# Potential Adaptation Strategies For DEP

## 3

Raising Departmental awareness of climate change issues was the first step in what will be a decades-long process of adjusting New York City's water supply, drainage, and wastewater management systems to climate change. DEP now understands that climate change must be a priority factor in all future strategic and capital planning efforts in order for the City's vital water systems to function under and be resilient to a range of potential future climate conditions. In its consideration of potential climate change impacts, DEP has made a formidable start in identifying strategies for adapting its infrastructure, operations, programs and policies to climate change. DEP is considering these adjustments early, with the goal of minimizing future service disruptions and financial demands on the water system's ratepayers due to climate change impacts.

Many ongoing DEP projects and PlaNYC initiatives for addressing current climate extremes, environmental regulations, aging infrastructure, and population growth are also adapting DEP's systems for climate change. Though these projects will improve system resiliency to future climate conditions, a more comprehensive effort is needed to truly build water systems for the future. This Chapter examines many of the potential adaptation strategies identified by DEP to date, the projects that DEP is implementing to confront other challenges that are also effective climate change adaptations, as well as actions that DEP will take to implement or further study various adaptation strategies. The potential adaptation strategies and DEP actions to study and implement adaptations are also summarized in Chapters 5 and 6.


## NYC Watershed Region

NYC Watershed Region spans approximately 40.5 N to 42.5 N and 73.5 W to 75.5 W and includes both the NYC metropolitan area and the upstate watersheds.

Base image courtesy of NASA Johnson Space Center

# 3.1 Potential Water Supply Adaptation Strategies

**DEP has identified adaptation strategies for helping to mitigate the three categories of climate change impacts to the water supply system examined in Chapter 2:**

- **Decreased quantity of water supply**
- **Decreased quality of water supply**
- **Increased demand**

## Maintaining Water Supply

DEP is currently assessing various projects for their potential to prevent future water supply and demand imbalances due to non-climate-related factors. Such projects could also potentially assist in the prevention of water shortages due to climate change. For instance, because its infrastructure is aging, DEP is studying a range of measures that could be implemented to ensure the Department's ability to provide an adequate amount of water to the City and upstate communities while its aqueducts are taken out of service for inspection or repair.

**Managing shared water resources in a potentially more volatile future climate will likely require watershed-wide strategies to fully address the issue.**

The actions that could help protect the City from major shortages due to planned system outages include implementing a range of demand-reducing conservation measures, developing or enhancing alternative auxiliary sources such as groundwater, backing up systems by creating regional interconnections with pipes between New York City and New Jersey, Connecticut, or Long Island, and using reservoir models and other tools to balance flows and releases in order to optimize system operation and provide increased resiliency. This existing planning effort complements climate change-related water quantity concerns, as the imbalance between demand and supply due to planned system outages will likely be larger in scale than the quantity imbalances that might be manifested due to climate change.

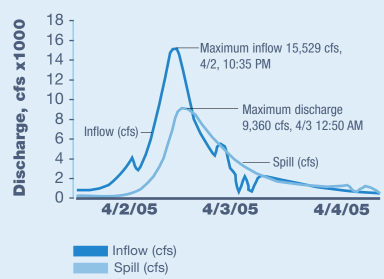
The actions that will increase water supply dependability during system outages will make the water supply system more resilient overall to challenges, such as drought and intense rain events. However, managing shared regional water resources in a potentially more volatile future climate will likely require watershed-wide strategies to fully address the issue.

For example, although the City's water supply reservoirs were not designed as flood control structures, and the City is not obligated to engage in flood control, the City has agreed to undertake certain measures for making controlled releases to help attenuate flooding as an accommodation to other parties. To more comprehensively address the potential flooding impacts of climate change however, a broad basin-wide flood mitigation strategy would be necessary. In addition, if future studies show that the Maximum Probable Flood will become more severe due to climate change, DEP will need to work with other agencies to examine whether additional dam stabilization efforts may be necessary to ensure public health and safety.

### Flood Dampening

Watershed reservoirs were designed to ensure a safe and reliable supply of water for the City. They were not designed as flood control structures, and the City has no duty to engage in flood control. Nonetheless, the City's reservoirs confer a benefit on local communities, in terms of flood mitigation, simply by virtue of their existence. As this figure demonstrates, even when full, the City's reservoirs slow the rate at which water cascades downstream, thus reducing inundation areas during storm events. In this example, during an April 2005 storm, the City's Rondout Reservoir reduced the peak flow below the reservoir by approximately 60%.

**Rondout Reservoir, Runoff vs. Spill Discharge Storm Event April 2-4, 2005**




Some parties have called for the City to release water from its reservoirs to provide storage capacity and, thus, additional flood dampening in anticipation of storm events. Given the uncertainty of whether and when the amount of water released can be recaptured, such releases create concerns about the ability of the City's water supply system to meet the demands placed upon it, especially if droughts become more frequent.




**BMPs**
Several types of stormwater best management practices (BMPs) are used throughout the watershed to control erosion and facilitate the infiltration of runoff to reduce the sediment load to the reserviors, such as riprap-lined swales and pervious berms pictured above.

