Climate Change and a Global City: An Assessment of the Metropolitan East Coast Region

INSTITUTIONAL DECISION-MAKING SECTOR REPORT

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I. INTRODUCTION

THE ISSUES

The international scientific community has begun to focus upon the reality of global climate change and sophisticated research techniques provide increasingly accurate models of the potential impacts of associated weather extremes, disease outbreaks, and global and local environmental destruction. Yet, decision-making institutions have not, for the most part, incorporated global climate change in their policies and planning efforts. This report presents the implications of climate change, normally thought of in global terms, as a very local issue. As a consequence of how this plays out in the Metropolitan East Coast (MEC) region, decision-makers in the MEC region and elsewhere should be able to arrive at practical policies affecting their land use, infrastructure, natural resource management, public health, and emergency and disaster response.

During the past year, the MEC region experienced a series of events of the kind anticipated to accompany climate change. In August 1999, a sudden and severe rainstorm brought New York City's transit system and many of its streets to a standstill for hours.[1] In September 1999 Hurricane Floyd flooded parts of upstate New York and Northern New Jersey, causing substantial property damage. An outbreak of West Nile Encephalitis in New York City in the Fall of 1999 caused seven deaths and 62 reported cases of the disease[2] and provoked an unprecedented public response. Prolonged summer heat waves caused power outages and drought-related water restrictions. Although these events are difficult to attribute to global climate change, they generated widespread public awareness of more severe and frequent climate-related incidents and should provide an incentive for decision-makers to more actively consider policies for adaptation that reflect the potential for future climate change and variability.

The scientific findings presented in the MEC Assessment, project climate change impacts that escalate by the end of the 21st century. Ongoing and future research is likely to produce more conclusive results and more targeted guidance for decision-makers. The region's institutions can begin, however, to expand their capacity to anticipate and respond to potential impacts and to minimize associated vulnerabilities by leveraging existing planning and operations and new investments to accommodate changes in climate and the environment. Actions that increase the resiliency of the built environment and strengthen institutional collaboration will serve current and future generations and decrease the long-term costs of adaptation.

ADAPTATIONS FOR INSTITUTIONAL DECISION-MAKING

The MEC region is a world leader. A large and varied group of institutions throughout the region plans and manages activities associated with the vulnerability of populations, land use, and land-based structures, and is responsible for a high level of investment in the region's resources. The three main effects of global climate change—increasing temperatures, precipitation, and sea level—which are expected to impact the region in different ways by the end of the next century, pose new challenges to these institutions. Their decisions and efforts are likely to determine the region's ability to cope with or adapt to the changes.

For purposes of this report, an adaptation (or coping) action is defined as one that reduces or avoids the adverse impacts, effects and/or consequences of global climate change. Potential adaptive measures are extensive, and can be applied long before, just before or after the effects of global climate change have been realized. Some examples of adaptive action are given below oriented primarily toward the effects of sea level rise.

Adaptations Associated with Planning and Construction

- planning for the use of land through land use and environmental planning and capital programming to ensure the location of new structures and relocation of existing structures outside of impact areas associated with sea level rise,
- acquiring property to prevent or guide development in hazard areas,
- redesigning structures to avoid impacts, including the removal of traditional flood retaining structures,
- retrofitting existing and redesigning new structures with barriers, higher elevations, and other forms of protection against the inundation of water and the extremes associated with heat and wind,
- using operational procedures and controls for infrastructure services and facilities to reduce or avoid population exposure during hazard events.

Adaptations Directly Targeted to Vulnerable Populations

- educating the public about global climate change and adaptations and behaviors, including infrastructure and land usage patterns, that will reduce vulnerability,
- improving communication mechanisms such as warning systems,
- moving people and businesses away from vulnerable areas through incentives, relocations, and in extreme cases, evacuations,
- providing emergency response and disaster assistance for reconstruction.

The choice among these adaptations and the ability to respond in these different ways will depend upon criteria that often vary from place to place and institution to institution. Such criteria pertain to cost, reliability, equity, environmental compatibility, uncertainty, etc.[3]

Many of these options could be drastic if isolated from ongoing activities and undertaken simply as add-ons to existing activities. They become more feasible when they are coordinated with ongoing planning, design, construction and operational programs. Titus puts this approach in the following way: "Constructing a project *because* of the greenhouse effect will rarely if ever be an

easy solution: it will require more certainty than incorporating climate change into a project that would be undertaken anyway."[4]

SCOPE

This report targets key authorities and responsibilities by public sector agencies pertinent to adaptation to global climate change in the MEC region. The MEC region is comprised of 31-counties in Connecticut, New Jersey and New York.[5] Preventive actions, such as those that reduce greenhouse gas emissions, are beyond the scope of this study. It is important to note, however, that the same institutions that may implement adaptation mechanisms often have an interest in or authority over preventive actions.

APPROACH AND ORGANIZATION OF THE REPORT

This report consists of several parts that reflect the overall approach taken to analyze the institutional decision-making sector, the results of that analysis, and a synthesis or conclusion.

The *first* part, this introduction, sets forth the scope, purpose, approach, and organization of the report.

The *second* part briefly discusses how organizations make decisions in the MEC region with reference to the other sectors covered in the MEC assessment: Coasts, Wetlands, Infrastructure, Water Supply, Public Health and Energy Demand.

The *third* part identifies those global climate change conditions most likely to affect land use and infrastructure. This information, drawn from the MEC global climate change project, comprises the basis or reference point for adaptation by organizations and institutions likely to respond in the course of their decision-making authority in the MEC region. Using information primarily drawn from project data developed in the other sector reports, facilities and activities are identified that are expected to be vulnerable to sea level rise over the next century.[6]

The *fourth* and most extensive part is organized in terms of the vulnerabilities and adaptive measures relevant to specific sectors. This section assesses the decision-making strategies applicable to putting those adaptive measures in place, identifies the agencies responsible for making those decisions, and to some extent assesses their ability to do so (in terms of organizational characteristics and jurisdictional authorities and capacities). The agencies covered are primarily public sector or quasi-public agencies that directly influence adaptations for the built environment. Future organizational forms and responsibilities are not forecasted, and it is assumed that responses through the 21st century will occur by organizations that currently exist.

The *fifth* part offers key conclusions and directions for further research.

II. HOW ORGANIZATIONS MAKE DECISIONS IN THE METROPOLITAN EAST COAST REGION

Organizations make decisions about activities potentially applicable to adaptation to global climate change from many different perspectives and under many authorities. Some are engaged in policy identification and formulation (including regulatory policy) and planning. Others concentrate on implementation (design, construction, operations and maintenance). Still others focus on the ownership and financing of the built environment.

Organizations covered in this inventory are primarily involved in land use, infrastructure, and other support facility and service decisions. Within these broad categories the focus is on organizations whose jurisdictions extend to the activities and facilities predicted to become the most vulnerable to sea level rise and more frequent and greater extreme temperatures and weather events.

The inventory of public agencies and quasi-public organizations (such as authorities) summarized in Table A-1 is organized according to the institutional functions ranging from policy and planning through operation and maintenance within each sector category.[7] In reality, however, there is an implicit if not a formal dynamism among these functions, and they often become indistinguishable.

The major drivers of land use and infrastructure investment in areas that are vulnerable to global climate change related to sea level rise, for example, include the traditional forces related to the economy, programmatic elements and investments, and regulation as well as interactions of these forces with one another. Market mechanisms in the form of real estate investments and economic development have largely shaped the coastal areas given the fact that a large portion of the coasts is privately owned. Programmatic investments for capital construction and rehabilitation in transportation, wastewater collection and treatment, water supply, and waterfront parkland have created and transformed infrastructure that occupies or transgresses coastal locations to connect the region's activities. Regulation has also had a substantial impact, in the form of permitting and environmental review procedures, on the siting and operation of public and private structures in environmentally sensitive and/or coastal areas.

Given the enormity of and pervasiveness of these inplace programs and the principles behind them, it makes sense for adaptation measures for global climate change to link to these firmly entrenched institutions. For example, in the course of planning the rehabilitation of transportation infrastructure under the Intermodal Surface Transportation Efficiency Act (ISTEA) and its successor, the Transportation Equity Act for the 21st Century (TEA-21) it makes sense to incorporate global climate change requirements into the design, siting, and planning of new or updated facilities. The application of flood plain regulations under the National Flood Insurance Program (NFIP) also provides a critical opportunity. Because these regulations already govern the elevation of structures, changing their specifications and adding elevation restrictions above the flood plain that are responsive to global climate change scenarios will likely provide a useful adaptation approach.

The magnitude and complexity of the governmental and quasi-governmental jurisdictions within the 31-county MEC region is reflected in the very large investment in the built environment within the region, the number and variety of agencies and governments with direct and indirect authority over the built environment, and the types of mechanisms for coordination and integration that make those numbers manageable.

First, the level of financial investment and income generated in the MEC region is large. For governmental functions in 1993 alone in the MEC region, governmental revenues were estimated at $85.9 billion and governmental expenditures were $90.7 billion (in 1993 dollars).[8] Assets within the region are estimated at about $1 trillion.[9] Moreover, the region is undertaking some of the largest construction projects, exemplified by the construction of the Third Water Tunnel and Route 9A along the west side of Manhattan.

Second, the total number and variety of governing entities within the 31-county region is astounding. By mid-1995 the total number of such entities was estimated at over 2,000.[10] The number of incorporated places and census designated places and minor civil divisions with populations over 2,500 totalled close to 1,000. If one assumes that approximately two agencies per government entity will have some global climate related functions,[11] the number of local agencies grows to a couple of thousand. These estimates are shown in Table 1 and specific examples of these agencies are given in Table 2.

Third, while a number of institutional mechanisms in the MEC region promote some level of integration and coordination among this very large number of entities, most of these efforts tend to be highly specialized by function and by area of the region. For example, region-wide planning is not the formal responsibility of any given governmental agency, though the Regional Plan Association has undertaken this function. Development planning, coastal zone planning, and infrastructure planning occur within states and localities but by separate entities.

The ability of any organization to take on adaptive measures will depend on the extent to which it sees the immediacy and importance of the need to act in the context of its other interests and responsibilities. The following factors guide that vision and the ability of the organization to act.

- Knowledge and understanding of and experience with global climate change and its effects
- Mission, and its compatibility with global climate change issues
- Jurisdiction or domain, including mechanisms for interagency coordination
- Capacity (human, financial)
- Capability (politics, organizational culture)

The guiding concept is that organizations and institutional decision-making are more likely to promote adaptations to global climate change if they have:

(1) Missions that are compatible with and reflect commitment to managing global climate change hazards or can be convinced to alter their missions in a manner consistent with needs for global climate change management,
(2) Flexible or unallocated resources and discretion to use those resources for such activities,

(3) Knowledge and understanding of and experience with these issues (e.g., membership in hazard consortiums, skilled human resources in risk and safety), and
(4) Ongoing activities that are closely associated with actions necessary to adapt to global climate change so that global climate change adaptation can be seen as a part of or reinforce what they are doing or have to do for other purposes.

Although an extensive analysis of these factors as they apply to the MEC region institutions is beyond the scope of this report, these factors will be referenced in the sections below where information is readily available from secondary sources.

Table 1. Number of Governments and Agencies Engaged in Global Climate Change Activities

Level of Government	Estimated Number of Governments engaged in global climate change functions (2)	Number of Agencies engaged in global climate change functions
Federal(1)	1	12
Interstate	-	4
State	3	18(3)
Substate Regional	-	2
Local	928 approx.(4)	Est. 2000 (5)

Notes to Table 1:
(1)Includes departments, cabinet level agencies, and foundations and institutes only, not regulatory commissions or subunits of any of the above.
(2)The tabulation of agencies does not include the very large number of non-governmental or quasi-governmental entities in the form of authorities, commissions and special districts that operate and manage the various land uses potentially subject to the effects of sea level rise.
(3)Based on the assumption that there are six different kinds of agencies per state: Environmental; Coasts and Wetlands; Water Supply and Health; Transportation and Waste Management Infrastructure; Energy; Recreation. The number is based on governmental agencies only and does not include state corporations.
(4)This includes incorporated places, census designated places and minor civil divisions with populations over 2,500 in the 31-county MEC region. The data are tabulated from U.S. Bureau of the Census, *County and City Data Book*, 1994, Table D (Washington, DC: U.S. GPO, 1994).
(5)This estimate assumes two relevant agencies per local government unit – a planning/buildings department or official and a public works department or official. While many small governments are not likely to delegate authority beyond the Town or County level, many of the region's larger cities and especially New York City will have as many as a dozen or more applicable agencies. This approach is similar to the one used by Marr (1979) in a historical study for the Marine EcoSystems Analysis (MESA) Program, New York Bight Project.

