIFICATION

Some residents in the Jamaica Bay watershed drive fuel–efficient cars, engage in recycling initiatives, and practice water conservation or other activities that reduce the amount of impact they have on their local environment. Unfortunately, illegal actions such as dumping, littering, and vandalism, especially in the few remaining open spaces of the watershed, continue to occur and impair water quality and ecological integrity of Jamaica Bay. The sum of these actions is the "ecological footprint" of human uses in the watershed. Long-term ecological sustainability is directly linked to the actions and attitudes of the people that live, work, and play in the watershed. The concept of environmental stewardship is that residents understand, value, and care for their environmental resources, and thus are motivated to make decisions that improve the health of the watershed and the Jamaica Bay estuary.

Many residents in the Jamaica Bay watershed may not be aware of how their individual behaviors and lifestyle choices have a direct impact on the Bay. By increasing personal connections to Jamaica Bay, and providing education on the linkage between human activities and ecological health, public awareness of ecological issues within the watershed will be strengthened.

People typically do not care for what they do not know. Therefore, it is important to provide residents with opportunities to learn about the Bay – to explore it, study it, and play in it. These opportunities can help to promote a sense of value and environmental stewardship in individuals, both young and old. Diverse learning experiences encourages residents to gain knowledge of how their everyday actions affect water quality, human health, and the ecological processes of the landscape in which they live, develop a sense of caring for that environment, prioritize environmental health, and voluntarily modify their behaviors and practices toward more ecologically sustainable options.

While an individual's efforts may appear small, collective stewardship has the power to significantly reduce degradation of the Bay. In fact, education and outreach may be the most important factors in the attainment of an environmentally–healthy Jamaica Bay because significant change will be challenging without broad constituent support to alter status quo behaviors and to enact the political will needed to promote ecological health. Many outstanding education and outreach programs that focus on the importance of Jamaica Bay and stewardship currently exist; however, one challenge is that the efforts of different entities are uncoordinated and, therefore, may not target or reach the diverse population groups – public officials, property owners, business owners, school children, and other stakeholders – throughout the watershed.

In order to bring about effective and lasting change for improving the water quality and ecological conditions in Jamaica Bay, it is essential that there be a coordinated effort to promote and implement a comprehensive environmental education program. This will be most effective if the learning styles and needs of all people – watershed residents, visitors, students, educators and civic officials – are addressed. The Jamaica Bay Watershed Education Coordinating Committee, initiated by NYCDEP as part of the *Jamaica Bay Watershed Protection Plan* process, provides one such forum for formal and informal educators to collaborate and cooperate in its effort to provide comprehensive K-12 education curricula for students within the Jamaica Bay watershed. The Committee meets regularly and involves the participation of many organizations that provide school-based, after school and weekend education opportunities within New York City including NPS, NYSDEC, NYCDPR, HEP, NYCSWCD, Brooklyn College, EQA, Friends of Gateway, and many more.

An effective public outreach program includes instructive techniques of teaching as well as opportunities for the active engagement of the public in the natural environments that the *Jamaica Bay Watershed Protection Plan* endeavors to protect and restore, that is, direct, physical interaction with the natural world. To ensure widespread application and complete information throughout the watershed, outreach efforts also need a coordinated approach in which the programs and activities of different providers are integrated.

OBJECTIVE 4A: RAISE AWARENESS OF JAMAICA BAY'S UNIQUE ASSETS AND CHALLENGES

Current Programs

There are at least a dozen active Jamaica Bay natural resource and environmental education programs for people of all ages within the watershed. Community-based organizations and government agencies offer a wide variety of educational opportunities from classroom presentations to field trips to professional development workshops for educators and other professionals. Information about Jamaica Bay is available online, including the Jamaica Bay Research and Management Information Network (JBRMIN) website (http://nbii-nin.ciesin.columbia.edu/jamaicabay/). The Jamaica Bay Institute (JBI) website (www.nature.nps.gov/jbi/index.htm) publishes information about current research topics, scientific investigations, and scientific reports relating to the Jamaica Bay watershed. The JBI website contains summaries of current research efforts, and priority research needs in the watershed. The JBI organized and led a 2004 conference on the status and trends in the Jamaica Bay estuary. NYCDEP's website (www.nyc.gov/dep) provides relevant information about Jamaica Bay, including reports and links to these other organization sites.

There are many existing programs designed to raise awareness of Jamaica Bay-related issues. The following organizations and programs, although not an exhaustive list, currently provide opportunities for young people and adults to engage in the study of Jamaica Bay. See also Volume I, Chapter 7, for additional organizations.

- *Jamaica Bay Task Force (JBTF):* holds quarterly meetings, which serve as a forum for stakeholders to share information about ongoing activities and programs.

- *Jamaica Bay Research and Management Information Network (JBRMIN):* a website which includes an online bibliography; a catalog of stakeholders and universities involved in Jamaica Bay research, programming and advocacy; information on the Jamaica Bay Task Force and the Jamaica Bay Watershed Protection Plan Advisory Committee; a news page; and an events calendar. (http://nbii-nin.ciesin.columbia.edu/jamaicabay/)

- *Jamaica Bay Ecowatchers*: the first environmental group to discover the loss of marshes in Jamaica Bay, Ecowatchers coordinates research about marsh loss and holds conferences to promote ecosystem restoration in the Bay.

- *American Littoral Society, Jamaica Bay Guardian:* provides educational programs about Bay resources for schools and civic groups and bi-weekly programs on general ecology issues with the NPS; maintains an extensive resource slide library, which is available to other organizations; and coordinates International Beach Clean-up Day along Jamaica Bay.

- *Eastern Queens Alliance:* gives presentations to local groups and individuals to increase awareness of Idlewild Park's resources and encourage community involvement.

- *Gateway National Recreation Area, Jamaica Bay Institute:* houses the Jamaica Bay Resources Library - a collection of over 3,000 books, reports, theses, maps, and other materials relating to the natural and cultural resources of the Jamaica Bay Watershed.

- *Gateway National Recreation Area, Jamaica Bay Unit:* operates the Jamaica Bay Wildlife Refuge which provides a variety of public programs and services; offers day programs to provide students (ranging from 4th-8th grade) with a variety of lessons about marine explorations and environments at Gateway National Recreation Area (GNRA), and overnight camping programs at Ecology Village for grades 4-12; and serves as a cooperating agency for Operation Explore, a year-long school program for 4-6th graders which includes a full day professional development workshop for participating teachers, a guided interpretive walk by Rangers at GNRA field sites followed by a visit to Stonykill Farm and a two-night trip to the Taconic Outdoor Education Center. NYCDEP is also a cooperating agency, together with the New York City Department of Education (NYCDOE), NYCDPR, Cornell Cooperative Extension and the NYSDEC.

- *New York/New Jersey Harbor Estuary Program (NY/NJ HEP):* maintains on online stewardship network; and hosted Estuary Live, on September 29, 2006, which was an interactive program that involved many different environmental education partners and high school students from the watershed in an hour-long live nationwide web broadcast from Big Egg Marsh.

- *Friends of Gateway:* operates the Gateway Greenhouse Education Center which provides learning opportunities at Jamaica Bay by getting children to the Bay and offering a set of lesson and activities.

- *Metropolitan Waterfront Alliance:* produces an electronic newsletter, "Waterwire," which includes articles on Jamaica Bay. (http://www.waterwire.net/)

- *New York City Soil and Water Conservation District (NYCSWCD):* hosts an annual Jamaica Bay Roundtable, in cooperation with The New School University, to discuss critical issues facing the Bay.

- *New York City Audubon Society:* sponsors trips to the Jamaica Bay Wildlife Refuge.

In addition to serving as a cooperating agency for Operation Explore, NYCDEP sponsors the International Beach Clean-up Day; provides program and financial support for the NYCSWCD to help them achieve their mission; participates in HEP educational activities including Estuary Live; hosts the annual Water Conservation Art and Poetry Contest which encourages fifth and sixth grade students to creatively express their understanding of New York City's water resources; offers professional development opportunities for formal and informal educators on water quality issues; produces and distributes education materials related to New York City's water resources; offers student internship opportunities; assists with curriculum development and student research projects; and, organizes and supports the Jamaica Bay Watershed Education Coordinating Committee that was formed as part of the *Jamaica Bay Watershed Protection Plan* development process.

As part of the development of an ecological restoration project at Paerdegat Basin, NYCDEP will implement a 6 acre Ecology Park designed to showcase many of the ecosystems present within New York City and enable a close-up view of these communities. NYCDEP expects the Ecology Park at Paerdegat Basin will be an important environmental tool in helping area residents to gain an understanding of the many ecosystem types found within New York City and the important role the residents have in maintaining a delicate ecosystem.

The NYCDEP will strengthen its ongoing public education and outreach program to promote stewardship of the Jamaica Bay area among residents and visitors. NYCDEP's public education program includes school programs, public education programs, volunteer programs, publications, promotional items, and a website that provides useful educational resources.

Public Education Programs: NYCDEP attends numerous outreach events during the year. Events are typically programmed upon request and include table top displays and outreach at fairs, festivals, and concerts, most of which are community based. Last year NYCDEP participated in community group events in the Jamaica Bay watershed that included presentations and table top displays at churches, professional associations, and the Boy Scouts, as well as events conducted at city parks and museums.

Volunteer Programs: NYCDEP leads and supports various volunteer cleanup and environmental programs. In 2006 the NYCDEP conducted two major volunteer cleanup events in the Jamaica Bay watershed and participated and contributed to additional initiatives by other organizations. These programs have a positive effect on the reduction of floatable litter through its physical removal and the environmental education messages inherent in these hands-on programs.

Publications: NYCDEP distributes or displays flyers, brochures, posters, and other publications at public outreach events. Most of this material is readily available on the NYCDEP website. Each piece of literature is targeted to a particular message, *i.e.*, water conservation, floatable litter prevention, etc.

Promotional Items: NYCDEP has developed numerous promotional items designed to communicate a targeted environmental message, *i.e.*, water conservation, floatable litter prevention, etc., and distributes hundreds of thousands of these items yearly.

NYCDEP Website www.nyc.gov/dep: The NYCDEP website constitutes one of the most accessible and far reaching portions of the NYCDEP public education program. The site has numerous pages and links that connect viewers to all manner of environmental education topics, including information on how New York City protects its water environment, pollution control programs, harbor water quality programs, floatable litter reduction, as well as information on how citizens can make a difference.

Other City agencies have educational and outreach programs including:

- *New York City Department of Parks and Recreation (NYCDPR):* operates the Salt Marsh Nature Center in Marine Park which provides an in-park community center for public education, recreational activities and environmental studies.

- *The New York City Department of Education's (NYCDOE):* Scope and Sequence provides the structure and themes to ensure that students meet the standard requirements for the upcoming year's curricula in science and other subjects.

- *The New York City Department of Education (NYCDOE):* The new Science Scope and Sequence provides the structure and themes to ensure that students develop the skills to investigate important issues in the world around them through instruction and investigation and discovery. The gateway center for Science and the Environment at Floyd Bennett Field, Brooklyn, serves as an important site for coordinating and hosting professional development trainings for NYCDOE and collaborating organizations' staff.

- *The New York City Department of Sanitation (DSNY)* participates with the Mayor's Fund to Advance New York City, and Waste Management, Inc., in conjunction with STOMP, the long-running New York hit theatre troupe, and Keep America Beautiful, the nationwide organization that sponsors beautification projects and mobilizes volunteers to conduct a major city-wide anti-littering public awareness campaign; "STOMP Out Litter." The campaign delivers its message through several methods, including print media, television and radio public service announcements, billboards, and posters, many featuring the cast of STOMP. Street litter is tracked through the SLR system conducted by the Mayor's Office of Operations. In addition, the Litter Prevention Working Group (LPWG) represents one avenue for coordination among city, state, and federal litter prevention efforts.

Management Strategy 4a1: Raise awareness among young people to promote local environmental stewardship early during a child's development.

STRATEGY DESCRIPTION

Young children learn about the natural environment best through physical interaction with their natural surroundings. Children that play on the beach, in streams, or in forests within their neighborhood develop an early awareness and appreciation of wild plant and animal communities. They experience an essential connection to the natural world and react when it is disturbed or changed in any way. Without this exposure, children can grow to feel "disconnected" from the natural landscape and have little perspective of their ability to influence, or be influenced by these natural environments. Especially in the ultra-urban environments typical in many of the neighborhoods in the Jamaica Bay watershed, it is essential to understand the reciprocity between human use and environmental conditions, and promote a "value" to maintaining ecological health. Instilling some measure of environmental awareness at a young age, through education and direct experience, may help to encourage stewardship as the child becomes an adult. In the classroom, this can be accomplished by offering environmental science in the curriculum starting at an early age. Outside of the classroom, this can be achieved by offering programmed opportunities for children to participate in stewardship and other hands-on activities which offer direct connection with natural areas in the Jamaica Bay watershed.

Evaluation of Management Strategy

This strategy would have a positive environmental benefit through fostering environmental stewardship and protection at the grassroots level. There are no significant technical or legal obstacles to its implementation. Costs are discussed below under the specific Implementation Strategies.

RECOMMENDATION

It is recommended that schools, city agencies, educational organizational programs, after school programs, and camps and other summer programs further pursue existing educational and youth programs that provide environmental, science and water-based educational resources and can be applied within the Jamaica Bay watershed.

IMPLEMENTATION STRATEGIES

The following Implementation Strategy will be pursued in the near term. Additional strategies for future consideration are discussed in Chapter 9. A key strategy for implementing public outreach and education strategies is the development of a Education and Outreach Steering Committee to be managed by the Soil and Water Conservation District through funding from NYCDEP. The Soil and Water Conservation District will provide staff to organize these efforts. (See Chapter 8, Plan Implementation and Coordination, for information on the Education and Outreach Steering Committee.)

Enhance Jamaica Bay-Related Educational Curriculum

The Jamaica Bay Watershed Education Coordinating Committee is in the process of developing the Jamaica Bay Educators' Resource Guide to provide a comprehensive directory of multi-disciplinary, inquiry-based environmental education resources for kindergarten through 12th grade formal and informal educators within the Jamaica Bay watershed. The resource guide will be organized according to specific topics young people should know about Jamaica Bay and organizations with existing curricula or programs for each topic. Each program will be described to encourage educators to contact the organization or utilize the program that most suits their educational needs. Information included in the guide will be formatted in several ways to allow users to look up information by program type, topic, or sponsoring organization. Programs offering educational field trips and recreational opportunities on the Bay will also be identified in the guide to encourage teachers to provide students with hands-on, outdoor experiences.

Since a network and partnership has been established through the Jamaica Bay Watershed Education Coordinating Committee, the distribution mechanism for printed and electronic versions of the resource directory will be through members to colleagues and co-workers. A promotional letter will be developed to introduce the Guide and describe its development and use. NYCDEP will also promote the Guide through on-going professional development workshops in cooperation with the NYCDOE and independent schools, participation on the NYCDOE Science Education Task Force and professional organizations such as the Environmental Education Advisory Council. Most importantly, both NPS and NYCDEP are cooperating agencies for Operation Explore and will provide information about Jamaica Bay resources directly to teachers participating in the Fall 2007 professional development training at the Gateway Center for Science and the Environment.

The resource guide, once completed, will align existing curricula and programs with key topics related to Jamaica Bay and identify gaps, if any, in topics and resources. This information could be used in the future to establish priorities for creating new Jamaica Bay education resources and will encourage continued communication about planning, implementation and evaluation processes among educators involved in the Jamaica Bay Watershed Education Coordinating Committee (see strategies for future consideration in Volume 2, Chapter 9).

Cost: Final design of the prototype will cost approximately $1,000; printing and distribution will cost approximately $5,000.

Schedule: The Jamaica Bay Educators' Resource Guide prototype will be completed Fall 2007; printing and distribution will begin in Winter 2008.

Management Strategy 4a2: Raise awareness of Jamaica Bay-related issues through creating an informed citizenry.

STRATEGY DESCRIPTION

Educating businesses and residents in the watershed about sustainable water use, sustainable energy use, and low impact development can bring about reductions in the amount of pollutants entering the Bay, and savings in energy and water utility costs. Framing this type of educational campaign as both a long-term cost savings to businesses and residents, as well as a positive environmental action, will make these type of volunteer-based efforts more attractive. Disseminating information about the methods to be implemented (including water and energy conservation techniques, proper disposal of toxic materials, invasive species management, landscaping techniques, and stormwater management techniques), the environmental and economic benefits (including taxpayer savings related to overall infrastructure costs, increased property values, enhanced community features, and improved overall watershed conditions), and providing a list of resources to further aid the individual, requires coordination between many city agencies, including the Mayor's Office of Sustainability, NYCDDC, and NYCDEP. This approach is meant to complement and provide the public education aspect to many of the Stormwater Best Management Practices articulated in Chapter 5.