## Maintaining Water Quality

Large and intense storms, and the associated runoff and flooding, are existing threats to water quality, particularly to the unfiltered waters from the Catskill and Delaware watersheds. Due to its rigorous watershed protection and planning, DEP has been able to confront these challenges very effectively. However, larger and more intense storms due to climate change may affect the level or frequency of water quality challenges. Since existing water quality protection measures depend heavily on natural systems, temperature and precipitation changes and the consequent effects on local ecology will bring a new dimension to DEP's management of the City's water supply. The ongoing Watershed Protection Program approved by EPA under the City's series of Filtration Avoidance Determinations (FADs), which includes land acquisition, land use, forest management, and numerous other programs, also serves as an adaptation for mitigating climate change impacts and will continue to guide DEP's goal of continued filtration avoidance.

Alternative strategies of dealing with water quality impacts due to climate change divide along structural and non-structural lines. One structural strategy is relying more heavily on the filtered Croton system during turbidity events. The non-structural strategy of bolstering the watershed protection program to account for potential larger storms and ecological changes will necessitate further research and study with experts and institutions in the fields of agriculture and forest ecology. DEP currently consults with Cornell University and others on such matters, and these relationships and programs of study may need to be increased to make technical assessments of the efficacy of natural systems to continue to meet water quality standards when they are stressed by more intense climatic events. Alternatively, the application of the coagulant alum (aluminum sulfate) is an operational strategy that has been used for decades to separate out particles that are suspended after a storm event in the water transported through the Catskill Aqueduct.

Although this improves drinking water quality, it does require dredging part of the Kensico Reservoir in order to remove the alum sediments that settle at the bottom.

### Desalination Options

In January of 2007, United Water New York announced plans to construct a desalination facility that will treat water from the Hudson River for its customers in Rockland County (United Water, 2007). The Vice President of the utility company stated: "The Hudson River gives us a drought tolerant water supply that is eminently expandable."

The desalination option is also being investigated in Australia to relieve recurrent water shortages and the threat of salinization of water supplies. This planning illustrates that some locales believe desalination to be a feasible alternative and may be a particularly desirable option for ensuring a reliable water supply in the face of potential climate changes.

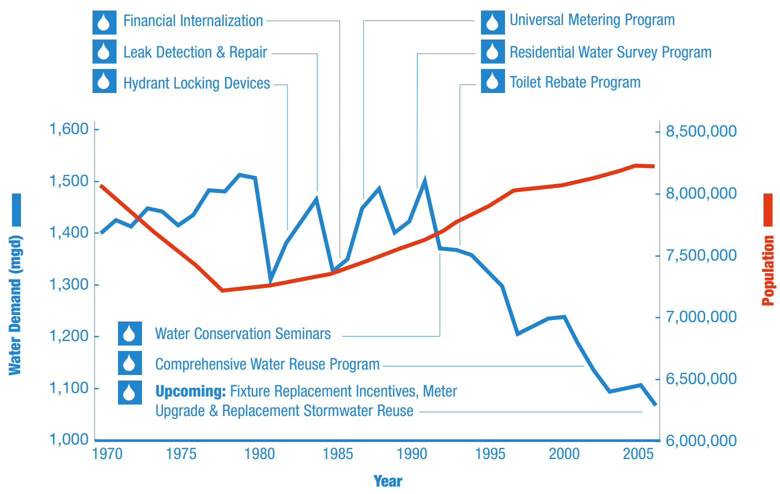
## Reducing Water Demand

Climate change concerns can also exacerbate supply-demand imbalances. Particularly during short-term, peak demand periods, such imbalances may require additional measures for controlling the events that cause water pressure problems in the City distribution system. Climate change presents an additional reason to complete, or accelerate, structural improvements to the aqueduct system that could reduce pressure problems associated with an inability to refill Hillview Reservoir for peak daily demands. The Department's Kensico-City Tunnel Project (KCT), although motivated by reliability concerns over being able to take either the Delaware or Catskill Aqueducts south of Kensico Reservoir out of service for repair, could also help to alleviate low system pressure events by sizing to the KCT to convey volumes greater than can be currently delivered to Hillview Reservoir. For projects in the early planning stages, such as the KCT, DEP must consider the full range of climate changes projected to be experienced.

Alternatively, peak demand problems caused by climate change could be addressed by more small-scale approaches such as installation of better hydrant-locking mechanisms, use of more spray caps, provision of more public swimming pools and spray stations in City parks, better enforcement of illegal hydrant openings, agreements with upstate users of City water to impose conservation measures, and in-City conservation measures that reduce overall demand. These are all measures that can be considered in a programmatic way to manage this peak demand issue. Also, additional roof-top water tanks could assist individual buildings in tolerating multiple-day drops in water pressure, which can prevent water tanks from being refilled.

### Water Supply Conservation Programs: Supply vs. Population

NYC population and water demand changes from 1970 to 2006. Water conservation programs reduced water demand even during periods of population expansion.




