Section 3.6: DROUGHT

2014 SHMP Update
• Reformatted Drought Profile into the new outline • Added additional drought types • Added four drought stages • Added New York State (NYS) regional drought indicator weighting system • Enhanced the location section • Inserted updated map of NYS drought events from 1960-2012 • Inserted updated table for estimated losses by jurisdiction • New map displaying jurisdiction property loss • Updated local plan integration section

3.6.1 Drought Profile

Hazard	Definition and Key Terms
Drought	*Drought* - A prolonged period with no rain, particularly during the planting and growing season in agricultural areas. Limited winter precipitation accompanied by moderately long periods during the Spring and Summer months can also lead to drought conditions.

Characteristics

Drought is a normal, recurrent feature of climate, although at times considered a random event. It occurs in virtually all climatic zones, but its characteristics vary significantly from one region to another. Drought is a temporary aberration; it differs from aridity, which is restricted to low rainfall regions and is a permanent feature of climate.

Drought is an insidious hazard of nature[1]. Although it has scores of definitions, it originates from a deficiency of precipitation over an extended period of time, usually a season or more. Drought can have a widespread impact on the environment and the economy, depending upon its severity, although it typically does not result in loss of life or damage to property, as do other natural disasters. Drought should be considered relative to some long-term average conditions of balance between precipitation and evapotranspiration (i.e., evaporation + transpiration) in a particular area, a condition often perceived as "normal." It is also related to the timing (i.e., principal season of occurrence, delays in the start of the rainy season, occurrence of rains in relation to principal crop growth stages) and the effectiveness (i.e., rainfall intensity, number of rainfall events, antecedent moisture conditions, etc.) of the rains. Other climatic factors such as high temperature, high wind, and low relative humidity are often associated with drought in many regions of the world and can significantly affect its severity.

[1]National Drought Mitigation Center. http://drought.unl.edu/DroughtBasics/WhatisDrought.aspx

Drought should not be viewed as merely a physical phenomenon or natural event. Its impacts on society result from the interplay between a natural event (less precipitation than expected resulting from natural climatic variability) and the demand people place on water supply. Human activity often exacerbates the impact of drought. Recent droughts in both developing and developed countries, resulting economic and environmental impacts and personal hardships have highlighted the vulnerability of all societies to this natural hazard. According to the National Weather Service - Climate Prediction Center there are four identified drought types: Meteorological/ Climatological, Hydrological, Agricultural, and Socioeconomic.

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

  Links to Climate Change**:** While this type of drought normally results from natural climatic cycles and conditions, there is increasing scientific evidence that the effects of climate change may impact the normal temperature cycles, potentially resulting in rising summer temperatures. These, along with little change in summer rainfall, are projected to increase the frequency of short-term (one to three month) droughts. This scenario will lead to impacts to the natural and managed ecosystems across the state, including agriculture, water supply, and hydrology. Additional information related to the characteristics, vulnerabilities and losses related to climate change is described in **Section 3.4, Climate Change**

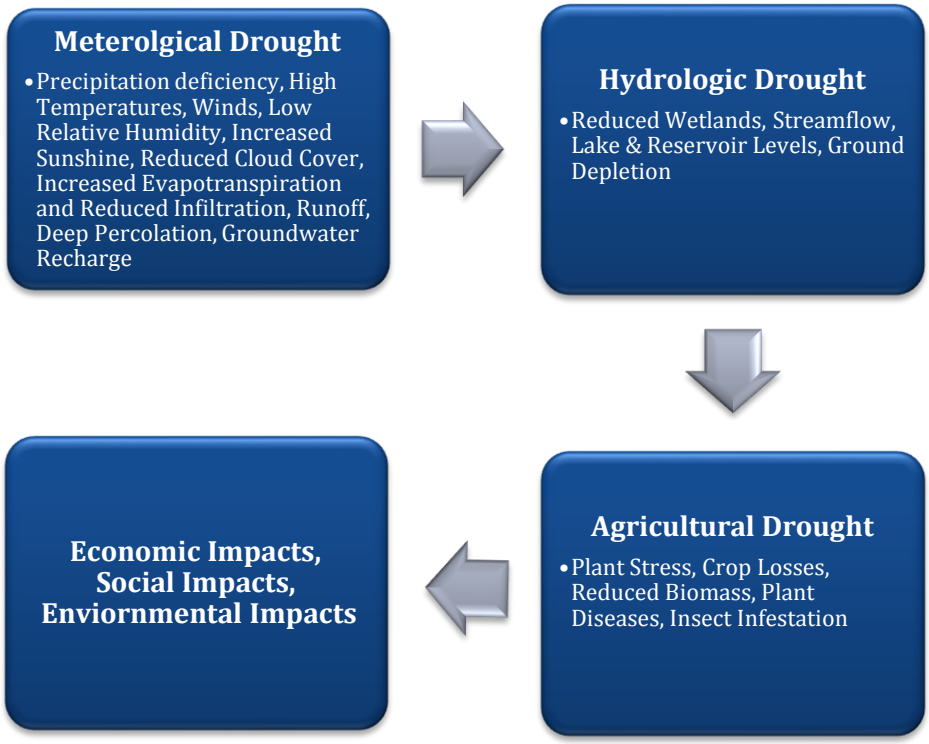
- ***Hydrological Drought*** is associated with the effects of substandard periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (i.e., stream flow, reservoir and lake levels, groundwater). The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency plays out through the hydrologic system. Hydrological droughts are usually out of phase with, or lag the occurrence of, meteorological and agricultural droughts. It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, stream flow, and ground water and reservoir levels.

- ***Agricultural Drought*** links various characteristics of meteorological (or hydrological) drought to agricultural impacts, focusing on precipitation shortages, differences between actual and potential evapotranspiration, soil water deficits, and reduced ground water or reservoir levels. Crop water demand depends on prevailing weather conditions, biological characteristics of the specific crops, its stage of growth, and the physical and biological properties of the soil.

- ***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.

Although climate is a primary contributor to hydrological drought, other factors such as changes in land use (e.g., deforestation, increases in impervious area), land degradation, and the construction of dams all affect the hydrological characteristics of the basin. Because regions are interconnected by hydrologic systems, the impact of meteorological drought may extend well beyond the borders of the precipitation-deficient area. For example, meteorological drought may severely affect portions of the northern Adirondack region of the State; however, since the Hudson River and its tributaries drain this region to the south, there may be significant hydrologic impacts downstream. Similarly, changes in land use upstream may alter hydrologic characteristics such as infiltration and runoff rates, resulting in more variable streamflow and a higher incidence of hydrologic drought downstream. Land use change is one of the ways human actions alter the frequency of water shortage even when no change in the frequency of meteorological drought has been observed. **Figure 3.6a** shows the interrelationship of the hydrological cycle.

Figure 3.6a: Interrelationship of the Hydrological Cycle



Agriculture effects from drought vary depending on the time of year, period of precipitation, amount of stored soil moisture, type of crop, stage of growth, and meteorological measures (i.e. temperature, humidity, and wind). Precipitation scarcities as little as four to six inches can be the foundation of an agriculture drought situation.

The Department of Environmental Conservation (DEC) and the New York State Drought Management Task Force identifies droughts in the following four stages:

1. ***Normal*** is considered the standard moisture soil levels found throughout the State.

2. ***Drought Watch*** is the first stage. This stage is declared by DEC and is intended to give advanced notice of a developing drought. At this stage, the general public is urged to conserve water. Public water purveyors and industries are urged to update and begin to implement individual drought contingency plans.

3. ***Drought Warning*** is the second stage. This stage also is declared by DEC and is a notice of impending and imminent severe drought conditions. A warning declaration includes stepping up public awareness and increasing voluntary conservation. Public water supply purveyors and industries are urged to continue to implement local drought contingency plans. Federal, state, and local water resources agencies are notified to prepare for emergency response measures.

