8) Drought Hazard Analysis for New York City

a) Hazard Profile

i) Hazard Description

The NWS describes four types of drought: meteorological, agricultural, hydrological, and socioeconomic.

Meteorological/climatological drought is defined in terms of the departure from a normal precipitation pattern and the duration of the drought hazard.
Meteorological/climatological drought has a slow-onset that usually takes at least three months to develop and may last for several seasons or years.

Agricultural droughts link the various characteristics of meteorological drought to agricultural impacts. The focus is on precipitation shortages and soil-water deficits. A plant's demand for water is dependent on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil. This kind of drought has minimal direct impact to New York City because there is no significant agriculture activity within the City's boundaries.

Hydrological droughts refer to deficiencies in surface water and sub-surface water supplies. The frequency and severity of hydrological drought is often defined on a watershed basin scale. Although climate is a primary contributor, other factors such as changes in land use, land degradation, and the construction of dams all affect the hydrological characteristics of the basin. Hydrological droughts often lag behind meteorological and agricultural droughts.

Socioeconomic droughts occur when physical water shortage begins to affect the population, individually and collectively. Most socioeconomic definitions of drought associate it with supply, demand, and economic good.

Drought differs from other hazards in many ways. First, the effects of drought take a considerable amount of time to accumulate and the extent of the hazard can linger for prolonged periods after the drought itself has ceased. Second, the absence of a definitive and universally accepted definition of drought complicates the determination of whether a drought is occurring and the level of its severity. Third, compared to other natural hazards, the geographical area, impacts, and duration of drought are difficult to quantify. This is especially true in New York City because its water comes from three upstate sources.

ii) Severity

DEP has developed the New York City Drought Management Plan to guide the City's response to a drought. The Drought Management Plan has three phases: drought watch, drought warning, and drought emergency. Drought emergency is further subdivided into four stages, each with increasingly severe mandated use restrictions. The Drought Management Plan establishes guidelines for declaring a watch, warning, or emergency

and the appropriate response for each phase. Factors such as prevailing hydrological and meteorological conditions, as well as certain operational considerations inform the guidelines.

DEP declares a *drought watch* when there is less than a 50% probability that either of the two largest reservoir systems, the Delaware (Cannonsville, Neversink, Pepacton, and Rondout reservoirs) or the Catskill (Ashokan and Schoharie reservoirs), will fill by the following June 1, the start of the water-year.

DEP declares a *drought warning* when there is less than a 33% probability that either the Delaware or Catskill Systems will fill by the next June 1.

DEP declares a *drought emergency* when there is a reasonable probability that, without the implementation of stringent measures to reduce consumption, a protracted dry period would drain the City's reservoirs. DEP estimates this probability during dry periods in consultation with the New York State Drought Management Task Force and the New York State Disaster Preparedness Commission. Analyses of the historical record, the pattern of the dry period months, water quality, sub-system storage balances, delivery system status, system construction, maintenance operations, snow cover, precipitation patterns, use forecasts, and other factors inform the estimation.

iii) Probability

Occasional drought is a normal, recurrent feature of virtually every climate in the United States. New York's average annual precipitation that ranges from 60 inches in the Catskills to 28 inches in the Lake Champlain Valley feeds the state of New York's streams, lakes, and coasts. However, even with a temperate moist climate, normal fluctuations in regional weather patterns can lead to periods of dry weather. The last severe droughts in New York State occurred in the mid 1960s and again in the early and mid 1980s. According to the National Drought Atlas, a guide to the severity, frequency, and duration of droughts for the continental United States measured in terms of precipitation and stream flow, weather that brings 62% of normal precipitation or less occurs only one year out of 50 in New York City.

iv) Location

Droughts can occur within any region of New York State. The major components of the New York City water system are shown in Figure 24 of this Plan, however, the location of the City's water supply system upstate makes it vulnerable to weather conditions outside its borders. As part of the New York State Drought Response Plan, NYSDEC subdivided New York State into different drought management regions. New York City is located in Drought Region IIA; however most of its watershed lies to the north in Region II.