Table 2. Selected Governments and Agencies Engaged in Global Climate Change Activities

Type	Government Agencies
Federal	U.S. Department of Defense, U.S. Army Corps of Engineers (USACE), U.S. Environmental Protection Agency (EPA); U.S. Department of the Interior (DOI) Fish and Wildlife Service and National Park Service; Federal Emergency Management Agency (FEMA); U.S. Department of Commerce, National Oceanic and Atmospheric Administration; U.S. Department of Transportation; U.S. Department of Energy; U.S. Department of Agriculture, Soil and Water Conservation Service; U.S. Department of Health and Human Services, Public Health Service – Centers for Disease Control and Prevention, Agency for Toxic Substances and Disease Registry (ATSDR); National Institutes of Health; National Science Foundation
Regional Interstate	Interstate Sanitation Commission (tri-state), The Port Authority of NY and NJ, Delaware River Basin Commission, Palisades Interstate Park Commission
State	Numerous agencies, generically dealing with: Environmental; Coasts and Wetlands; Water Supply; Health; Transportation and Waste Management Infrastructure; Energy; Recreation
Substate Regional	Hackensack Meadowlands Development Commission, New York Metropolitan Transportation Council, North Jersey Transportation Planning Authority
Local	Numerous agencies, generically dealing with: Planning and Zoning; Buildings; Public Works; Parks and Recreation

Note: See Table A-1 for more detailed examples of these organizations and their potential roles in global climate change adaptation.

III. POTENTIAL ENVIRONMENTAL CHANGES AS A BASIS FOR ADAPTATION TO GLOBAL CLIMATE CHANGE

An understanding of institutional decision-making systems should be framed by attributes of global climate change to which organizations are likely to react. Other sector reports identify many of these attributes. The pertinent ones for institutional decision-making are summarized here for reference.

The most commonly cited attributes or environmental conditions from global climate change are temperature increases, changes in precipitation, and sea level rise. These are interrelated. Although this report focuses largely on adaptations to sea level rise, changes in temperature and precipitation patterns are an important backdrop and are discussed briefly.

As indicated above, institutional decision-making is likely to be driven by public concern, anticipated costs, and the perception that actions will reverse the predicted consequences (have an impact) and that such actions are within an institution's jurisdiction or mission.

Institutions are most likely to respond to the physical or statistical attributes of the consequences or effects of global climate change rather than to global climate change phenomena directly. For example, institutions are not likely to react to a rise in sea level or temperature per se, but rather to the suddenness or severity of the events precipitated by sea level rise and temperature changes, such as flooding from storm surges.

Each of the global climate change attributes can be measured or characterized in terms of:

- Timing
- Duration
- Frequency
- Magnitude
- Severity (extent in terms of area affected and cost of damage; type of damage, the most serious of which is the loss of human life)
- Suddenness/predictability
- Location of the effect relative to vulnerable structures and settlements and large population
- Synergism with other events

Several examples of past events in the MEC region and elsewhere reveal the significance of these measures. *Timing* was a significant factor in the enhanced effects of the December 1992 Nor'easter that coincided with and was reinforced by the high tide. A March 1962 Nor'easter which persisted through five tidal cycles illustrated the effects of *duration.*[12] More recently, the severe and unpredicted rainstorms of August 27, 1999 underscored the consequences of *suddenness* when flash flooding halted transportation systems throughout the MEC region in a virtually unprecedented manner.

The most relevant metrics for the measurement and expression of data for each of these factors are averages, extreme values (existence of outliers), variability, and rate of change. The choice of metrics for measuring attributes of events affects what future forecasts will look like. For

example, the persistent use of averages may underestimate future events if, as global climate change forecasts/models predict, extremes become more frequent. Thus, figures below are given for both average values and extremes where the data are available.

The dimensions of effects identified below are not necessarily irreversible. In other words, when a given adverse condition or impact occurs, actions in the form of interventions may reduce or reverse it. Moreover, events and interventions to reduce impacts do not occur in isolation. Interventions which involve coordinated and integrated inter-organizational cooperation can improve the effectiveness (at least as perceived by decision-makers) of both adaptation and prevention.

The MEC region global climate change scenarios and the global climate models upon which they are based are described in detail in the Executive Summary of the MEC Assessment. The results for temperature, precipitation, and sea level rise are summarized below and are shown in Tables 3-5 for four different global climate models[13] for 2020, 2050 and 2080. They are summarized here since they are the foundation and an important reference for identifying which activities are at risk and hence, which agencies are relevant to adaptation.

Direct Heat Effects

Temperature is a common indicator of heat and its potential effects. Table 3 shows the results for temperature change in the MEC region (Rosenzweig, May 2000; Goldberg, April 2000). It is critical to recognize, however, that heat stress is a product of both temperature and relative humidity.[14] Table 3 contains both average and extreme values for temperature. Extremes are significant because many of the effects of global climate change on structures and materials are related to extremes rather than to averages. Also significant, but less readily available, is data on forecasting how temperature and weather extremes may cluster, since many materials and structures may withstand a short period of extreme weather but not sustained periods. Information on extremes of cooling (expressed as number of days at temperatures less than 32 degrees F) is not included since all scenarios show cooling declining often dramatically over the next century.

Table 3. Selected Data on Temperature Change for Institutional Decision-making, MEC Region*

	Scenario				
	Current Trend*	CCGG	CCGS	HCGG	HCGS
Year	Incremental Increases in Ave. Temperature (F)				
2020	0.98	3.45	2.10	2.58	1.68
2050	1.57	6.52	4.80	4.37	2.63
2080	2.16	10.15	6.47	6.25	4.35
Year	Extreme Temperatures (Ave. No. of Days Per Year >90 degrees F.)**				
Base	13.0	13.0	13.0	13.0	13.0
2020	20.0	31.6	28.0	24.7	23.6
2050	22.6	50.9	38.1	37.0	27.9
2080	26.4	71.0	59.9	46.2	34.6

Notes to Table 3.
* Temperature is measured in degrees Fahrenheit. The current trends of the temperature were obtained by fitting a straight line through a monthly dataset for Central Park for 1901-1998, and extrapolating outward. All changes are with respect to 1961-90 means.
**These numbers are based on a daily dataset for La Guardia Airport in Queens, NY and went from 1979-96.

Some of the direct consequences of temperature change are stresses imposed upon the materials used in the construction of our built environment, increased energy demand, and changes in hydrologic regimes (described in the next section).

Materials Stress

The heat tolerances of materials depend upon the type of material, the duration of the condition, and the loading upon the material. Increased vulnerability of materials under increasing temperatures may be particularly critical for transportation when the size of loads, pattern of load release, and usage of the materials is combined with the effects of increased temperature.

Thermodynamic concepts largely govern the extent to which materials stress occurs. Resistance to heat changes is a function of the strength of weaker molecular bonds in the materials. Small temperature changes affect asphalt and coatings since smaller temperature changes (that occur around room temperature) can break weaker bonds in organic materials that are typical of some of these materials. In contrast, steel and concrete are generally more resistant to small changes in temperature. There are also kinetic causes, such as corrosion, that are exacerbated in hot humid environments and contribute to materials stress.

Energy Demand

Energy demand is projected to increase with a warmer climate, but in particular ways. According to the Energy Sector Report, it is the combination of increasing temperature and humidity, rather than a higher temperature alone that is likely to produce heat stress and raise peak demand.

Changes in Hydrologic Regimes

Changes in hydrologic regimes result from a combination of changes in temperature, precipitation patterns, and other factors. More detailed description of this concept is found in other sector reports for this study. Some of the most significant results from these other reports are presented below as specific reference points for institutional decision-making.

Table 4. Selected Data on Precipitation for Institutional Decision-making, MEC Region

	Scenario				
	Current Trend*	CCGG	CCGS	HCGG	HCGS
Year	Precipitation (% change)				
2020	1.1	9.0	1.4	5.0	8.6
2050	1.6	0.1	-15.6	13.9	10.4
2080	2.3	0.1	-2.1	29.9	21.6

*See footnotes to Table 3

Drought

Causes

Drought conditions occur when evaporation rates exceed precipitation rates, and consequently produce changes in the safe yield of the region's system. It is uncertain how the balance between losses due to evaporation and gains due to precipitation will change in the region.[15]

Consequences

Accordingly, it is difficult to predict how a drought will affect the region's water supply and distribution systems. The flexibility of the region's systems has so far prevented any severe scarcity of supply.

Flooding

Table 5. Selected Data on Flood Levels (including sea level rise effects), MEC Region (only values for NYC – at the Battery – are shown)*

	Scenario				
	Current Trend	CCGG	CCGS	HCGG	HCGS
Year	Flood Levels (in feet)				
2020	10.2	10.5	10.4	10.2	10.2
2050	10.4	11.4	11.3	10.8	10.6
2080	10.7	12.8	12.2	11.5	11.1
Year	Return Frequency (in years)				
2020	63	43	49	58	62
2050	48	19	20	34	41
2080	36	4	8	16	24

Notes to Table 5:

*These are conversions to feet from Gornitz (February 2000, Table 5) and reflect values for the 100-year flood levels for combined extratropical and tropical cyclones, MEC (in feet), including projected global sea level rise, local subsidence, mean high water, and combined extratropical and tropical storm surge. This scenario is consistent with but not identical to that used for the Infrastructure Sector report. For explanations of the scenarios see Gornitz (April 26, 2000).

Causes

Temperature increases are associated with many changes in water systems, including several which result in sea level rise and related flooding, such as thermal expansion, glacial melting, seasonal snow melt, increased precipitation, and ice jams. These would occur in addition to or exacerbate further some of the human-related causes of flooding, such as the increase in impervious surfaces from watershed development, reduction in water retention ability of soil from land clearance for development, obstruction of channels, and straightening of channels. The extent and impact of flooding depends on a number of environmental factors such as soil and land mass types as well as on the intensity and duration of precipitation.

Consequences

Floods often have vast impacts on human settlements depending on the magnitude of the flooding and the extent of exposure of human populations. Immediate impacts are numerous. The key impact of flooding and the one that is the most quantifiable is loss of income and property. Another potential effect is an increase in waterborne pathogens as increases in water masses and standing water combine with increased pollutants washing into the waterways to provide new breeding grounds for bacteria. Another consequence is the cumulative loss of community and culture. Individual losses are also aggregated into societal losses in the form of erosion of revenue and tax bases. The MEC region, which accounts for among the largest number of claims under the National Flood Insurance Program,[16] is clearly already vulnerable to such hazards.

IV. INSTITUTIONAL AND DECISION-MAKING ADAPTATIONS BY SECTOR

Adaptive responses to climate change affect a range of decision-making authorities, from location, design and construction of activities to detailed operations. The applicability of responses depends upon the type and degree of threat and the location of the activity or structure at risk.

The adaptive responses introduced earlier in the report can be consolidated into the following categories of adaptations for structures and activities. The categories are similar to and align with agency functions.

- Planning
- Regulation
- Construction, including initial construction retrofit and redesign
- Operation
- Emergency Preparedness, Response and Assistance

Not all of these adaptations are applicable to or are as important to each sector.

This section highlights the vulnerabilities, decision-making authorities, and proposed adaptations relevant to climate change for each MEC sector.[17] Table A-1 lists in summary form many of the relevant agencies and organizations by type and function. Table A-2 identifies a number of examples of existing planning programs that are applicable to adaptation to global climate change impacts.

COASTS AND WETLANDS

The region's geography has been one of its most valuable assets for global trade and economic growth, and its abundance of prized waterfront real estate make its coastal areas among the most densely populated in the nation. Ironically, these same geographical advantages and patterns of development are likely to incur the largest costs in adaptation to global climate change impacts.

The coastal zone as delineated on coastal zone management plan maps, generally encompasses an area that is larger than floodplains. Within New York City's coastal area alone there are an estimated 3,000 acres of freshwater wetlands (of which 2,000 acres are on Staten Island)[18] and 4,000 acres of tidal wetland (Jamaica Bay). Additional tidal wetlands are located on Staten Island (Prince's Bay), the Bronx (Pelham Bay), and Queens (Alley Pond Park). The number, size and diversity of the region's wetlands has declined over the past couple of centuries, while the population and density of the coastal areas has increased.[19]

Vulnerabilities and Impacts

The Coastal Zone Sector Report (Gornitz, April 26, 2000) and the Wetlands Sector Report (Hartig, et al., April 26, 2000) forecast impacts of climate change related sea level rise on the region's coasts and wetlands, some of which were summarized in the earlier section. These impacts, predicted from climate change models are:

- a rise in sea level from 4.3-11.7 inches by 2020, 6.9-23.7 inches by the 2050s, and 9.5-42.5 inches by the 2080s (Gornitz, April 26, 2000, Table 4; these ranges combine variations across stations and scenarios). Gornitz emphasizes that the rise is non-linear and should accelerate significantly after about 2050.

- an increase in the frequency and severity of high impact coastal storms.

- a possible increase in beach erosion rates of 3 to 6 times by the 2050s and 4 to 10 times by the 2080s; sand volumes needed for beach replenishment could increase by 10% by 2020 and by another 5-20% by 2050.

Ultimately, impacts from increasing rates of sea level rise in the region include: permanent inundation of low-lying areas and wetlands; higher rates of beach and salt-marsh erosion; more frequent and severe flooding; and northward migration of the salt front up the Hudson River.

The Wetlands Sector Report (Hartig, et al., April 26, 2000) notes that the region's loss of 75% of its wetlands is largely due to human activities like dredging and development. Sea level rise is expected to exacerbate and accelerate future loss.

Adaptations

Recommended adaptations in the Coastal Zone Sector Report (Gornitz, April 26, 2000) in the near-term (over the next 20 years) are:

- factoring sea level rise and higher erosion rates into coastal planning decisions and setting new construction set back lines;
- strengthening existing hard structures to protect vital coastal infrastructure and highly populated areas;
- changing zoning and land-use policies to provide for systematic and equitable retreat from vulnerable areas and to allow for landward migration of beaches; this could include easements and acquisition of coastal property, especially for remaining open space, for recreation;
- removing or abandoning structures in imminent danger;
- increasing investment in stabilizing dunes and beach nourishment.