NYCDEP Water Demand and NYCDCP Adjusted Population Data


### PlaNYC Water Supply Initiatives with Adaptation Benefits

On April 22, 2007, Mayor Michael Bloomberg announced PlaNYC, a far-ranging plan to ensure sustainable and environmentally conscious development of New York City to the year 2030. PlaNYC initiatives are primarily being implemented to address environmental regulations, aging infrastructure, and a growing population. However, many of the actions have the potential advantage of making DEP's water supply system more resilient and robust, thus serving as system adaptations for ensuring drinking water quality and quantity in the face of climate change:

**PlaNYC DEP actions that will support drinking water quality as the climate changes:**

- Enhance the Watershed Protection Program in order to maintain a Filtration Avoidance Determination for the Catskill and Delaware Water Supplies, with efforts such as a $300 million investment in land acquisitions in the watershed over the next ten years.
- Construct the Catskill/Delaware Ultraviolet Light Disinfection Facility to neutralize potential disease-causing organisms from the City's upstate watershed west of the Hudson River.
- Construct the Croton Filtration Plant to safeguard the Croton system.

**PlaNYC actions that will support an adequate water supply as the climate changes:**

- Launch an effort to reduce City-wide water consumption by 60 mgd by 2012 through rebate programs for toilets, urinals and high-efficiency washing machines in laundromats. Evaluate extending this effort to include water-efficient industrial equipment, water-saving dishwashers and ice machines for the food service industry; water audits, early leak detection, and gray water reuse and recycling.
- Maximize water supply from existing facilities such as the groundwater system in Jamaica, Queens, which is currently underutilized, and the New Croton Aqueduct, which is being improved to maximize the reliable delivery of water from the Croton system. Expanding the use of the groundwater system will also lower the water table and thus reduce localized flooding in the City.
- Establish a connection between the New Croton and Delaware Aqueducts to provide an alternative means for delivering water from the Croton and Delaware systems to the City during an emergency.
- Evaluate new water sources and projects that could help the City to meet a shortfall during a prolonged shutdown of the Delaware Aqueduct for repair, including demand-reduction programs, system diversification through desalination or storage of surface water in aquifers, and operational modifications.
- Continue to modernize in-City distribution by completing Water Tunnel No. 3, completing a backup tunnel to Staten Island, and accelerating the replacement of old water mains from 60 miles annually to 80 miles annually.

Source: Bloomberg (2007)

# 3.2 Potential Drainage and Wastewater Adaptation Strategies

**DEP has identified adaptation strategies for minimizing the three categories of climate change impacts to the drainage and wastewater management systems examined in Chapter 2:**

- **More frequent flooding of basements, streets, and coastal areas**
- **Challenged ability to meet wastewater treatment requirements**
- **Water quality impacts to receiving waters**

## Minimizing Flooding

### STREET, BASEMENT, SEWER FLOODING

Street, basement, and sewer flooding will potentially be more frequent because the intensity of storms is projected to be greater, and sea level rise will reduce the hydraulic capacity of existing outfalls to discharge.

Sewer systems and drainage designs are a precise business. Pipe grades and elevations are set so flow is driven by gravity, and street topography and property elevations are important design details. Equally important considerations in the design process are storm intensity and frequency criteria and land use characteristics that determine the amount and timing of runoff that reaches the sewers. The New York City system was designed to minimize standing water on roadways and streets, is mostly gravity based, and has been built out over hundreds of years. The sunk-cost investment in the City's sewer systems is enormous, and there is almost no flexibility to modify existing piping, either in size or slope, without digging up entire areas tributary to each outfall, and replacing such entire systems with new and larger pipes. In addition to the cost and disruption, the time to effect such changes would be extremely long, additional space would be required within the maze of subsurface utilities below streets, and pumping might be needed in some instances to convey storm and wastewater flows.  However, some change in the system will likely be necessary to prevent unreasonable levels and frequency of street and basement flooding.

Projections of the increased frequency of intense storms and the magnitude of sea level rise are essential in developing critical risk-based policy analysis and decision making.

**Green Drainage Corridors**

The Staten Island Bluebelt is DEP's award-winning, ecologically sound and cost-effective stormwater management system for approximately one third of Staten Island's land area. The program preserves natural drainage corridors, called Bluebelts, including streams, ponds, and other wetland areas. Preservation of these wetland systems allows them to perform their functions of conveying, storing, and filtering stormwater, while providing community open spaces and diverse wildlife habitats. The Bluebelt program saves tens of millions of dollars in infrastructure costs, when compared to providing conventional storm sewers for the same land area.

Identified alternatives include:

- Augmentation of the capacity of the existing collection system using conventional, structural methods such as:
    - Increasing the size of sewer pipes in select areas where installation of new pipes is planned or where there is space within City rights-of-way not overcrowded with utility infrastructure
    - Constructing supplemental "high level storm sewers" where there is space within City rights-of-way and favorable topographic conditions
    - Pumping of stormwater or combined sewer flows and WPCP discharges
    - Increasing wet weather pumping and treatment capacities at WPCPs, where feasible
- Management of increased flows by more frequently cleaning sewers and maintaining catch basins in flood-prone areas
- Continued development of methods that use and enhance natural landscape and drainage features for runoff control such as the concept of the Bluebelt on Staten Island
- Implementation of stormwater controls at the source in order to decentralize key management processes
- Promotion of the use of green roof technology to reduce and reuse stormwater for ecologically productive purposes (as well as to reduce energy needs for cooling top floors of buildings and to collectively moderate the urban heat island effect)