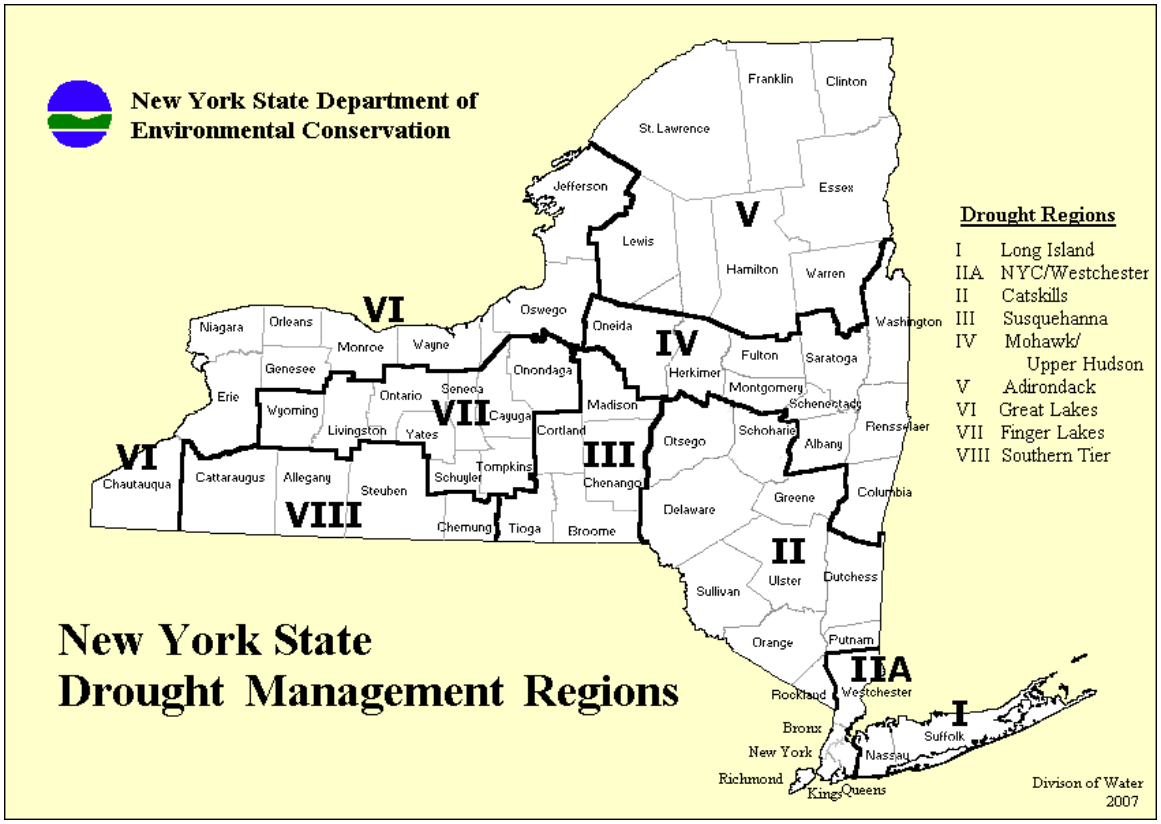

Figure 49: Drought Management Regions Map (Source: NYSDEC, 2007)

v) Historic Occurrences

Historic Occurrences of Drought in New York City			
Date	**Event**	**Location**	**Description**
1963–1965	Drought Emergency	Citywide	• Intense water conservation campaign Nov. 1963 until May 1964 • Aug. 18, 1965, federal government declared a water shortage disaster for New York City • New York State's only federal disaster declaration for a drought • No damages recorded for this event