Adaptations identified in the Wetlands Sector Report (Hartig, et al., April 26, 2000) include:

- strengthening existing environmental and land use regulations to offer greater protection for existing wetlands;
- transferring undeveloped wetlands and adjacent landward properties to agencies that oversee parks and open space to avoid further loss;
- restoring wetlands and providing for inland migration of marshes through measures such as the removal of sea walls and debris in certain locations.

Short-term interventions to avoid consequences include immediate evacuations and diking to redirect flood waters. Long-term interventions involve a complex system of land use controls and design modifications to avoid exposure to flooding. One of the more common and traditional types of intervention under the jurisdiction of the U.S. Army Corps of Engineers is structural controls, such as levees and sea walls.

Planning for the Location of Structures and Activities

Planning activities potentially guide development away from areas that are projected to be inundated in the future. These planning authorities also afford the opportunity for the purchase of land for protection from threats and human exposure. Some of these mechanisms already exist under the National Flood Insurance Program (NFIP). State and local programs and financial institutions usually require flood insurance for properties in flood-prone lands as a condition for obtaining a mortgage, and as such, these requirements are also important interventions to reduce exposures.

Land Use and Economic Development Planning

Many planning activities throughout the MEC region affect the disposition of coastal and wetland areas. Municipal planning departments are largely responsible for basic land use plans and needs assessments. The organization of these departments and the extent of their planning activities vary within the region.

County and municipal planning agencies throughout the MEC region should recognize opportunities to adapt current and future plans and zoning ordinances to cope with and minimize forecasted global climate change impacts. For example, land use agencies can propose more restrictive zoning along the coasts, promote uses that are less vulnerable to flooding associated with sea level rise, and/or impose design conditions that provide better flood protection.

A critical function of the NYC Department of City Planning (DCP) is identifying capital facility and land-use related program needs. Under the NYC Charter, the Department prepares for the Mayor the annual Citywide Statement of Needs (SON) for presentation to and approval by the City Council. The City Office of Management and Budget, the NYC Borough Presidents, borough boards, and community boards also play important roles in the review process. This needs assessment process identifies many projects or projects that ultimately become vulnerable to sea level rise if not adequately designed and sited in the land use review process.

Within New York City, quasi-governmental economic development authorities play a significant role in determining land use and coastal development. The New York City Economic Development Corporation (NYC EDC) influences the location of built structures through planning and market analysis as a quasi-governmental agency for the purpose of promoting long-term economic growth.[20] The Empire State Development (ESD), a state authority whose mission is business development, also influences waterfront development. One example of a project assisted by the ESD in the MEC region that reflects the complexity of interagency arrangements is the Queens West Waterfront Development – a 75 acre mixed-use waterfront development project estimated at $2.3 billion. The Queens West Development Corporation, a subsidiary of New York State's ESD Corp., initiated the project.[21]

Coastal, Waterfront and Harbor Planning

Coastal zone management planning provides a potentially strong mechanism for controlling land use along the coasts. The potential significance of these plans for global climate change is that they identify, set development policies for, and restrict as well as suggest uses in areas within zones and boundaries threatened by flooding. The federal Coastal Zone Management Act (CZMA, Public Law 92-583), first called for state implementation of coastal zone management plans in 1972. It provides the backbone for state and local planning and regulatory action in coastal areas, and essentially delegates authority to states and localities. The 1990 amendments explicitly referenced potential sea level rise from global climate change as a factor that should be "anticipated and addressed" in the state plans prepared for coastal zones.[22] In Connecticut, the CT Department of Environmental Protection administers Municipal Coastal Programs. In New Jersey this function is carried out by NJ Department of Environmental Protection & Energy. In New York State, the Department of State oversees the plan and implements it by means of the

Local Waterfront Revitalization Program (LWRP). NYC exemplifies a strong local coastal management planning process where the NYC Department of City Planning is responsible for coastal planning. The City's latest plan dates from 1992 with a revision currently under review.[23] In the three states, coastal planning provides the foundation for a number of regulatory programs for the control of tidal, coastal and wetland areas.

In many areas of the region, the record with respect to plan development and/or plan implementation has been limited. By the mid-1990s, New York City and about 80 percent of the municipalities in Connecticut and Westchester had completed a coastal management plan, but only about a third of the municipalities in Suffolk County and none in Nassau had plans, according to a report by the Citizens Campaign for the Environment and Citizens Environmental Research Institute.

The U.S. Army Corps of Engineers' substantial harbor planning and management activities in the MEC region focus on coastline alterations, restorations, and channel deepening. To the extent that this influences landside land uses it is a potential adaptive measure for sea level rise effects. This work is coordinated with other agencies, such as the Port Authority of NY and NJ (PANYNJ), economic development agencies, and federal and state environmental agencies. The Corps' most recent study, the National Economic Development (NED) Plan (September 1999), sets forth a plan for the deepening of seven harbor channels in the harbor area to a depth of fifty feet or more. This is seen as needed to maintain and increase the competitiveness of the port of NY and NJ. PANYNJ has extensive port investment plans for construction and expansion, which is a potential area for adaptations prior to events occuring. $5-7 billion in new port investment is planned.[24] The Port Authority's web site states that the Port of NY and NJ is the largest port complex on the East Coast of North America. Its standing in 1998 relative to other ports was the following, according to several different measures of port activity:[25]

Rankings for Activity in the Port of NY and NJ, 1998

Indicator of Activity	Metric	Competitors	Rank
Container Traffic	TEUs (20 foot equivalent units)	Long Beach and Los Angeles	3*
Cargo Value	U.S. dollars for exports U.S. dollars for imports Total trade	-- Long Beach and Los Angeles "	1 3 3
Cargo Volume	Metric tons: Cargo volume for exports Cargo volume for imports Total cargo volume	 12 other ports Houston Houston, New Orleans, and South Louisiana	 13 2 4

*Rank also applies to North America and the Western Hemisphere in addition to the U.S.
Source: American Association of Port Authorities (www. AAPA-PORTS.org)

Over the course of the twentieth century, the dredging has deepened these channels from depths of 30 feet to about 45 feet.

Parkland, Park, and Open Space Planning

A large proportion of coasts and wetlands is parkland or open space. Thus, the manner in which parkland is sited, developed and used is an adaptation measure. In NYC, the City's waterfront plan of 1992 pointed out that: "Fully 42 percent of the waterfront is city, state or federal parkland which includes hundreds of acres of natural or undeveloped land, active recreation areas and narrow strips along highways and rail lines." The largest coastal parkland areas, some of which encompass substantial wetlands, are Gateway National Recreation Area, Palisades Interstate Park, the Hackensack Meadowlands, and the Long Island parks including Robert Moses State Park, Fire Island National Seashore. These and other parks are managed by many different kinds of agencies – such as state commissions (e.g., the Hackensack Meadowlands Development Commission, the Palisades Interstate Park Commission – a bistate entity, various authorities, and state government agencies), local, state, and national park agencies (e.g., the National Park Service, the Department of City Planning and the NYC Department of Parks). Responsibilities are often split between state and local agencies depending on who owns the parkland.

Development pressures in and around parklands and open spaces have persisted in recent years. For example, Gateway Estates in Brooklyn, NY and the Trump development on the west side of Manhattan were built on wetlands. The efforts of public and nonprofit organizations to counter such development have successfully protected some lands, and in some cases have supported land purchases and wildlife designations. In the Hackensack Meadowlands, the Hackensack Meadowlands Preservation Alliance, representing eighty environmental groups, municipalities, foundations, businesses and civic organizations, is actively preventing further development of the Hackensack wetlands.[26]

Given that parkland is particularly suitable as a buffer zone against natural hazards, yet must also be protected, opportunities now exist to develop parkland with those objectives in mind. One important example is the five mile strip of the Hudson River Park that is going to be redeveloped. Much of this land and its structures lie below the 10-12 foot level and thus would be at risk over the next century from inundation. The processes that occurred to clear the park for redevelopment provide examples of some of the institutional issues that arise with respect to such activities.

Property Acquisition

Property acquisition throughout the MEC region is used to protect coastal, wetland, floodplain, watershed lands and open space, and many of the areas acquired are in areas vulnerable to the effects of sea level rise. An expansion of this strategy holds considerable promise as an adaptive mechanism to reduce vulnerability to sea level rise.

Since 1990 New York State has prepared open space conservation plans, and the 1998 plan identifies the purchase of land or easements for purposes such as greenways, habitat protection, the consolidation of coastal properties for conservation, and the State's purchase of 15,280 acres in Sterling Forest (the largest land purchase in the MEC region).[27] New York State created the NYS Environmental Protection Fund in 1993 for purpose of preserving open space and land

acquisition. In New Jersey 886,000 acres has been acquired under the Green Acres program since 1961.[28] Within the MEC region, both New York and New Jersey are purchasing land for the purpose of establishing walkways under the New York-New Jersey Harbor Estuary Program. Although many of the purchases have not been in areas projected to be vulnerable to sea level rise, they nevertheless provide a model for such purchases as adaptations in areas vulnerable to global climate change in the future.

Regulation

Agencies throughout the MEC region exercise regulatory authority over coasts and wetlands under the jurisdiction of numerous environmental and land use laws. Although these are too numerous to identify here, the basic types are summarized below along with the role in adaptation and which agencies are responsible for each of them.

Zoning ordinances provide broad conditions for building and site use and layout. NYC DCP for example, through its zoning ordinance, regulates the siting and design of activities that involve new construction not in conformance with or needing variants from the zoning ordinance. Once in the process, projects may also undergo the Uniform Land Use Review Procedure (ULURP) and an environmental review. Those that are in conformance are considered "as of right" and do not undergo the same level of review. Proposed changes to the City's zoning, called the Unified Bulk Program, primarily focus on height limitations, site design, transfer of development rights, and simplifying zoning procedures. The impact on buffering against potential flooding from sea level rise and the possibility of increasing the lot coverage if heights are constrained in areas potentially flooded are uncertain. More direct protection against natural hazards is incorporated into building codes.

Environmental review procedures are a common, quasi-regulatory tool over land use, practiced in the MEC region within New York City, by the States, and by federal agencies under the National Environmental Policy Act. Within New York City the City Environmental Quality Review (CEQR) process provides the major control over the environmental impacts associated with projects of a certain magnitude and in certain locations.

Environmental criteria are extensive and are incorporated primarily into State permits for construction, structural modification, and waste discharges in coastal areas, floodplains, wetlands, and other environmentally sensitive areas (see Table A-1 for a listing of some of these programs). These permits will play a central role in any adaptations for global climate change for activities already requiring such permits.

Emergency Response

The responsibility for adapting to emergencies created by flooding, one of the major effects of sea level rise upon coasts and wetlands, rests with federal, state and local emergency management agencies. The Federal Emergency Management Agency (FEMA) provides financial support, design and construction technical expertise to municipalities, and generally works with state and other federal agencies to adapt to disasters similar to those anticipated from global climate change. Through its administration of the National Flood Insurance Program (NFIP) it

provides regulatory oversight for floodplain development for those communities that are in the program. Most of the communities within the MEC region are in the NFIP. In order to obtain coverage, the community must adopt and enforce floodplain management ordinances that meet FEMA-established criteria.

Once a disaster occurs, FEMA provides disaster relief during a natural hazard under the Robert T. Stafford Disaster Relief and Emergency Assistance Act (PL 93-288, as amended) and E.O. 12148.[29] FEMA also manages Project Impact, a nationwide initiative to help communities prepare and protect themselves. Participation in Project Impact has helped a number of communities improve their disaster-resistance and bounce back with much less loss of property.

WATER SUPPLY

Vulnerabilities

Climate change related stressors on the MEC region's water supply, as identified in the Water Supply Sector Report (Major, April 2000), include:[30]

- potential pressure on water supplies due to increased water demand and evaporation from temperature increases and decreased precipitation. This could increase the frequency and/or severity of droughts and compromise safe yields. This pressure will not be felt equally throughout the region.

- increases in the supply from increased precipitation and runoff; and

- increased stress on existing fresh-water supplies from the movement of the salt front in estuaries as a consequence of sea level rise and increased salt water infiltration into aquifers on Long Island.

Adaptations

The water supply systems of the New York region are managed by a complex set of organizations. The mix of organizations differs by function (i.e., from ownership through operation and maintenance), system component (ranging from the sources of the supply through distribution and ultimate use), and geographic location within the region. Moreover, the combination of function and system component for a given geographic area within the region represents yet another layer of complexity. This is the context in which any adaptations for water supply will occur. Interagency coordination within and across the functions of planning, regulation, operations, and emergency management will be key here.

Water Supply Planning and Facility Design

Water supply planning addresses the balance between water supply and demand, the deployment of water sources, and the development of water conservation strategies. Opportunities for altering the current system face the fact that the water supply systems in the region have been in

place for over a century. New York and Newark both tapped watersheds beyond their borders by the turn of the 20th century and the region has accordingly achieved often complex but firmly grounded water supply policies.[31] The amount of water or its quality has rarely been a limiting factor to human activity and settlements in the MEC region.