Water use, landscaping practices, and energy use also have a direct impact on environmental conditions in the watershed. The more water that is used, the more treatment capacity must be provided by WPCPs prior to that water ending up in the Bay. In combined sewer areas, where treatment plant capacity is often exceeded, water conservation efforts can directly reduce the amount of sewage entering the receiving waters of Jamaica Bay. The use of stormwater BMPs can also reduce the amount of water that ends up in the combined sewer system, and similarly affect water quality conditions. Through education and outreach, knowledge about how individual behaviors affect environmental conditions in the watershed, and recommendations for changing behaviors (through conservation and sound land use practices) to reduce the amount of impact can be passed along to watershed residents.

Littering, dumping, and vandalism occur in many urban communities, including those in the Jamaica Bay watershed. This can take the form of street litter, which ends up in the Bay via the storm drain system, or dumping refuse in open areas around in the watershed, creating an eyesore and degrading habitat. Water pollution from improper residential, commercial, or industrial waste disposal can end up in the storm drain system, and eventually drains to the Bay. Whether intentional or unintentional, these types of polluting behaviors can seriously degrade water quality and environmental conditions in the places that they occur. Anti-littering and anti-dumping campaigns, and education to promote the proper disposal of waste materials, can limit these types of destructive practices and help to remind residents that their actions have a direct influence on the condition of their local environmental resources. The proper placement of signage can often be used to great effect, in combination with public messages that discourage pollution.

In addition, citizen awareness of environmental conditions in the Jamaica Bay watershed is reliant on research and scientific investigations to ascertain physical, ecological, and biological trends, as well as the effective broadcast of this information to citizens and stakeholders. The transfer of information necessary to allow stakeholders the ability to make good, informed decisions can be enabled through scientific conferences, organization of research efforts, and utilization of service learning opportunities for higher education.

Evaluation of Management Strategy

This strategy would have a positive environmental benefit through fostering environmental stewardship and protection at the grassroots level. There are no significant technical or legal obstacles to its implementation. Costs are discussed below under the specific Implementation Strategies.

RECOMMENDATION

It is recommended that city agencies, elected officials, universities, environmental organizations and other entities further pursue educational programs focused on the Jamaica Bay Watershed.

IMPLEMENTATION STRATEGIES

The following Implementation Strategy will be pursued in the near term. Additional strategies for future consideration are discussed in Chapter 9.

Organize a "State of the Bay" Scientific Symposium

The NYCSWCD, working with NYCDEP and the JBI, will organize a "State of the Bay" symposium every two years to bring together researchers, academicians, civic groups, community members, resource managers and agencies to coordinate and guide scientific investigations and report scientific findings related to the Jamaica Bay watershed. There is already considerable momentum to build upon for developing this symposium. Jamaica Bay is currently an epicenter of research and scientific investigations for major academic institutions throughout New York City and Long Island, as well as the focus of ongoing research efforts by many federal, state, and City agencies. JBI serves as a clearinghouse for much of this research and hosts several events a year dedicated to disseminating new research and information about Jamaica Bay. In addition, Jamaica Bay has been the subject of several targeted "research symposiums" in the last six years including JBI's March 2004 conference on the State of the Bay, and a recent "Borrow Pit Workshop" hosted at Stony Brook University in the summer of 2006, which brought together scientists and managers to compare research and discuss the borrow pits in the Jamaica Bay estuary. The formalization of a biennial "State of the Bay" conference would expand upon the efforts of the JBI to continue information-sharing and coordination between the citizens and the scientific community to continue, and potentially compel more research efforts in the watershed. In addition, the symposium could be timed with the biennial *Jamaica Bay Watershed Protection Plan* update process.

JBI's March 2004 conference will be used as a model for the development of the "State of the Bay" symposium. The format of the workshop would be designed to discuss scientific investigations and findings during concurrent sessions featuring a number of scientists, natural resource managers, educators, or outreach coordinators working on Jamaica Bay related projects or have had demonstrated success implementing similar scientific studies and programs in other locations facing similar issues as Jamaica Bay. The morning session will consist of speaker presentations on the current state of the Bay with respect to water quality and ecological restoration. The afternoon session will feature a panel discussion with audience participation to identify priority research topics and additional needs for scientific data and knowledge. Discussions will be arranged with other governmental and non-governmental organizations to identify keynote speakers, presenters and panelists and to further develop a symposium based on scientific investigations and the *Jamaica Bay Watershed Protection Plan*.

Cost: $20,000 for one full day conference with 250 attendees including refreshments, speaker travel, speaker honoraria, outreach, and materials.

Schedule: The first symposium would be held Summer 2008 to allow the proceedings to be used for the *Jamaica Bay Watershed Protection Plan* Update in October 2008, per Local Law 71.

Create a targeted campaign for developers, residents, and business owners to protect Jamaica Bay

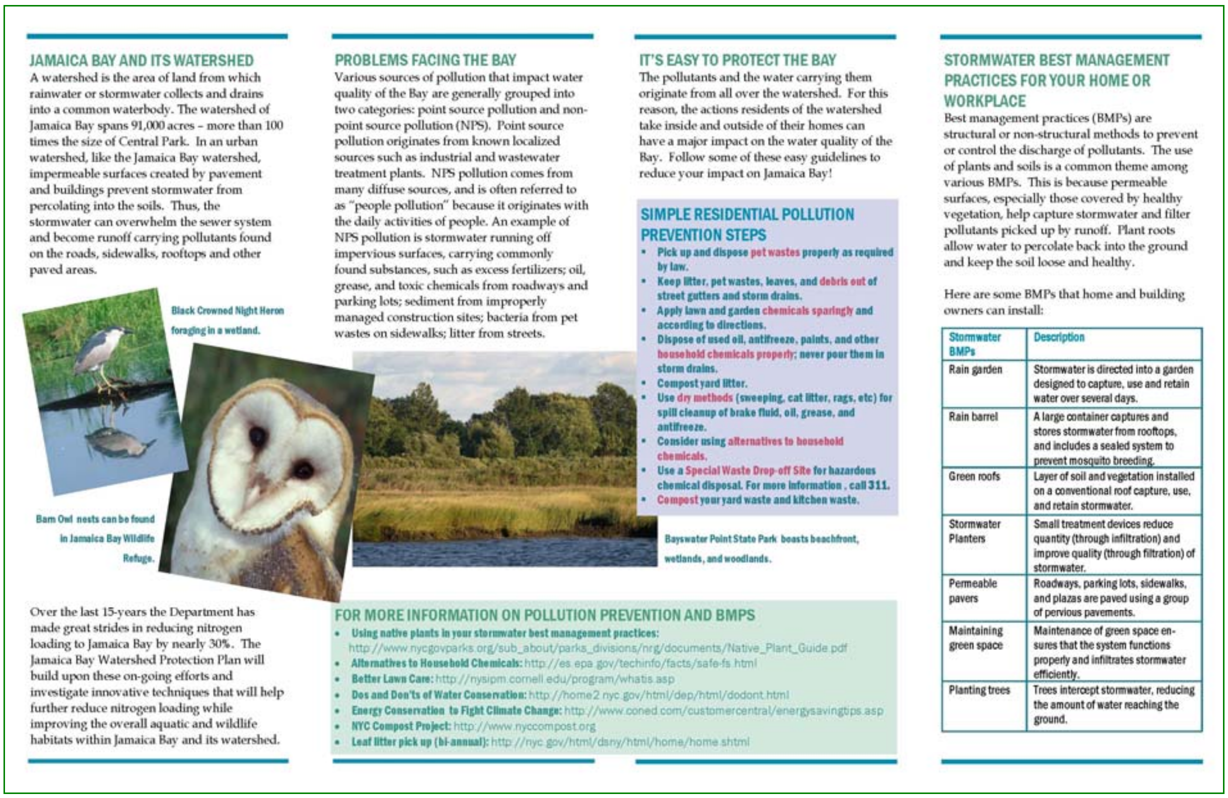
NYCDEP will create a targeted campaign for developers, residents, and business owners to provide information about how to protect Jamaica Bay through on-site stormwater management techniques, wise use of household chemicals, water conservation, and energy conservation measures.

For example, the Division of Pollution Prevention and Monitoring within the Bureau of Wastewater at the NYCDEP has made tremendous progress in the development of BMPs for the automotive industry. The BMPs being studied include workplace placards designed to educate workers on good housekeeping practices and provide establishments with literature that explain in greater detail the damage to the environment. BMPs under this program focus on key areas of concern such as chemical storage, facility upkeep, and typical daily operations in an effort to prevent or reduce impacts from contaminated stormwater runoff. The NYCDEP has taken a proactive approach in implementing anti-pollution strategies and projects that are cost-effective, publicly accepted, and environmentally sound.

As a first step, NYCDEP will develop a brochure to identify actions that developers, residents, and business owners can take to conserve water and energy, install on-site stormwater runoff management, minimize use of household chemicals, and promote sound landscaping practices to address lawn care and invasive species. Information included in the brochure could be expanded upon in the future to create a series of brochures, newsletters or guides targeted toward property owners. The City of Philadelphia's *A Homeowner's Guide to Stormwater Management* (2006) provides a model of detailed, user-friendly guidance for property owners to improve stormwater management and pollution prevention on their own property or in their community. In addition, a media or ad campaign similar to the Mayor's GreeNYC TV campaign *Small Steps, Big Strides* could be developed to help spread the word about best management practices for the home and business. Following the production and early distribution of the brochure described above, NYCDEP will partner with other organizations including the NYCSWCD to expand upon the information about how to protect Jamaica Bay and develop a watershed-wide ad campaign to spread the message.

Cost: Printing and distribution of the brochure will cost approximately $2,000.

Schedule: The brochure prototype will be completed Fall 2007; printing and distribution will begin in Winter 2008.



JAMAICA BAY AND ITS WATERSHED

A watershed is the area of land from which rainwater or stormwater collects and drains into a common waterbody. The watershed of Jamaica Bay spans 91,000 acres – more than 100 times the size of Central Park. In an urban watershed, like the Jamaica Bay watershed, impermeable surfaces created by pavement and buildings prevent stormwater from percolating into the soils. Thus, the stormwater can overwhelm the sewer system and become runoff carrying pollutants found on the roads, sidewalks, rooftops and other paved areas.

Black Crowned Night Heron foraging in a wetland.

Barn Owl nests can be found in Jamaica Bay Wildlife Refuge.

Over the last 15-years the Department has made great strides in reducing nitrogen loading to Jamaica Bay by nearly 30%. The Jamaica Bay Watershed Protection Plan will build upon these on-going efforts and investigate innovative techniques that will help further reduce nitrogen loading while improving the overall aquatic and wildlife habitats within Jamaica Bay and its watershed.

PROBLEMS FACING THE BAY

Various sources of pollution that impact water quality of the Bay are generally grouped into two categories: point source pollution and non-point source pollution (NPS). Point source pollution originates from known localized sources such as industrial and wastewater treatment plants. NPS pollution comes from many diffuse sources, and is often referred to as "people pollution" because it originates with the daily activities of people. An example of NPS pollution is stormwater running off impervious surfaces, carrying commonly found substances, such as excess fertilizers; oil, grease, and toxic chemicals from roadways and parking lots; sediment from improperly managed construction sites; bacteria from pet wastes on sidewalks; litter from streets.

IT'S EASY TO PROTECT THE BAY

The pollutants and the water carrying them originate from all over the watershed. For this reason, the actions residents of the watershed take inside and outside of their homes can have a major impact on the water quality of the Bay. Follow some of these easy guidelines to reduce your impact on Jamaica Bay!

SIMPLE RESIDENTIAL POLLUTION PREVENTION STEPS

- Pick up and dispose pet wastes properly as required by law.
- Keep litter, pet wastes, leaves, and debris out of street gutters and storm drains.
- Apply lawn and garden chemicals sparingly and according to directions.
- Dispose of used oil, antifreeze, paints, and other household chemicals properly; never pour them in storm drains.
- Compost yard litter.
- Use dry methods (sweeping, cat litter, rags, etc) for spill cleanup of brake fluid, oil, grease, and antifreeze.
- Consider using alternatives to household chemicals.
- Use a Special Waste Drop-off Site for hazardous chemical disposal. For more information , call 311.
- Compost your yard waste and kitchen waste.

Bayswater Point State Park boasts beachfront, wetlands, and woodlands.

FOR MORE INFORMATION ON POLLUTION PREVENTION AND BMPS

- **Using native plants in your stormwater best management practices:** http://www.nycgovparks.org/sub_about/parks_divisions/nrg/documents/Native_Plant_Guide.pdf
- **Alternatives to Household Chemicals:** http://es.epa.gov/techinfo/facts/safe-fs.html
- **Better Lawn Care:** http://nysipm.cornell.edu/program/whatis.asp
- **Dos and Don'ts of Water Conservation:** http://home2.nyc.gov/html/dep/html/dodont.html
- **Energy Conservation to Fight Climate Change:** http://www.coned.com/customercentral/energysavingtips.asp
- **NYC Compost Project:** http://www.nyccompost.org
- **Leaf litter pick up (bi-annual):** http://nyc.gov/html/dsny/html/home/home.shtml

STORMWATER BEST MANAGEMENT PRACTICES FOR YOUR HOME OR WORKPLACE

Best management practices (BMPs) are structural or non-structural methods to prevent or control the discharge of pollutants. The use of plants and soils is a common theme among various BMPs. This is because permeable surfaces, especially those covered by healthy vegetation, help capture stormwater and filter pollutants picked up by runoff. Plant roots allow water to percolate back into the ground and keep the soil loose and healthy.

Here are some BMPs that home and building owners can install:

Stormwater BMPs	Description
Rain garden	Stormwater is directed into a garden designed to capture, use and retain water over several days.
Rain barrel	A large container captures and stores stormwater from rooftops, and includes a sealed system to prevent mosquito breeding.
Green roofs	Layer of soil and vegetation installed on a conventional roof capture, use, and retain stormwater.
Stormwater Planters	Small treatment devices reduce quantity (through infiltration) and improve quality (through filtration) of stormwater.
Permeable pavers	Roadways, parking lots, sidewalks, and plazas are paved using a group of pervious pavements.
Maintaining green space	Maintenance of green space ensures that the system functions properly and infiltrates stormwater efficiently.
Planting trees	Trees intercept stormwater, reducing the amount of water reaching the ground.

FIGURE 6.1 Excerpt from NYCDEP's draft brochure prototype, *Protecting Jamaica Bay: It Starts with Where You Live and Work in the Watershed*, to be printed and disseminated in 2008; Source: NYCDEP

REFERENCES

City of Philadelphia. 2006. A Homeowner's Guide to Stormwater Management. Office of Watersheds, Philadelphia, PA.

CHAPTER SEVEN

CATEGORY 5, PUBLIC USE AND ENJOYMENT

INTRODUCTION AND ISSUES IDENTIFICATION

Jamaica Bay is the largest natural area in New York City, and presents some of the best opportunities for wildlife viewing, recreation, and outdoor education within the City limits, a natural respite within an extensively urban environment. The area is a valuable resource for New York City residents, including 12,000 acres of bayside and island landscapes within the public, long-term protection of the NPS GNRA. The Bay is internationally renowned for its avian and fisheries habitats, and is a haven for fisherman, birders and naturalists of all manner and levels of sophistication. To many visitors, the intact beauty and wildness of the landscape is surprising, considering the juxtaposition to such a highly urbanized environment. Ensuring and enhancing public access, recreation, and enjoyment opportunities within Jamaica Bay's diverse natural, cultural, and scenic resources is an objective of this Plan. This must occur in ways that are environmentally sustainable, and do not harm sensitive habitat areas.