4. ***Drought Emergency*** is the third stage. This stage is declared by the New York State Disaster Preparedness Commission (DPC), based upon recommendation of the Task Force. It is a notice of existing severe and persistent drought conditions. An emergency declaration is a notice for local water resources agencies to mandate conservation and implement other emergency response measures. A continuing and worsening drought emergency may result in the Governor declaring a drought disaster. It is a notice of the most severe and persistent drought conditions. At this stage a significant proportion of communities in the impacted area likely are unable to respond adequately.

The State of New York uses two methodologies to determine the various drought stages. According to the "NYS Comprehensive Emergency Management Plan", the commonly used indicator is the Palmer Drought Index (PDI) that is primarily based on soil conditions[2]. These are typically the first indicators that a moisture deficit is present. These values range from -5 to +5, with positive values indicating wetter conditions and negative values representing drier conditions.

The second methodology used was created by DEC and is referred to as the State Drought Index (SDI), which evaluates drought conditions on a more comprehensive basis by measuring whether numerous indicators reach dire thresholds. The data collected is compared against critical threshold values to show a normal or changeable drought condition. The indicators are weighted on a regional basis to reflect the unique circumstances of each drought management region.

(The New York State Disaster Preparedness Commision, 2012) [2]

Table 3.6a: Illustrates the State Drought Index (SDI) range of values for each drought by stages.

Drought Stage	Drought Index Range
Normal Watch	100 – 150 75 – 100
Warning Emergency	50– 70 0– 50

*Source: NYS DPC, Drought Management Coordination Annex, May 2012 (Note: *The value of the State Drought Index equals the sum of the weighted indicator values.)*

The data gathered below in **Table 3.6b**, demonstrates the New York State regional weighting system for each drought indicator, **Figure 3.6f** on page 17 is a map that identifies drought management regions as established by DEC.

Table 3.6b: Drought Indicator Regional Weighting Values

Regions	Stage	Indicator Values			
		Precipitation	Reservoir/ Lake Storage	Stream Flow	Groundwater Levels
I	Normal	20 - 30	10 - 15	10- 15	60 - 90
	Watch	15 - 20	7.5 - 10	7.5 - 10	45 - 60
	Warning	10 - 15	5 - 7.5	5 - 7.5	30 - 45
	Emergency	0 - 10	0 -5	0 - 5	0 - 30
II and IV	Normal	30 - 45	20 - 30	20 - 30	30 - 45
	Watch	22.5 - 30	15 - 20	15 - 20	22.5 - 30
	Warning	15 - 22.5	10 - 15	10- 15	15 - 22.5
	Emergency	0 - 15	0 - 10	0 - 10	0 - 15
IIA	Determined by the New York City Department of Environmental Protection using their reservoir refill probability curves				
III and VIII	Normal	30 - 45	10 – 15	20 – 30	40 - 60
	Watch	22.5 - 30	7.5 – 10	15 – 20	30 - 40
	Warning	15 - 22.5	5 - 7.5	10 – 15	20 - 30
	Emergency	0 - 15	0 – 5	0 – 10	0 - 20
V, VI and VII	Normal	30 - 45	40 – 60	20 – 30	10-15
	Watch	22.5 - 30	30 – 40	15 – 20	7.5 - 10
	Warning	15 - 22.5	20 – 30	10 – 15	5 - 7.5
	Emergency	0 - 15	0 – 20	0 – 10	0 - 5

Location

New York State has an abundant supply of water found throughout the State with streams, lakes, and coastal areas that have an average annual precipitation ranging from 60 inches in the Catskills to 28 in the Lake Champlain Valley. The normal variations in the area's weather can lead to periods of dry weather even though the State has a moderately humid climate. The State of New York's last two severe droughts were in the mid-1960s and then again in the mid-1980s.

The State is divided into nine drought management regions based loosely on the drainage basins and county lines. The precipitation, lake and reservoir levels, stream flow, and groundwater level is monitored by DEC at least once a month and more frequently if droughts appear present. The data generated is used to assess and analyze each regions condition and then classified anywhere from *normal* to *drought emergency*.

In some cases, the different areas within the regions make their own determination of what drought stage they fall within based on their own criteria. An example of this is New York City's systems that are greatly dependent on upstate reservoirs for its water supply. The City drought conditions are based on probability assessments of reservoirs being full by June each year.

Previous Drought Occurrences

New York State local communities generally have access to an ample amount of water supply that's used for agriculture, recreation, industrial, medical, residential, and drinking needs. In the 1960s and then again in the 1980s the State was impacted by two major drought occurrences. During the 1960s, the State of New York had an extended period of droughts that affected the entire state. The worst stint lasted from 1964 to 1965 placing a severe impact on agriculture, water quality, and forest and human health. As a result, there were widespread impacts, including forest fires, crop failure, fish kills, water shortages, harmful algal blooms, and heat related deaths. [3]

The drought of the 60s ended in 1967 only for the State to experience another drought in 1980 that has had a continuing affect into the present. Although New York State has seen an increasing number of occurrences of prolonged dry spells, none have been severe enough to classify officially as droughts. In response to water deficiency spells, recurring drought awareness efforts have been implemented as the agricultural communities and home owners struggle to cope with drought conditions.

The table below (**Table 3.6c**) is an overview of drought occurrences in New York State dating from August 1993 to October 2007.

[3] New York State Comprehensive Emergency Management Plan: *Disaster Preparedness Commission (DPC)/ readiness, response, recovery. Drought Management Coordination Annex,* May 2012

Table 3.6c: Past Occurrences of Drought in New York State

Date	County/Area Effected	Types of Damages	Dollar Amount of Damages
August – December 1993	Albany, Columbia, Delaware, Dutchess, Greene, Otsego, Rensselaer, Schoharie, Sullivan, Ulster	The damage primarily affected the agriculture sector's feed grain. The estimated losses were over 40% and in some areas nearly 100% in feed losses. There were significant losses in hay, corn, and a few other fruit and vegetable crops.	$50,000,000
February – April 1994	Delaware, Dutchess, Greene, Otsego, Schoharie, Sullivan, Ulster	New York City experienced a reduction in the usable storage of the City's water supply.	Unknown
October 1994	Statewide	Albany County had a record breaking month in October 1994, tying for 7th driest county in that month.	Unknown
June – September 1995	Catskills, Hudson Valley, Mohawk Valley, Southern Tier	The lack of rainfall across much of eastern NYS prompted officials to enforce water restrictions in some areas and seek federal aid in other parts. - Rensselaer and Oneida Counties had significant damage to various vegetables and grain crops. - Vine crops were hard hit. Plants either died or experienced limited production. Other crops severely impacted include: corn, hay, peppers and onion. - Private drinking wells ran dry. Municipal water supplies in Montgomery County were dangerously low. Water tankers were brought into Herkimer and Montgomery Counties to assist farmers and residents with dry wells. - The salt front had migrated	Unknown

Date	County/Area Effected	Types of Damages	Dollar Amount of Damages
		north on the Hudson River, causing communities that drew drinking water from the Hudson to experience high levels of sodium in their drinking water. - The Susquehanna River was 1/3 of its normal level. - The Capital District annual crop harvest was down 35% - The Mohawk Valley crop yields were down 30-60%.	
August 1 – 31, 1997	Sullivan County	An extremely dry summer created major crop failure at the end of August 1997. Having an effect on sweet corn and tomatoes, two of the major money making crops for small farmers. - Sullivan County had some of the worst crop damage. - According to figures provided by individual farmers as well as the New York State Agricultural Extension Service, losses neared a quarter of a million dollars. In many cases, financial assistance was granted. - For the period from June 1st to the end of August, precipitation figures across the region averaged less than 30% of normal levels.	$200,000