Institutionally, water supply planning has a very long history, initiated originally at the federal level under various federal Water Resources Planning Acts and under areawide water quality management planning provisions of the Clean Water Act and its amendments. Within the past two or three decades, water resources demand and supply forecasting and planning for the MEC region has been undertaken on an intermittent basis by special task forces and study groups usually under the auspices of federal, state or local governments. Planning studies within the past decade or two have included the Corps of Engineers' northeast water supply study, the Mayor's Intergovernmental Task Force on New York City Water Supply Needs (1987; 1992), and the Water Resources Management Strategy for the Delaware/Lower Hudson Sub-State Region by the NYS Department of Environmental Conservation and conducted by Hazen & Sawyer Engineers (1987).

Water supply decision-makers, especially those in already water scarce regions, are increasingly conscious of the effects of climate change. In the MEC region, in fact, the Mayor's Task Force on Water Supply recognized the value in an awareness of climate change and potential impacts over a decade ago (Major, April, 2000). As Major points out, New York City's system incorporates one of only a few existing tangible adaptations to climate change among the nation's large water supply systems: an outflow pipe for the new Third Water Tunnel on Roosevelt Island was built higher than had been originally specified in order to accommodate sea level rise associated with climate change.

A key planning function is the ability to forecast demand accurately. Water supply demand is currently projected by the City of New York through the NYC DEP and the New York City Mayor's Intergovernmental Task Force on NYC Water Supply Needs, the Regional Plan Association, and in previous years by the NYS DEC. Wide discrepancies often exist in water demand projections by organization and by projection scenario. These differences result in forecasts that show both declines and increases in the occurrence of droughts.

Regulation

State regulations relevant to adaptations via altering water demand include those that provide for water conservation measures during drought periods and often guide day-to-day conservation with incentives for flow restrictive devices on plumbing.

Operations

Water supply operation does not have the same level of integration and coordination that occurs in water supply planning. Distribution is usually divided geographically into discrete jurisdictional units that rarely if ever exchange supplies. Within the region, water supply operations vary by geographical and organizational scope. New York City's public system services the entire municipality and a number of others located outside of its borders, with

withdrawals subject to an arrangement with the Delaware River Basin Commission. Northeastern NJ is serviced by United Water NJ and southeastern NY is serviced by United Water NY as well as by private well systems. The parent company of both of these companies is United Water Resources (recently acquired by Suez Lyonnaise des Eaux). Its service area is characterized by a patchwork of arrangements – maintaining and operating some systems and not others in the area – and a patchwork of supplies, some of which are from groundwater and others from surface water supplies. Water supply operations and management have probably improved over the years as common ownership has dominated the water supply industry in northeastern NJ.

Depletion of water supplies due to more severe or frequent droughts or salt water intrusion effects would likely necessitate improved mechanisms for exchange among the water supply systems to equalize water availability. Alternatively, new supplies would have to be tapped or the more expensive option of desalination would have to be practiced. Past periods of water shortage in the region provide lessons in drought response capabilities. Although New York City has never experienced a complete shutdown of its water supply system, it came close to often extremely serious shortages during severe droughts in 1950, 1965, the early 1980s, 1985, the late 1980s, 1995, and in 1999. Drought periods appear to have become more frequent. The safe yield in the driest year is estimated at 1.290 billion gallons per day from upstate sources, with an additional 33 mgd from groundwater sources in southeastern Queens. The City has increased the security and reliability of its water system and expanded its flexibility to distribute water within the City as well as to Long Island with the construction of the Third Water Tunnel. In the early 1980s, a temporary pipe was constructed across the George Washington Bridge at a cost of $5 million for 20 million gallons a day to move from the Delaware system through New York City and then to what used to be the Hackensack Water Company. The pipe was tested, but never operational, and was ultimately dismantled.[32] Interagency coordination occurred between the U.S. EPA, the water companies, and the Port Authority which owned the bridge.

Emergency Preparedness, Response and Assistance

Drought management planning is another key water supply planning activity as well as an essential vehicle for emergency preparedness.[33]

INFRASTRUCTURE

The MEC region's infrastructure ranks among the largest and most heavily used in the nation.[34] The differences in the size of facilities, interdependencies among different modes, types of technologies, and condition of the infrastructure are equally dramatic.

The scale of the region's infrastructure needs, investments, and revenues exceeds most other areas of the country. The Metropolitan Transportation Authority's Capital Program for 2000-2004, for example, calls for $16.46 billion in investment and the Port Authority of NY and NJ (PANYNJ) has a $3.9 billion budget for 2000 alone.[35] A 1998 study by the NYC Office of the Comptroller estimated that infrastructure costs (encompassing education, health, transportation, environmental facilities, recreation, human resources and safety services) would require an

investment of $92 billion of which $52 billion was in the City's Ten Year Capital Strategy for FY 1998-2007, leaving a shortfall of $40 billion.[36] Together, transit and transportation, environmental and sanitation services account for $50 billion or 53% of the $92 billion in estimated needs and about the same proportion of the shortfall. On the one hand, this situation reveals the relatively low priority given to infrastructure maintenance and investment and the resultant enormous amount of resources required simply to achieve the engineering criteria for a "State of Good Repair" (SOGR). On the other hand, this situation creates important opportunities to accommodate into SOGR investments changes that will reduce the vulnerabilities of infrastructure to climate change impacts.

Vulnerabilities

According to the Infrastructure Sector Report (Jacob, April 2000), sea level rise and an increase in the severity and frequency of storms threaten to flood or otherwise damage much of the region's transportation infrastructure. As the report reveals, supported by the findings of a USACE/FEMA/NWS (1995) report, many of the transportation systems, including the nation's largest public transit system are at critical elevations between 6 and 20 feet above sea level (NGVD) and will become vulnerable over the next century to the rising sea levels, increased storm surge heights, and shorter storm recurrence periods predicted by climate change models. Table 6 shows the large number of vital transportation corridors and facilities, from the Holland Tunnel to the World Trade Center PATH station to La Guardia Airport that would be at risk to storm surges of 10-12 feet, levels expected to become probable within the next century according to sea level projections.[37] The December 1992 Nor'easter and the severe rainstorm of August 1999 both flooded parts of New York City's transit system and, though the impacts were short-lived, the crippling of the system caused delays and disruptions for millions throughout the transit-dependent city.

Non-transportation infrastructure facilities such as water treatment plants, power generation plants, and storm sewers are also located at low elevations along coasts and rivers and are similarly vulnerable to sea level rise and flooding. In New York City, for example, 70% of its sewers are combined sewers which discharge when the tide is low and tide gates open.[38] Under climate-related sea level rise projections, they could become permanently submerged and cause backups.

Adaptations

Infrastructure planning and management will determine to a large extent how potential climate change effects will affect structures and systems. Infrastructure ownership, location, type and, to some extent, function determine planning and management authorities. These authorities hold the potential for integrating changes in siting, materials and structural criteria into the design, construction, operation, and maintenance which will ultimately affect the vulnerabilities to sea level rise and flooding. Infrastructure planning in the MEC region is widely diffused across types of infrastructure agencies and levels of government, and often overlaps with land use and coastal planning.

The region's past experience with storm-related impacts on its transportation infrastructure system and several other factors that are not related to climate change provide a strong basis for consciousness of and response to the vulnerability of its infrastructure to extreme weather events. First, even without future climate change or sea level rise, there is an increasing potential for storm-related loss due to growth in the region's population and assets. Second, the region is currently in the midst of a major capital investment period as it seeks to repair overused and aging infrastructure and to build new facilities to accommodate current and future demands. This provides many opportunities to incorporate environmental and storm-related factors into the planning, engineering and management of infrastructure investments. Third, the Infrastructure Sector Report states that FEMA's Q3 Flood Zone Maps, which show 100-year flood zones, is upgraded periodically but has not systematically accounted for changes in land use and the widespread loss of greenlands and wetlands that serve as buffers between water bodies and developed areas. FEMA could adjust its Q3 maps to document this increase of land in flood zones and thus guide future land use and technical standards for infrastructure siting and operation.

The Infrastructure Sector Report (Jacob, April 2000) further recommends the following adaptation strategies which do recognize the potential for significant loss of life and assets to climate change impacts on the built environment over the next century:

- an agency-by-agency but coordinated, systematic and thorough inventory of infrastructure assets, vulnerabilities, potential hazards, and loss potential that reflects climate change impact scenarios;
- short-term protective engineered solutions that elevate or block individual systems or system components, when feasible and cost-effective;
- land use changes which move critical infrastructure landward and maintain waterfront as open space and recreational areas;
- engineering code changes which site critical infrastructure at sufficient elevations.

Transportation

Efforts to reduce the vulnerabilities of the region's transportation infrastructure to potential sea level rise and more frequent and severe storms should reflect its value to the region's day to day operations and to evacuation strategies. Current and future responses to deferred maintenance and expansion needs could incorporate engineering and land-use decisions that safeguard transportation structures from sea level and flood scenarios.

State and regional authorities that plan and/or manage bridges, roads and transit systems in the MEC region potentially play a key role in adapting design, construction, operation, and maintenance. Current planning for the rehabilitation and reconstruction of many of the region's transportation arteries provides the opportunity to incorporate adaptation needs in a relatively unobtrusive way.[39] Some of the major transportation planning agencies in the region include state, county, and city DOTs, the New York Metropolitan Transportation Council (NYMTC), the PANYNJ, the Metropolitan Transportation Authority (MTA), NJ Transit, and AMTRAK. Table A-1 lists infrastructure agencies by function and jurisdiction and Table A-2 lists current infrastructure plans. Any given corridor or transportation system in the region is often

jurisdictionally divided among a number of these agencies. Planning initiatives are primarily guided by federal transportation policy and air quality legislation, by current needs and conditions, and by capital budgeting concerns.

Wastewater Treatment

The primary form of adaptation to sea level rise for wastewater treatment and collection systems will be reconstruction and retrofit of existing facilities and construction of new facilities at higher elevations. In the case of a shut-down of New York City's combined sewer overflows due to long-term inundation, wastewater would have to be pumped out on an immediate basis. These discharges occur via a complex system of regulators and tide gates.[40] A more long-term solution would require raising drainage fields or providing for permanent pumping arrangements. In certain parts of the region with smaller volumes of wastewater flow, natural drainage systems could replace traditional outflow systems. For example, efforts are currently underway to use wetlands for stormwater discharge and treatment in the Staten Island Bluebelt.

Wastewater treatment system planning throughout the region was completed a couple of decades ago under the Clean Water Act with the exception of several new plants and upgrades in the New York City watershed. The construction of wastewater treatment and collection systems is largely controlled by financial and regulatory programs such as the federal National Pollutant Discharge Elimination System (NPDES) permitting regulations. In New York, the Environmental Facilities Corporation coordinates financing programs for construction and modification of wastewater treatment facilities, and these programs include the Clean Water State Revolving Fund for new wastewater treatment plants and modifications of existing ones and other special programs for the watershed.

Any organizational responses to climate change impacts on wastewater treatment systems will occur in the context of a variety of kinds of arrangements that currently exist for system operation. New York City's system of 14 wastewater treatment plants with a dry weather flow of 1.77 billion gallons a day and an over 6,000 mile distribution system, is operated by a single municipal agency, the NYC Department of Environmental Protection (DEP).[41] In New Jersey, public authorities or private companies manage wastewater treatment systems. United Water of NJ, recently acquired by Suez Lyonnaise des Eaux, operates a number of wastewater collection and treatment facilities in northeastern New Jersey. Authorities like the Passaic Valley Sewerage Authority also direct operations. Connecticut has a mix of municipally and privately operated facilities.

Table 6. Transportation Facilities Experiencing the Greatest Threat of Inundation from Global Climate Change (NGVD < or = to 10 ft.)