A major area of public access to the Bay including the water, marshes, and sandy beaches is available at GNRA, owned and operated by the NPS. It is estimated that GNRA's Jamaica Bay Unit hosts between 3 and 4 million visitors per year (by comparison, New York City's Central Park typically hosts about 25 million visitors annually). Visitors typically engage in hiking, biking, bird watching, picnicking, sightseeing, photography, and fishing. Boating on the Bay is also popular, although at times the use of personal watercraft on the Bay has been restricted due to health and environmental impact concerns. Boat wakes may also contribute to marsh erosion. Public pedestrian access to the Bay occurs at several programmed areas in the GNRA including Jacob Riis Park, Canarsie Pier, Fort Tilden Beach, Plum Beach and Jamaica Bay Wildlife Refuge, and informal footpaths along the perimeter. The access provided by the above sites is easily reachable by residents in the western and southern neighborhoods of the watershed such as Mill Basin, Mill Island, Marine Park, Bergen Beach, Canarsie, Sheepshead Bay, Neponsit, Belle Harbor, Seaside, Breezy Point, and the Rockaways.

There are other areas along the shoreline, comprising approximately half of the Bay, where public access is restricted due to property ownership, the presence of hazards, and lack of amenities including parking and trails. Few subway lines reach as far as the Jamaica Bay watershed and existing bus routes are often slow or hard to access by pedestrians. Southeastern Queens, in particular, has been identified as an area with limited public access. Limited bus service and no subway access is available in this area. On a positive note, bicycle and pedestrian-friendly greenways have been planned, including a loop around Jamaica Bay. Beginning phases have provided the implementation of much of the northern part of the loop and the east and west cross-bay loop segments. The Greenway loop connects Southeastern Queens to the waterfront and to the rest of the City's greenway infrastructure (see Figure 7.1 Public Access). Despite the popularity of GNRA, public access to the shoreline areas and open waters of the Bay could be greatly enhanced.

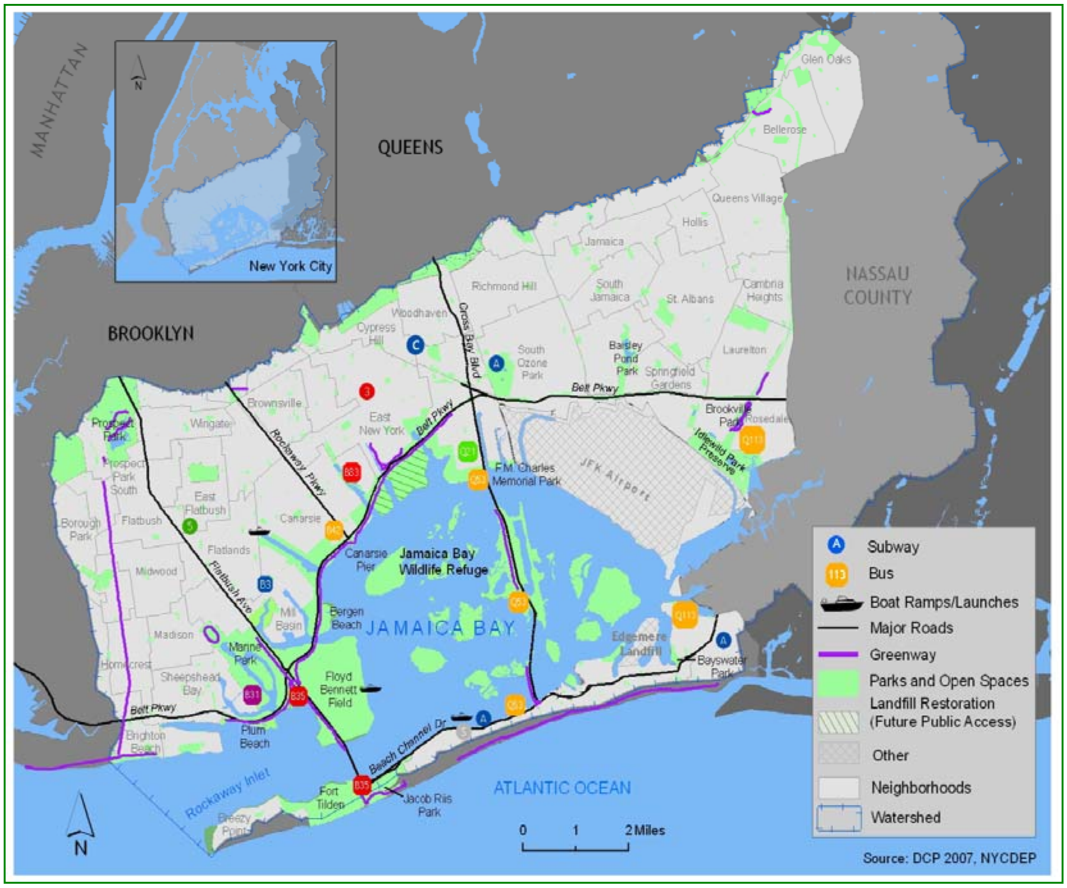


FIGURE 7.1 Public Access to Jamaica Bay; Source: NYCDEP

Public access to portions of the Bay is limited largely as a result of barriers that have been constructed along or adjacent to the shoreline of the Bay. The pressures of urban expansion and population growth in Brooklyn and Queens, including the Rockaways, have led to residential, commercial, industrial, and transportation infrastructure running along the perimeter of the Jamaica Bay estuary. The Belt Parkway is one such obstacle that acts as a 20 mile divide between the Bay and its adjacent landscapes, particularly for residents on the north side who cannot easily cross the Parkway to access the Bay. Large properties located directly on the Bay that are privately owned or not designated for public uses also act as a barrier to public access. For example, JFK Airport in southeastern Queens prohibits public access due to strict security concerns associated with the airport. Finally, some of the Bay's shoreline has been hardened or bulkheaded, limiting direct public access to the waters of the Bay.

Boating access for the general public is also limited. While private boating access can be achieved at one of the many marinas located around the perimeter of the Bay (including Dead Horse Bay, Sheepshead Bay, Shellbank Creek, Mill Basin, East Mill Basin, Paerdegat Basin, Shellbank Basin, Motts Basin, Little Bay, Broad Channel, and several others along Rockaway), public boating access is very limited and only a few public boat launches exist within the Bay. In addition, public access to recreational activities such as fishing, hiking, biking, picnicking, bird watching, photography, etc. is currently restricted to areas designated as New York City or State Parks (see Volume 1, Chapter 5) or areas within the GNRA (parts of Floyd Bennett Field, Breezy Point, Canarsie Pier, Dead Horse Bay, Fort Tilden, and Jacob Riis Park).

Beach at Jacob Riis Park; Source: NPS

The implementation of potential management strategies included in other categories of this *Jamaica Bay Watershed Protection Plan*, particularly Category 1: *Water Quality* (see Volume 2, Chapter 3) and Category 2: *Restoration Ecology* (see Volume 2, Chapter 4), would have ancillary benefits for the public use and enjoyment of landscapes in the Jamaica Bay watershed by improving water quality and ecosystem health in these areas. Shell fisheries were closed to the public in 1921 as the result of elevated pathogen concentrations in the shellfish harvested from the Bay and have never reopened. Fishing is limited or restricted due to the presence of toxins in certain finfish populations. Swimming is limited by elevated levels of pathogens in the tributary basins, as well as a lack of water clarity due to extensive eutrophication throughout the estuary. Neighboring residents and businesses often report bad odors at the head of tributary basins that receive sediments and waters from CSOs as well as the presence of floatable debris and litter along the shorelines, in wetlands, and along the upland buffers.

Shoreline Fishing at GNRA; Source: NPS

There are opportunities to enhance the public use and enjoyment values of these natural resources. This should be done in a coordinated manner that facilitates greater understanding of ecological processes, inspires environmental stewardship, and provides enjoyment to residents and visitors alike. The upland and waterside landscapes of the Jamaica Bay watershed have become severed. By reestablishing connections between the upper watershed and the estuary, both ecologically and recreationally, essential links can be recreated. Additionally, enhancing public access to natural landscapes in the upper portions of the watershed is also important.

One of the best ways to secure public support for Plan implementation strategies is to viscerally engage citizens in the aesthetic experience of Jamaica Bay. Through their personal participation, citizens are not only more receptive to educational lessons but also, and much more importantly, able to find their own reasons to care about the landscape, advocate for the preservation of the Bay, and become connected to the watershed.

OBJECTIVE 5A: INCREASE PUBLIC ACCESS TO JAMAICA BAY.

Current Programs

A *New York City Comprehensive Waterfront Plan* (1993) and the *New Waterfront Revitalization Program* (1992) developed by the NYCDCP provide specific goals to increase the amount of public access to New York City's waterfront areas. The existing document *A Greenway Plan for New York City* (1993) developed by NYCDCP is responsible for the 350-mile greenway system currently being constructed throughout New York City. This plan articulates a lengthy, spatially extensive greenway through bayside lands (on the northern and western edge of the Bay) with plans for future segments to create a continuous loop around the Bay from Plumb Beach, northwest to Spring Creek Park, south through Cross Bay to Rockaway Park (this portion is an on-street trail), west to Jacob Riis Park, and returning north through Floyd Bennett Field.

NYCDOT and NYCDPR are in various stages of planning, designing and constructing multiple greenway projects within the Jamaica Bay watershed. Priority projects include portions of the Shore Parkway Bicycle Path and the Rockaway Gateway Greenway. Completed greenways projects include a portion of the Shore Parkway Path, Knapp to Pennsylvania Avenue (1997) and the Ocean Parkway Greenway (2004). The NYCDOT is also in the final stages of approval for federal grant money to implement additional greenways projects, entitled; "Citywide Greenways Connector and Access," and "Greenway Integration into the Streets." Some of these projects, upon construction, will improve public access within the watershed. NYCDOT connector streets coordinate with NYCDPR off-street greenways. For example, NYCDOT will be installing bike facilities along 157th Avenue via 84th Street to link to the northern loop of Gateway-Rockaway Greenway (also known as the Shore Parkway Pathland and Cross Bay Boulevard Greenway segments).

GNRA has been studying various alternatives that would enhance access on NPS properties, although the majority of considerations focus on vehicular access. When the Pennsylvania Avenue and Fountain Avenue Landfill restoration projects are completed, NYCDEP will cede these areas totaling approximately 400 acres to NPS for maintenance as passive recreational areas. NYCDEP is also in the process of designing the Ecology Park, a six-acre park adjacent to Paerdegat Basin that will showcase many of the ecosystems present within New York City and will enable a close-up view of these communities along Paerdegat Basin.

The USACE (2002) prepared conceptual restoration designs for eight high priority sites in and around Jamaica Bay. Five of these eight designs included various amenities for public access, such as interpretive features, hiking and bicycling trails and blinds for bird watching. The Ecology Park has been incorporated into the USACE's concept project for Paerdegat Basin. These designs were developed based on the results of the Jamaica Bay Ecosystem Research and Restoration Team, Final Report, March 2002 (Volumes I, II and III) (JBERRT 2002).

The Waterfront Park Coalition, an alliance of over 35 diverse non-profit organizations, proposed a number of projects that would revitalize and improve access to NYC's waterfront in *New York Waterfront Park Coalition* (2002). The proposed projects included for the Jamaica Bay waterfront are currently in various stages of development with funding commitments from a variety of governmental agencies including NPS, NYSDEC, DSNY, and NYCDOT and NYCDPR. Several community groups have taken steps to address the lack of public access to the Bay in southeastern Queens. The

SQPA completed a study on the lack of legal access in southeastern Queens; the study was used to request state funding to implement its findings. The EQA has designed a boat launch for the edge of Idlewild Park with NYCDPR and secured grant funding for its construction following NYSDEC approval. Although this boat launch will provide access to Thurston Basin, current plans do not include access to Jamaica Bay.

Management Strategy 5a1: Provide access and connections to the waterfront for neighborhoods most in need, based on consideration of current lack of access, population density, and physical barriers.

STRATEGY DESCRIPTION

Many residents who live in close proximity to the Bay do not use it as a resource because of the barriers to access and physical disconnection from the Bay. The Belt Parkway, JFK Airport, and other infrastructure girdles the Bay, disconnecting the shoreline area from the adjacent neighborhoods, particularly in southeastern Queens. The lack of natural area connections from the estuary to the upper watershed, typically provided by tributaries and riparian corridors in other watersheds but lacking in the Jamaica Bay watershed because the tributaries are piped, leads to a lack of awareness that there is a unique natural landscape in close proximity. Providing physical access points to more areas along the shoreline of the Bay and creating recreational and aesthetic connections between the estuary and the upper watershed would enable more residents to use and enjoy this resource. Plans have been developed for improvements to public access throughout the Jamaica Bay watershed.

EVALUATION OF MANAGEMENT STRATEGY

Environmental

The main environmental benefit of increasing public access is that when residents have increased contact with natural areas this translates to increased understanding of the importance of conservation. This will help residents to understand why these areas are important now and for generations to come.

Increased public access also provides important social benefits. The opportunity for exercise and peaceful contemplation provided by Jamaica Bay within easy access for many residents provides many health benefits. These benefits are important for all residents, young and old. Opportunities to interact with nature are thought to be especially important for children in terms of reduction of stress, attention-deficit disorder, anxiety, depression, and childhood obesity. Children who are given the opportunity to enjoy and interact with nature are more likely to become good environmental stewards in the future. As residents realize these social benefits, protection of the watershed and the Bay will be given a greater priority these residents' daily lives.

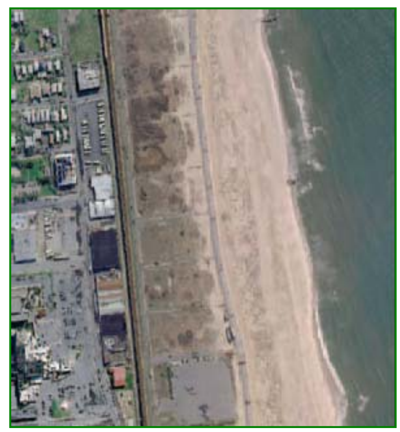
Belt Parkway Bicycle Access in Brooklyn; Source: NYCDOT

Technical

The Belt Parkway:
The Belt Parkway separates Jamaica Bay from most of the upper watershed. The Belt Parkway, also referenced to as Shore Parkway Path, is a minimum of 6 lanes wide where it crosses through Brooklyn and Queens. According to recent estimates by the NYSDOT, these sections of the Belt Parkway carry 135,000 – 140,000 vehicles per day. The entire Belt-Cross Island Parkway route was originally constructed with only six pedestrian overpasses. The Belt Parkway is currently the location of many infrastructure and safety improvements.

JFK Airport:
Although public access cannot be allowed through JFK Airport for security reasons, greenway connectors and purchase of land adjacent to JFK Airport have been proposed to increase access to the Bay in the Southeast Queens area. See *Implementation Strategies* below, for details.

The Rockaways:
The Rockaways are viewed by many to be so inconvenient to access that they never undertake the trip. For example, it takes over an hour on the A train to get to the Rockaway Peninsula. The NPS has been trying to change this view of the Rockaways. Two ways to make the Rockaways more accessible have been proposed – connection via ferry service to and from Manhattan and connection via a bicycle route to encircle the entire Bay. Details of these proposals are included in *Implementation Strategies*, below.



Rockaway Beaches;
Source: NYCDPR

Cost

A total of approximately $10,063,000 in local, state, and federal funding has been allocated for Greenway connections discussed below. All dollar amounts discussed below are initial planning numbers and do not necessarily reflect final or current costs of the project.

Legal

If properties need to be acquired to implement greater access, legal issues may be triggered. Projects along the waterfront areas may also require NYSDEC permits. In New York City, the NYSDEC regulates all “adjacent areas” located within 150 feet of mapped tidal wetlands.

RECOMMENDATIONS

It is recommended that the city work with state, federal, and other entities to further pursue opportunities for enhancing public access to Jamaica Bay and informing residents of these opportunities, pending funding availability. Since space is a limiting factor throughout the Jamaica Bay watershed, many of the greenway plans discussed below are located adjacent to or within the right-of-way of the adjacent roadways. A coordinated, multi-agency approach to on-going management and maintenance of roadways, especially in areas of bridges, is essential to the continued development of pedestrian and bicycle-friendly access to the Bay. Involvement of a number of agencies in the designing and planning phases of roadway projects would also avoid costly retrofitting for pedestrian and bicycle access in the future

IMPLEMENTATION STRATEGIES

The greenway and connector projects below are all in various stages of implementation by City agencies and include new greenway connections and improvements such as new sidewalks, bike paths, pedestrian ramps, improved entries/exits to in-park greenways, neckdowns or other safety features, and improved connectors and linkages between existing paths in adjacent areas and other parts of the watershed (see Figure 7.2). Depending on their specific locations these greenways may include some or all of the following: path/sidewalk construction, drainage improvements, pavement markings, tree plantings, entrance enhancements, intersection access improvements, striping, and signage. Each of the proposed projects is further described on the following pages.