Date	County/Area Effected	Types of Damages	Dollar Amount of Damages
September 1 – 30, 1999	Broome, Cayuga, Chemung, Chenango, Cortland, Delaware, Madison, Oneida, Oneida, Onondaga, Otsego, Schuyler, Seneca, Steuben, Sullivan, Tioga, Tompkins, Yates	A very dry spring and summer season caused major crop failures and some wells to run dry. Many streams and rivers were also brought to their lowest recorded levels. - Most affected crops were corn and hay, which was a major blow for dairy farmers - According to figures from the New York State Department of Agriculture and Markets, the worst drought damage was reported in Cayuga ($17.7 million), Steuben ($15.3 million) and Madison ($5.9 million) Counties	$ 50,000,000
November 2001 – January 2002	Orange, Putnam, Rockland, Westchester, New York City, Long Island	New York City's combined storage in water supply reservoir systems was at a low 41% capacity (normal levels for this time of year are 71%).	Unknown
April – October 2002	New York City, Long Island, Westchester, Orange, Putnam, Rockland,	Ground water and water storage facilities were below normal. New York City reservoir system reached a low of 64.5%, which was 34% below normal.	Unknown
September – October 2007	Hamilton and northern Herkimer Counties	Some portions of the Adirondack region accrued 90 day rainfall deficits of 8 to 12 inches from normal levels. The Palmer Drought Severity Index reached severe drought levels. Natural stream flow levels dropped into the lowest 10 percentile of recorded flows. Shallow wells and farm ponds reportedly ran dry in portions of Northern Herkimer County. In addition, reservoir levels had become low enough to stop recreational activities and some hydropower generation.	Unknown

Table 3.6d, Figure 3.6b, and **Figure 3.6c** found below displays historical and economic (property and crop damage) loss information for drought events dating from 1960 – 2012. The data derives primarily from the Spatial Hazard Events and Loss Database for the United States (SHELDUS). The State of New York has recorded 104 previous occurrences with no reported injuries or deaths directly related to this specific hazard. Although previous events have appeared, including one declaration, overall this hazard has caused the State minimal damage yet could potentially have a substantial influence to the agriculture industry.

Drought, a "low" ranked hazard, has estimated economic losses of less than $1.2 million with a significant amount in crop loss. This specific hazard can significantly impact New York State due to the fact that 60% of its topography is forested creating a relatively large economic asset for State residents. Approximately $2 billion in high-paying jobs are found in rural areas of the State employing 47,000 New Yorkers[4].

[4] *New York Wood Products Development Council Annual Report for 2010-2011*
http://www.agriculture.ny.gov/NY_Wood_Prod_Dev_Council_Annual_Report.pdf

Table 3.6d: Drought Events and Losses by County

Historical Record (1960-2012)							
County	**Future Probability %**	**Recurrence Interval**	**Number of Events**	**Fatalities**	**Injuries**	**Property Damage**	**Crop Damage**
Albany	6	17	3	0	0	$16,667	$2,685,185
Allegany	0	0	0	0	0	$0	$0
Bronx	0	0	0	0	0	$0	$0
Broome	6	17	3	0	0	$38,406	$4,825,234
Cattaraugus	0	0	0	0	0	$0	$0
Cayuga	4	26	2	0	0	$21,739	$3,158,568
Chautauqua	0	0	0	0	0	$0	$0
Chemung	4	26	2	0	0	$21,739	$3,158,568
Chenango	4	26	2	0	0	$16,667	$4,607,843
Clinton	2	52	1	0	0	$16,667	$1,666,667
Columbia	6	17	3	0	0	$16,667	$2,685,185
Cortland	6	17	3	0	0	$38,406	$4,825,234
Delaware	8	13	4	0	0	$38,406	$5,010,420
Dutchess	6	17	3	0	0	$16,667	$2,685,185
Erie	0	0	0	0	0	$0	$0
Essex	2	52	1	0	0	$16,667	$1,666,667
Franklin	2	52	1	0	0	$16,667	$1,666,667
Fulton	6	17	3	0	0	$38,406	$2,069,243
Genesee	0	0	0	0	0	$0	$0
Greene	6	17	3	0	0	$16,667	$2,685,185
Hamilton	6	17	3	0	0	$38,406	$2,069,243
Herkimer	6	17	3	0	0	$38,406	$2,069,243
Jefferson	4	26	2	0	0	$21,739	$402,576
Kings	0	0	0	0	0	$0	$0
Lewis	4	26	2	0	0	$21,739	$402,576

Historical Record (1960-2012)							
County	Future Probability %	Recurrence Interval	Number of Events	Fatalities	Injuries	Property Damage	Crop Damage
Livingston	0	0	0	0	0	$0	$0
Madison	6	17	3	0	0	$38,406	$4,825,234
Monroe	0	0	0	0	0	$0	$0
Montgomery	6	17	3	0	0	$38,406	$2,069,243
Nassau	0	0	0	0	0	$0	$0
New York	0	0	0	0	0	$0	$0
Niagara	0	0	0	0	0	$0	$0
Oneida	8	13	4	0	0	$38,406	$5,010,420
Onondaga	4	26	2	0	0	$21,739	$3,158,568
Ontario	0	0	0	0	0	$0	$0
Orange	4	26	2	0	0	$16,667	$1,851,852
Orleans	0	0	0	0	0	$0	$0
Oswego	4	26	2	0	0	$21,739	$402,576
Otsego	8	13	4	0	0	$38,406	$5,010,420
Putnam	4	26	2	0	0	$16,667	$1,851,852
Queens	0	0	0	0	0	$0	$0
Rensselaer	6	17	3	0	0	$16,667	$2,685,185
Richmond	0	0	0	0	0	$0	$0
Rockland	2	52	1	0	0	$0	$185,185
Saratoga	4	26	2	0	0	$16,667	$1,851,852
Schenectady	4	26	2	0	0	$16,667	$1,851,852
Schoharie	6	17	3	0	0	$38,406	$2,069,243
Schuyler	4	26	2	0	0	$21,739	$3,158,568
Seneca	4	26	2	0	0	$21,739	$3,158,568
St Lawrence	6	17	3	0	0	$38,406	$2,069,243
Steuben	2	52	1	0	0	$0	$2,941,176
Suffolk	0	0	0	0	0	$0	$0

Historical Record (1960-2012)							
County	**Future Probability %**	**Recurrence Interval**	**Number of Events**	**Fatalities**	**Injuries**	**Property Damage**	**Crop Damage**
Sullivan	8	13	4	0	0	$16,667	$4,993,028
Tioga	6	17	3	0	0	$38,406	$4,825,234
Tompkins	4	26	2	0	0	$21,739	$3,158,568
Ulster	6	17	3	0	0	$16,667	$2,685,185
Warren	4	26	2	0	0	$16,667	$1,851,852
Washington	4	26	2	0	0	$16,667	$1,851,852
Wayne	2	52	1	0	0	$21,739	$217,391
Westchester	2	52	1	0	0	$0	$185,185
Wyoming	0	0	0	0	0	$0	$0
Yates			1	0	0	$0	$2,941,176

Source: Spatial Hazard Events & Losses Database for the U.S. (SHELDUS) (*Future Probability equals the number of events divided by the number of years of record [52], expressed as a percentage.)

Figure 3.6b and **Figure 3.6c** illustrate the number of events accounted for in each county found within the State, as well as the total loss in crop damage from 1960-2012. The total crop loss for the State is more than $1.15 million primarily affecting the crops in Delaware, Oneida, and Otsego Counties.