Facility	**Elevation (NGVD)**
MTA	
AMTRAK/LIRR East River Tunnel, Long Island Shaft	9
LIRR Long Beach Branch Line, Oceanside Tunnel	6.2
LIRR Port Washington Branch Line, Flushing Tunnel	9.2
LIRR Far Rockaway Station	9.2
LIRR Oyster Bay Station	9.5
Metro-North Hudson Line tracks, South of Croton River	6.3-6.5
Metro-North Hudson Line tracks, Croton River Bridge	7.0-7.5
Metro-North Hudson Line, Spuyten Duyvil Station	7.7
Metro-North New Haven Line at Sherwood Millpond	9.8
Metro-North New Haven Line at Grasmere Brook	9.6
14th St. Tunnel at Avenue D vent (L line)	7.2
Canal Street Grate (1, 2, 3, 9 lines)	9.8
Canal Street Station (A, C, E lines)	8.7
Clark Street Tunnel at Front Street vent (2, 3 lines)	9.1
Cranberry Street Tunnel at Front Street vent (A, C lines)	7
Greenpoint-Jackson Ave. (Newtown Center) vent (G line)	8.1
Joralemon Tunnel at State St. Grate (4 and 5 lines)	9.8
Lexington Ave. Tunnel at 135th St. Bronx Vent (4, 5, 6 lines)	9.9
Montague St. Tunnel at Broad St. Vent (M, N, R lines)	7.5
South Ferry Station (1, 9 lines)	9.1
Whitehall St. Station (M, N, R lines)	9.1
Christopher St. Station	-14.6
9th St. Station	-15
12th St. Station	0
Brooklyn-Battery Tunnel, Morris St. Entrance	8.6
Brooklyn-Battery, West St. Entrance	8.6
Cross Bay Parkway (Bridge), Queens	8
Marine Parkway/Gil Hodges Memorial Bridge	8
Verrazano-Narrows Bridge	8

Table 6 (continued)

PANYNJ	
PATH Stations at Exchange Place, Grove St., Hoboken, Pavonia	7, 9.8, 7.4, 10
PATH shafts at Morton St., Railroad Ave., Washington St.	7.3, 9.7, 7.6
PATH/TA Station (Ramp D) at World Trade Center	8.1
Holland Tunnel, New Jersey Entrance	7.6
Holland Tunnel, New Jersey Land Vent Shaft	7.6
Holland Tunnel, New York Entrance	9.5
Holland Tunnel, New York River Vent Shaft	8.6
Holland Tunnel, New York Land Vent Shaft	8.6
Autoport Marine Terminal in Essex County, NJ	9.5
Howland Hook Marine Terminal in Staten Island	9.9
Port Newark & Elizabeth	9.6
Red Hook Marine Terminal in Brooklyn	9.8
Passenger Ship Terminal	8.9
Pier 40	8.9
LaGuardia Airport	6.8
Teterboro Airport	5
NYC DOT	
Battery Park Tunnel	9
West Street	9
FDR Drive, above 59th St. and vicinity of Williamsburg Bridge	6
NJ DOT	
U.S. Highway 1 at Rahway and Elizabeth in Union County	9.4 and 9.6
U.S. Highways 1 and 9 at Jersey City and Newark in Hudson County, and North Bergen Township in Bergen County	2, 6.8, 8.
I-95 in Bergen County	5.8
N.J. Route 17 in Bergen County	3.9
U.S. Highway 46 at Little Ferry in Bergen County	5.6
N.J. Route 3 at Secaucus in Hudson County	8
NYS Department of Parks and Recreation	
Meadowbrook Parkway	7.3
Wantaugh Parkway	6.3

Source: USACE, FEMA, NWS (1995) and reported in (Jacob et al., April 2000)

Table 7. Transportation Facilities Experiencing a More Modest Threat of Inundation from Global Climate Change (NGVD 10 ft < NGVD </= 12 ft)

Facility	**Elevation (NGVD)**
MTA	
AMTRAK/LIRR East River Tunnel, Top of ramp	12
AMTRAK/LIRR West Side Storage Yard	10
LIRR Far Rockaway Branch Line, Valley Stream Station	11.4
Metro-North Grand Central Terminal, Steinway Tube, Queens Vent (#7 line)	11.0
53rd St. Tunnel at Nott Ave. Vent	10
Rutgers St. Tunnel at South St. Vent (F line)	10.6
Metro-North/TA Steinway Tunnel at 50th Ave. Vent (7 line)	11
Brooklyn-Battery Tunnel, Brooklyn Entrance	11.6
Queens Midtown Tunnel, Queens Entrance	10.6
Bronx-Whitestone Bridge	12
Throgs Neck Bridge	10
PANYNJ	
Holland Tunnel, New Jersey River Vent Shaft	10.6
Holland Tunnel, New Jersey Vent Shaft	10.6
Lincoln Tunnel, New York River Vent Shaft	11.6
Lincoln Tunnel, New York Third Tube Vent Shaft	10.6
JFK International Airport	11.7
Newark International Airport	10.3
NJDOT	
U.S. Highway 1 at Linden, Union County	11

Source: USACE, FEMA, NWS (1995) and reported in (Jacob et al., April 2000)

ENERGY DEMAND

Vulnerabilities (Related to Electricity Only)

As a result of global climate change, demand for cooling during the summer is expected to increase over the next century while demand for winter heating is expected to decrease. The factors associated with energy demand during the summer months are similar to those related to heat stress, which is a combination of both temperature and relative humidity, extreme conditions rather than averages, and a longer duration of hot spells.[42]

Two ways in which electric power generation, fuel and energy storage and transmission facilities are vulnerable to global climate change, all other things being equal, are:

- First, prolonged heat or cold can increase energy demand while reducing the ability of energy supply systems to produce, transmit, and distribute energy for cooling and heating respectively. The potential outcome is more frequent outages or periods of reduced service (e.g., brownouts).

- Second, energy production and fuel storage facilities typically have coastal locations by virtue of their need for nearby and plentiful sources for cooling and transport of fuel, and as such can be threatened by flooding as a consequence of sea level rise.

Adaptations to Balance Energy Supply and Demand

The adaptations that have been identified in the Energy Sector Report (Hill, April 26, 2000), include:[43]

<u>Increasing supply</u> by increasing capacity by means of :

- constructing new power plants
- constructing new transmission lines
- upgrading local lines for electricity distribution

<u>Reducing demand</u> by means of:

- increased energy conservation
- employing a wide range of technologies that reduce demand, such as passive cooling, weatherization, alternatives to electricity demand
- increasing shading through tree planting, high-albedo surfaces,
- educating the public to encourage energy efficiency

<u>Increasing Energy Capacity and Supply</u>

Adaptation measures that increase the capacity of existing plants, new plants, and redistribution of power via transmission systems involve a constellation of policy, planning, investment, and regulatory authorities that occur primarily at the state level in the MEC region. Local action and

intervention are also common. Coordination at the state planning level within the region and between the region and outside as well as vertical coordination from planning through operations will be needed to expand capacity and supply and to meet environmental requirements to reduce emissions. At the operational level, electric power producers and distributors will play key roles.

Planning and Policy

State energy plans and policies are potentially important determinants of the distribution of energy within the region. In New York State, the State Energy Planning Board issues the State Energy Plan and its accompanying environmental impact assessment that forecasts energy supply and demand as a basis for changes in capacity. The New York State Energy Research and Development Authority (NYSERDA), established by state statute in 1975 as a public benefit corporation, focuses on energy efficiency, the environment, and economic development through research and development activities, financial and technical support, and partnerships. It has virtually no direct authority over the operations or siting of electric utility plants, but can influence investment through some of its public finance authority.

Within New York City, the Economic Development Corporation's Energy Division assumed the jurisdiction of the NYC Energy Policy Office and currently develops policies for electricity and natural gas (not transportation). The Energy Division influences policy with respect to the development of new plants in the City. Since the infamous 1977 blackout in New York City, the NYS Independent Power Operator has required that 80% of the City's electricity be supplied by plants located within the City or directly linked by transmission lines to the City. The one New Jersey plant that is directly connected to the City is considered "in-City generation".[44] Expansion of power plant capacity within New York City is highly controversial, and the East River repowering project involving the closure of the Waterside plant and the expansion of the 14th Street plant in Manhattan is a case in point.

Plans are underway in the MEC region for expansion in capacity involving either the construction of new plants or the redistribution of power production among existing plants. In the mid-Hudson Region of New York State, Pacific Gas & Electric Corp. has proposed a new 1,080 megawatt, $500 million plant in Athens, Green County with new technology for emissions and water usage, and which could account for 4-5 percent of the statewide demand. On June 2, 2000 it received final approval in connection with environmental requirements from the state. No new plant has been built in the region since the late 1980s.[45]

Transmission lines provide the MEC region with the ability to obtain power from other parts of the country. Some of these systems, described in the Energy Sector report, have limitations on expansion due to rights-of-way requirement necessitating new cable technologies. Transmission capacity, particularly to New York City and Long Island, is considered a limiting factor to the provision of extra power in certain parts of the region.[46] In Connecticut, a new transmission line, the Long Island Sound 24 mile line is under construction to enhance exchanges between Connecticut and Long Island, and other enhancement projects are underway to expand transmission capacity in portions of the MEC Region in Connecticut.[47]

A critical factor in outages is considered to be "failure of distribution feeders leaving high voltage substations and distribution transformed near end use customers" resulting from old equipment.[48] Upgrading of underground lines can benefit from alliances with optic fiber lines being installed by telecommunications companies, which is already occurring.

Regulation

Energy supply regulations are primarily centralized at the state level. Regulations offer potential leverages for introducing adaptations into energy provision and management to balance supply and demand.

These controls exist at least with respect to siting, capacity, operations, and pricing. In Connecticut, for example, the Connecticut Siting Council approves siting. In New York State, a multi-agency siting review process is required after applications are filed under Article X of the NYS Public Service Law. The state public service commissions, e.g., the CT Department of Public Utility Control, the NJ Board of Public Utilities Energy Division, and the NYS Public Service Commission, regulate prices.

Operational Controls

Electric power within the New York area is managed by utilities that provide generating and distribution functions throughout the region. The region's system is interconnected to a power grid that extends well beyond the New York area. The key service providers/distributors or suppliers and their jurisdictions are summarized in Table A-1, and more detailed descriptions are contained in the Energy Sector Report.[49]

The institutional arrangements for energy production are becoming radically transformed as a result of deregulation. Companies that were typically vertically integrated from production through to distribution to the customer are now selling production units. As a result, a more complex arrangement for obtaining energy has occurred and one that involves obtaining energy from more distant locations. For example, within the MEC Region, the United Illuminating Company, serving the Greater New Haven and Greater Bridgeport areas sold its New Haven and Bridgeport Harbor generating plants to Wisconsin Electric Corporation in April 1999. Con Edison's sale of its nuclear plants (Indian Point 3 in Westchester County and another plant outside of the region) to Entergy Nuclear of Jackson, MI was approved by the NY Power Authority in March 2000. The transaction was described as "the largest sale of a public asset in New York State history" and one which amounted to "at least four times as much as any previous sale of a nuclear plant, based on dollars per generating capacity."[50]

It is uncertain how this trend in physically and institutionally separating energy production and distribution will impact the energy sector's ability to adapt to climate change and associated higher demands. Paralleling the separation of production and distribution is often an increase in the size and geographic reach of conglomerates that control the network. On the one hand, such conglomeration enlarges the size of the resources that can be tapped. On the other hand, demand areas increase and introduce new constraints on the reach of this power. As noted above, some

areas, such as New York City, are required to generate a large portion of their power from local plants.

Utilities respond to unplanned, unanticipated extremes of heat or cold with many different kinds of operational controls. Connecticut for example used the following resource management approaches to adapt to existing periods of high demand as well as normal demand during system downtime: "additional power purchases; full operation of all available generation units; power factor correction through transmission and distribution capacitors; reinforcement of electric substations; reconductoring of transmission lines; continued temporary reactivation of units in Norwalk and Wallingford; transfer of load to be served by facilities outside of Connecticut; and voluntary interruption of service to customers who agree to such interruption."[51]

Adaptations and Strategies to Reduce Demand

Energy consumption is relatively high in the MEC region, peak demand has been rising,[52] and much of the consumption is in the buildings and transportation sectors. NYSERDA's 1999 Three Year Plan, citing the NYS Energy Plan, identified the following statewide trends in energy usage:

- NYS ranks fourth among the states in energy consumption.
- About two-thirds of energy expenditures are in the buildings sector and almost a third are in the transportation sector.
- Energy use in the State has risen 5% between 1990 and 1997, primarily attributed to a rise in the buildings and energy generation sectors.

These trends have considerable implications for how facilities are designed and operated to withstand the effects of global climate change.

Many programs exist to promote energy conservation, and the key is to implement them in a manner that effectively reduces demand.

Adaptations to Reduce Vulnerabilities of Energy Production and Distribution Facilities

Key vulnerabilities of energy production systems occur by virtue of the traditional location of power plants at waterfront locations because of the need for cooling water and shipments of fossil fuel via waterborne transport. Distribution systems are also vulnerable. Overhead power lines are extremely vulnerable to high winds and icing associated with storm events. Underground lines are vulnerable to flooding. Adaptations involve a wide range of design measures similar to those for other infrastructure, for example, dikes to shield plants from flooding. Operational adaptations in the form of shifts in power distribution are common among the Region's five New York State plants, New Jersey's four plants, and the plants in Connecticut.

Utilities also have jurisdiction over the location of distribution lines, including their elevations to protect them against flooding. However, utility rights of ways and acquisition of those rights are governed by complex arrangements among utilities that depend on location.

PUBLIC HEALTH

The health effects of global climate change are likely to be new and unpredictable. The capability of public health institutions to effectively anticipate and respond to these effects will depend on their capacity to adapt to a more dynamic and demanding environment. In the MEC region, resources for adaptation to health trends and crises are provided by a network of public and private organizations through research, detection and surveillance, eradication, evacuation, health services, education and training, and actions that reduce the sensitivity of individuals and populations to disease. This network includes government, academic and for profit institutions, and encompass state and local health departments and hospital and health service networks. Because of the critical linkages between health outcomes and environmental and ecological factors, environmental agencies also play an important role in the public health sector.

Vulnerabilities

According to the Public Health Sector Report (Kinney, et al., April 2000), impacts of climate change on public health in the MEC region will likely fall under three categories:

- heat stress;[53]
- water and vector-borne diseases;[54]
- respiratory diseases, including asthma, aggravated by ground-level ozone, particulates, and other pollutants.

According to the Public Health Sector Report (Kinney, et al., April 2000), heat stress mortality in New York City could increase by 2-7 times over the next century as the number of days over 90 degrees F increases from about 20 days/year in 2000 to 27-80 days/year during the 2090s. The effects of heat stress on the poor, elderly and infirm will be most extreme and should invoke decisions about more equitable provision of air conditioning. The increasing number of hot days and increasing duration of extreme temperatures will also increase ground-level ozone concentration and likely aggravate an already high rate of asthma and other respiratory disease in the MEC region, especially among sensitive populations. This potential impact has implications for both healthcare institutions and agencies that monitor and regulate air quality.