### The Jamaica Bay Watershed Protection Plan

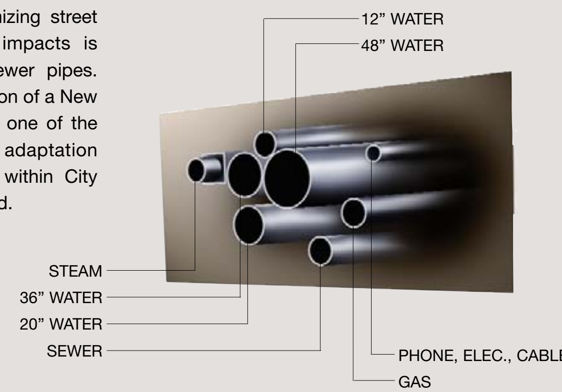
Jamaica Bay is one of the largest tidal wetlands in New York State. It remains ecologically rich, with at least 325 bird species and 91 fish species. However, its watershed is one of the most densely populated regions in the country with approximately 1.7 million people living or working within the watershed boundaries. The water quality of the Bay has deteriorated over the last 150 years due to dredging and changes in bathymetry; the introduction of WPCP and CSO discharges; the hardening of shorelines; and the replacement of most of the natural features within the Bay's watershed with impervious surfaces. Rainwater, which was once filtered by soil and vegetation, now runs off to the Bay carrying pollutants found within urban areas.

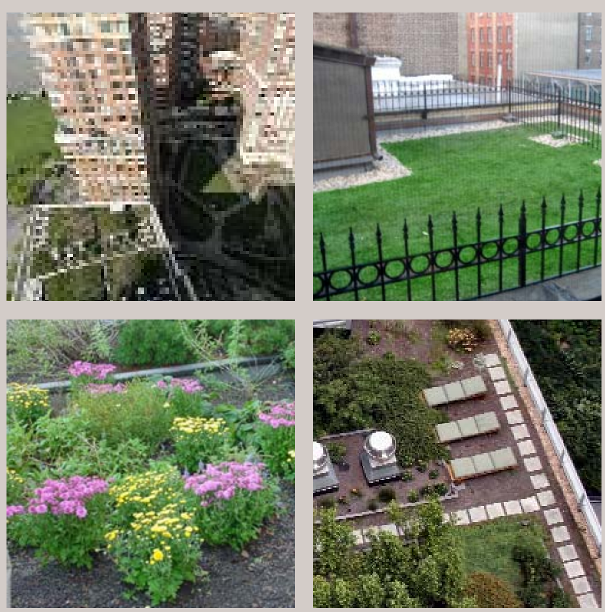
Even with DEP's tremendous ongoing efforts to improve water quality in the Bay, more needs to be done. Under Local Law 71, passed by the NYC Council and signed by Mayor Bloomberg in July 2005, DEP has developed a Jamaica Bay Watershed Protection Plan. The goal is to develop strategies to protect and restore the Bay's water quality and to improve and sustain its ecological integrity. To achieve this goal, in coordination with PlaNYC initiatives, numerous BMPs for managing stormwater at its source and capturing runoff from streets are being evaluated and will soon be implemented as a pilot project. In addition to mitigating the additional stormwater runoff and CSOs that could be triggered by climate change, these initiatives will also improve the health of the Bay's wetlands and, therefore, their ability to act as a buffer to storm surge as storms become more intense.

### Flood Relief

One adaptation for minimizing street and basement flooding impacts is increasing the size of sewer pipes. This schematic cross section of a New York City street illustrates one of the many challenges this adaptation would present as space within City rights-of-way is very limited.

**Street Cross Section**



Photos courtesy of Ed Clerico, Solaire and Shinjinee Pathak, Columbia University.

### Green Roofs

In addition to reducing some amount of stormwater runoff, green roofs collectively moderate the urban heat island effect (Rosenzweig, 2006). Intensive green roofs tend to require irrigation and are designed to address aesthetic considerations, in the style of roof gardens. Extensive green roofs, on the other hand, are generally designed to require little or no irrigation and to optimize stormwater retention as opposed to aesthetics.

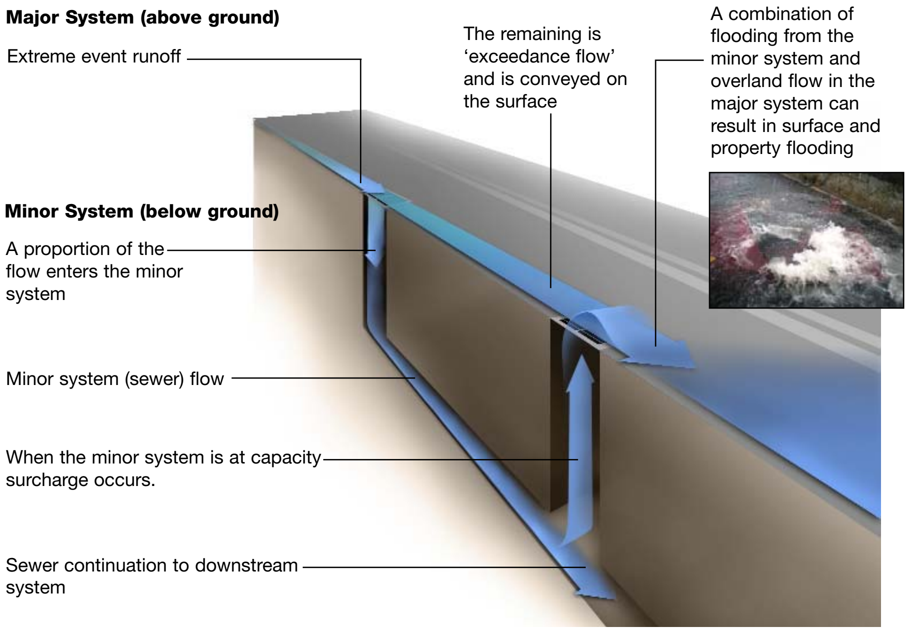
Because there are many barriers to a number of the adaptation alternatives listed previously, DEP will need to think outside the box and examine drainage and treatment methods currently used or being considered in other regions such as in the Netherlands, which is almost entirely at or below sea level, or in the United Kingdom, which is at the forefront of adaptation planning. For example, an alternative drainage strategy could involve designating roadways for above-ground conveyance of waters during extreme events. This approach manages flooding in a controlled manner that minimizes damage but does not eliminate flood waters to the same extent as has been attempted by past engineering strategies. Such an approach is now a planning requirement for new developments in England, because their studies have indicated that the conventional underground conveyance approach is not affordable or sustainable for the most extreme events. It remains to be seen whether a very dense urban area such as New York City will be able to allow some roadways or open space areas to be purposely inundated on a periodic basis as an acceptable way of dealing with flooding from more frequent high-intensity storms. However, this and other innovative approaches need to be studied as alternatives to conventional structural solutions.