Figure 3.6b: New York State Drought Events

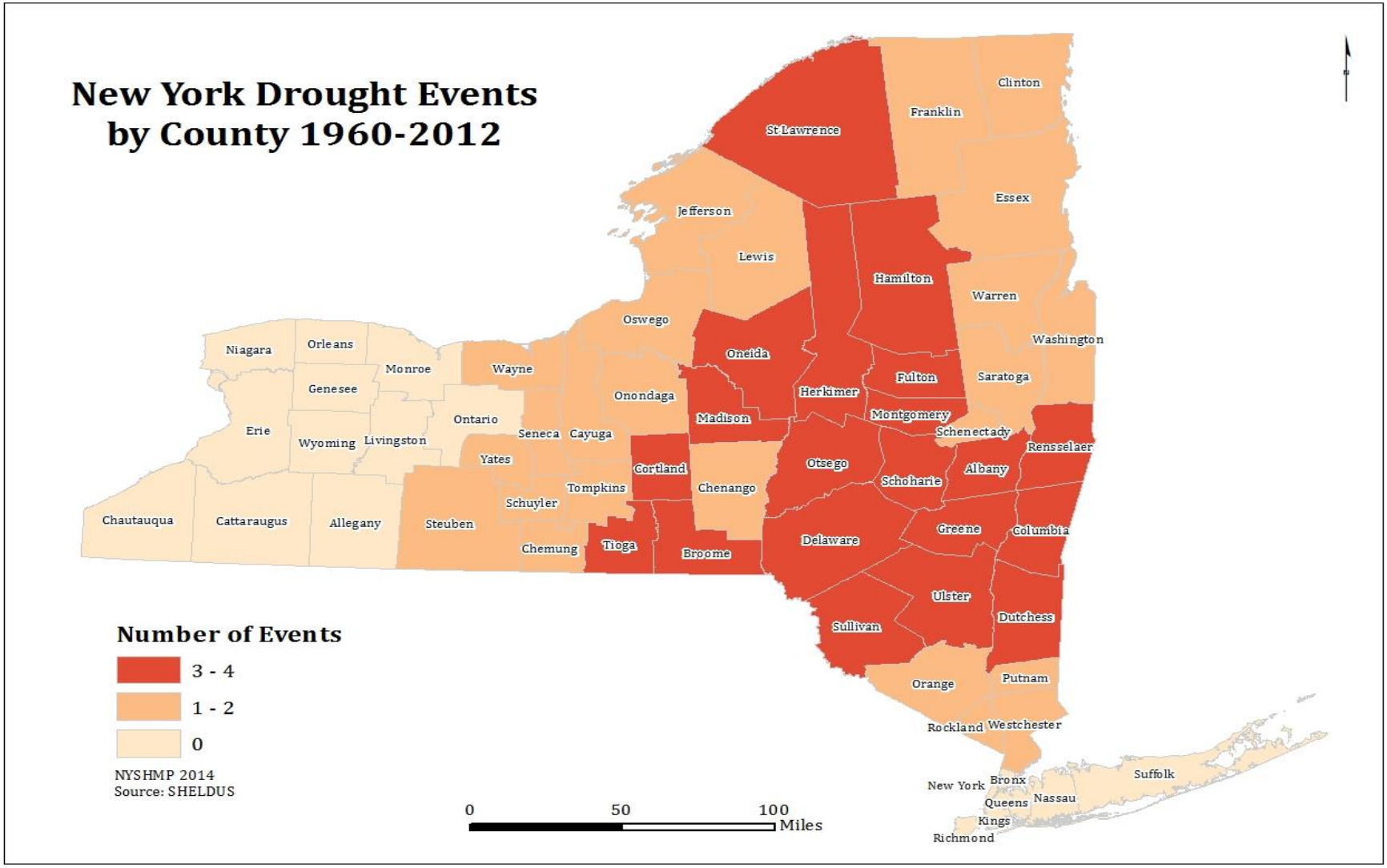


Figure 3.6c: New York State Drought Crop Damage

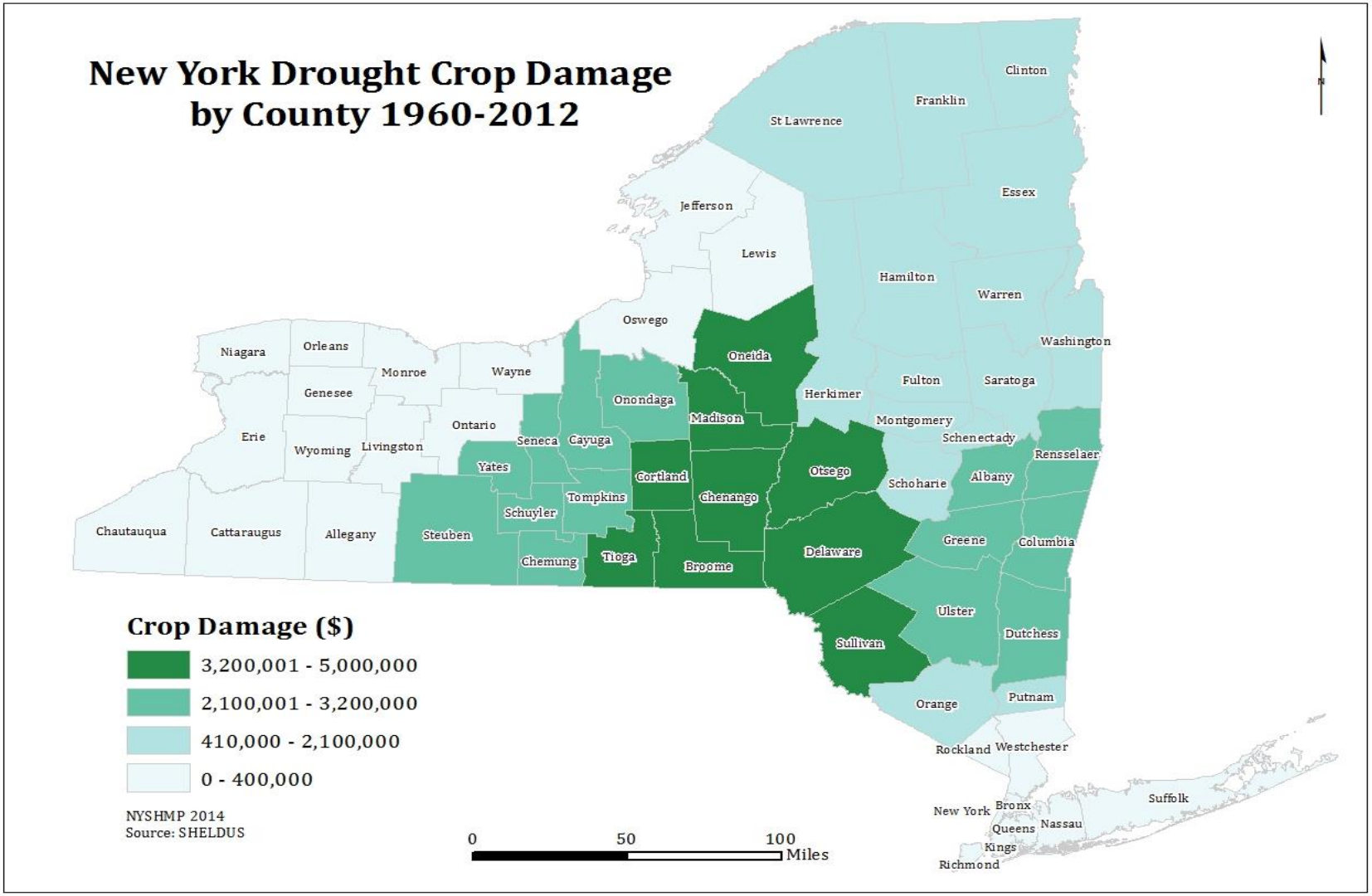
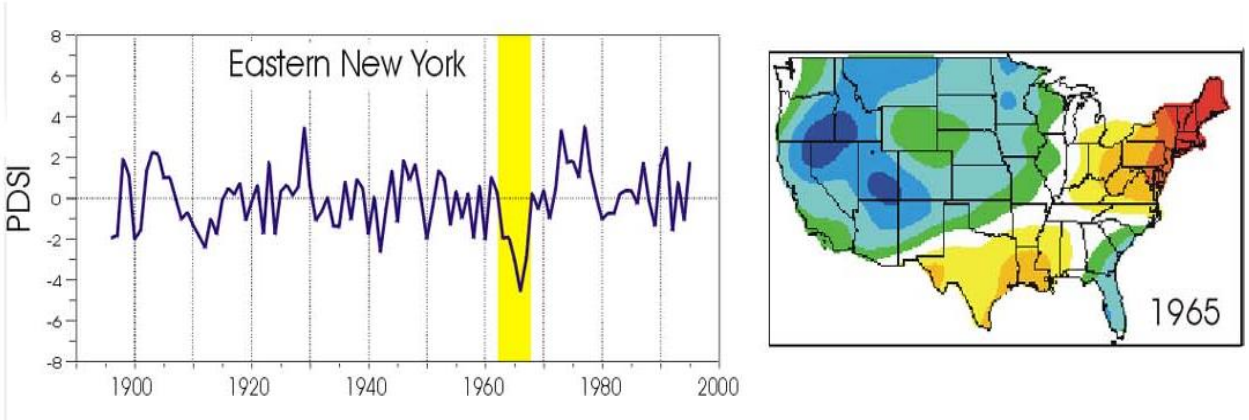