Historic Occurrences of Drought in New York City			
Date	**Event**	**Location**	**Description**
1980–1982	Drought Emergency	Citywide	• Drought watch was issued in Oct. • Drought warning issued in Nov. • Drought emergency put into effect when water storage levels reached 33% on Jan. 1, 1981 • Downgraded to warning Jan. 18, 1982 and to watch on Nov. 11, 1982 • No damages recorded for this event
1985–1986	Drought Emergency	Citywide	• Drought watch issued Feb. 25, 1985 when water storage levels reached 50% • In span of two months, drought conditions upgraded from drought watch, to drought warning, to drought emergency • Downgraded to warning Nov. 1985 • Conditions restored to normal on Feb. 25, 1986 • No damages recorded for this event • New York State Drought Management Plan revised based on lessons learned from this and the previous 1980 drought occurrences
1989	Drought Emergency	Citywide	• Drought watch issued Jan. 17, 1989 when water-storage facilities were at 58% • Drought conditions were upgraded to drought emergency (Stage II) on Mar. 22, 1989 • Drought conditions downgraded to normal on May 15, 1989 • No damages recorded for this event
1991	Drought Warning	Citywide	• Drought watch issued Sept. 25, 1991 when water-storage facilities were at 53% • DEP subsequently issued drought warning • No damages recorded for this event

Historic Occurrences of Drought in New York City			
Date	**Event**	**Location**	**Description**
1995	Drought Warning	Citywide	• Drought watch issued July 5, 1995 when water-storage capacities fell to 84% • DEP issued drought warning on Sept. 13, 1995 • Conditions restored to normal Nov. 14, 1995 • No damages reported for this event
2001–2003	Drought Emergency	Citywide	• Drought watch issued Dec. 23, 2001 with water-storage capacity levels at 44% • One month later DEP issued drought warning • Drought emergency issued Apr. 1, 2002 • Over the next eight months, increased precipitation and reduced water consumption alleviated drought conditions • Conditions restored to normal Jan. 2, 2003 • No damages reported for this event

Table 20: Historic Occurrences of Drought in New York City

b) Vulnerability Assessment

i) Impact to New York City

Each drought produces a unique set of impacts, depending not only on its severity, duration, and spatial extent but also on ever-changing social conditions. A wide-range of factors, both physical and social, determine society's vulnerability to drought.

Understanding both direct and indirect impacts is one of the most significant challenges in preparing for drought. The direct impacts include loss of revenue from businesses reliant on water, such as car washes, landscapers, and manufacturers. In a drought, water use restrictions may force businesses to suspend all or a portion of their activities. The indirect impacts associated with drought may be far-reaching. The more removed the impact from the cause, the more complex the link to the cause. Indirect impacts are diffuse, making it very difficult to determine financial estimates of damages.

The following is a list of impacts associated with drought. Each one can directly or indirectly impact New York City's economy, environment, and people.

Drought Impacts		
Economy	**Environment**	**People**
• Damage to crops • Increase in food prices • Increased transportation costs for food • Reduced dairy and livestock production • Increased fire hazard • Loss to recreational and tourism industry • Revenue loss to water-reliant businesses • Loss of hydro-electric power • Loss of navigability of rivers and canals • Reduction of economic development	• Reduction and degradation of fish and wildlife habitat • Wind and water erosion of soils • Loss of wetlands • Increased number and severity of fires • Air quality effects • Damage to plant species, loss of biodiversity • Lower water levels in reservoirs, lakes, and ponds • Water quality effects (e.g., salt concentration, increased water temperature, pH, dissolved oxygen, turbidity)	• Food shortages • Public dissatisfaction with government • Loss of aesthetic values • Reduction or modification of recreational activities • Health issues related to use restrictions • Increased fire hazard • Mental and physical stress • Decrease in quality of life • Increased poverty • Population migrations

Figure 50: Drought Impacts

ii) Structural Vulnerability

In general, drought does not cause structural damage and does not affect infrastructure such as highways, bridges, and electric conveyance systems. A rare exception is severe soil shrinkage. When it occurs, severe soil shrinkage compromises the foundation upon which the infrastructure stands. Soil shrinkage requires expansive soil, types of soil that shrink or swell as the moisture content decreases or increases, to cause any real damage. According to the U.S. Geological Survey (USGS), New York City soils do not have high swelling potential, therefore, there is a very low risk of structural damage associated with drought.

iii) Potential Loss Estimate

Although potential direct and indirect impacts are detailed above, accurate loss estimates for drought are not available. Reduced water levels and subsequent curtailment of water usage will have a direct economic impact on businesses and industries that are water-dependent. The indirect impacts associated with drought are far-reaching but so diffuse that financial estimates of potential damages are not feasible.