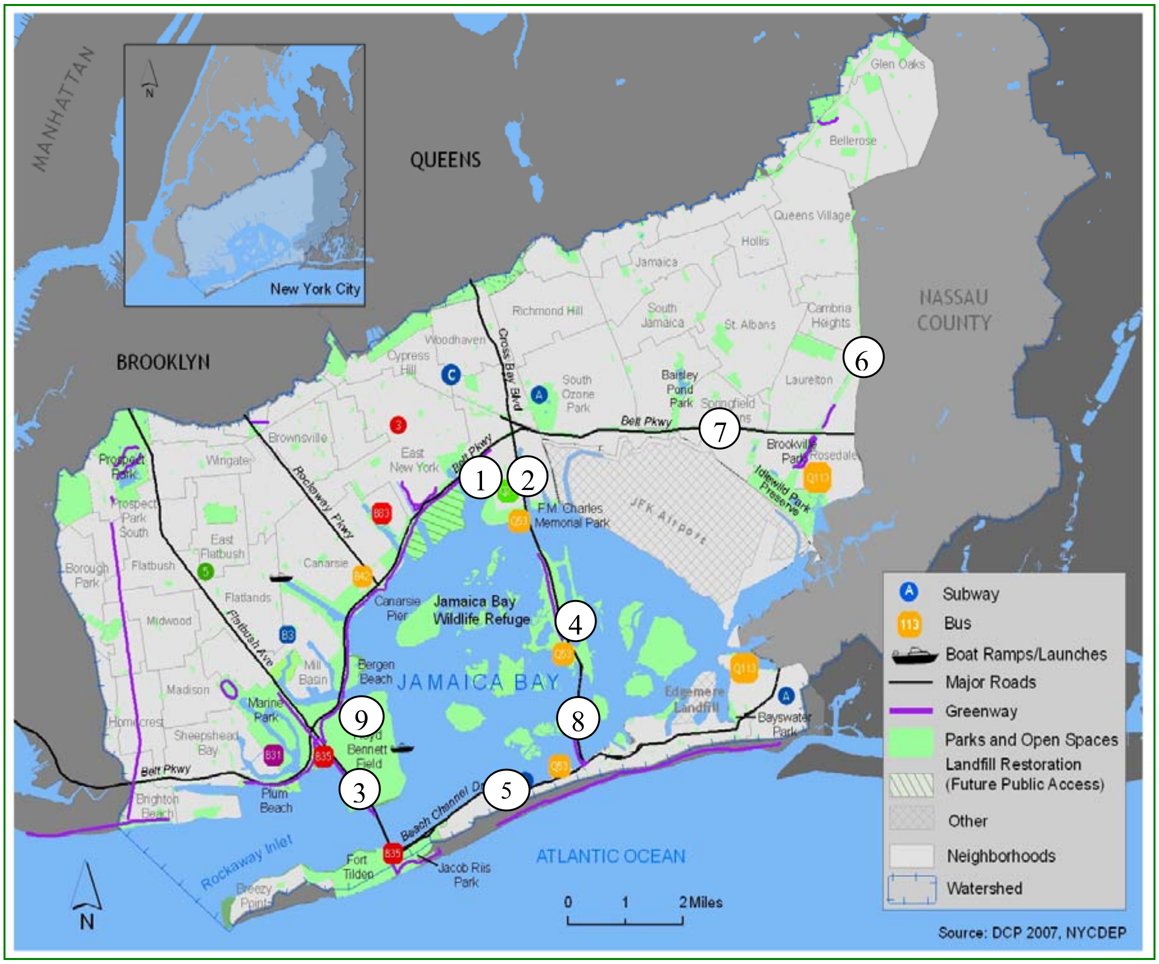


FIGURE 7.2 Public Access Areas to Waterfront and Proposed Improvements; Source: NYCDEP.
(1) Indicates Proposed Improvements to Public Access.

Greenway and Connector Projects

① Shore Parkway: Pennsylvania Avenue to 84th Street

This project is a section of the Rockaway Gateway Greenway, which would establish a continuous approximately 20-mile greenway loop around the Bay. When completed, the loop will connect Floyd Bennett Field, Fort Tilden, Jacob Riis Park, and the Jamaica Bay Wildlife Refuge, providing bike and pedestrian access around the Bay, across bridges and to the Rockaway's ocean beaches. Much of the trail along the Shore Parkway was built at the time the roadway was originally created however, the trail exists in the form of interrupted pathways. Although no additional access is proposed from the upland communities, the proposed improvements and additions to the greenway route will facilitate connections to existing access points.

Schedule: Construction was started in April 2007 and is anticipated to be completed during 2007.

Cost: The cost for this portion of the Shore Parkway Path is estimated to be $2,574,000.

② Shore Parkway Path: 84th Street to JFK Airport

This project will accomplish two goals – to implement a new segment of the Rockaway Gateway Greenway loop, discussed above, and to provide improved connections to JFK Airport.

Schedule: To be determined.

Cost: The cost for this portion of the Shore Parkway Path is estimated to be $1,500,000. Federal Enhancement Funding in the amount of $1,200,000 has been provided. An additional $300,000 in matching funds is required.

③ Rockaway/Gateway Greenway: Flatbush Avenue

Proposed activities within this section of the Rockaway/Gateway Greenway include improvements to access at eight Belt Parkway ramps, to install controls and allow pedestrian/cyclist flow between Brooklyn residential and commercial areas to the GNRA's Floyd Bennett Field and Jacob Riis Park.

Schedule: This project was mostly completed in 1998. However, improvements to pedestrian access and connections to other portions of the greenway are needed.

Cost: To be determined.

3a Rockaway/Gateway Greenway: Spring Creek Portion (not shown on map)

This portion of the Rockaway/Gateway Greenway will connect the Shore Parkway Path section described above with the Cross Bay Boulevard portion, described below.

Schedule: Planning phase is ongoing. Final placement of the trail is still being discussed.

Cost: To be determined.

(4) Rockaway/Gateway Greenway: Cross Bay Boulevard

This portion of the Rockaway/Gateway Greenway will likely consist of mostly roadside paths due to concerns regarding nesting bird habitat.

Schedule: Construction is mostly complete. Improvements such as landscaping work are required. Landscaping is important in this section of the greenway due to nesting bird habitat concerns.

Cost: Costs for landscaping and other improvements to be determined.

(5) Rockaway/Gateway Greenway: Rockaway Boulevard along Beach Channel Drive

This portion of the Rockaway/Gateway Greenway will provide bicycle access to the Rockaway Peninsula and will provide a connection between the Rockaways and Riis Park. Logistical issues including traffic safety, flooding, and infrastructure improvements to the existing roadway at Riis Park must be addressed prior to construction.

Schedule: No proposed start date. Final placement of the trail is still being discussed.

Cost: To be determined.

(6) Laurelton and Cross Island Parkway Greenways

NYCDOT and NYCDPR are planning and designing this 22-mile path through parkland located adjacent to the roadways. This route will provide a link from the Brooklyn/Queens Greenway system, through the upper Jamaica Bay watershed area, to the Southern Parkway Greenway (discussed below) and to the waterfront in the Southeast Queens area.

Schedule: The Phase I section between 147th and 135th Avenues was completed in 2006. Construction of Phase II, between 135th Ave. and 100th Dr., is pending acquisition of additional funding.

Cost: The Phase I Section cost was $895,000. Phase II projected cost is $3,420,000. To date, $2,000,000 in Federal Enhancement Funding has been obtained. An additional $1,420,000 is needed to complete the project.

(7) Southern Parkway Greenway and Conduit Boulevard

This greenway will connect to the Brooklyn/Queens Greenway via the Laurelton Greenway (discussed above) and continue east out of the Jamaica Bay watershed through Nassau County and west to the Rockaway/Gateway Greenway (discussed above).

Schedule: This project has not been implemented. Design and construction are pending acquisition of additional funding.

Cost: To be determined. This project is currently unfunded.

(8) Far Rockaway North Shore Greenway

This proposed trail could connect communities in Far Rockaway with the Rockaway/Gateway Greenway around Jamaica Bay (discussed above). It would also link together Somerville Basin, Conch Basin, North Basin, and several proposed parks that lie adjacent to public housing projects in the vicinity of these basins.

Schedule: The U.S. Department of Housing and Urban Development (HUD) is currently moving forward with public housing improvements in this area, including recreational and waterfront access opportunities.

Cost: To be determined. NYCHA has expressed an intention to work with public agencies and local organizations to secure funding for these improvements.

Other Waterfront Access Projects

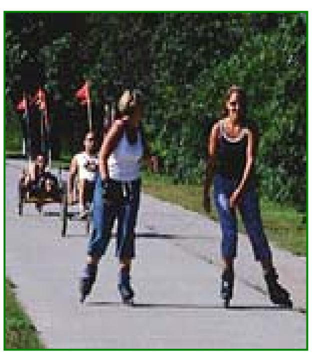
(9) Floyd Bennett Field/Gateway National Recreation Area

NPS has identified numerous capital improvement projects within the GNRA, including rehabilitating Park visitor centers and stabilizing the nine historic hangars at Floyd Bennett Field.

Schedule: Capital improvements are in planning and design. No final schedule available.

Cost: $30 million. Contingent on securing congressional funding.

OBJECTIVE 5B: INCREASE PUBLIC ACCESS TO A WIDER RANGE OF LANDSCAPE TYPES IN THE UPPER WATERSHED IN ORDER TO EXPAND THE PUBLIC'S UNDERSTANDING OF THE INTERCONNECTIVITY OF THE ENTIRE JAMAICA BAY WATERSHED.



Recreational Opportunities in the Upper Watershed; Source: NPS

Current Programs

In addition to proposed greenways along the Bay, the current NYCDOT and NYCDCP *New York City Bicycle Master Plan* and *A Greenway Plan for New York* includes some smaller, isolated greenway segments throughout the upper watershed. These Plans also articulate a series of on-street bike trails that connect discrete public landscapes with one another, connect discrete public landscapes and greenways, and connect greenways with one another. While funding continues to be identified and allocated toward greenway development, NYCDOT, NYCDPR, and NYCDCP are currently undertaking project planning and development to identify gaps in the current New York City greenway network.

These projects will increase the integration of the thriving perimeter greenways into the City's urban street network, including arterials, retail corridors, and transit-oriented development corridors. Such improvements may include signage and markings for delineating greenway use, sidewalk installation, path paving, greenway extensions, intermodal bike facilities, traditional and innovative pedestrian and bicycle facilities, street tree planting and landscape improvements, and weekly street openings throughout the city. The 40-mile long Brooklyn Queens Greenway extends from the Atlantic Ocean at Coney Island in Brooklyn to Fort Totten on the Long Island Sound in Queens, passing through 13 parks, two botanical gardens, the New York Aquarium, the Brooklyn Museum, the new Hall of Science, two environmental education centers, four lakes, and numerous ethnic and historic neighborhoods.

PLANYC 2030, a comprehensive plan to achieve sustainability for New York City's future, includes an initiative to increase the number of accessible parks throughout New York City. The goal of this initiative is to ensure that all New Yorkers from every neighborhood live within a 10 minute walk of a park. Implementation of this plan will include the opening and/or renovation of many school playgrounds for use as public parks after school hours. Proposed improvements to Highland Park and Rockaway Beach are also part of the initiative.

The CENYC also includes an open space component. The Open Space and Greening (Greening) program empowers people in neighborhoods to create, manage, and sustain community gardens. Greening has helped transform vacant land into open spaces where citizens can work together. The project includes a community garden mapping project that enables residents to access locations of all community gardens associated with Greening. Other resources provided by CENYC include the Grow Truck, a vehicle which traverses all five boroughs to deliver garden tools, plants, and horticultural advice, and the Greenmarket programs, which coordinates farmers markets for growers of local produce throughout the city.

Management Strategy 5b1: Build upon the existing New York City Bicycle Master Plan and A Greenways Plan for New York City to establish landscape connectivity within the watershed.

STRATEGY DESCRIPTION

A greenway is defined as, "a multi-use pathway for non–motorized transportation along natural and manmade linear spaces such as rail and highway rights-of-way, river corridors, waterfront spaces, parklands and, where necessary, city streets NYCDPR. This management strategy seeks to leverage existing greenways, bikeways, and plans in ways that enhance public access to restored natural landscapes and habitats that contribute to the health of Jamaica Bay and a sustainable watershed. In essence, the strategy proposes the use of greenways as connections between fragmented landscapes within the watershed.

Bicycle Path on Ocean Parkway, Brooklyn; Source: NYCDPR

EVALUATION OF MANAGEMENT STRATEGY

See Potential Management Strategy 5a1 for environmental and legal issues associated with this strategy. See costs under *Implementation Strategies* below.

RECOMMENDATION

It is recommended that the City work with state, federal, and other entities to further pursue opportunities for enhancing connections between diverse landscapes and natural areas throughout the Jamaica Bay watershed and informing residents of these opportunities, pending funding availability

IMPLEMENTATION STRATEGIES

Highland Park; Source: NYCDPR

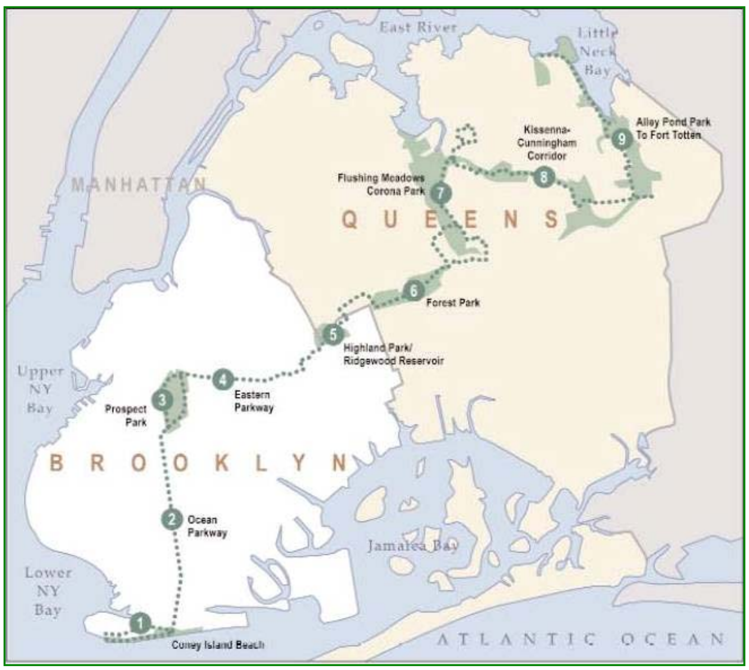


FIGURE 7.3 Brooklyn/Queens Greenway System; Source: NYCDPR

Implementation of additional greenways will involve work with stakeholders to identify connections, infrastructure requirements, improvements to public amenities (including educational signs and displays), and funding sources for the continued management and maintenance.

Brooklyn/Queens Greenway-Queens

The current *Greenway Plan for New York City (*NYCDEP, 1993*)* and the *NYC Master Bicycle Plan* (NYCDPR, 1997) includes over 900 miles of on and off street routes within the city. This planning is comprehensive in nature and is based on a thorough review of appropriate destinations. "Parks" were cited as one of the major destinations during the Bicycle Master Plan design process. The Greenway Plan for New York City also seeks to connect existing parks, open spaces and the waterfront via existing natural or man made corridors. The Brooklyn Queens Greenway traverses and connects a number of parks and significant cultural locations within the upper watershed (see Figure 7.3). There are currently significant planning efforts to provide connectivity between natural destinations within the upper watershed as well as connections to the waterfront.

This project includes the portion of the Brooklyn/Queens Greenway that runs through the Jamaica Bay watershed. The project will include actions such as installing landscaping and streets trees; installing bike racks, and marking bike facilities. Traffic signals, new crosswalks, and bike lane striping many also be a part of this project. This project will overlap with other greenway integration projects, some of which are discussed in Management Strategy 5A.

Schedule: The segment known as the “Eastern Parkway Extension: Brooklyn Queens Greenway” between Eastern Parkway at Buffalo Avenue and Highland Park is under design. This greenway link is scheduled to be trail blazed with greenway signs for both pedestrians, who will be using sidewalks, and cyclists, who will follow new bicycle markings in the streets. Projected completion date is June 2010.

Cost: To be determined.