Figure 3.6d shows the Palmer Drought Index (PDI) values for Eastern New York along with the drought coverage in North America for the year of 1965. The map to the right shows that while the east coast of North America was experiencing droughts the west coast had wetter conditions. The 1965 drought was one of the worst on record for eastern New York.

Figure 3.6d: New York PDI's from 1900-2000 and U.S. Drought Coverage in 1965[5]



Data found in the table and figure below was derived from a FEMA data source that examines Presidential Declarations from 1954 to 2013. **Table 3.6d** and **Figure 3.6e** illustrates the affected counties from drought events. Although the data dates back to 1954, New York State's only Presidential Declaration was August 1965.

Table 3.6d: Major Drought Presidential Declared Disasters

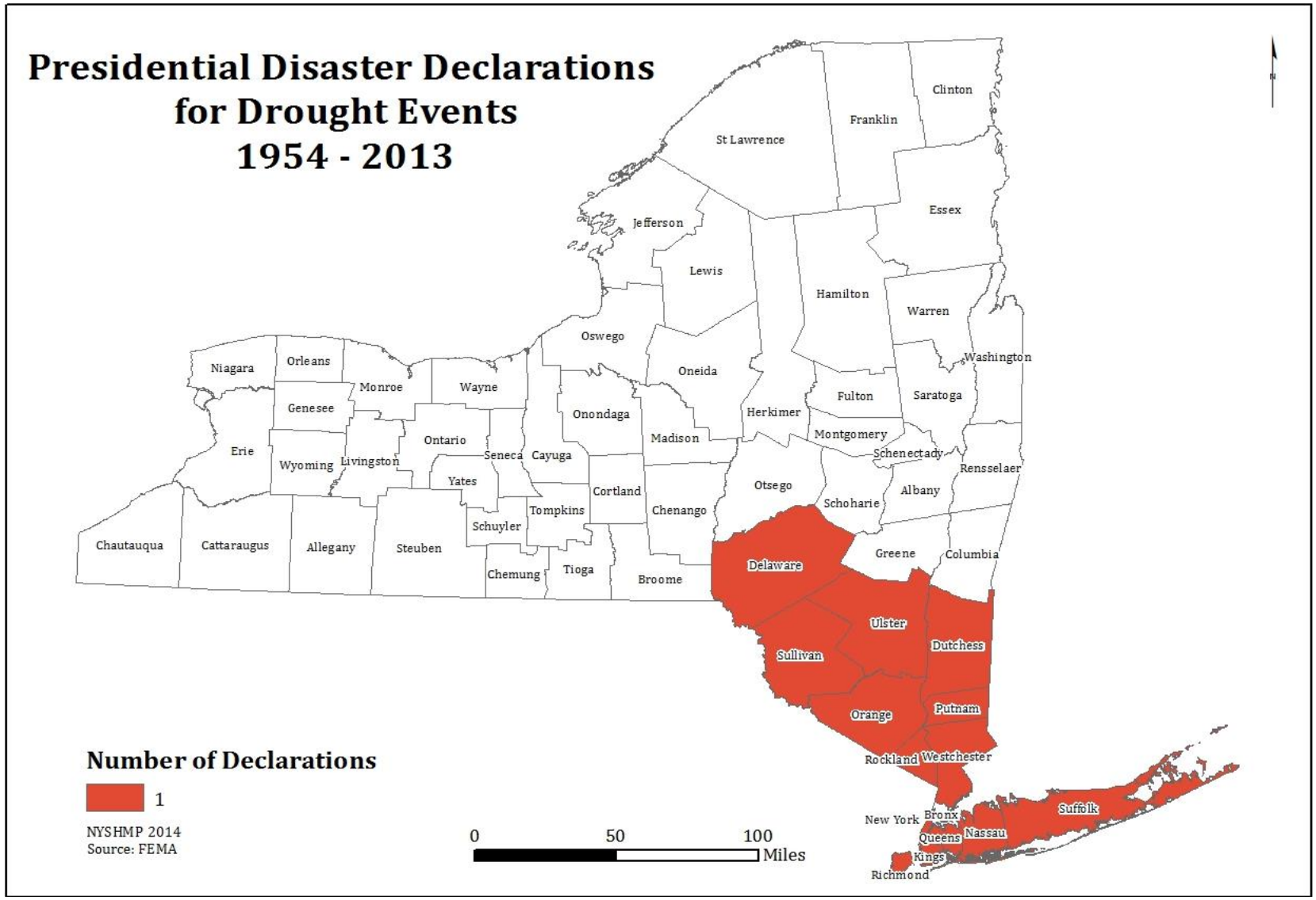
Disaster Number	Date Declared	Affected Counties
DR- 204	08/18/1965	Delaware County, Dutchess County, Kings County, Nassau County, New York County, Orange County, Putnam County, Queens County, Richmond County, Rockland County, Suffolk County, Sullivan County, Ulster County and Westchester County.

Source: FEMA, 2013

Figure 3.6e displays the Presidential Declared Disaster totals by county for drought events for the period of 1954 through July 2013. Counties with the greatest number of drought declarations are concentrated around the southeastern counties of New York.