### Designing For Exceedance

A potential adaptation strategy for accommodating increased runoff from more intense storms is to design above-ground conveyance pathways for sewer system

exceedances. This approach, which is being applied in the United Kingdom for new developments, aims to minimize runoff on roads and other default pathways that are not designed to accommodate the flow. Instead, features on the surface such as swales, pathways, or roads are designed to control flooding by functioning during storm events as conveyance systems for the run-off that exceeds the capacity of the sewer system.

## Interaction Between the Minor and Major System During an Extreme Event




**COASTAL FLOODING**

Coastal flooding due to sea level rise and storm effects on tide height and wave action may be even more difficult to address. New York City has 578 miles of coastal shoreline, and the metropolitan area of New York Harbor has significant additional shoreline. "How much sea level rise" and "what intensity of storm, hurricane, and tide and wave action should be planned for" are key risk based policy decisions that will determine which alternative solutions would most effectively minimize coastal flooding.The larger the magnitude of event (such as the worst-case scenario of a Category 4 hurricane moving north-north westerly and making landfall during high tide near Atlantic City, New Jersey, which would amplify the effect of storm surge through the "New York Bight"), the more appropriate regional approaches to this problem may be. Should studies of potential coastal damage reveal that coastal flooding events result in damage assessments far lower than the cost of protective measures, then more modest local protection strategies such as flood walls at key facilities or areas may be more appropriate. The range of possible approaches to coastal flooding may include:


**Tallman Island WPCP Local Barrier during April 2007 Nor'Easter.**

- Raising elevations of key site-specific facilities above projected flood heights and construction of watertight doors and windows to protect critical equipment and control rooms
- Consideration of submersible pumps rather than wet/dry well pumps
- Having additional backup emergency management equipment in reserve so that the time to bring facilities on-line post-storm is minimized

"How much sea level rise" and "what intensity of storm, hurricane, and tide and wave action should be planned for" are key risk based policy decisions that will determine which alternative solutions would most effectively minimize coastal flooding.

### Storm Surge Barriers

In 2002, the State University of New York at Stony Brook conducted research with sponsorship from New York State Sea Grant and DEP to investigate the feasibility of storm surge barriers to protect most of New York City from the effects of storm surge. The Storm Surge Research Group developed a coupled hydrodynamic and atmospheric model to simulate storm surge and evaluate the effectiveness of barriers at multiple seaward access points of New York Harbor. Two historical storms were evaluated, Hurricane Floyd and the December 1992 Nor'easter, and the barriers were shown to be operationally effective. Such an approach would be a regional adaptation strategy requiring approval of multiple governing agencies. How to protect areas not within the confines of the barriers would need to be addressed.

STORM SURGE BARRIER

Hurricane Floyd, 1999. Image produced by Hal Pierce, Laboratory for Atmospheres, NASA Goddard Space Flight Center

- Development of local protective barriers such as dunes, riprap, or sea walls
- Construction of large, multiple barriers such as tidal gates that would span openings to New York Harbor and provide regional protection
- Gradual retreat from the most at-risk areas or different use of these areas, such as for park land that could flood with minimal damage