Greenstreets Program

NYCDPR is establishing an enhanced Greenstreets Program under PLANYC 2030. See Management Strategy 3b1 for more information.

REFERENCES

Dittersdorf, Joanne. Personal Communication. Rivers and Trails, New York Park Service, New York City Field Office. September, 2007.

Kao, Jennifer. Personal Communication. City of New York Parks & Recreation. August 2007.

New York City Department of City Planning (NYCDCP). 1993. *A Greenway Plan for New York City*. New York, NY.

New York City Department of Parks and Recreation (NYCDPR). 1992. *New York Waterfront Revitalization Program.* New York, NY.

New York City Department of Parks and Recreation (NYCDPR). 1993. *A New York City Comprehensive Waterfront Plan*. New York, NY.

New York City Department of Parks and Recreation (NYCDPR) and New York City Department of Transportation (NYCDOT). 1997. *New York City Master Bicycle Plan*. New York, NY.

The City of New York. 2007. PLANYC 2030. New York, NY.

Barry A. Vittor & Associates and Environmental Concern, Inc. (Vittor and ECI). 2002. Final Conceptual Plan Report. U.S. Army Corps of Engineers, New York, NY.

CHAPTER EIGHT

CATEGORY 6, IMPLEMENTATION AND COORDINATION

INTRODUCTION AND ISSUES IDENTIFICATION

There are a myriad of federal, state, and city government agencies, non-governmental organizations, academic institutions, and private interests working to preserve and enhance the unique resources of Jamaica Bay and reverse the trends of water quality degradation and wetland loss. The Public Outreach chapter of Volume One lists dozens of organizations committed to these goals. Despite all of these efforts, there is a lack of resources to do all that needs to get done.

Neither individual organizations nor individual agencies, acting alone, can accomplish the aggressive agenda outlined in this *Jamaica Bay Watershed Protection Plan*. Only through coordinating separate efforts and pooling resources will the strategies recommended in this Plan be realized. There is much more to be gained from working collectively.

A key issue for Plan implementation is funding. As presented above, a number of the priority implementation strategies are currently unfunded. Partnerships will need to be developed between the public and private sectors to fund these initiatives. And coordinated advocacy efforts are needed across the many non-governmental organizations working in the Jamaica Bay watershed to help leverage additional funding from state and federal agencies. NYCDEP also suggests fostering the development of a conservancy that would act as an umbrella organization to support efforts to preserve and enhance the Bay.

Partnerships and collaborations among the range of entities engaged in environmental research and management in Jamaica Bay are already occurring. An example of this are the salt marsh restoration projects in the Bay interior, the result of successful collaboration between USACE, NYSDEC, NPS, NYCDEP, and a host of academic institutions and citizen groups. Additionally, as part of the development of the *Jamaica Bay Watershed Protection Plan*, NYCDEP has been reaching out to other agencies, engaging them in the planning process, and identifying mechanisms by which coordination could be further leveraged to implement the plan’s strategies.

Four additional strategies should be pursued to coordinate the implementation of this Plan and ensure that its recommendations turn into actions:

- Form a Jamaica Bay Water Quality and Ecological Restoration Committee under the auspices of the NY/NJ HEP
- Continue to work through the Mayor’s Office Interagency BMP Task Force to implement BMPs
- Continue the Jamaica Bay Education Coordinating Committee under the auspices of the Soil and Water Conservation District

- Monitor Land Use, Water Quality and Ecological Restoration Efforts through Coordination with the Office of Environmental Coordination and other agencies with jurisdiction over the Jamaica Bay area

In addition, a strong enforcement strategy is a key implementation issue. Enforcement is needed to deter polluters, address violations, and ensure that strategies are implemented and maintained over time. Under the proposed review of the Sewer Code (see Chapter 5, Stormwater BMPs), it is anticipated that there may be revisions concerning requirements for installation of stormwater BMPs. As part of the Code review, NYCDEP will identify enforcement measures related to BMP implementation and maintenance. With respect to pollutant discharges to the sewer system from industrial sources, the NYCDEP tracks compliance with the Industrial Pretreatment Program. The Department of Sanitation's (DSNY) City-wide Illegal Dumping Task Force provides for local enforcement actions against illegal dumping. DSNY also provides monetary rewards for reporting observations of illegal dumping.

At the State level, NYSDEC is responsible for enforcement of water quality standards and wetlands protection. Through its permitting programs, NYSDEC evaluates compliance with water quality standards and requires mitigation with respect to water pollution control plants and other facilities discharging to the Bay. Penalties for violation of Environmental Conservation Laws generally include both civil and criminal fines. Additional fines can be assessed for each day that an operation remains in violation, and jail sentences can be imposed. Under a consent order with NYSDEC, an individual or company typically agrees to pay a penalty for its environmental violations, come into compliance with state and federal environmental laws and regulations, and, where necessary, clean up any pollution that it caused. Governor Spitzer recently issued a press release announcing that the State will provide additional resources to support an expanded environmental enforcement initiative within NYSDEC. (For additional strategies related to enhanced monitoring see Chapter 9, "Strategies for Future Consideration.")

Form a Jamaica Bay Water Quality and Ecological Restoration Steering Committee under the auspices of the Harbor Estuary Program (HEP).

A "Jamaica Bay Collaborative" should be established specifically to coordinate the implementation of Water Quality and Ecological Restoration strategies under this Plan. The Collaborative could be modeled after, or incorporated into, the NY/NJ HEP which provides a working example of multi-entity coordination within this region. Using the NY/NJ HEP as a template, the Collaborative could be composed of federal (USEPA, USACE, NPS, NOAA, USFWS), state (NYSDEC), and City (*e.g.*, NYCDEP, NYCDOT, NYCDDC, NYCDPR, NYCDCP, NYCDOB) agencies and non-governmental agencies with jurisdiction and/or interest in the Bay and its watershed.

The role of the Collaborative would be to track the results of water quality and ecological restoration monitoring (see Objective 1E), identify positive trends and problem areas that need to be addressed, track the progress of restoration and acquisition efforts and raise funds needed for these efforts, review and advise on the effectiveness of water quality and ecological restoration pilot projects, among other similar tasks.

NY/NJ HEP receives funding from USEPA, and state and local partners. Compared to other National Estuary Programs in the Mid-Atlantic/Northeast, NY/NJ HEP receives considerably less federal funding and currently does not have the resources to incorporate a Jamaica Bay focus. It will be critical to coordinate efforts across many organizations to leverage the funding that is needed to ensure the establishment of a comprehensive stakeholder entity that can oversee the implementation of the water quality and ecological restoration elements of the Plan. National Estuary Programs can be well-situated to leveraging funding by developing strategic alliances with implementing partners to obtain their financial support and providing seed money or staff to initiate and develop new funding sources.

Continue to work through the Mayor's Office Interagency BMP Task Force to implement BMPs.

While NYCDEP will continue its leadership role on evaluating and monitoring BMP pilot projects and updating its sewer code and guidelines to better foster BMPs, interagency coordination is key to ensuring widespread incorporation of BMPs into both public and private development. The Mayor's Office Interagency BMP Task Force is playing a key role in coordinating the implementation of BMPs through providing a vehicle for cross-agency communication. The Task Force will also play a key role in formulating City policy with respect to regulating and/or incentivizing BMP implementation on public and private development.

Continue the Jamaica Bay Education Steering Committee under the auspices of the Soil and Water Conservation District.

Public education and outreach are vital to creating awareness and fostering environmental stewardship for the Bay and watershed. The Jamaica Bay Education Coordinating Committee, formed as part of the *Jamaica Bay Watershed Protection Plan* development process, was instrumental in developing the education and outreach implementation strategy concepts included in the Plan. To implement these strategies, NYCDEP will partner with the NYCSWCD, which will oversee and direct these efforts. The Education Coordinating Committee will continue to work with and advise the NYCSWCD on strategy development and implementation. NYCDEP is committed to funding a one year effort with the NYCSWCD, with additional funding possibilities in the future.

Monitor Land Use, Water Quality and Ecological Restoration Efforts through Coordination with Office of Environmetnal Coordination and other agencies with jurisdiction over the Jamaica Bay area

Another key implementation and coordination issue is monitoring and reviewing growth and changes in the watershed over time. NYCDEP will facilitate an initiative to track new development in the watershed and coordinate this effort with appropriate federal, State, and City governmental entities that have jurisdiction over the Jamaica Bay area. The Department will work with the Office of Environmental Coordination (OEC) to review and track proposed development projects in the

Jamaica Bay watershed that are subject to CEQR and to add a section to the CEQR Technical Manual to require these developments to identify stormwater management measures to be implemented as part of their environmental assessments (see also Chapter 5, Stormwater BMPs). NYCDEP will combine this effort with reviewing building and sewer connection permits in the watershed to develop a comprehensive tracking system of new development and stormwater BMPs that are being implemented. As part of this effort, NYCDEP will also develop indicators and a tracking system to monitor the effectiveness of stormwater BMPs over time (see Chapter 5, Stormwater BMPs). The Department, in coordination with OEC, will make these data accessible to other agencies including the National Park Service, NYSDEC and other regulatory agencies. The tracking of land use and development data, coupled with developing a robust scientific monitoring program to track water quality and ecological restoration changes over time (see Chapter 3, Water Quality), will ensure a comprehensive review of the impacts of changes in the watershed over time.

C H A P T E R N I N E

CATEGORY 7, STRATEGIES FOR FUTURE CONSIDERATION

INTRODUCTION

Chapters 3 through 8 describe priority categories, objectives and management strategies required in accordance with Local Law 71. In Chapter 9, a number of additional management and implementation strategies are discussed. These additional items are not required to meet requirements of Local Law 71. However, they are strategies that could be considered in the future as additional ways to improve Jamaica Bay. These strategies could be implemented over time pending the availability of additional funding and other resources. Categories 1 through 6 are discussed in detail in Chapters 3 through 8. Numbering for the strategies discussed below continues from the priority objectives and strategies discussed in Chapters 3 through 8.

CATEGORY 1: WATER QUALITY

Chapter 3, Category 1, Water Quality, describes water quality issues in the context of Jamaica Bay's ecological health and proposes a number of management strategies planned to improve water quality within the Bay. In this chapter, additional proposed management strategies are discussed that could further improve water quality and could be implemented as funding and resources become available.

Potential Management Strategy 1a5: Review and evaluate on-site sewage treatment decentralization technologies for potential application with the Jamaica Bay watershed.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Proceed with a Pilot Program

A number of compact, decentralized wastewater treatment technologies that have been used in rural areas of Europe may be suitable for use in the Jamaica Bay watershed. Using technologies to decentralize the treatment of wastewater and treat sewage at the source would help reduce nitrogen loadings into the sewer system. These types of small scale systems can be designed to provide treatment for 10 to 500 individuals and may also be modified to potentially harness energy from methane production. Similar to the larger WPCPs, they use activated sludge to biologically remove nutrients from the wastewater. According to one manufacturer, typical domestic systems require sludge removal every 3-5 years and systems that receive higher flows may require desludging every 1-2 years. In contrast, lightly loaded systems may go for 10 years or longer before requiring the removal of sludge (EWT Waste Solutions, 2007).

Additional technologies may include solar aquatic systems, anaerobic treatment systems, and composting systems. Composting systems may be the simplest to implement since they require the least amount of water, energy and maintenance and with recent technology advances, can be designed and built for almost any application. These systems use aerobic decomposition to reduce human waste by 97% in volume, with the byproduct of a nutrient rich soil building resource. In summary, composting systems may provide a simple, self-sustaining, low-tech, low-energy, low-maintenance, water conserving and reliable approach to managing human waste.

An analysis of the potential benefits of composting systems was performed to determine the reduction in wastewater flows and in TN discharged. This analysis found that domestic and commercial toilet flows make up approximately 12% of the wastewater flow and contribute as much as 76% of the influent TN to the WPCPs. The large scale installation of composting toilets has the potential to result in water quality improvements and may address some of the impending infrastructure challenges due to anticipated population growth. Implementation could consist of a pilot project to be installed at a public building; and monitoring effectiveness and public acceptance.

It is unclear at this time whether this could be a cost effective treatment for other City agencies or private developments. Therefore, a pilot study will be developed to help to address some of the issues and challenges associated with compact, decentralized wastewater technologies including the performance of new technology, private property issues, maintenance, potential for large scale implementation, and how they function within an urban setting with many existing underground sterilities and structures.

Potential Management Strategy 1c5: Correct compromised sanitary sewers and implement a sanitary sewer connection program focusing enforcement and monitoring of interconnections between sanitary and storm sewers within the Jamaica Bay watershed.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Review Existing and Alternative Procedures

The detection of illegal sanitary sewer connections to the storm sewer system is difficult and is typically found through upgrades to the existing sewer system. NYCDEP requires property owners to immediately correct illegal storm/sanitary sewer connections when they are found through existing storm and sanitary construction projects. Alternative procedures used by other municipalities along with existing NYCDEP procedures will be reviewed to make future recommendations.

Potential Management Strategy 1c6: Increase efforts to promote the proper disposal of pet waste, including the provision of pet waste disposal bags and enforcement of sanitation ordinances.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Determine the effectiveness of existing enforcement and outreach programs

The DSNY has implemented a far-reaching citywide campaign to encourage New Yorkers to comply with the law and pick up after their dogs. Through outreach programs, DSNY aims to educate the public on the fact that canine waste is not only an unsightly nuisance, but it can also pose health hazards when it's not cleaned up. DSNY's campaign seeks to educate the public into the "Pooper Scooper" law – officially known as Section 1310 of the New York State Public Health Code – which became law in New York City on August 1, 1978. "With the enactment of this law, the Big Apple became the first major American city requiring dog owners and dog walkers to be responsible for picking up and disposing of their dog's waste. Many other cities across the country – and around the globe – followed suit with similar 'pooper scooper' laws (DSNY, 2007)." Fines for violating the "Pooper Scooper" law have recently been doubled from $50 per violation to $100.

While known as a contributor, the level of pet waste contribution to fecal coliform levels in Jamaica Bay is unknown. New York City Community Board Cleanliness Ratings track levels of accumulated trash along sidewalks and streets but do not specify accumulation of pet waste, thus it is difficult to quantify the magnitude of the problem specific to Jamaica Bay. Adapting the Cleanliness Ratings system to include pet waste may be one way to track and monitor enforcement and outreach efforts.

Coordinate ad campaigns/public service announcements to convey connection between water quality and pet waste accumulation

Public outreach currently consists of sidewalk signs posted throughout the City, NYCDPR sign postings, and information distributed by non-profit organizations such as the Green Thumb community gardens program. A Spring 2007 ad campaign was launched by DSNY to encourage people to comply with the intensive enforcement program. The message focuses on "keeping your shoes clean by keeping the sidewalks clean." With a coordinated or collaborative outreach program, this message could be expanded upon to describe the interconnections between pet waste, fecal coliform levels in Jamaica Bay and overall water quality impacts.

Potential Management Strategy 1d2: Improve dissolved oxygen in Grassy Bay and North Channel by evaluating alternative strategies such as mechanical aeration, fountains, or other engineering solutions.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Utilize coarse bubble diffuser aeration to deliver air to the water column in Grassy Bay

Coarse bubble diffuser aeration utilizes compressors to supply air, and a network of pipes and diffusers located beneath the water surface to distribute the air. At the diffusers, the compressed air is released to the water column in the form of coarse bubbles. These bubbles rise to the water surface, transferring oxygen to the water as they rise. Coarse bubble diffuser aeration is a proven means of transferring oxygen to a water body and is more efficient in moderate to deep waters than surface aeration technologies such as floating aerators.

The advantages of coarse bubble diffusion aeration is that it is a proven aeration system used in many wastewater treatment systems including the Cardiff Bay Project to improve dissolved oxygen within the man-made escarpment. Typically, these systems are relatively easy to operate once installed, with all mechanical parts located on shore for ease of repair and maintenance.

Identifying an appropriate on shore location for these facilities, however, can be a challenge as the potential for noise and air impacts must be taken into consideration. Also, aeration of Grassy Bay, utilizing coarse bubble diffusion given a uniform bottom depth of 28 feet, requires compressors totaling 6,000 horsepower (hp). These compressors would be designed to deliver 57,000 standard cubic feet/min (scfm) of air to the bottom of Grassy Bay. A distribution network would be needed to deliver the air to the water column including a 42-inch diameter ductile iron main to convey the air under pressure to the diffuser network at 28 feet of depth. The air mains would be installed in a trench from the compressor building to the risers, a potential distance of more then 12,000 feet. Installation of the air main within the subaqueous trench and the installation and maintenance of the diffuser networks within Grassy Bay are important considerations for this alternative. Installation and maintenance of the diffuser system within Grassy Bay would also require the use of divers to place, level the diffusers, and perform necessary annual inspections and repairs to the system.