Another key potential impact of global climate change on public health in the MEC region and around the world is an increase in vector-borne diseases. Potential manifestations include unpredictable expansions in known diseases and the emergence of new diseases from excessive and sustained heat and humidity, excess precipitation and flooding which can increase and redistribute areas of hibernation of disease vectors, and alterations in the chemical composition of the atmosphere.

Extreme weather conditions that increase the potential for flooding, electrocution, and mold problems also have public health implications.

Institutions and Adaptations

The Public Health Sector Report (Kinney, et al., April 2000) recommends adaptive responses to these potential public health impacts such as the following:

- increasing access to air conditioning, especially among the poor and elderly;
- improved early warning mechanisms and outreach regarding heat, vector-borne disease, and ozone levels;
- coordinated responses to vector-borne disease and wetland management.

State health departments maintain primary responsibilities for health policy and management and for addressing new and emerging threats. These state departments delegate many of their functions to local health departments. The NYC Department of Health (DOH) and county health departments are thus also relevant entities for regulation and planning, while a constellation of health service organizations manage the service delivery process.

Several federal agencies also assume critical functions in the surveillance and response to disease outbreaks. The U.S. Department of Health and Human Services houses the Centers for Disease Control and Prevention (CDC) and the Agency for Toxic Substances and Disease Registry (ATSDR). A major responsibility of the CDC is the tracking and detection of new diseases or outbreaks of known diseases and direction of rapid responses to reduce the incidence of disease. The CDC also provides testing protocols, training and other resources to local governments. In the New York City region, the CDC gave grants of $2.7 million to 19 state and local health agencies specifically for West Nile virus programs to reduce the time between disease onset and diagnosis. The National Institutes of Health also provide research support for disease identification.[55]

Health institutions are most likely to actively respond to the following climate change related trends and events:

- Increase in the emergence of new disease-related vectors
- Increase in the lifetime/survival time of disease-related vectors
- Redistribution of species in a manner that reduces the natural predators of disease-related vectors
- Increased aerosol production and ozone production leads to increased respiratory illness
- Increased mortality and morbidity, particularly among sensitive populations (such as the elderly) which are growing as a proportion of the region's population)
- Increased northward and altitude migration of species, whose effects on the food chain can have repercussions on disease, economic and recreational activity

The institutional response to the emergence of the West Nile Virus is an example of the ability of health institutions to create the capacity to meet the needs of a new health threat.[56] The NYS DOH created the West Nile Virus Response Plan, and in the course of developing the plan collaborated with the Centers for Disease Control and Prevention (CDC), the U.S. EPA, and the NYC Mayor's Office of Emergency Management.[57] The plan outlines prevention, response and

control systems, specific surveillance systems for mosquitoes, animals, and humans, improved data collection and dissemination systems, and a public awareness and education campaign. The NYS DOH and local health agencies have increased staff and fiscal resources to implement the plan.

In April 2000, New York City announced its own comprehensive West Nile virus prevention and control plan which includes larvicide efforts, mosquito, bird and human surveillance activities, and a public education campaign.[58] According to its web site, the New Jersey Department of Health also has been in direct communication with New York City and State health officials and has enhanced its intergovernmental coordination in implementing its mandated county-based mosquito surveillance and control programs.[59]

V. SUMMARY, CONCLUSIONS AND SYNTHESIS

This report has covered the manner in which institutional decision-making can respond to the vulnerability of populations, land use, and land-based structures in the MEC region to the three kinds of effects anticipated from global climate change: increases in temperatures, precipitation, and sea level and associated flooding. This approach has focused on those agencies, primarily public agencies, whose authorities are most relevant to adaptations to global climate change based on their prominence as planners or managers of the affected facilities, activities, or land uses.

This assessment reveals that many of the region's most influential decision-making institutions already possess missions and authorities compatible with the kinds of actions and policies that could ease adaptation to climate change impacts. The region's current capital planning efforts and revisions of land-use and environmental policies offer prime opportunities to incorporate measures that increase resiliency in the face of climate change. Such a broadening of the scope of traditional decision-making criteria to include potential climate change impacts, however, requires more targeted education of institutions about climate change, specifically in terms of the kinds of regional impacts presented in this MEC assessment. The extent to which institutions integrate climate change considerations into their policies and actions, and the potential for such actions to be effective, will also depend on a process to increase the level of agency interaction and collaboration within the region.

The most challenging adaptations will involve operational improvements in the in-place built environment, particularly in the region's most densely populated areas along the coasts. While in some cases adaptation will be more cost-effective as a post-disaster effort, opportunities for pre-disaster adaptation do exist. The nature of adaptations is likely to depend on the magnitude of both the anticipated impacts and the costs of adaptation. For large, immovable structures, for example, temporary barricades against sea level rise might in some cases be the best precautionary measure. Other more flexible structures could be elevated or moved to provide more permanent protection against sea level rise.

Examples of some of the many opportunities that exist to promote the introduction of adaptations in the course of existing planning and project development for existing projects or projects in the planning stages, proposed or underway in the MEC region are the following:

Transportation investments are being made for new roadway design, airport modifications, and transit systems under the Transportation Equity Act for the 21st Century (TEA-21). Where such changes already incorporate flood protection, modifications might be considered to incorporate new vulnerabilities posed by projected sea level rise beyond the levels for which they have been planned and designed.

The Region already has in place many planning and regulatory mechanisms for protecting the coastal zone, wetlands and floodplains, such as coastal zone plans, the National Flood Insurance Program, and wetland restoration. The key to adaptation is to add any additional requirements imposed by global climate change to existing ones as well as to promote implementation of even the existing policies and regulations.

Existing facilities are more problematic and the more relevant adaptations are structural such as the construction of temporary barricades and the use of operational controls. The use of operational controls can and has been innovative. In the water supply area, for example, the Third Water Tunnel was able to elevate one of its structures in response to global climate change. A pipe was constructed between New York and New Jersey during the 1980 drought. The Chelsea Pump Station along the Hudson River continues to be a possible alternative water supply for the City in an emergency.

Non-structural adaptations are possible as well. Some are very short-term such as communication, while others are more long-term that alter population exposure through relocation and altering usage patterns through behavioral changes. In areas where uses are marginal, over time, programs such as property acquisition can gradually restore areas to non-developed uses reducing population exposure during extreme events.

Institutional Factors

Institutional factors mentioned at the outset as influencing adaptability include: knowledge and understanding of and experience with global climate change and its effects; consistency of an organization's mission with global change issues; jurisdiction or domain, including mechanisms for interagency coordination; capacity (human, financial); and capability (politics, organizational culture). Among these factors, jurisdictional and capacity issues are noteworthy.

<u>Jurisdiction or domain and interagency coordination</u>

Few agencies, especially at the local level, currently consider global climate change as part of their authority. Climate change policies generally reside with environmental and energy agencies and are often limited to mitigation rather than adaptation concerns. In the MEC region, however, a number of agencies have begun to adapt their functional jurisdictions and related policies in ways that accommodate the kinds of impacts associated with global climate change. As more severe weather events have affected a larger population, emergency management has

gradually diffused throughout agencies, often in subtle ways. Rising temperatures and longer periods of high temperatures have also mobilized agencies to anticipate and address the consequences of waterborne pathogens in drinking water supplies and vector-borne diseases.

More systematic and effective adaptations to climate change will require improved interagency coordination. While current planning and regulations tend to guide certain land use activities away from coasts, wetlands, and floodplains, the mechanisms determining land use vary by sector and across the region necessitating coordinated action in many instances. Natural resource management across the region is similarly fragmented. While a number of water and energy agencies, for example, recognize to some extent the challenges associated with climate change impacts, a lack of coordination currently restricts their capacity to respond and plan for the future. The region's tradition of highly specialized organizations by function and geographically limits the kind of interagency collaboration required to tackle the regional threats to physical and socioeconomic stability associated with climate change. Mechanisms for collaboration and coordinated action among them are largely ad hoc and project specific in spite of the fact that jurisdictions are often overlapping functionally and geographically. This is not a new theme, and extends to the ability to adapt to climate change as it does to other things.

Capacity

Knowledge Resources. Agencies identified as having global climate change related functions are information rich in some areas and information poor in others. Information about flooding, a key impact associated with sea level rise and increasing storm frequency and severity, is highly centralized. Regardless of their authorities or jurisdictions, it seems that agencies rely on just a few sources of information on flood risks as they take action in coastal areas, namely the location of floodplains on FEMA maps that may be outdated. Engineering design and practice continue to use these maps as reference points.

Capital Investments. The past few decades have witnessed considerable growth in land development and revitalization in the MEC region as well as increased attention to issues of environmental quality. This has been accompanied by new capital investment for support systems. The MEC region has some of the highest levels of investments in both private investment and public infrastructure and development. Climate change adaptations could reinforce these investments, given necessary institutional recognition and coordination. An increasing trend in property acquisitions for environmental purposes also offers a ready context and mechanism for adaptation to sea level rise.

Further Research

Several areas of research emerge from the evaluation of institutional decision-making capability to guide adaptation to global climate change in the MEC region.

First, in addition to more conclusive research on the impacts of climate change in the region in terms of timing and severity, research is needed to establish the costs of various adaptive measures. Such research should consider a range of scenarios of impact and adaptation and distinguish between actions that are undertaken de novo and those that are an integral part of the

operations of the built environment. In addition, an understanding of the forces that shape coastal development is key to an adaptive strategy that includes incentive systems for guiding growth away from areas vulnerable to sea level rise. The results of such research would provide the foundation for the kind of cost-benefit analysis that guide decision-making in many institutions.

Second, research should focus on achieving a clearer understanding of the capacity of individual agencies to deal with global climate change issues either in the context of existing responsibilities or as additional responsibilities. This effort should identify linkages between various adaptation needs and the actions and activities already underway in the region.

Third, research is needed on how to apply managerial concepts for coordination, collaboration, and negotiation to the global climate change issues faced by agencies and other organizations in the MEC region. These applications will have to be particularly sensitive to existing agency jurisdictions and capacities.

Finally, the heart of effecting change and sensitivity to a new issue is education. There is clearly a growing base of concern in the MEC region regarding global climate change and its potential effects. Future research should determine effective means with which to further educate decision-makers and the general public about climate change and adaptation issues. Such efforts should ultimately mobilize well-informed institutional responses.

Table A-1: KEY INSTITUTIONS AND ORGANIZATIONS APPLICABLE TO ADAPTATION TO GLOBAL CLIMATE CHANGE, the MEC Region

Function/ Authority	Key Organizations	Jurisdiction in MEC region only*	Existing Mandate (applicable to global climate change)
I. COASTS and WETLANDS			
A. MANAGEMENT/PLANNING/ECONOMIC DEVELOPMENT			
Land Use	Statewide planning agencies	Statewide	Provide population, economic and land use forecasts; occasional development of statewide development or growth plans. Specific functions vary by state; provide assistance to local governments to do planning.
	NJ Office of State Planning; Plan Development and Implementation Committee, State Planning Commission	NJ	NJ State Development and Redevelopment Plan (1992), under revision (expected adoption 2000).
	NY Dept. of State	NYS	
	CT Office of Policy and Management, Policy Development and Planning Div.	CT	Conservation and Development Policies Plan for CT, 1998-2003.
	County and Municipal Planning Agencies		
	NYC Department of City Planning (DCP)	NYC	Prepares annual capital program plans at the community board level; zoning; prepares the coastal zone management plan.
	Regional Plan Association (RPA)	CT, NJ, NY 31-county region RPA – a private organization	Produces the regional land use, economic development, and transportation plan and associated studies for the 31-county region.
Economic Develop-ment	NYS Economic Development Corp.; Business Improvement Districts (BIDs)	NYS	Influences economic development under state statute.
	CT Economic Development		
	NJ Department of Commerce & Economic Development		
	NYS Dept. of Economic Development		
Coastal Zone Planning	NYS Department of State, Division of Coastal Resources	NYS	Responsible for overseeing the preparation of coastal zone management plans.
	NJ Office of State Planning, Dept. of Community Affairs	NJ	In addition to state agency responsibilities, the federal government is involved in The Long Island Sound Study and Plan and its Comprehensive Conservation and Management Plan (CCMP). It
	CT Department of Environmental Protection, LI Sound office, Planning & Standards Section	CT	specifies coastal land use and environmental objectives for the protection of the waters of the Sound and encompasses Long Island Sound, the southern coast of CT, and portions of NYC bordering the Upper East River.