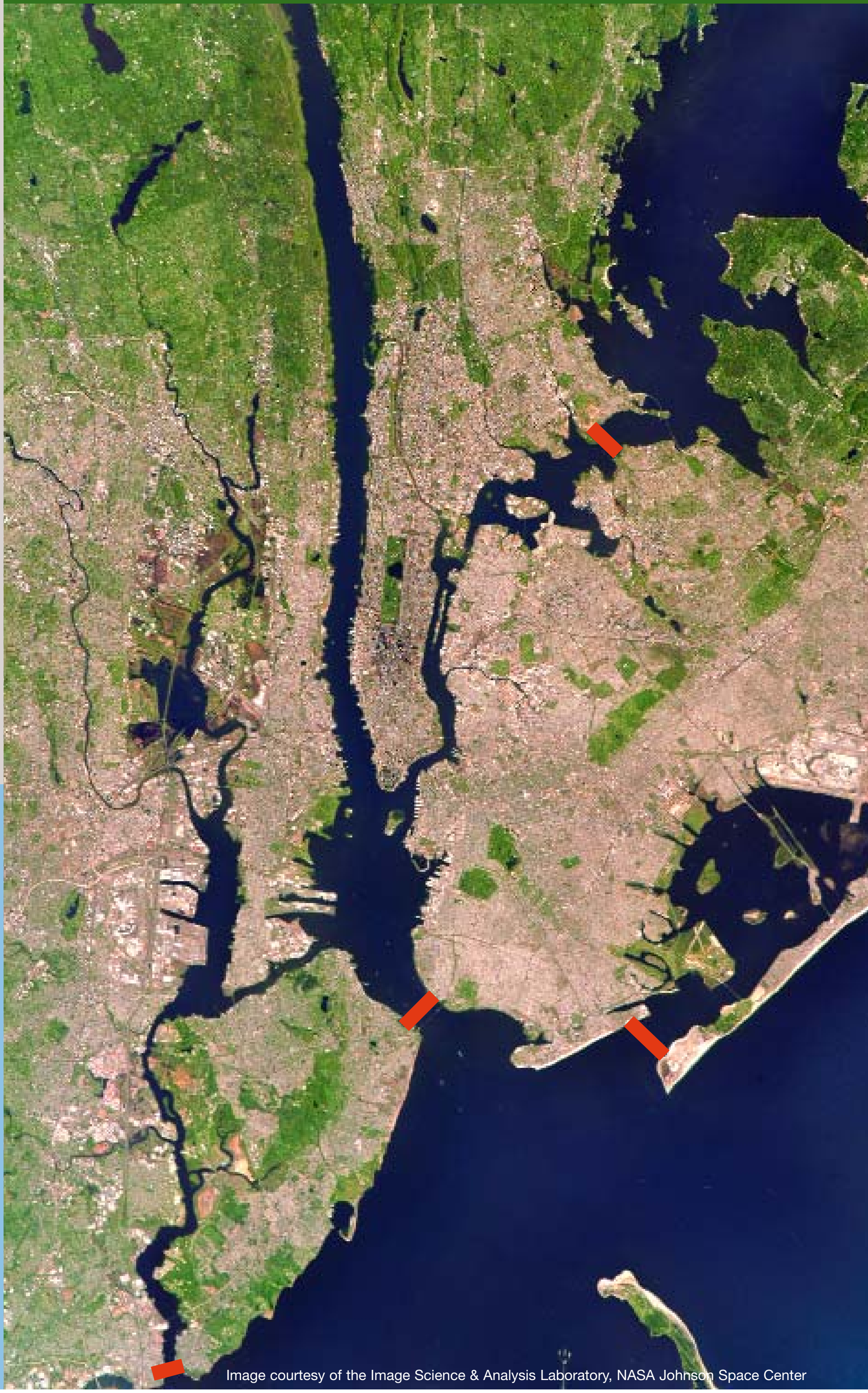


Image courtesy of the Image Science & Analysis Laboratory, NASA Johnson Space Center

Raising elevations of key site-specific facilities, or portions thereof, may be an appropriate strategy for some DEP facilities such as WPCPs or pump stations that lie in areas susceptible to coastal inundation. Raising key electrical equipment to higher elevations may be called for as a fairly low-cost protective measure that may be warranted without much further study if performed in conjunction with other remedial work on such systems.

Local protective barriers around entire facilities such as WPCPs may be warranted in the future, based on current and projected storm surge levels and estimated facility damage and extent of service outages. However, more study of site-specific facilities and noted parameters of surge and cost is warranted before such investments are committed.

Constructing storm surge barriers in New York Harbor has been considered in the past based on storm protection and water quality considerations. Such facilities transcend just protecting DEP facilities, they are targeted instead at large portions of the multi-state metropolitan areas that border New York Harbor. In addition to the large cost and controversial environmental considerations associated with this type of project, it is not clear what agency, other than the U.S. Army Corps of Engineers, or possibly the Port Authority of New York and New Jersey, would have jurisdiction over the construction and operation of such barriers.


Phil Simmons, HydroQual

**Sea level rise may warrant modifications to existing shoreline protective structures such as bulkheads and seawalls.**

## Maintaining Ability to Meet Wastewater Treatment Requirements

Wastewater treatment processes can be impacted by all projected climate changes: temperature, precipitation, sea level rise, and inundation from increased storm surge. Temperature affects biodegradation kinetics and process requirements, and power disruptions from heat-related outages place demands on backup systems. Precipitation increases result in more flow and pollutant loadings to WPCPs and CSO control facilities and compromise the capacities of the WPCP digesters. Sea level rise may reduce the hydraulic capacity at WPCPs to pass peak design flows and may result in sea water entering the sewer system and WPCPs through faulty tide gates. Possible adaptation strategies for improving DEP's ability to maintain wastewater treatment requirements as the climate changes include:

- Regulatory relief of water quality criteria and attainment requirements for severe and extreme weather conditions
- Increased WPCP blower capacities or redundancy equipment for critical high temperature events
- Increased backup power capacity; scheduled interceptor and catch basin cleaning to reduce grit and sediment loads to WPCPs during rainfall events
- Improvements in capacity and operations of WPCP main sewage pump and screening capacity and operation to avoid failures during wet weather
- Relocation of vulnerable equipment above critical flood elevations; raising the height above the high water line of waste water treatment tanks, channels, and wet wells to prevent floodwaters from over-topping and entering the wastewater treatment process; and construction of watertight doors and windows to protect critical equipment and control rooms
- Revision of design criteria so that they address sea level rise
- Provision for effluent pumping to overcome sea level induced reductions in outfall capacity


## Minimizing Water Quality Impacts to Receiving Waters

Receiving water quality in New York Harbor and western Long Island Sound can be adversely affected by temperature increases which affect thermal stratification, reduce dissolved oxygen concentrations, and increase ammonia toxicity which affects aquatic life. Increased annual precipitation and changes in rainfall intensity can create additional stormwater and combined sewage to manage in order to prevent additional runoff and CSOs to surrounding waters and the associated adverse impacts to recreational water quality.

Potential adaptation strategies for managing these risks include:

- In-stream aeration for critical water bodies that may be vulnerable to dissolved oxygen or stratification impacts, as has been done with DEP's destratification facility in Shellbank Basin, Queens
- Further upgrades to WPCP treatment processes to expand wet weather capacity and improve effluent quality
- Enlargement or supplementation of existing CSO control facilities
- Management of CSOs through best management practices such as on-site collection and reuse of stormwater

Fountain Avenue Landfill Planting

Jamaica Bay Wildlife Refuge

## PlaNYC

**Pilot Promising BMPs**

☑ **Investigate low-impact development strategies on individual tax lots, such as design guidelines for off-street parking lots, bioinfiltration BMPs, such as rain gardens, on-site stormwater reuse techniques, such as rain barrels, and possible incentive programs**

☑ **Create vegetated ditches (swales) along highways**

☑ **For five years pilot a property tax incentive to offset 35% of the installation cost of extensive green roofs**

☑ **In Hendrix Creek, a tributary to Jamaica Bay near the 26th Ward WPCP, reintroduce 20 cubic meters of ribbed mussel beds to test mollusks' ability to improve the water quality of tributaries around combined sewer overflow outfalls**

☑ **In the Jamaica Bay Watershed, pilot vegetation and infiltration techniques for treating and capturing stormwater from large parking lots**

## PlaNYC Harbor Water Quality Improvement Initiatives with Adaptation Benefits

Many of the PlaNYC actions being implemented to achieve the City's goal of opening 90% of its waterways for recreation also serve as system adaptations for mitigating the potential impacts of climate change on harbor water quality as shown below:

- Develop and implement comprehensive Long-Term Control Plans for all New York City drainage areas
- Expand wet weather capacity at the Newtown Creek and 26th Ward WPCPs, which will reduce CSO discharges during rainstorms
- Capture some benefits of New York City's open space plan, which will expand the amount of green, permeable surfaces across the City and reduce stormwater runoff
- Expand the Staten Island Bluebelt program
- Convert certain combined sewers into High Level Storm Sewers (HLSS), and integrate HLSS into major new developments, especially on the waterfront
- Develop a comprehensive policy for protecting and managing the remaining wetlands in the City
- Expand, track, and analyze new BMPs for runoff and CSO control
    - Develop an interagency approach to stormwater control to maximize stormwater capture at its source
    - Identify locations with the New York City Department of Parks and Recreation for stormwater management in the Bronx River Watershed
    - Partner with the New York City Department of Transportation to incorporate BMP designs into the reconstruction of the Belt Parkway bridges
    - Identify City property for opportunities to convert impervious pavement to porous pavement

Source: Bloomberg (2007)

Image courtesy of the Image Science & Analysis Laboratory, NASA Johnson Space Center

# 3.3 Uncertainty and Planning for System Adaptations

The first step towards efficiently implementing adaptation strategies is to reduce uncertainties about climate change scenarios and the magnitude and timing of impacts on the Department's operations and programs (see Chapters 1 and 2 for the DEP's comprehensive plans for reducing those uncertainties and responding to the range of potential impacts to the extent feasible). Responsible adaptation will require striking a balance between (a) waiting until the changes are well understood or evident before deciding whether to implement an adaptation project, thus risking being unprepared for change; and (b) proceeding immediately with costly system adaptations, despite uncertainties in climate science, that may prove unnecessary or inadequate. The Department's goal is to strike this balance responsibly.

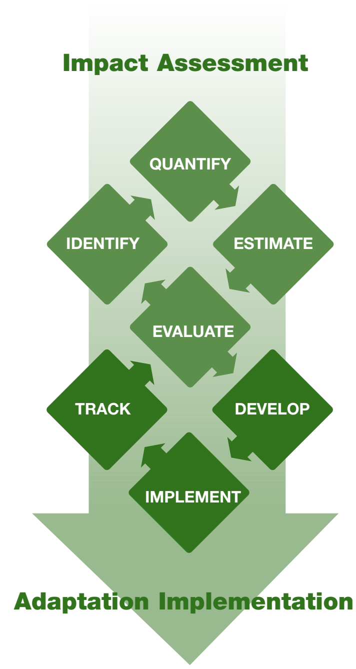
Because there are risks associated with taking no action because of the uncertainties about the future, system adjustments must proceed concurrently with ongoing studies to better define potential impacts. Therefore, the Department is proceeding immediately with the implementation of select adaptations that will also serve to increase the reliability of the systems under current climate conditions, will not involve large expenditures or cause large impacts on the Department or the public, and/or are in response to the most likely impacts.