In addition, the use of coarse bubbler diffusers could be potentially disruptive to the aquatic and benthic environments and faces strong opposition from the NPS for its use within its jurisdictional boundaries. Permits or authorizations would be required from NYSDEC, USCOE, NPS, and perhaps others. There may also be potential multi-jurisdictional issues associated with aeration in Grassy Bay; the project may overlap regulatory boundaries, requiring a jointly implemented project to maximize success. Operational priorities and missions may also be different for the various City, state and federal agencies.

Potential Management Strategy 1e1: Continue the ongoing floatables booming, skimming, and netting programs, as appropriate, until other floatable control operations become effective.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Continue existing booming, skimming, and netting program and tracking mechanisms

Floatables booms and nets capture discharged floatables at or downstream of CSO and storm drain outfalls, preventing dispersion to the open waters of Jamaica Bay. Recovery of the captured floatables by skimmer vessels removes the material for proper disposal.

As a result of the June 1992 Combined Sewer Overflow Abatement Program Consent Order, the June 1997 City-Wide CSO Floatables Plan, and the July 2005 City-Wide CSO Floatables Plan, NYCDEP has maintained a booming, skimming, and netting program since 1993 to contain and remove floatable material after discharge from priority CSOs and storm drains throughout New York Harbor. As of December 31, 2006, the City wide system included 21 boom sites and 5 netted sites corresponding to stormwater and combined sewer drainage areas totaling approximately 60,000 acres.

Boom and net locations, inspection, maintenance, service characteristics, and captured floatables volumes are currently tracked through the NYCDEP's Annual Report on Best Management Practices for CSOs. Among other items, this report tracks all of the City's 26 floatables containment facilities, including the five existing booms and net facilities in Jamaica Bay tributaries (*i.e.*, Bergen Basin, Fresh Creek, Hendrix Creek, Paerdegat Basin, and Thurston Basin). Materials contained by the booms and nets are recovered by five. City-owned skimmer vessels, which are off-loaded at NYCDEP facilities. A contractor is engaged to operate and maintain the skimmer vessels as well as maintain the boom and net facilities.

Based on the data, the Pilot Floatables Monitoring Program observations have tended to confirm expectations that the open water at most of the monitoring sites tends to be clear of floatables, and that only a minority of sites have had a significant amount of floatables in near shore areas. Notably, four of the five sites had good or very good ratings during all open water and near shore observations. J3, Canarsie Pier, did have poor ratings for less than 10% of the observations in the near shore (*i.e.*, one poor rating on April 24, 2007 out of thirteen total ratings). For the shoreline ratings, only J8, near the mouth of Spring Creek, has a non-pier, non-bulkhead, "ratable" shoreline, which was rated fair during 100% of the observations.

The booming, skimming, and netting program will continue within Jamaica Bay and its tributaries, with the existing five facilities (*i.e.*, Paerdegat Basin, Fresh Creek, Hendrix Creek, Bergen Basin, and Thurston Basin). Evaluation and reporting programs, including periodic operations performance reviews, CSO Annual BMP Reports, Floatables Monitoring Program, and the multi-agency LPWG participation should continue also.

In addition, the program should be adjusted, as appropriate, to optimize floatables containment operations and to adjust or remove containment facilities should more effective floatables controls come on line in the future. Additional CSO and floatables control mechanisms may also be put in place for other LTCP waterbodies. Boom and net performance reviews should be conducted after implementation of such LTCP controls to determine if the presence of the existing floatables containment facilities will continue to be warranted.

Implement Jamaica Bay Study area-specific cleanliness ratings reviews

In addition to the current programs, Community Board Cleanliness Rating reviews specifically for the Jamaica Bay watershed could be added as a section to the CSO Annual BMP Report to ensure this issue is addressed at least annually. The results, along with Floatables Monitoring Program results for Jamaica Bay monitoring stations, could be presented to the LPWG to help spur discussion about litter and floatables in the study area and local control program improvements.

Potential Management Strategy 1e2: Review and strengthen enforcement activities and sanctions against illegal dumping into Jamaica Bay.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Support DSNY illegal dumping enforcement programs

Illegal dumping is the disposal of liquid, solid, and/or hazardous waste without a permit. Existing local, state, and federal laws prohibit illegal dumping into Jamaica Bay and the Jamaica Bay watershed. Local enforcement is conducted by the DSNY Citywide Illegal Dumping Task Force.

Clear and timely enforcement of all illegal dumping regulations has the potential to improve the water quality of Jamaica Bay, as well as citizen satisfaction with the protection of the Bay's natural resources. Potential obstacles to enhanced legal enforcement sufficient to greatly reduce illegal dumping in the Jamaica Bay watershed include greater law enforcement and surveillance costs, increased coordination among regulating agencies, and costs associated with providing an uncomplicated and legal disposal system for all waste material.

Investigate opportunities to dedicate penalty fines to watershed protection projects (such as the Jamaica Bay Damages Account) and increase public service announcements concerning the environmental dangers of illegal dumping.

Penalties for violation of Environmental Conservation Laws generally include both civil and criminal fines. Additional fines can be assessed for each day that an operation remains in violation, and jail sentences can be imposed. Under a consent order with NYSDEC, an individual or company typically agrees to pay a penalty for its environmental violations, come into compliance with state and federal environmental laws and regulations, and, where necessary, clean up any pollution that it caused. "New York State Governor Eliot Spitzer recently signed legislation that increased revenue to the State's Environmental Protection Fund (EBF) from $225 million to $250 in the 2008-09 fiscal year and to $300 million in fiscal year 2009-10 and thereafter. Established in 1993, the Environmental Protection Fund provides money for recycling, landfill closure, urban parks, smart growth, open space, water quality, pollution prevention and a range of other environmental programs administered by the Department of Environmental Conservation and the Office of Parks, Recreation and Historic Preservation" (New York State Governor's Office, 2007).

Increase advertising of the illegal dumping programs

DSNY has two programs through which the public can collect monetary awards for reporting observations of illegal dumping. Under the first—The Illegal Dumping Award Program — an individual must be willing to sign an affidavit and appear at the Environmental Control Board (ECB) hearing. Under the second — The Illegal Dumping Tip Program — information about the individual's identity remains confidential. Posting clear and easily accessible information regarding these programs as well as all applicable regulations, fines and penalties for violations may help to deter illegal dumping.

Potential Management Strategy 1f1: Review NYCDEP's portfolio of industrial pre-treatment permittees within the Jamaica Bay watershed with the goal of enhancing BMPs with respect to their industrial processes.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Map industrial and commercial businesses containing automotive and/or transportation facilities

Proper control of industrial and commercial wastes and materials is essential to prevent the introduction of unacceptable levels of pollutants into storm and combined sewers that discharge to waterbodies. Rules of the City of New York (15 RCNY), Sewer Use Regulations Chapter 19, Section 3 (§19-03), Materials and Substances Excluded from Public Sewers prohibit the discharge of certain chemicals to the sewer system. NYCDEP has existing pollution prevention programs targeted at industrial and commercial (*e.g.*, auto repair shops) businesses that provide outreach and technical and regulatory assistance to raise awareness and help the business community address and avoid the discharge of pollutants such as heavy metals, pathogens, oil and grease, suspended solids, nutrients, floatable materials, and chemicals. To determine additional effectiveness, there may be an opportunity to increase the effectiveness of existing pollution prevention programs by identifying additional BMPs that could be utilized by the dischargers to reduce the amount of wastewater pollutants. In order to identify additional BMPs, automotive and/or transportation facilities would need to be mapped to determine the appropriate types of BMPs, since BMPs are site specific and the potential benefits of implementing additional BMPs would need to be evaluated.

Potential Management Strategy 1f2: Perform risk identification of potential sources of contamination, including airports and other industrial operations, as well as known underground storage tanks, oil storage facilities, former landfills, and Superfund sites.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Review performance and enforcement data within a quarter mile of the Bay and its tributaries

Jamaica Bay was identified by the USEPA and NYCDEP as an impaired waterbody. There are various environmental and human health concerns associated with current conditions within the Jamaica Bay watershed. Industrial and commercial operations and land uses pose significant actual and potential threats to water quality in Jamaica Bay and its tributaries.

In addition to NYSDEC-required registration, the New York City Fire Department (FDNY) also requires registration for those activities that have the potential to cause disruptive environmental spills and flammability issues. To help identify sources and types of industries that pose the highest risk for impairment, a qualitative identification of risk for actual and potential sources of contamination to Jamaica Bay and its tributaries would need to be performed.

Increases in monitoring and enforcement efforts could be developed pursuant to the existing authority in the City's industrial pretreatment program. Spills anywhere in the watershed are problematic; however, those occurring within a quarter mile of the Bay, pose the greatest threat as there are limited opportunities for quick remediation or attenuation prior to reaching Jamaica Bay. The first step toward monitoring and enforcement improvements would require a review of existing performance and enforcement data.

Potential Management Strategy 1f3: Examine the list of brownfields within the Jamaica Bay watershed/sewershed and evaluate on a case-by-case basis how to improve their ecological functioning.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Coordinate with and facilitate existing brownfields programs

Potential benefits of brownfield remediation include reduction of contaminants leaching into the Bay and opportunities to implement sound land use and development strategies designed to restore the Bay. A coordinated brownfields program could help achieve a number of restoration ecology objectives and minimize post-cleanup costs and costly maintenance of caps, pump, and treatment systems.

City and State Brownfield Remediation Programs currently exist. In addition, the OEC is planning to create additional programs for sites that fall outside of state program parameters. Implementation would involve coordination with OEC to pursue funding opportunities such as Brownfield Opportunity Area (BOA) funding as a way to assess and provide for long term remediation of brownfields in the Jamaica Bay Watershed. The BOA program is designed to assist municipalities and community groups with assessment, prioritization and implementation by:

- Identifying and delineating brownfield remediation sites;
- Identifying known or perceived contamination of the site;
- Developing appropriate reuses; and
- Identifying appropriate remediation technology and actions for priority sites.

Potential Management Strategy 1g1: Identify the nature and extent of contaminated sediments in Jamaica Bay.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Identify existing data gaps and validate currently used or proposed models

The Hudson River Foundation in consultation with HydroQual, Inc. expects to release a mathematical modeling report for contaminated sediments by early 2008. The model will evaluate point and non-point source loading inputs, estuarine hydrodynamics and sediment transport, contaminant fate and transport, bioaccumulation, and toxicity for the Contaminant Assessment and Reduction Project (CARP). Review of the mathematical model would support further sediment evaluation of Jamaica Bay. Other sediment toxicity and bathymetric references were identified, but not reviewed for the preliminary conceptual site model including:

- Hudson River Foundation. 2004. Health of the Harbor: The First Comprehensive Look at the State of the NY/NJ Harbor Estuary 2004.
- Harbor Estuary Program (HEP). March 1, 1996. Comprehensive Conservation and Management Plan.
- Jamaica Bay Institute research.
- Numerous studies from local universities including Columbia, City University of New York (CUNY) at Staten Island, and State University of New York (SUNY) at Stony Brook.
- NOAA data for 1934, 1950, and 1995 related to sedimentation rates in Jamaica Bay.

Review of these references may provide additional information for the sediment toxicity component of the conceptual site model.

Develop a plan for collection and analysis of additional sediment data, including current bathymetry

NYSDEC technical guidance (TOGS 5.1.9, NYSDEC 2004) suggests the collection of approximately 200 to 300 sample locations would be required to evaluate an area of the approximate size of Jamaica Bay. Several investigations of Jamaica Bay sediment have been completed. Nonetheless, the data set for Jamaica Bay appears limited. For example, the Regional Environmental Monitoring and Assessment Program (REMAP) investigation collected and analyzed 28 surface samples (0 to 2 cm) from Jamaica Bay. To further refine the extent of contamination and limit disturbance to benthic communities, the evaluation of sediment would require more extensive sampling and analysis than that of current conditions.

Potential Management Strategy 1g2: Create a plan to mitigate toxic sediment mounds in Jamaica Bay, either through on-site capping or sediment removal.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Obtain physical data of sediment to support sediment management options

Assessment of sediment toxicity is best completed by a weight of evidence (WOE) approach; this approach, accepted by regulatory agencies, represents current risk assessment practice so that decision-making reflects potential impacts in a manner not necessarily determined by a review of one set of information and data. The objective of the WOE approach is to integrate results from various lines of evidence collected in the ecological risk assessment to identify areas requiring further evaluation; endpoints are selected and weighted based on the quality of the underlying information. This approach may eliminate from consideration some locations, while focusing attention on others.

Dredging and recontouring schedules for Paerdegat Basin, Fresh Creek, Bergen Basin and Thurston Basin have been developed and submitted to NYSDEC for approval in the Paerdegat Basin LTCP report and the Jamaica Bay and Tributary Waterbody/Watershed plan report. These efforts will reduce the level of toxic sediments within these tributaries.

In addition, the HEP workgroup on toxics has developed the CARP to quantify the sources of contamination to harbor waters. The goal of this program is to reduce the amount of contaminants entering local waterways. The group is also reviewing and revising the list of Chemicals of Concern (COC) and developing mathematical models to predict those that may be problematic (HEP, 2005). The continued work by this group and others is critical in developing appropriate and successful remediation measures. In addition, this information can be used to continue monitoring the rate of natural attenuation following implementation of source controls.

Evaluate sediment management options relative to technological capabilities and management objectives for Jamaica Bay

The TOGS 5.1.9 guidance defines three sediment quality threshold classes of sediment materials based on the magnitude of certain organic and inorganic constituents. Options for managing dredged sediments are based on the threshold class that applies. The threshold classes as defined in TOGS 5.1.9 are as follows:

- *Class A*: No appreciable contamination (no toxicity to aquatic life) and "dredging and in-water riparian placement, at approved locations, can generally proceed."

- *Class B*: Moderate contamination (chronic toxicity to aquatic life) where dredging and riparian placement may occur with restrictions.
- *Class C:* High contamination (acute toxicity to aquatic life) where "dredging and disposal requirements may be stringent."

The TOGS 5.1.9 guidance suggests that evaluation of dredge material classified as Class B or C include evaluation of the underlying sediment that would be exposed as a future sediment surface. In situations where the concentrations of target constituents in the sediment increases below the proposed dredge sediment, the TOGS 5.1.9 guidance presents three options for consideration:

- dredge shallower
- dredge deeper and cap
- dredge deeper until cleaner.

There are several factors to be considered in the development of sediment management goals. The Sediment Management Work Group identifies the most important questions to be answered in the decision process. Sediment management decisions should incorporate the current level of technical capabilities and experience to define realistic project goals. Performance based dredging goals allow these factors to be considered.

CATEGORY 2: ECOLOGICAL RESTORATION

Chapter 4, Category 2, Restoration Ecology, proposes a number of strategies to evaluate and prioritize land acquisition and ecological restoration projects throughout the Jamaica Bay watershed. Additional land acquisition and ecological restoration projects that could be implemented as funding and resources become available are discussed in this chapter.

Potential Management Strategy 2b2: Identify and compile all known freshwater habitat restoration plans. Where applicable, implement federal, state and local agency projects along the periphery of Jamaica Bay and within the watershed.

STRATEGY DESCRIPTION

As described in the Jamaica Bay Conservation and Restoration Project Inventory, under Management Strategy 2b1 of the JBWPP, this strategy recommends a collaborative effort among multiple agencies and environmental groups to identify potential restoration opportunities within the Jamaica Bay watershed. This inventory will include the identification of potential freshwater-based restoration opportunities. In addition, where applicable, many of the existing restoration projects occurring within the watershed consider the installation of freshwater wetland habitat. Category 3, Stormwater Management through Sound Land Use of the *Jamaica Bay Watershed Protection Plan* also identifies a number of on-site and off-site BMPs, such as constructed wetlands, bioinfiltration basins and vegetated swales that result in the creation of modified freshwater-based wetland habitats.

Freshwater wetlands provide a unique habitat for a variety of plants and also for a suite of animal species that may not utilize tidal wetlands. These types of wetlands can provide important flood control functions, improve water quality by capturing sediments and sequestering and processing nutrients and contaminants, and provide habitats for myriad plant and animal species.