Table A-1 (continued)

I. COASTS and WETLANDS (continued)			
B. REGULATION/ OVERSIGHT			
Land use; environment	NYC Office of Environmental Review	NYC	Has authority over the environmental review of facilities regulated under SEQRA/CEQR, including large housing developments and infrastructure facilities.
"	NYC Department of City Planning (DCP)	NYC	Approves development plans for housing, commercial, institutional and infrastructure under the Uniform Land Use Review Procedure.
Coastal Zone Regulation	CT Department of Environmental Protection Office of Long Island Sound NJ Department of Environmental Protection & Energy, Land Use Mgmt. & Compliance Div., Land Use Regulation NYS Department of Environmental Conservation	Statewide	Responsible for issuance of permits for regulation of development in environmentally sensitive areas, such as wetlands, coastal areas and floodplains. CT: Coastal Management Act, Tidal Wetlands; Structures, Dredging and Fill; NJ: Waterfront Development Law, the Coastal Area Facility Review Act or the Wetlands Act of 1970, Flood hazard Area Control Act, and the Tidelands Act. NY: Environmental Conservation Law Permits-Protection of Waters, Tidal Wetlands, State Water Quality Certification
"	U.S. Army Corps of Engineers – NY District State environmental agencies	NY and NJ*	Directly regulates wetlands development through permits; Issues dredge and fill permits (Rivers and Harbors Act) and wetlands permits (Clean Water Act).
II-A. INFRASTRUCTURE: Infrastructure (general) and Transportation			
A. PLANNING (including Needs Assessments)			
Transportation Planning (including Transportation Improvement Programs (TIPs) under Clean Air and transportation legislation	Connecticut DOT Greater Bridgeport and Valley Metropolitan Planning Organization NJ DOT North Jersey Transportation Planning Authority, Inc. NYS DOT Transportation New York Metropolitan Transportation Council (NYMTC) NYC Department of City Planning, Transportation Division	CT Ansonia, Bridgeport, Derby, Easton, Fairfield, Monroe, Seymour, Shelton, Stratford, Trumbull NJ 13 counties (bounded by Hunterdon, Somerset, Middlesex, Monmouth); Jersey City and Newark NY NYC DOT, NYS DOT, Putnam, Nassau, Suffolk, Westchester, Rockland NYC	CT Master Transportation Plan (General Statutes, Sec. 13b-15) CT Transportation Improvement Program CT TIP for Bridgeport Region prepared in conjunction with the CT DOT, regional planning agencies and transit districts. NJ State Transportation Improvement Program Northern NJ Transportation Improvement Program NYS Transportation Improvement Program NY TIP for the downstate area NYC DCP conducts studies and creates transportation plans, including bicycle modes of travel.
Port and Harbor Planning	NYC EDC	NYC	Strategic Plan for the Redevelopment of the Port of NY (forecasts and investments for the port)

Table A-1 (continued)

Function/ Authority	Key Organizations	Jurisdiction in MEC region only*	Existing Mandate (applicable to global climate change)
II-A. INFRASTRUCTURE: Infrastructure (general) and Transportation (continued)			
B. OPERATIONS AND DEVELOPMENT			
Harbor	U.S. Army Corps of Engineers - NY District	NY and NJ*	Maintains/deepens harbor ship channels through dredging (which is affected by storm surges); dredged material management plan.
Trains, Ports, Bridges, Airports	Port Authority of NY & NJ	Portions of NY and NJ	Develops, operates and maintains Port Authority bridges, tunnels, the PATH system, port facilities, ferries and airports.
Roads, bridges	NYC Department of Transportation (DOT) NYC Department of Design & Construction NYC Office of Management & Budget	NYC	Operates and maintains city-owned roads and bridges. Construction of large facilities and design-related decisions
Roads, bridges	NYS DOT	NYS	Operates and maintains state-owned roads and bridges.
Subways, Buses, Rail	Metropolitan Transportation Authority (MTA)	NYS (with NYC focus, holdings in other states, e.g., New Haven RR)	Owns, manages, operates and maintains the NYC subway system, selected rail facilities, and maintenance yards; responds to flooding.
Buses, Rail	NJ Transit	Portions of NJ	Owns, manages, operates and maintains buses and rail in NE NJ with routes between NJ and NY.
Transporta - tion, Water-Related infrastruc-ture	NJ Office of State Planning	NJ (statewide)	Infrastructure Needs Assessment: 2000-2020. A long term infra needs assessment info on present and prospective conditions, needs and costs with regard to state, county and municipal capital facilities.
II.-B INFRASTRUCTURE: Wastewater Treatment			
A. PLANNING			
Water Quality Planning	State environmental agencies; designated localities	Statewide	Water quality planning occurs at areawide and facility levels and has been ongoing at least since the federal Clean Water Act of 1972.
B. OPERATIONS AND CONSTRUCTION			
Waste-water Treatment and Collection	NYC Department of Environmental Protection (NYC DEP) NYC Department of Design & Construction NYC Office of Management & Budget NY municipal agencies and authorities NJ municipal agencies and authorities, e.g., PVSC CT municipal agencies and authorities	Five boroughs of NYC and upstate watershed areas	Owns, manages, operates and maintains wastewater treatment plants, sewers and associated facilities (pumps, regulators), etc. in both surface and subsurface locations.

Table A-1 (continued)

Function/ Authority	Key Organizations	Jurisdiction in MEC region only*	Existing Mandate (applicable to global climate change)
II.-B INFRASTRUCTURE: Wastewater Treatment (continued)			
C.REGULATION/ OVERSIGHT			
Environ-ment; environ-mental facilities	NYS Department of Environmental Conservation (DEC) NJ Department of Environmental Protection (DEP) CT Department of Environmental Protection	NYS; Regions I, II and III encompass counties of the NY area. NJ CT	Regulatory authority over the design and operation (permits/compliance) for wastewater treatment facilities, air emissions, and solid and hazardous waste transport, storage and disposal facilities and for construction in waterfront, coastal and environmentally sensitive areas such as wetlands and floodplains.
"	U.S. Environmental Protection Agency (EPA) – Region II	NY and NJ*	Exercises oversight authority over the design and operation (permits/compliance) for wastewater treatment facilities, air emissions, and solid and hazardous waste transport, storage and disposal facilities; NY/NJ Harbor Estuary Project; REMAP.
"	Interstate Sanitation Commission (ISC)	Portions of NY, NJ, CT	Exercises oversight of sources of air and water discharges, including infrastructure.
III. WATER SUPPLY			
A. PLANNING			
Water Resources Planning	State and local environmental agencies Federal, state, and local agencies CCMP	NYS, NJ, CT Long Island Sound NY-NJ Harbor Estuary Program	Plan development for the disposition of wastewater outfalls and land use development for the specification of wastewater discharge capacity; regulates wastewater treatment facility permit conditions. Estuary plans for estuaries under the National Estuary Program specifying sources and restrictions on pollutants into regions waterways.
B. OPERATIONS			
Water Supply	NYC DEP NYC DDC NYC OMB Suez Lyonnaise des Eaux; United Water NY; United Water NJ, PVWC, Jersey City, Newark, North Jersey District Delaware River Basin Commission*	NYC, selected upstate towns; Acquisition of United Water applied for Rockland county, NY NE NJ, portions of NYS west of Hudson Delaware River basin	Owns, manages, operates and maintains water supplies, transmission, storage and distribution. Manages, operates and maintains water systems under contract to municipalities. Manages, operates and maintains water systems.
C. REGULATION			
Water Quality	State health departments	Statewide	Quality of water regulated through standards in conformance with federal and state Safe Drinking Water Act Standards

Table A-1 (continued)

Function/ Authority	Key Organizations	Jurisdiction in MEC region only*	Existing Mandate (applicable to global climate change)
IV. PUBLIC HEALTH			
Funding; research/ surveill-ance	U.S. Department of Health and Human Services (DHHS) – Region II; CDC	NYS and NJ* and national	Financial support for health programs; Monitoring and assessment of health patterns and trends; mortality, morbidity statistics.
Service provision	Hospital and Health Service Organizations	Various	Managing and carrying out health support services
Service provision	NYC Health and Hospitals Corp.	NYC	Manages and operates NYC hospitals
Health oversight	NYC Department of Health (DOH) NYS DOH NJDOH	NYC NYS NJ	Responsible for health of populations, enforcing the public health code, overseeing water supply systems; monitoring of health condition; and related functions
V. ENERGY DEMAND			
A. PLANNING			
Energy Planning and Policy	CT Energy Advisory Board NJ Office of State Planning; NJ Board of Public Utilities, Bureau of Planning & Research NYS Energy Planning Board NYSERDA NYC, EDC Energy Div	CT NJ NYS NYC	Energy Policy Report Energy Master Plan – a portion of the NJ State Development and Redevelopment Plan NYS Energy Plan and Final EIS Research and development
B. OPERATIONS			
Electric Utilities	NY: Con Edison Orange & Rockland Utilities NYS Electric & Gas Corp. Central Hudson Gas and Electric Co. Rockland Electric Company Long Island Power Authority (LIPA) NY Power Authority NJ: General Public Utilities Public Service Electric and Gas (PSE&G) The Connecticut Light and Power Company (subsidiary of Northeast Utilities) The United Illuminating company The Connecticut Municipal Energy Electric Cooperative	NYC Orange and Rockland counties Westchester and Putnam (part) Parts of Putnam, Orange, Dutchess, Ulster, Greene NY NE NJ at the NY/NJ border Nassau and Suffolk counties, NY (s. NJ - Monmouth County, NJ south and NW NJ); NE NJ	Owns, manages, operates and maintains electrical production and distribution systems.

Table A-1 (continued)

Function/ Authority	Key Organizations	Jurisdiction in MEC region only*	Existing Mandate (applicable to global climate change)
V. ENERGY DEMAND (continued)			
C. REGULATION			
Rate-setting, etc.	CT Department of Public Utility Control NJ Board of Public Utilities Energy Division NYS Public Service Commission	Statewide	Regulatory authority over distribution companies and licensing authority for suppliers; rate management functions.
VI. CROSS-CUTTING RESPONSIBILITIES			
EMERGENCY RESPONSE			
Disaster assistance; analysis	Federal Emergency Management Agency (FEMA), Region II	NYS and NJ*	Research and response capabilities for natural and manmade disasters. National Flood Insurance Program (NFIP)
Response	NYC Office of Emergency Management (OEM); county offices	NYC; Applicable counties	Response capabilities for natural and manmade disasters.
"	NYS Emergency Management Office NJ Office of Emergency Management CT Office of Emergency Management	Statewide	Response capabilities for natural and manmade disasters.
FINANCE			
Utility Rate-setting	CT Department of Public Utility Control NJ Board of Public Utilities Energy Division NYS Public Service Commission (PSC) NYS Environmental Facilities Corp. Water Finance Authority NYC Water Board	Statewide	Approves electric power rates. Sets water supply rates for City and adjacent county users, where applicable.
Bond Rating	Moody's Standard & Poor	National	Rates bonds for city and county facilities (including infrastructure) based on economic condition and other criteria.
Invest-ment	Investment Banks (numerous)	National	Provide capital for public and private development.
Insurance	Various	Various	

Notes to Table A-1.

Notes:

There are numerous professional organizations that provide the standards for planning, designing, operating, maintaining and constructing the built environment in the region, such as American Society for Civil Engineering (ASCE), American Society for Testing and Materials (ASTM), American Water Works Association (AWWA), American Public Works Association (APWA), IEEE, American Institute of Architects (AIA), Water Environment Federation (WEF), etc. In addition, the academic institutions and consortia and public and private organizations in the region and elsewhere that can provide a research base for the project are not portrayed here, but their input will be a key part of the institutional analysis.

*Some jurisdictions extend beyond the region. For example, U.S. EPA Region II's jurisdiction extends to Puerto Rico and the Virgin Islands.

Selected Abbreviations: CCMP- Comprehensive Conservation and Management Plan, CDC-Centers for Disease Control, DHHS-Department of Health and Human Services, DEP-Department of Environmental Protection, DEC- Department of Environmental Conservation, DOT-Department of Transportation, EDF-Environmental Defense Fund, EPA-Environmental Protection Agency, FEMA-Federal Emergency Management Agency, ISC-Interstate Sanitation Commission, MTA-Metropolitan Transportation Authority, NRDC-Natural Resources Defense Council, NYMTC-New York Metropolitan Transportation Authority, NYSERDA-NYS Energy Research and Development Administration, OEM-Office of Emergency Management, PVWC-Passaic Valley Water Commission, REMAP-Regional Environmental Monitoring and Assessment Program, RPA-Regional Plan Association.