[5] http://www.ncdc.noaa.gov/paleo/drought/drght_temporal.html

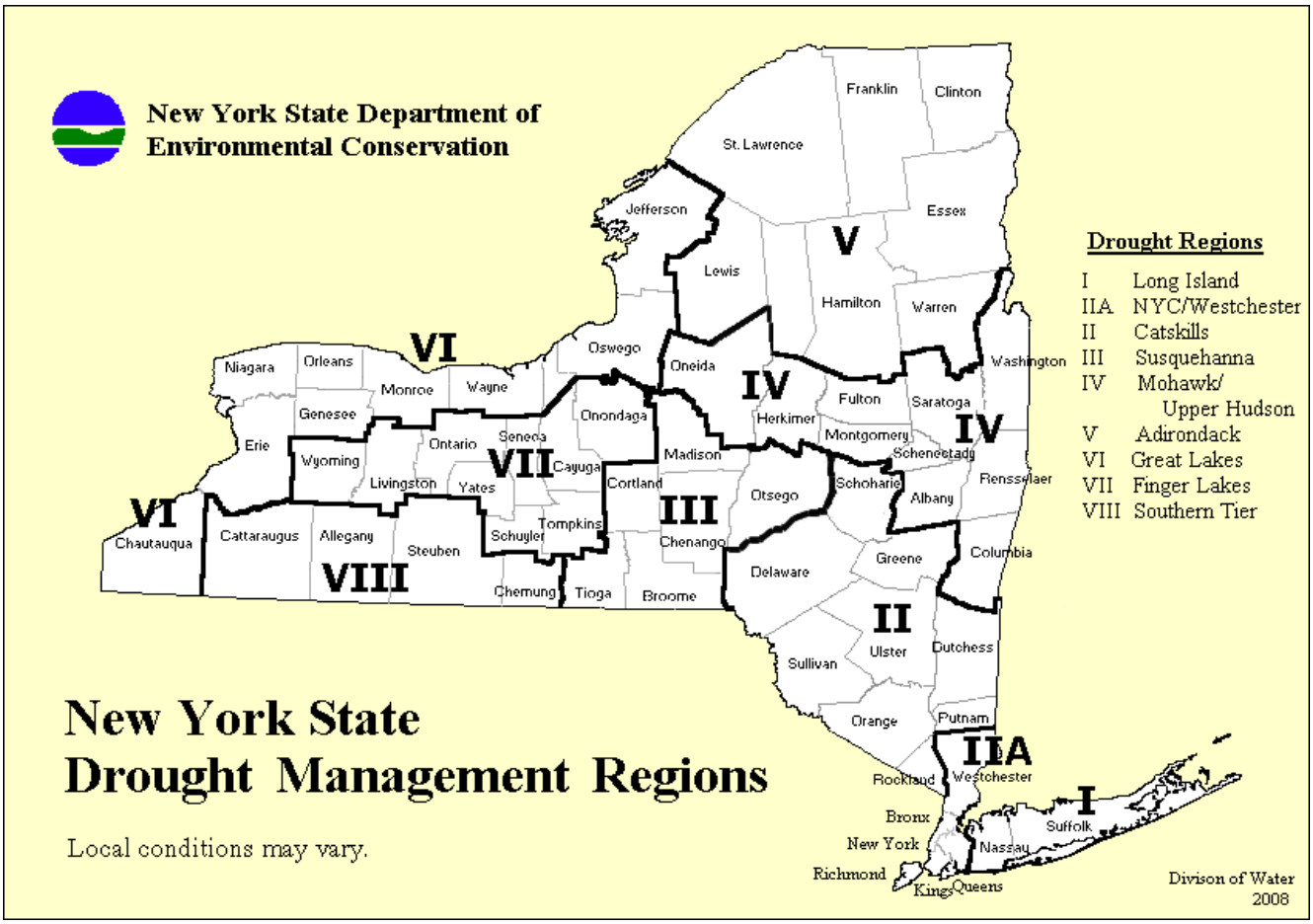
Figure 3.6e: Drought Presidential Disaster Declaration 1954-2013



Generally, New York State receives ample annual precipitation to recharge the State's reservoirs, lakes, rivers, and groundwater aquifers. But from 1979-81, particularly the winter and spring of 1981, precipitation levels declined and drought-related impacts and problems started to become evident. Of particular concern were water shortages in the southern part of the State, including the New York City metropolitan area, where nearly two-thirds (2/3) of the State's population resides. As a result, the State's Drought Task Force was formed.

Figure 3.6f identifies drought management regions as established by NYS DEC.

Figure 3.6f: New York State Drought Management Regions



Source: New York State (NYS) Drought Management Plan (EDMP)

Table 3.6e provides is a list of the counties located within each of the eight drought management regions.

Table 3.6e: Counties within Drought Management Regions

Region	Counties
I Long Island	Nassau, Suffolk
IIA NYC	New York City and Westchester. Additional upstate communities that draw water from the New York City water supply system are also subject to its Drought Management Plan and Rules. (See Appendices D and E)
II Catskills	Delaware, Dutchess, Greene, Orange, Putnam, Rockland, Schoharie, Sullivan, Ulster
III Susquehanna	Broome, Chenango, Cortland, Madison, Otsego, Tioga
IV Mohawk/ Upper Hudson	Albany, Columbia, Fulton, Herkimer (south), Montgomery, Oneida, Rensselaer, Saratoga, Schenectady, Washington
V Adirondacks	Clinton, Essex, Franklin, Hamilton, Herkimer (north), Lewis, St. Lawrence, Warren
VI Great Lakes	Chautauqua, Erie, Genesee, Jefferson, Monroe, Niagara, Cayuga (north), Orleans, Oswego, Wayne
VII Finger Lakes	Livingston, Onondaga, Ontario, Schuyler, Seneca, Cayuga (south), Tompkins, Wyoming, Yates
VIII Southern Tier	Allegany, Cattaraugus, Chemung, Steuben

Source: New York State (NYS) Drought Management Plan (EDMP)

The New York State Drought Plan was written in 1982 and last updated in May 2012. Public water supplies are the main focus of the plan, which is primarily based on lessons learned from the 1980–81 and 1984–85 droughts. The Drought Management Task Force (DMTF) operates the plan, and the lead agency on the DMTF is the Department of Environmental Conservation.

The plan is divided into two parts: a state drought preparedness plan focusing on monitoring and evaluating conditions and options to minimize drought impacts, and a drought response plan that defines specific actions to be taken during various stages of drought. This arrangement is unique among state drought plans. The New York State Drought Management Plan also recommends programs and projects that should be

completed to better prepare the State for drought, based on two time scales: short-term (up to 3 years), and long-term (3–10 years).

New York State recently enacted new legislation to regulate the use of water resources of the State by implementing a water withdrawal permitting, registration and reporting program. The DEC has the authority to regulate water usage under the Environmental Conservation Law, §§ 3-0301(2)(m), article 15 titles 15, 16 and 33, title 10 of article 21). Part 601 provides for Water Withdrawal Permitting, Reporting and Registration (Exclusive of Long Island Wells regulated under Part 602). The law became effective on February 15, 2012 and final implementing regulations became effective on April 1, 2013. The law regulates the use of the water resources of the state by implementing a water withdrawal permitting, registration and reporting program for water withdrawals equaling or exceeding a threshold volume. The regulations include protections for present and future needs for sources of potable water supply. In certain conditions, permits may be modified to prevent over- allocation or use of a water source to protect the environment and health, safety and welfare of the public, such as during a drought.[6]

After identifying communities that are most susceptible in the event of drought activities, New York State's Department of Environmental Conservation (DEC) recognizes that many small and mid-sized communities will need alternate water supply systems available for dozens of communities depending on the scope/ severity of the occurrence. New York State believes that the approach of partnering public/ private entities will make the State better prepared for water shortages and adequately protect public health. As stated in the May 2012 *New York State Comprehensive Emergency Management Plan-Drought Management Coordination Annex*, "This partnership should include identification of water suppliers, haulers, well drillers, water testers, and other similar private experts and providers who could be called upon to serve the communities during a disaster."

Probability of Future Drought Events

Sporadic occurrences of drought are not uncommon within the United States. The State of New York streams, lakes, and coastal regions are supplied by an annual average precipitation ranging from 28 to 60 inches per year. Although the State manages mild moist climates, typical variations in weather patterns can lead to dry periods. According to the Department of Environmental Conservation, the last severe drought for the State was in the mid-1960's and then again in the early and mid-1980's. Based on historical occurrences, New York State's overall annual future probability is three percent. From data gathered by the SHELDUS database Delaware, Oneida, and Otsego Counties are most probable to experience a drought event.

While it is unknown how climate change impacts regional water supply, however it has been identified that water resources are stressed and any added stress from climate change only increases the competition for water resources. Warmer climates increase potential drought frequency, severity, and create longer-lasting events. As mentioned in **Section**

[6] http://www.dec.ny.gov/enb/20121121_not0.html

3.4-Climate Change, it is projected for at least one short-term drought occurrence to happen every summer if greenhouse emission levels continue to increase specifically in the Catskill and Adirondack Mountains.