A review of the National Wetland Inventory (NWI) mapping prepared by the USFWS for the Jamaica Bay watershed finds that there are only about 434 acres of freshwater habitats remaining in the watershed, making freshwater-based habitats extremely rare. Approximately half of this area is open water (lake or pond) and the remaining areas are mapped as emergent or forested wetland. Much of the emergent wetland is located on JFK Airport property and is managed for safety reasons to eliminate use by wildlife. The remnants of the freshwater systems that once traversed the watershed are represented by the dead-end basins and creeks such as Paerdegat Basin, Spring Creek, Fresh Creek and Hawtree Basin. The stream corridors have been culverted and the riparian wetlands and uplands were filled and cleared as the watershed was developed. In summary, there is very little freshwater-based habitat remaining in the watershed, and the few areas that do remain tend to be isolated and disconnected.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Restore Freshwater Wetlands

During an initial review of projects within the Jamaica Bay watershed, the following freshwater habitat creation projects have been completed:

- Big John Wildlife Pond and Return a Gift Pond on Floyd Bennett Field
- Strack Pond - Forest Park Twin Ballfields
- West and East Ponds (brackish)
- Idlewild Park
- Belt Parkway stormwater wetlands (in design)

Additional freshwater wetland projects currently proposed or with potential for restoration opportunities within the Jamaica Bay watershed include the following:

- South Garden Pond Freshwater (Jamaica Bay Wildlife Refuge – west side of Cross Bay Blvd.)
- 20th Road (near Big Egg Marsh)
- Springfield Pond
- Conselyea’s Creek, Brookville Park
- Baisley’s Pond
- Interborough Parkway stormwater capture in created wetlands near Ridgewood Reservoir.

Due to the many functions provided by freshwater wetlands and the scarcity of this habitat type throughout the watershed, existing restorations where applicable are recommended that freshwater habitat creation and restoration occur in the watershed. The construction of freshwater habitats would enhance plant and animal species diversity, could potentially benefit a number of endangered and threatened species, and would also be important to migratory birds, which are extremely reliant on Jamaica Bay for resting and feeding during migration through the urban New York metro corridor. The creation of freshwater wetland should be coordinated with other restoration efforts in order to increase connectivity and wildlife corridors.

CATEGORY 3: STORMWATER MANAGEMENT THROUGH SOUND LAND USE

Chapter 5, Category 3, Stormwater Management Through Sound Land Use, describes stormwater BMPs to be implemented in conjunction with the JBWPP and includes a discussion of how human uses of land within the Jamaica Bay watershed affect ecological processes. The JBWPP does not include any additional stormwater management strategies for future consideration at this time.

CATEGORY 4: PUBLIC EDUCATION AND OUTREACH

Chapter 6, Category 4, Public Education and Outreach, proposes a number of initiatives to address public education and outreach. In this chapter, other implementation strategies are suggested for future consideration. These strategies could be implemented over time pending the availability of additional funding and other resources. As discussed in Plan Implementation and Coordination, Chapter 8, the NYCSWCD can coordinate and foster many of these initiatives.

Potential Management Strategy 4a1: Raise awareness among young people to promote local environmental stewardship early during a child's development.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Develop New K-12 Curricula for Jamaica Bay

Based on the development of the Jamaica Bay Educators' Resource Guide (see Chapter 6 for a description of this implementation strategy), the Jamaica Bay Watershed Education Coordinating Committee determined that numerous environmental education resources related to Jamaica Bay already exist and have proven successful among educators. However, in the future, a more comprehensive, long-term strategy will be needed to raise awareness and stewardship among young people. Such a strategy may involve the design, development, implementation and subsequent evaluation of new or enhanced inter-disciplinary, inquiry-based environmental education curricula for K-12 grade students. The curricula developed would include opportunities to learn specifically about Jamaica Bay's ecological systems, introduce environmental careers, and ultimately facilitate environmental stewardship. New curricula developed would need to be aligned with the NYCDOE Science Scope and Sequence and other performance standards to ensure usefulness and support from educators and administrators.

Modifying curricula to incorporate watershed ecology topics will ensure that young people are exposed to local environmental issues. In addition, there are great opportunities to incorporate inquiry-based learning techniques, such as environmental research science projects and data collection programs that focus on the Jamaica Bay watershed. Finally, facilitating interaction between students and the large community of professional scientists, planners, engineers, and resource managers in the watershed can expose students to a multitude of careers and professional education opportunities to which the students may otherwise be unaware.

The Jamaica Bay Watershed Education Steering Committee (recommended in Chapter 6, Plan Implementation and Coordination) will need to continue to engage NYCDOE in a review of the proposed program and discussions of potential projects. Appropriate partnerships, required resources and roles would be identified for the implementation of new curricula and different funding opportunities will be explored. Additional steps include the design of a coordinated outreach approach and training program for educators and schools within the watershed to promote new resources for curriculum planning and implementation, and methods for field testing and program evaluation.

Deliver educational messages about Jamaica Bay and its watershed through informal mechanisms and non-traditional media.

Providing a variety of resources for formal and informal educators will allow Jamaica Bay-specific information to be more easily adopted in the classroom, after school program sites, parklands and other community settings in the watershed. Estuary Live, hosted by the HEP on September 29, 2006, is a good example of an interactive program that involved many different environmental education partners and high school students from the watershed in an hour-long live web broadcast from Big Egg Marsh. The nationwide broadcast focused on the importance of coastal wetlands to people and nature, the disappearance of salt marshes in Jamaica Bay, and the roles we can all play in understanding and improving the health of the estuary. Approximately 500 nationwide registrations, including entire schools, were received to watch the live broadcast, and over 200 students emailed questions during the broadcast. Using Estuary Live as a model, different media and various technologies (*e.g.*, web conferencing, web streaming) may provide effective and efficient means for delivering educational messages to broad audiences and supplementing curricula targeted toward specific audiences.

Many benefits can be found in productions such as Estuary Live. The live broadcast provides an opportunity to get students actively engaged in the field and for others nationwide to learn interactively. The ability for students to view, from their classroom, other students' interaction with the natural environment is beneficial given the many challenges that limit educators' ability to schedule field trips that would encourage field and hands-on learning experiences (*e.g.*, lack of staff, lack of funding for transportation, and standardized testing requirements that can limit curricula development). However, this type of production can be costly and labor-intensive. The Estuary Live production required intense planning by two individuals for six months prior to the production (Laura Bartovics, pers. comm.), plus individual preparation time by all participants. Satellite linkages provide professional-quality video but are prohibitively expensive (on the order of tens of thousands of dollars for a production). In addition, to successfully implement alternative instructional tools and techniques that would allow the Jamaica Bay watershed to become a "living classroom" may require teacher training or new equipment within schools.

Global Learning and Observations to Benefit the Environment, or GLOBE, is a K-12 program to improve science education by involving students and their teachers in world-wide research examining long-term global change. GLOBE provides protocols in the areas of atmosphere, water, soil, land cover and phenology which allow students to make scientific measurements and send their data via the Internet to the GLOBE database. The data is then used by various scientists studying global change as well as other teachers and students to compare environmental conditions worldwide. CUNY at Queens College in the Jamaica Bay watershed is the local GLOBE partner for the New

York City area and has trained hundreds of metropolitan area schools to record environmental data and post it online.

Several organizations and agencies are looking into ways to use non-traditional media or alternative technologies to deliver educational messages to widespread audiences including schoolchildren. Potential tools could consist of video conferencing, Web streaming, and Webinar systems and potential funding opportunities include corporate or foundation grants in addition to government partnerships.

Other projects can include:

- Design, develop, implement and evaluate new and enhanced inter-disciplinary, inquiry based environmental education programs for after school programs, on weekends, and during summer vacations for young people to learn about Jamaica Bay's ecological system, introduce environmental careers and facilitate environmental stewardship.

- Create multi-media resources using video or Web technology that feature the Jamaica Bay watershed and ways young people can collect and share data and interact with and learn from the Bay's ecological system.

Provide Educational Opportunities for Teachers and Other Educators

Classroom teachers and informal educators from youth groups, environmental organizations and government agencies will need to learn about Jamaica Bay so that they can develop and implement lessons and activities that match the appropriate learning styles of the young people and adults they work with. This strategy would help educators to become familiar with the topics that can be learned from exploring Jamaica Bay and the diversity of resources available to them. Ongoing coordination and networking will enable educators to continue to learn from one another and form partnerships that support their educational goals.

Currently, the GNRA Jamaica Bay Unit offers teacher workshops for ranger-guided and teacher-led school programs to discover, explore, and measure and compare environmental conditions in different habitats around the estuary. As part of Operation Explore, NPS along with its cooperating agencies provide teachers with full day training sessions to teach teachers about coastal plants, animals and environmental conditions at GNRA and then compare them with upstate forest, aquatic, farm and community environments. NYSDEC offers professional development opportunities for K-12 teachers including Project WET, Project WILD, and Flying WILD which range from 3 to 6 hour training sessions and provide teachers with manuals, curricula and activities to use in the classroom.

Utilize service learning opportunities at elementary and high schools, higher education institutions, and community organizations to create an informed citizenry.

Service learning is a teaching and learning strategy that integrates community service with instruction and reflection to enrich the learning experience, teach civic responsibility, and strengthen communities. This is accomplished by combining service tasks with structured opportunities that link the task to the acquisition of knowledge, skills, and values. For example, if high school students participate in planting trees in the watershed, they are learning about soil erosion, stormwater management and hydrology while providing an important service. The students can analyze trash collected in the watershed, monitor floatables in the Bay and share observations with elected officials and community members along with recommendations for reducing pollution. Along with suggestions for reducing pollution, they are engaging in service learning. Therefore, the service learning objective is to combine service with learning in intentional ways. In the past several years, service learning has spread rapidly through communities, K-12 institutions, and colleges and universities nationwide. The National Service Learning Clearinghouse (http://www.servicelearning.org) includes more information on this nationwide trend. The Council on the Environment of New York City, a member of the Jamaica Bay Watershed Education Coordinating Committee has been involved in service learning through their successful, Training Student Organizers Program.

The purpose of service learning is to build upon these efforts by expanding the range of learning opportunities through active engagement in meaningful hands-on community service projects, where people of all ages gain skill and knowledge while exploring and discovering Jamaica Bay.

Becoming engaged with local environmental issues through hands-on volunteering projects will help students make the connection that the environment is impacted in both positive and negative ways by human activities. Children as young as pre-school age can enjoy being involved. It is also important to encourage the involvement of parents and community leaders. This would allow parents to lead by example and model stewardship concepts.

Potential Management Strategy 4a2: Raise awareness of Jamaica Bay-related issues through creating an informed citizenry.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Promote the economic value of open space, wetlands, "green" development, and low impact development within the watershed.

Environmental regulations enforced by governments to protect environmental resources, are often seen as being "unprofitable" to businesses and property owners. For environmental protection and sustainability to become truly integrated into the City, it is necessary to demonstrate that these can also be economically viable. In fact, environmental protection most often makes economic sense when all the public costs are considered and often no choice between economic growth and environmental protection is necessary. Further, it is well-documented that amenities such as open space can significantly add to property values. For instance, the stormwater BMPs under construction in Staten Island have increased adjacent property values. It is also well documented that neighborhoods with tree-lined streets are more desirable, and thus return higher property values, than neighborhoods without mature street trees. Existing information on the private benefits of land preservation and sustainable development can be used to educate developers and other city agencies that environmental sustainability is not only desirable, but also makes economic sense.

For example, The Trust for Public Lands published a report in 1999 entitled "The Economic Benefits of Parks and Open Spaces" which offered case studies of how land conservation and protection have served as economic investments to help communities attract investment, revitalize cities, boost tourism, etc. The 2007 book "The Economic Benefits of Land Conservation" was based on the success of the 1999 report and includes analysis by many experts in the field regarding the dividends, including economic ones, of conserving and protecting land. These documents are available from The Trust for Public Lands website (http://www.tpl.org) at no charge.

As part of this implementation strategy, informational materials can be developed and publicized to public and private development entities in New York City, with the goal of encouraging land use and development practices to be more environmentally sustainable.

Develop a series of interpretive exhibits at GNRA facilities and beyond.

Currently, the GNRA uses interpretative signage to describe natural features and ecological processes that can be observed at different locations throughout the Jamaica Bay Unit including the Jamaica Bay Wildlife Refuge. NYCDEP recently provided GNRA with information and illustrative materials developed as a result of the *Jamaica Bay Watershed Protection Plan* planning process to date for a temporary display at the Jamaica Bay Wildlife Refuge. In addition, interpretive signage in other locations outside of the GNRA system, developed in conjunction with *Public Use and Enjoyment* strategies, would allow public educational opportunities to be expanded throughout the watershed.

As part of this strategy NYCDEP will review its existing interpretive exhibits to determine any gaps in Jamaica Bay-related information. In addition, the assessment of this strategy will involve a review of other potential locations in addition to GNRA for interpretive exhibits such as city parks, schools and community centers throughout the watershed.

Establish a program of events including a “Bay Day” or “Eco-festival” that increases awareness and enjoyment of Jamaica Bay through celebration and learning.

The Jamaica Bay watershed is endowed with a rich ecological, cultural, and recreational heritage, and can truly be called one of the “gems” of New York City. Public celebrations of these assets will provide environmental education about the watershed to the general public in ways that other programs may not. It will also support a number of *Jamaica Bay Watershed Protection Plan* values: supporting Jamaica Bay watershed restoration and improvement efforts; fostering public outreach; providing opportunities for public education; promoting public use and enjoyment of Jamaica Bay in a safe and ecologically sustainable manner; and building community cohesion related to the ecological sustainability of Jamaica Bay.

In recent years, increased environmental awareness appears to have resulted in an upswing in popularity for festivals involving environmental issues in the suburban New York region. For example, the June 15, 2007 edition of the Journal News reported that the Clearwater Festival, a local music/environmental festival celebrating the nearby Hudson River Estuary, has received more volunteers than there are jobs for them to do.

This strategy involves identifying outreach and recreational groups to discuss opportunities to leverage and coordinate current activities that are designed to increase awareness and enjoyment of Jamaica Bay, and the potential for organizing a Jamaica Bay event or festival. Local musicians/bands may be willing to provide entertainment and promote Jamaica Bay.

Create a targeted campaign for public officials and public agency representatives that include briefings, workshops and boat tours about Bay-related issues and opportunities.

Coordination and communication between elected officials, public agency representatives, researchers and stewards of the Bay would enhance ecosystem restoration efforts underway in the watershed by bringing attention to the issues facing the Bay. A combination of briefings, workshops, and boat tours of the Bay would be organized to foster this transfer of knowledge and provide current information on the status of ongoing projects. This strategy is designed to gain consensus and commitment to reverse negative impacts on the Bay. Continual education and awareness of the ecological linkages between human uses and water quality and ecosystem health is especially critical for the decision-makers as the *Jamaica Bay Watershed Protection Plan* is implemented.

This strategy would utilize the *Jamaica Bay Watershed Protection Plan* to formalize issues, current efforts, and necessary future actions with public officials and local, state and federal agencies. A "tool kit" can be developed to cover critical information about the Bay and its watershed. The information included in the kit could serve as the foundation for a "traveling show" that could be easily tailored based on the target audience.

Develop an expanded grease remediation program

Grease is a byproduct of food preparation, and represents a source of pollution to Jamaica Bay, contributing to high levels of eutrophication and low dissolved oxygen. In addition, grease can coagulate in pipes, and restrict flow or cause blockages, causing maintenance problems for individual property owners and the City. One way of preventing grease discharges into our sewer systems is utilizing grease traps. Grease traps are devices that are installed in the waste line leading from sinks and floor drains of restaurants, kitchens, cafeterias, or other establishments where grease can be introduced into the sewer system. The primary purpose of grease traps is to prevent discharge and buildup of grease in the sewer system, thereby reducing the potential for clogging.

In May 2000, NYCDEP initiated the Grease Response Education and Enforcement Program in order to reduce the amount of fat, oil and grease discharges from food service establishments from entering the sewer system. This program approaches the problem with a combination of enforcement actions and public outreach and educational efforts, including foreign language materials which are distributed to restaurants. Educational efforts include trade show appearances, Community Board and other public meetings, direct mailings, informational hand outs, and NYCDEP website postings. Residential grease discharge is also a problem. NYCDEP distributes leaflets and promotional items reminding the public not to pour grease down the drain. There is a growing market for these restaurant waste products since it can be filtered and burned in place of diesel fuel in vehicles that have been converted for such use. For example, in the July 1, 2006 edition of the Washington Post it was reported that one company that sells "conversion kits" to allow diesel cars to burn vegetable oil as fuel has gone from selling about 20 kits a month in 2000 to as many as 100 a week in 2006. There may be an opportunity for an entrepreneur to establish a grease recycling program by collecting, filtering and selling the grease as fuel.