At the same time, DEP will be undertaking detailed assessments of other adaptation strategies that will consider cost, the space needed for their construction, the time required for planning and construction, and the energy that each would require. As uncertainty will diminish over time, DEP's ability to select the most effective adaptation strategies and the time frame for their implementation will only improve.

### The Adaptation Process

A series of coordinated and iterative technical and management steps are needed in order to best formulate specific strategies for addressing climate change impacts:

1. **Identify a climate change impact to DEP's water supply, drainage, or wastewater management systems**
2. **Quantify the impact using DEP watershed, sewershed, or harbor water quality models as well as other tools**
3. **Evaluate the likelihood that the impact will occur**
4. **Estimate the timeframe for when the impact will become significant**
5. **Identify various types of adaptation strategies to overcome or minimize impact**
6. **Quantify the cost and effective lifetime of each adaptation strategy**
7. **Evaluate risks associated with proceeding or not proceeding with the implementation of the adaptations: compare the estimated impacts, the likelihood of occurrence, and the economic, engineering, and environmental aspects of the strategies**
8. **Develop a financial model that will sustain climate change investment**
9. **Develop indicators that would trigger the need to start implementation of the adaptations**
10. **Implement and monitor the success of adaptations**
11. **Track advances in climate modeling, and periodically reevaluate the need for additional adaptations**



## 3.4 DEP Actions to Determine and Implement System Adaptations

In addition to implementing and building upon the Department's numerous ongoing programs and PlaNYC initiatives that will help to mitigate the impacts of climate change on DEP's water systems, the Department will initiate the following actions in direct response to the work of its Climate Change Program:

### ACTION 1

**Add climate change as a factor in DEP's Risk Prioritization project.**

The Department's ongoing Risk Prioritization project is used to rank projects and allocate funding by assessing the probability and severity of failure of various infrastructure components and their associated costs. Adding climate change as a factor to this process will ensure that additional risks due to climate change are reflected in the Department's capital planning and that the timely implementation of necessary system modifications is feasible

### ACTION 2

**DEP will identify and evaluate potential adaptation strategies based on the findings of each phase of DEP's integrated water supply and watershed modeling project to study the impacts of climate change on the water supply system.**

A wide range of adaptation strategies will be considered, such as additional best management practices (BMPs), i.e., a device, practice, or method used to manage stormwater runoff, modifications to the level of storm that BMPs are designed to withstand, additional treatment, and diversification or increased capacity of the supply system. Comprehensive recommendations will then be made about adjustments needed immediately and in the future to mitigate climate change impacts on water supply system operations and infrastructure.

### ACTION 3

**DEP will assess the cost, environmental impact, and engineering feasibility of a range of adaptation strategies for mitigating the impacts of climate change on drainage, wastewater management facilities, and harbor water quality, which are to be identified by DEP's impact assessment project for vulnerable areas; and develop a long-term, phased strategy for monitoring impacts and implementing adaptation measures City-wide. As part of this project, DEP will:**

- Review and update flood protection design criteria.
- Recommend modifications to DEP's current stormwater management programs (such as facility plans, Long Term CSO Control Plans, and the Jamaica Bay Watershed Protection Plan) in order to address the potential exacerbation of street and basement flooding and CSOs.
- Weigh the costs and benefits of additional structural and non-structural measures that may be necessary to prevent or greatly mitigate: 1) damage to specific DEP infrastructure components (e.g., flood walls, changes to the level of storm and surge for which DEP plans), 2) flooding problems throughout the drainage system (e.g., BMPs, changes to drainage level of service and design criteria for outfall elevations), and 3) harbor water quality impacts that could result from climate impacts on the drainage and wastewater treatment systems (e.g., BMPs, reintroduction of mollusk habitat).
- Recommend an adaptation plan that includes cost estimates, conceptual designs; estimated implementation time frames and schedules that prioritize measures and integrate implementation with the capital planning process and current planning initiatives to the extent practicable, as well as processes for monitoring and evaluating the effectiveness of adaptations.
- Identify "indicators" that DEP should track that may trigger the planning or implementation of specific adaptations when identified thresholds of change are crossed.

## ACTION 4

**Identify equipment at WPCPs and pump stations that are vulnerable to flood damage and integrate flood prevention measures into the capital upgrade cycle.**

Most immediately, DEP will evaluate flood protection measures for the Rockaway, Hunts Point, and Tallman Island WPCPs, which will be undergoing rehabilitation, and use these improvements as a template for guiding future upgrades at other facilities. Examples of flood prevention measures will include elevating critical equipment and armoring critical facility components with water tight doors and windows.

## ACTION 5

**Create a methodology for the City Environmental Quality Review process so that potential climate change impacts are assessed and considered before decisions are made.**

## ACTION 6

**Develop a procedure for providing the resources and equipment needed to functionally operate when water supply, drainage, or wastewater management systems are damaged during an extreme storm event and to rapidly restore full services after the storm recedes.**