For the sake of the 2014 Update, the planning team reviewed Delaware County's LHMP, one of three counties most probable for drought occurrences. Delaware County LHMP identified a single significant event in September 1999 that was recorded in the NOAA NCDC Storm Event database. Records indicate impacts of major crop failure and drying wells, in addition to several streams and rivers being at their lowest recorded levels. Due to the damage to the crops within the county, specifically corn and hay, many dairy farmers experienced problems. Delaware County's probability of future drought hazard events, with respect to the HAZNY report, describes the frequency as an "infrequent event", occurring once every eight years to fifty years[7].

Justification for Minimal Vulnerability/ Loss Assessment

Drought occurrences can potentially affect any area in the State; however the hazard received an overall "low" ranking following the HAZNY-Mitigation methodology. It was acknowledged that there are potential cost-effective and technically feasible initiatives and programs that address drought mitigation. Specifically New York State's Drought Management Task Force which was established in 1980 and then reconstituted in 2002 under the Disaster Preparedness Commission. The Department of Environmental Conservation has been involved in the monitoring and evaluation of drought occurrences for many years, and has been directed by the Task Force to prepare a Drought Forecasting Plan [8].

Consequently, it is determined that there is not sufficient evidence based on probability to justify further analysis for the 2014 plan update, but it is recommended that local jurisdictions consider addressing drought preparedness measures in future plan updates.

3.6.2 Assessing Drought Vulnerability by Jurisdiction

The sequence of impacts associated with meteorological, agricultural, and hydrological drought further emphasizes their differences. When drought begins, the agricultural sector is usually the first to be affected because of its heavy dependence on stored soil water. Soil water can be rapidly depleted during extended dry periods. If precipitation deficiencies continue, then people dependent on other sources of water will begin to feel the effects of the shortage. Those who rely on surface water (i.e., reservoirs and lakes) and subsurface water (i.e., ground water), for example, are usually the last to be affected. A short-term drought that persists for 3 to 6 months may have little impact on these sectors, depending on the characteristics of the hydrologic system and water use intensity.

[7] Delaware County LHMP www.dcdes.org.
[8] http://www.dec.ny.gov/enb/20121121_not0.html

When precipitation returns to normal and meteorological drought conditions have abated, the sequence is repeated for the recovery of surface and subsurface water supplies. Soil water reserves are replenished first, followed by stream flow, reservoirs and lakes, and ground water. Drought impacts may diminish rapidly in the agricultural sector because of its reliance on soil water, but linger for months or even years in other sectors dependent on stored surface or subsurface supplies. Ground water users, are often the last to be affected by drought during its onset, may be last to experience a return to normal water levels. The length of the recovery period is a function of the intensity of the drought, its duration, and the quantity of precipitation received as the drought event terminates.

Many economic impacts occur in agriculture and related sectors, including forestry, fisheries, and waterborne activities, because of the reliance of these sectors on surface and subsurface water supplies. In addition to obvious losses in yields in crop and livestock production, drought is associated with increases in insect infestations, plant disease, and wind erosion. Droughts also bring increased problems with insects and diseases to forests and reduce growth. The incidence of forest and grass fires increases substantially during extended droughts, which in turn places human and wildlife populations, as well as property, at higher levels of risk.

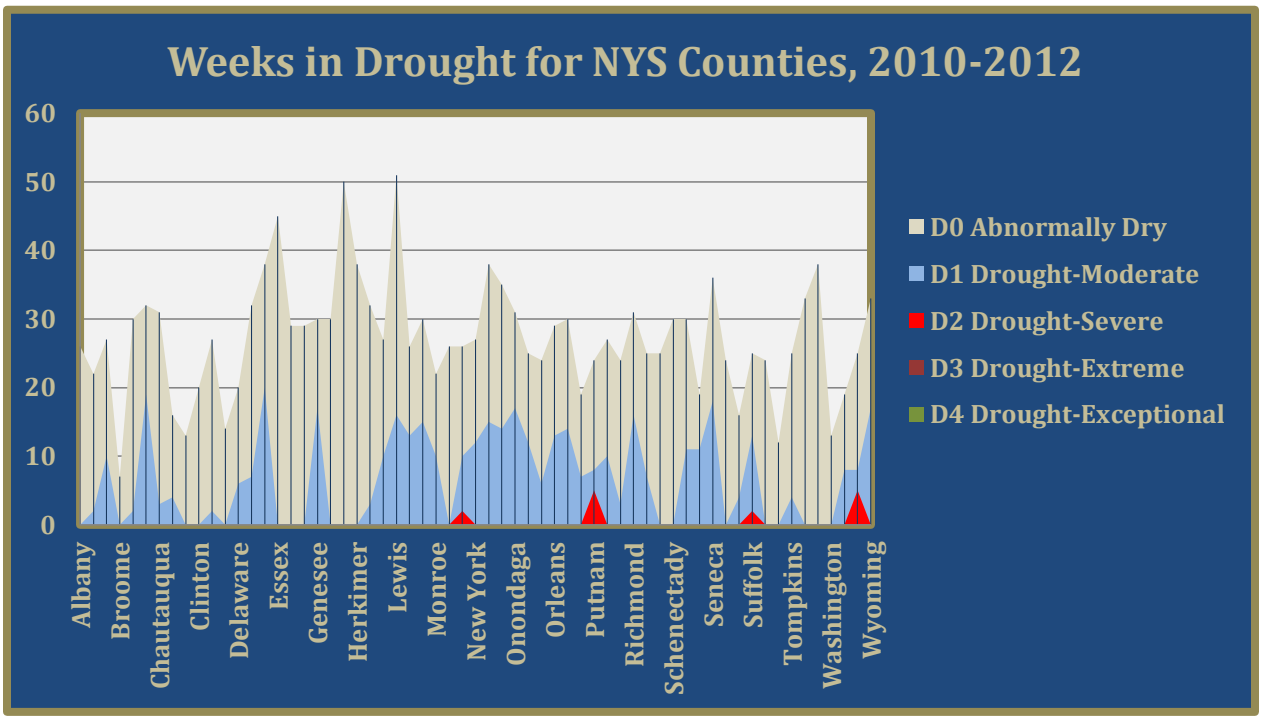
Income loss is another indicator used in assessing the impacts of drought because so many sectors are affected. Reduced income for farmers has a rippling effect. Retailers and others who provide goods and services to farmers face reduced business. This leads to unemployment, increased credit risk for financial institutions, capital shortfalls, and loss of tax revenue for Local, State, and Federal government. Less discretionary income affects the recreation and tourism industries. Prices for food, energy, and other products increase as supplies are reduced. In some cases, local shortages of certain goods result in the need to import these goods from outside the affected region. Reduced water supply impairs the navigability of rivers and results in increased transportation costs because products must be transported by rail, or truck. Hydropower production may also be curtailed significantly, due to the effects of a drought.

Environmental losses are the result of damages to plant and animal species, wildlife habitat, and air and water quality; forest and grass fires; degradation of landscape quality; loss of biodiversity; and soil erosion. Some of the effects are short-term and conditions quickly return to normal following the end of the drought. Other environmental effects linger for some time or may even become permanent. As more effects of climate change are felt in future years, environmental impacts may become more intensified. Wildlife habitat, for example, may be degraded through the loss of wetlands, lakes, and vegetation. However, many species will eventually recover from this temporary aberration. The degradation of landscape quality, including increased soil erosion, may lead to a more permanent loss of biological productivity of the landscape. Although environmental losses are difficult to quantify, growing public awareness and concern for environmental quality has forced public officials to focus greater attention and resources on these effects.

Social impacts mainly involve public safety, health, conflicts between water users, reduced quality of life, and inequities in the distribution of impacts and disaster relief. Many of the impacts specified as economic and environmental have social implications as well.