Table A-2. EXAMPLES OF PLANNING PROGRAMS APPLICABLE TO ADAPTATION TO GLOBAL CLIMATE CHANGE, the MEC Region

PROGRAM	ORGANIZATION
COASTS AND WETLANDS	
Coastal Zone Management Act – CZMA Plans	NYS Dept. of State, NYC City Planning
Statewide Comprehensive Outdoor Recreation Plans (SCORP)	State environmental and parks agencies
The New Waterfront Revitalization Program – a Proposed 197a Plan (11/99)	NYC Department of City Planning
Economic development planning Strategic Plan for the Redevelopment of the Port of NY (2/99)	NYC Economic Development Corp. (EDC)
Bight Restoration Plan, as part of the National Estuary Program, NY-NJ Harbor Estuary Program, Comprehensive Conservation & Management Plan (3/96)	U.S. EPA, NYS DEC, NJDEP, Hudson River Foundation
National Economic Development (NED) Plan – Jurisdiction is the USACE "Principles and Guidelines" NY & NJ Harbor Navigation Study (9/99) Dredged Material Management Plan for the Port of NY/NJ (9/14/98)	U.S. Army Corps of Engineers (USACE)
Emergency Management Plans	FEMA; CT, NJ, NY emergency management offices
New Jersey State Development and Redevelopment Plan (1999 Interim Plan)	NJ Office of State Planning
Conserving Open Space in New York State 1998. State Open Space Conservation Plan.	New York State Department of Environmental Conservation & the Office of Parks, Recreation and Historic Preservation
New Jersey Common Ground – 1994-1999 New Jersey Open Space and Outdoor Recreation Plan.	NJ DEP, Green Acres Bureau of Recreation and Open Space Planning
Conservation and Development Policies Plan for Connecticut, 1998-2003	CT Office of Policy and Management, Policy Development and Planning Division
Long Island Sound Study and Plan and Comprehensive Conservation and Management Plan	CT Department of Environmental Protection, Long Island Sound Office
INFRASTRUCTURE	
NYC Solid Waste Management Plan - Enclosed Barge Unloading Facilities (EBUFs)	NYC Department of Sanitation (DOS)
Clean Air Act State Implementation Plan (SIP) – Transportation Element	U.S. EPA, NYS DEC, NYC DEP; similar agencies in NJ and CT
ISTEA/TEA2/NEXTEA Transportation Improvement Program	U.S. DOT, NYS DOT, NYMTC
Statewide transportation master plans	CT, NJ, NY DOTs
Five Year Capital Plan for Transit	MTA
New Jersey Infrastructure Needs Assessment 2000-2020	NJ Office of State Planning
WATER SUPPLY	
Numerous regional and statewide plans for water supply	CT, NJ, NY environmental agencies
ENERGY	
NYS Energy Plan - Action Plan for Global Warming	NYS Energy Research and Development Administration (NYSERDA); NYS Energy Planning Board
PUBLIC HEALTH	
West Nile Virus Response Plan (5/00)	NYS DOH, NYC DOH

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NYC Department of City Planning (DCP): http://www.ci.nyc.ny.us/html/dcp/home.html
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NYC Department of Sanitation: http://www.ci.nyc.ny.us/html/dos/home.html
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New York State Energy Research and Development Authority: http://www.nyserda.org
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ENDNOTES

[1] R.D. McFadden, "Water Everywhere: the Overview; Surprise Deluge Cripples Morning Rush in New York," *New York Times*, August 27, 1999.
[2] L.K. Altman, "Officials Working to Contain West Nile Virus," *New York Times*, April 26, 2000, Edition L, p. B6.
[3] Titus has proposed the following set of criteria specifically for adapting to global climate change: economic efficiency, performance under uncertainty, urgency, low cost, equity, institutional feasibility, threat to unique or critical resources, health and safety, consistency with other societal goals, private versus public sector strength. J.G. Titus, "Strategies for Adapting to the Greenhouse Effect," *APA J* (Summer 1990), p. 313.
[4] Titus (1990), p. 316.
[5] This is identical to the Tri-State Metropolitan Region adopted by the Regional Plan Association covering 13,000 square miles (R.D. Yaro and T. Hiss, *A Region at Risk*, Washington, DC: Island Press, 1996, pp. 19-20).
[6] This listing compatible with those identified in the Infrastructure sector report: K.H. Jacob, N. Edelblum, and J. Arnold, "Climate Change and a Global City: An Assessment of the Metropolitan East Coast (MEC) Region. Sector Report: Infrastructure." New York, NY: Columbia University, April 26, 2000. First Review Draft, which were in turn, obtained from the USACE/FEMA, NWS report.
[7] Other organizations are indirectly involved in the effects of global climate change on the built environment too numerous to account for here. These include the many research organizations at academic institutions, national laboratories, and companies and professional associations that set standards and guidelines for the built environment, for example, governmental associations like the Environmental Council of States (ECOS), the New England States for Coordinated Air Use Management (NESCAUM), mayors and governors associations, the american associations of state officials for wetlands, transportation, air quality, etc.
[8] R.D. Yaro and T. Hiss, *A Region at Risk*. Washington, DC: Island Press, 1996, p. 204, Figure 95.
[9] K.H. Jacob, N. Edelblum, and J. Arnold, "Climate Change and a Global City: An Assessment of the Metropolitan East Coast (MEC) Region. Sector Report: Infrastructure." New York, NY: Columbia University, April 26, 2000. First Review Draft, p. 3 citing HAZUS, "FEMA Tool for Estimating Earthquake Losses, NIBS/FEMA, Washington, DC: NIBS/FEMA,1999.
[10] R.D. Yaro and T. Hiss, *A Region at Risk*. Washington, DC: Island Press, 1996, p. 197. This includes "local governments, commissions, special districts, and authorities."
[11] This approach is similar to the one used by Paul D. Marr in a historical study for the Marine EcoSystems Analysis (MESA) Program, New York Bight Project, entitled "Jurisdictional Zones and Governmental Responsibilities" (Albany, NY: NYS Sea Grant, October 1979), p. 26. Marr multiplied by 3 rather than 2.
[12] V. Gornitz, "Coastal Zone Sector Report: Sea Level Rise and Coastal Hazards," April 26, 2000, p. 8.
[13] The four scenarios are the Canadian Centre Greenhouse Gas (CCGG), the Canadian Centre Greenhouse gas and Sulfate aerosols (CCGS), the Hadley Centre Greenhouse Gas (HCGG), and the Hadley Centre Greenhouse gas and Sulfate aerosols (HCGS). This information is drawn from the Executive Summary.
[14] D. Hill, "Energy Sector Report," April 26, 2000.
[15] D. Major, Metro East Coast Study Water Sector Report, Draft #3, April 16, 2000.
[16] As of June 30, 1995, New Jersey and New York ranked 5th and 7th respectively in the number of policies in force under the National Flood Insurance Program; the two states ranked 3rd and 4th among states in the Nation in terms of the number of policies issued directly by FEMA, excluding "Write Your Own" policies (FEMA Mitigation Division, January 2000).
[17] Information presented is as of April 2000 drafts of sector reports.
[18] City of New York Department of City Planning. *NYC Comprehensive Waterfront Plan*. NY, NY: DCP, 1992.
[19] City of New York Department of City Planning. *NYC Comprehensive Waterfront Plan*. NY, NY: DCP, 1992. Pp. 18, 20.
[20] www.ci.nyc.us/html/edc/home.html and www. newyorkbiz.com
[21] www. empire.state.ny.us
[22] U.S. Congress, Office of Technology Assessment, Preparing for an Uncertain Climate-Volume I, OTA-O-567 (Washington, DC: U.S. Government Printing Office, October 1993), p. 37 and Chapter 4.
[23] The NYC Department of City Planning conducts coastal planning through its authority under the NYS Coastal Zone Management Program (under the NYS Waterfront Revitalization and Coastal Resources Act originally enacted in 1981) which in turn is mandated under the Federal Coastal Zone Management Act (originally enacted in 1972).

The City produced its major plan, "Reclaiming the City's Edge" in 1992, and its latest proposed plan was issued in September 1999, entitled "The New Waterfront Revitalization Program: A Proposed 197a Plan."
[24] PANYNJ, "Background Paper on Investment Options: the Port Authority of NY and NJ," c. 1999.
[25] American Association of Port Authorities (www. AAPA-PORTS.org).
[26] Hackensack Meadowlands Preservation Alliance, April 13, 2000.
[27] NYS Department of Environmental Conservation & the Office of Parks, Recreation and Historic Preservation, *Conserving Open Space in New York State 1998. State Open Space Conservation Plan*. Albany, NY: NYS DEC and NYS Office of Parks, Recreation and Historic Preservation, 1998.
[28] New Jersey Office of State Planning, *2000 State Development and Redevelopment Plan: Interim Plan*. Trenton, NJ: NJ OSP, 2000.
[29] USACE, FEMA, National Weather Service, NY/NJ/CT State Emergency Management, Metro NY Hurricane Transportation Study, Interim Technical Data Report, November 1995, p. 5
[30] D. Major, Metro East Coast Study Water Sector Report, Draft #3, April 16, 2000.
[31] New York City drew its water from the Catskill and Delaware systems which are about 125 miles from the City at the farthest point, and Newark drew its water from the Pequannock Watershed.
[32] D. Weissman, "Big pipeline project dries up after rains," *Newark Star Ledger* (September 20, 1981).
[33] New York State Environmental Facilities Corporation. *State Clean Water and Drinking Water Revolving Funds Revenue Bonds, Series 1998 C*, March 25, 1998, pp. B-51, 52
[34] The MTA carries 2 billion passengers a year (MTA Capital Program 2001-2004). PANYNJ reported that PATH ridership was at a level of 67.3 million passengers in 1999, the highest level in half a century (PANYNJ, "Port Authority Revenues at All Time High," News Release, April 4, 2000).
[35] MTA *Capital Program 2001-2004* (http:// www. mta.nyc.ny.us/mta/cap2000-2004.html) and PANYNJ News Release, "Port Authority Approves $3.9 Billion Budget for 2000-Record Net Revenues Help Fuel Record Capital Program," May 25, 2000 (http:// www. panynj.gov/pr/87-00.html).
[36] City of New York, Office of the Comptroller. *Dilemma in the Millennium*. Capital Needs of the World's Capital City. New York, NY: NYC Office of the Comptroller, August 1998. P. ES-8.
[37] The database for facility elevations is drawn largely from the 1995 multi-agency report on the flooding and wind effects of various categories of hurricanes (USACE, FEMA, National Weather Service, NY/NJ/CT State Emergency Management, Metro NY Hurricane Transportation Study, Interim Technical Data Report, November 1995). The scope of the study is the 5 boroughs; Morris, Passaic, Somerset, Bergen, Essex, Hudson, Union, Monmouth, Middlesex Counties (NJ); Westchester, Rockland, Nassau, Suffolk Counties (NY); Fairfield County (CT).
[38] NYS Environmental Facilities Corporation, 1998, p. B-56.
[39] For example, New York State condition rating systems reveal that three quarters of New York City's bridges connecting the five boroughs, are in "fair" or "poor" condition (NYC DOT, 1998 NYC Bridges and Tunnels Annual Condition Report," p. 65).
[40] The city currently has 490 sewer regulators and 552 tide gates (NYS Environmental Facilities Corporation, 1998, p. B-59).
[41] NYS Environmental Facilities Corporation, 1998, p. B-58.
[42] D. Hill, "Preparing for Climate Change in the Metropolitan East Coast Region: the Potential Consequences of Climate Variability and Change. Energy Sector Report." New York, NY: Columbia University, April 26, 2000.
[43] D. Hill, "Preparing for Climate Change in the Metropolitan East Coast Region: the Potential Consequences of Climate Variability and Change. Energy Sector Report." New York, NY: Columbia University, April 26, 2000. Review Draft.
[44] Richard Miller, SVP, NYC EDC, Energy Division. This reliability requirement was established by a non-profit corporation, the New York Independent System Operator (formerly the NY Power Pool), that is one of three power networks supplying power to the MEC region, and governs New York State's transmission system and establishes reliability rules.
[45] Perez-Pena, R., "Big Power Plant on the Hudson Wins Approval," *New York Times*, June 3, 2000, p. B4.
[46] Perez-Pena, R., op cit., p. B4.
[47] Connecticut Siting Council, "Review of the Connecticut Electric Utilities' 1999 Twenty-Year Forecasts of Loads and Resources," 1999, p. 9.
[48] Connecticut Siting Council, "Review of the Connecticut Electric Utilities' 1999 Twenty-Year Forecasts of Loads and Resources," 1999, p. 10.

[49] D. Hill, "Preparing for Climate Change in the Metropolitan East Coast Region: the Potential Consequences of Climate Variability and Change. Energy Sector Report." New York, NY: Columbia University, April 26, 2000. Review Draft, pp. 4-5.
[50] Chen, D.W., "Agency Votes to Accept Bid for 2 A-Plants," *New York Times*, March 29, 2000, L, p. B1.
[51] Connecticut Siting Council, "Review of the Connecticut Electric Utilities' 1999 Twenty-Year Forecasts of Loads and Resources," 1999.
[52] Hill, April 26, 2000, p. 5.
[53] The Public Health sector report indicates that heat stress mortality in New York City could increase by 2-7 times over the next century as the number of days over 90 degrees F increases from about 20 days/year in 2000 to 27-80 days/year during the 2090s. The most vulnerable populations are elderly and poor city-dwellers. P.L. Kinney, E. Chae, and B. Winston, "Metro East Coast Climate Change Impact Assessment: Public Health Sector Report," April 26, 2000.
[54] The Public Health sector report (April 26, 2000) indicates that the incidence of vector-borne diseases such as malaria, West Nile Encephalitis, and Lyme disease is likely to increase with an increase in warm and humid weather in the MEC region. Recent years have witnessed an increase in the incidence of malaria and Lyme disease in the region that correlates with increasing summer temperatures. The West Nile Encephalitis outbreak in New York City during the Fall of 1999 followed a wet and humid August, a dry July, and a mild winter. The mosquito-borne disease killed seven and infected over 60 others before the City's insecticide campaign and cooler temperatures ended the epidemic.
[55] L.K. Altman, "Officials Working to Contain West Nile Virus," *New York Times*, April 26, 2000, L, p. B6.
[56] This material is drawn from published documents and web sites of the NYS DOH and NYC DOH and news articles. NYS DOH Press Release: "State Plan for West Nile Virus Response Prepared: Public Comment is Solicited on Draft Plan." 2/18/00. New York State West Nile Virus Response Plan. NYS DOH, May 2000.
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http://www.ci.nyc.ny.us/html/doh/html/public/press00/mr132-00.html.
http://www.state.nj.us/dep/mosquito/depfs.htm
[57] New York State West Nile Virus Response Plan. NYS DOH, May 2000.
http://www.health.state.ny.us/nysdoh/westnile/final/report.htm#intro
[58] http://www.ci.nyc.ny.us/html/doh/html/public/press00/mr132-00.html
[59] http://www.state.nj.us/dep/mosquito/depfs.htm