Heighten public awareness through a "Don't Dump, Drains to Jamaica Bay" message affixed to curb inlets, storm drains, and catch basins.

Many municipalities that exist next to environmentally-sensitive areas, including major cities in the Chesapeake Bay, San Francisco Bay, and Puget Sound watersheds, to name just a few, affix signage to curb inlets, storm drains, and catch basins to remind residents not to dump household or industrial waste directly into the storm drain system. This type of public awareness program has been proven to effectively reduce the amount of liquid and solid wastes that end up in receiving waters. NYCDEP has designed a similar program for New York City and, as a result, NYCDDC has begun the gradual installation of the message - "Dump No Waste, Drains to Waterways" - next to the image of a fish on catch basin curb pieces. The message is installed during catch basin repair and curb reconstruction projects; consequently, the installation of the message on the City's 130,000 plus catch basins will occur over time per repair and reconstruction schedules. Painting the above message on catch basins would expedite communication of this issue and implant a heightened awareness of their relationship to the Bay and its watershed in the public.

In December 1998, the NYCDEP published a report titled "Evaluation of NYC Municipal Separate Storm Sewer System Stenciling Program 1998." The report describes and evaluates the stenciling program implemented in 1995 and 1996, in which the phrase "Don't Dump Here, Drains to Bay" was painted, using stenciling kits, onto the street or curb pavement adjacent to catch basins located in selected areas. Based on sampling data for four of the stenciled drainage areas, the number of complaints regarding dumping incidents rose more rapidly than that of the corresponding non-stenciled drainage area. This is an indication that stenciling has raised public awareness and encouraged the public to report discharge incidents to NYCDEP. Based on limited water quality sampling (nine stations, two of which were stenciled in the fall of 1995), no reductions in pollutants that could be attributed to the stenciling program were detected.

According to the 1998 NYCDEP report, stenciling lasts about two years. The report includes a table that evaluates each option in terms of many factors such as lifespan, maintenance, installation, visibility, and costs of different materials. The report recommends additional evaluation of the glue-down curb markers, cast iron signs, and/or pre-etched catch basins bearing the message "Don't Dump Here, Drains to Bay" as a potentially longer-term solution.

Past implementation of stenciling has been conducted by volunteers. This program could be coupled with the service learning implementation strategy discussed above.

Continue support for community, environmental advocacy, and volunteer groups to remove litter and other debris from accessible shoreline sites as well as upland areas.

Volunteers can be very effective at helping to remove debris and floatables that get washed onto the shoreline around Jamaica Bay, or keeping upland areas litter-free. Several on-going volunteer programs in New York City address litter-control issues, but there may be opportunities to augment these programs in the Jamaica Bay watershed. In 2007, NYCDEP will be working with the DSNY in an interagency partnership to support volunteer clean-up efforts. Every year, from April to October, under the support of the DSNY, volunteers conduct clean-up projects in their blocks, neighborhoods, and boroughs. Community groups, block associations, merchants associations, and concerned citizens contact the DSNY to reserve cleaning tools, such as brooms, rakes and shovels, which the DSNY makes available in short-term loans. After a clean-up, DSNY promptly collects and removes the bagged waste. The program can be promoted to similar volunteer groups in the Jamaica Bay watershed, to assist them in taking advantage of the resources that are available under the clean-up program.

In addition, NYCDEP will continue to organize and support multiple beach clean-ups each year and provide the heavy equipment needed to help communities remove large debris from their beaches. Planning of these events could include a review of the New Jersey Department of Environmental Protection's (NJDEP) Adopt-A-Beach Program, which is a biannual beach clean-up effort that has been successful since its inception in 1993. This program involves a service learning component in which volunteers keep a running tally of items of litter collected and forward this information to the Center for Marine Conservation (CMC) in order that it be included in the CMC's national and international marine debris database. Beach clean-up dates are often planned to coincide with national beach clean-up events, such as the observance of International Coastal Clean-Up Day (sponsored by the Ocean Conservancy, a Washington DC based non-profit).

NYCDEP will continue to work with other agencies on citywide litter reduction strategies as part of the Litter Prevention Work Group. Finally, NYCDEP will also support litter prevention public education campaigns by providing speakers, audio-visuals, literature, and promotional items related to floatable reduction, water quality, water conservation, stewardship of Jamaica Bay, and other relevant environmental topics.

Based on the Street Litter Ratings system through which the Mayor's Office of Operations tracks citywide cleanliness, New York is the cleanest it has been in over 30 years. Continued support of litter prevention public education campaigns and cleanliness tracking will help the City maintain such cleanliness and reduce the discharge of floatables.

Promote community gardens and other opportunities for urban plantings.

Community gardens reclaim open space and use it for community needs, including food production and education. They encourage the "greening" of the urban landscape, and increase the environmental sustainability of a neighborhood. The New York City Community Gardens Coalition is an organization dedicated to maintaining a cooperative between communities to enhance the experience by sharing in techniques, planting stock, and fun. The Coalition is also dedicated to converting open space to gardens. There may be opportunities to foster the development of additional community gardens in the watershed by increasing the level of communication between city agencies and existing community garden clubs such as the Community Gardens Coalition, and making additional public resources available to them. The New York City Open Accessible Space Information System Cooperative (OASIS, http://oasisnyc.net), a partnership for sharing data and information in the New York City area, contains a wealth of information regarding existing organizations that provide support for community gardens.

Implementation of community garden projects should include a discussion of soil testing for lead and other toxins. Soil contamination has been recognized as a concern in urban areas. Some community gardens, such as the 6/15 Green Community Garden in Brooklyn, conduct soil analysis on an ongoing basis to ensure the health and safety of the public. The Cornell Nutrient Analysis Laboratories (CNAL) in Ithaca, NY, is an organization that provides cost-effective soil testing. The CNAL website (www.css.cornell.edu/soiltest/newindex.asp) includes soil testing information and instructions on how to get soil tested.

Increase the number of volunteers throughout the watershed by promoting volunteer opportunities in a coordinated manner and by providing meaningful volunteering experiences.

Some citizens learn most effectively and become more engaged in watershed protection not through efforts aimed at "teaching" them but through active engagement in the landscape. By using their hands and feet and physically laboring in the areas they care for, they gain knowledge that they would never absorb from traditional learning methods. They also gain visceral connections with the landscape and solidify their commitment to it in ways which can modify their everyday practices toward greater resource conservation and protection. This strategy aims to expand upon existing programs and introduce new venues and opportunities for volunteering, including volunteer public landscape restoration and development, participation in service learning opportunities (see "Utilize service learning opportunities at elementary and high schools, higher education institutions, and community organizations to create an informed citizenry" above), and volunteering service-sector expertise toward *Jamaica Bay Watershed Protection Plan* efforts.

There are many ecological restoration projects currently underway within New York City, including the Jamaica Bay watershed. Many of the sponsors of these often labor-intensive projects reach out for volunteers. For example, the NYCDPR Natural Resources Group (NRG) regularly advertises for seasonal interns to work on a variety of ecological restoration projects. Many of these projects include education and research components in additional to physical labor.

The following programs currently provide volunteer services to advance the environmental restoration, protection, or enhancement of the Jamaica Bay watershed:

- *American Littoral Society, Jamaica Bay Guardian:* Sponsors Operation Jamaica Bay Clean Sweep (removal of derelict boats from shoreline) and beach clean-ups; conducts wildlife censuses for the National Park Service.

- *Bay Improvement Group:* Maintains three community gardens; organizes clean-ups and sweep-ups of the waterfront and adjacent communities.

- *Friends of Gateway, Gateway Greenhouse Education Center at Floyd Bennett Field:* Oversees a volunteer program to cultivate trees, shrubs, and plants for New York City's public spaces; conducts beach clean-ups.

- *Jamaica Bay Watershed Alliance:* Hosts community clean-ups, tree planting programs to prevent runoff, and stewardship activities for school children.

- *Norton Basin/Edgemere Stewardship Group:* Conducts clean-ups of the wetland area at the edge of Norton Basin; maintains the small strip of land running along the South Shore of Norton Basin.

- *Salt Marsh Alliance:* Provides support for the Salt Marsh Nature Center in the form of volunteer labor (building maintenance, trail patrol, litter and graffiti clean-up, and repairs) and provision of supplies and equipment.

- *VolunteerNYC.org:* Committed to opportunities in the New York City region for volunteering.

New York Restoration Project: Partners with individuals, community-based groups, and public agencies to reclaim, restore, and develop under-resourced parks, community gardens, and open space in New York City, primarily in economically disadvantaged neighborhoods.

CATEGORY 5*:* PUBLIC USE AND ENJOYMENT

Chapter 7, Category 5, Public Use and Enjoyment, proposes a number of initiatives to address public access. In this chapter, other implementation strategies are suggested for future consideration. These strategies could be implemented over time pending the availability of additional funding and other resources.

Potential Management Strategy 6a1: Provide access and connections to the waterfront for neighborhoods most in need, based on consideration of current lack of access, population density, and physical barriers.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Ferry Services to the Rockaways

As discussed above, access by train to the Rockaways is logistically difficult and time-consuming. The NPS has proposed a connection, via ferry service, between NPS sites along the Rockaways, other local NPS sites, and Manhattan. Currently in planning and design. The NPS has developed the former Coast Guard station at the foot of the Gil Hodges Memorial Bridge into a temporary ferry landing. Plans for a permanent dock are being finalized.

Idlewild Park/Thurston Basin Boat Access

The EQA recently implemented a waterfront access project including a boat launch at Idlewild Park. However, as currently implemented, this access point does not provide a connection for local residents of eastern Queens to Jamaica Bay via Thurston Basin. Feasibility of extending this access to Jamaica Bay should be explored.

Brochure Development

A brochure showing the current and potential future amenities and programs along the Bay could be developed through a multiple agency partnership and distributed to the public. The brochure will ensure that residents are aware of the location of recreational facilities adjacent to Jamaica Bay. This brochure could be part of series of informational brochures developed to raise awareness among watershed residents about Jamaica Bay and how to best protect its natural resources. A prototype for the first in a potential series of brochures has been developed as part the Jamaica Bay Watershed Protection Plan development process; see Management Strategy 4a2 for more information.

Mapping

Continue to develop comprehensive mapping and documentation of existing recreational amenities and public access points to Jamaica Bay that account for the current programs discussed above to ensure information about proposed or planned access points is integrated. Significant natural landscapes would be identified and the potential to provide connectivity to the bay would be evaluated. This implementation strategy should be combined with other open space mapping efforts including those related to the Mayor's PLANYC initiatives.

Potential Management Strategy 6b2: Brand the Jamaica Bay Watershed as a recognizable concept along with a process for disseminating related messages.

IMPLEMENTATION STRATEGIES FOR FUTURE CONSIDERATION

Develop Jamaica Bay Branding Strategy and Signage

Raising public awareness of sometimes intangible concepts like water quality, the effects of citizens' and businesses' behaviors within a watershed, and even conveying the idea of a watershed is an extremely difficult task. The abstract nature of these concepts and relationships to complex biophysical processes is challenging for scientists, let alone citizens or laypeople - however concerned they might be. One of the most effective ways to improve public awareness and structure public understanding is to "brand" the Jamaica Bay Watershed as an "imageable" concept and create a tangible construct for citizens and public officials. The success of branding efforts surrounding locales as varied as Curitiba, Brazil, the "Ecological City," and the Chesapeake Bay Foundation's "Save the Bay" campaign demonstrate how effective making a watershed "imageable" can be. These regions have had simple, palatable messages, compelling graphics, media materials, and a supportive public education campaign that have fostered long term public environmental sustainability efforts, involving a spectrum of stakeholders from business owners to residents and government officials to school children. Jamaica Bay could greatly benefit from a similar branding campaign. Branding nomenclature, slogan(s), and graphics could identify landscapes and projects, denote initiatives, and adorn various marketing materials associated with Jamaica Bay watershed events.

The initial project activity is to identify potential funding opportunities and develop a strategy for program implementation. Implementation strategies will be focused on the design of a brand for Jamaica Bay, identifying appropriate locations for sign installation through interagency discussions and funding to cover design, installation and maintenance costs for signs, and for the development of other mediums for disseminating Jamaica Bay-related messages.

NYCDEP will coordinate with NYCDOT in terms of sign locations, dimensions, and costs. The NYCDOT requires Standard Highway E Modified (thickest) Font (for highway signs) or 5" Highway C Font (for local street signs) and requests text and sign dimensions be kept to a minimum. Highway signs will be located at the beginning of the watershed area in each direction of the highway. The NYCDEP will submit a plan to NYCDOT that includes text and other information to be included on each sign, locations of signs, maintenance plans, and number of signs to be installed. Plans for signs to be installed on Expressways and Parkways must also be submitted to the NYSDOT for their approval. The branding design could also be used in informational brochures targeted toward residents of Jamaica Bay as well as interpretative exhibits in parks throughout the watershed.

"Brand" development would be initiated by reviewing the environmentally focused branding programs from other regions and the determination of applicability to the Jamaica Bay watershed. Next, the development of a community website, slogan, logo prototype, and other promotional materials to "brand" and publicize information about the Jamaica Bay watershed will be evaluated. A design competition among school children could be initiated to help design the "logo." Finally, NYCDEP will coordinate with multiple agencies including NYCDOT and NYCDPR to discuss roadway signs, signage requirements and sign installation. Signs could include the Jamaica Bay watershed brand as well as additional interpretive information to convey the interconnections between different parts of the watershed. These signs would be located along roadways that intersect the watershed boundary, within parks, schools, and other natural landscapes throughout the watershed.

REFERENCES

City of New York. April 22, 2007. "PLANYC 2030: A Greener, Greater New York." New York, NY.

EWT Waste Solutions. 2007. http://www.ewt-waste-solutions.com.

Hudson River Foundation. 2004. Health of the Harbor: The First Comprehensive Look at the State of the NY/NJ Harbor Estuary 2004. New York, NY.
http://www.seagrant.sunysb.edu/hep/reports/harborhealth.pdf

National Ocean and Atmospheric Administration (NOAA). 2004a. Are Marshes Losing Ground? Barbara Branca, New York Sea Grant. NOAA Research. May 30, 2004.
http://www.research.noaa.gov/spotlite/archive/spot_saltmarsh.html

National Ocean and Atmospheric Administration (NOAA). 2004b. New York Researchers Investigate Dramatic Loss of Long Island Wetlands. July 28. 2004.
http://www.seagrant.noaa.gov/newsevents/stories/newyork_wetlands.html

New York City Department of Sanitation (DSNY). 2006. Community Board Cleanliness Ratings. New York, NY.

New York City Department of Sanitation (DSNY). 2007.
http://www.nyc.gov/html/dsny/html/about/column.shtml.

New York City Mayor's Office of Environmental Coordination. 2007. http://www.nyc.gov/html/oec/html/brown/brownfields.shtml.

New York State Department of Environmental Conservation (NYSDEC). 2003. Contaminant Assessment and Reduction Project, Water. NYSDEC: Bureau of Water Assessment and Management, Division of Water. Albany, NY.

New York State Department of Environmental Conservation (NYSDEC). 2004. Division of Water, Technical and Operational Guidance Series (TOGS) 5.1.9. In-Water and Riparian Management of Sediment and Dredged Material. Albany, NY.

New York State Department of Environmental Conservation (NYSDEC). 2007. http://www.dec.ny.gov/ chemical/brownfields.html.

New York State Governor's Office. 2007. http://www.state.ny.us/governor/press/index.html.

New York/New Jersey Harbor Estuary Program (HEP). 2005. Toxics Work Group. http://www.seagrant.sunysb.edu/hep/toxics.htm

New York/New Jersey Harbor Estuary Program (HEP). 1996. Comprehensive Conservation and Management Plan. New York, NY.

US Army Corps of Engineers (USACE). 2004. Husdon-Raritan Estuary Environmental Restoration Feasibility Study. Jamaica Bay Study Area Report. www.nan.usace.army.mil/harbor/links/JamaicaBay_SAR_RevSep04.pdf

United States Fish and Wildlife Services (USFWS). 2007. National Wetland Inventory. http://www.fws.gov/nwi/.