Figure 3.6g shows graphically the total number of weeks between 2010 and 2012 in which New York counties had 50% or more land area under drought, as classified by the U.S. Drought Monitor. As the graphic shows, the majority of New York counties experienced abnormally dry conditions. A significant number of counties also experienced moderate drought, and some counties had severe drought. No counties were in extreme or exceptional drought. This graph does not specifically show which counties were in what type of drought, but provides a snapshot of which drought level was most pervasive during the period of 2010 through 2012.

Figure 3.6g: Weeks in Drought for New York 2010-2012



Source: SHELDUS

Table 3.6f summarizes the number of weeks during the years 2010 to 2012 in which each county had 50% or more land area in drought. Lewis County had the highest number of weeks with abnormally dry conditions (D0), at 51 weeks. In the moderate drought category (D1), Erie County had the highest total of 20 weeks. In severe drought (D2), Putnam and Westchester had the highest, both at five weeks. No New York counties had 50% or more area in extreme (D3) or exception drought (D4). Overall, Lewis County had the greatest total of weeks in any sort of drought category, at 67 weeks.

Table 3.6f: Total Weeks in Drought by County, 2010-2011

County	Number of Weeks County Area ≥ 50% in Drought				
	D0	D1	D2	D3	D4
Albany	26	0	0	0	0
Allegany	22	2	0	0	0
Bronx	27	10	0	0	0
Broome	7	0	0	0	0
Cattaraugus	30	2	0	0	0
Cayuga	32	19	0	0	0
Chautauqua	31	3	0	0	0
Chemung	16	4	0	0	0
Chenango	13	0	0	0	0
Clinton	20	0	0	0	0
Columbia	27	2	0	0	0
Cortland	14	0	0	0	0
Delaware	20	6	0	0	0
Dutchess	32	7	0	0	0
Erie	38	20	0	0	0
Essex	45	0	0	0	0
Franklin	29	0	0	0	0
Fulton	29	0	0	0	0
Genesee	30	17	0	0	0
Greene	30	0	0	0	0
Hamilton	50	0	0	0	0
Herkimer	38	0	0	0	0
Jefferson	32	3	0	0	0
Kings	27	10	0	0	0
Lewis	51	16	0	0	0
Livingston	26	13	0	0	0
Madison	30	15	0	0	0
Monroe	22	10	0	0	0
Montgomery	26	0	0	0	0
Nassau	26	10	2	0	0
New York	27	12	0	0	0
Niagara	38	15	0	0	0
Oneida	35	14	0	0	0
Onondaga	31	17	0	0	0
Ontario	25	12	0	0	0
Orange	24	6	0	0	0
Orleans	29	13	0	0	0
Oswego	30	14	0	0	0
Otsego	19	7	0	0	0
Putnam	24	8	5	0	0
Queens	27	10	0	0	0
Rensselaer	24	3	0	0	0
Richmond	31	16	0	0	0

County	Number of Weeks County Area ≥ 50% in Drought				
	D0	D1	D2	D3	D4
Rockland	25	7	0	0	0
Saratoga	25	0	0	0	0
Schenectady	30	0	0	0	0
Schoharie	30	11	0	0	0
Schuyler	19	11	0	0	0
Seneca	36	18	0	0	0
St Lawrence	24	0	0	0	0
Steuben	16	4	0	0	0
Suffolk	25	13	2	0	0
Sullivan	24	0	0	0	0
Tioga	12	0	0	0	0
Tompkins	25	4	0	0	0
Ulster	33	0	0	0	0
Warren	38	0	0	0	0
Washington	13	0	0	0	0
Wayne	19	8	0	0	0
Westchester	25	8	5	0	0
Wyoming	33	17	0	0	0
Yates	37	15	0	0	0
TOTAL	1,699	432	14	0	0

Source: SHELDUS

Local Plan Integration/ Risk Assessment

Since August 2013, 56 FEMA-approved local hazard mitigation plans (LHMP) have been reviewed for the 2014 Update. The State's planning team had the opportunity to review local county risk assessments to help the State better understand its vulnerability in terms of the jurisdictions most threatened by classified hazards. In its analysis, the State Hazard Mitigation Plan (SHMP) Team reviewed the processes used by local governments to rank hazards based on their vulnerabilities and potential losses (i.e., people, buildings, and dollar values) associated with the hazards of greatest concern.

Where data was available, the State extracted the ranking impact information from the LHMP hazard analysis. This ranking feature is based on a combination of probability, severity, and extent of the hazard and was determined to be the best measure of overall risk in the plans. This ranking was either numeric or described in terms of high, moderately high, moderate, or low. In cases where this information was not available, it was noted if the hazard was identified in the individual county local plans.

During the review of the local plan risk assessments, it was determined that a number of local plans used the New York HAZNY ranking system, and measured each hazard on a scale rating from 44 (low) to 400 (high). This analysis also revealed that a number of county-level plans included manmade hazards in their analysis, but the State hazard mitigation plan's 2014 update focused solely on natural hazards.

The local risk assessment summary allowed for an analysis of which hazards are of high concern to particular counties. **Table 3.2a** in **Section 3.2** lists all the hazards and the number of counties that ranked them at each of the scale levels: High, Moderately High, Moderate, Moderately Low, and Low. None of the State's Counties considered drought as a high-ranking hazard. All counties either ranked drought as a moderate, moderately low, or a low hazard. Specifically, two counties ranked drought as moderate, twenty-four moderately low, and ten counties ranked it as a low hazard. **Table 3.6g** displays the highest ranked county hazards, however due to low ranking there is no data available in the local plans.

Tables 3.6g Summary of Drought Hazard Impacts and Rankings by County

Local County Drought Hazard Impacts		
Highest Occurrences	**Highest Fatalities**	**Highest Property Damage**
*Delaware, Oneida, Otsego, Sullivan	N/A	*Delaware, Oneida, Otsego, Broome, Cortland, Fulton, Hamilton, Herkimer, Madison, Montgomery, Schoharie, St. Lawrence, and Tioga
*Broome, Cortland, Fulton, Hamilton, Herkimer, Madison, Montgomery, Schoharie, St. Lawrence, Tioga, Albany, Columbia, Dutchess, Greene, Rensselaer, and Ulster	N/A	*Cayuga, Chemung, Jefferson, Lewis, Onondaga, Oswego, Schuyler, Seneca, Tompkins, and Wayne

*Source: SHELDUS, 2013 (*Please note: Highest Occurrences and Property Damage are the same value for the counties listed.)*

Local County Drought Hazard Rankings
Moderate/Moderately Low/ Low
Drought is ranked as a moderate, moderately low, or low hazard by all counties throughout New York State.

Source: LHMP, 2013

Development in Hazard Prone Areas

Because Droughts are not limited to geographical boundaries or population groups, it is difficult to identify development and population trends that impact this hazard. Current land use and building codes incorporate standards that address and mitigate drought accumulation.

3.6.3 Assessing Drought Vulnerability of State Facilities

NYS has no recorded incidence of any damages to state buildings or critical infrastructures due to drought conditions.

3.6.4 Estimating Potential Losses by Jurisdiction- Overview

Overall, infrastructure such as highways, bridges, and electric conveyance systems are not affected by drought nor do they cause structural damage. A rare exception is severe soil shrinkage. When it arises, severe soil shrinkage compromises the foundation upon which the infrastructure stands. Soil shrinkage requires expansive soil, a soil type that contracts or expands as moisture content decreases or increases, to cause damage to property and/or infrastructure.

Direct and indirect potential impacts are explained in previous sections, yet accurate loss estimates for drought are not available. Reduced water levels and a decrease in water usage will have a direct economic impact on businesses and industries that are water-dependent. The indirect impacts associated with drought are broad but so diffuse that financial estimates of potential damages are not feasible.

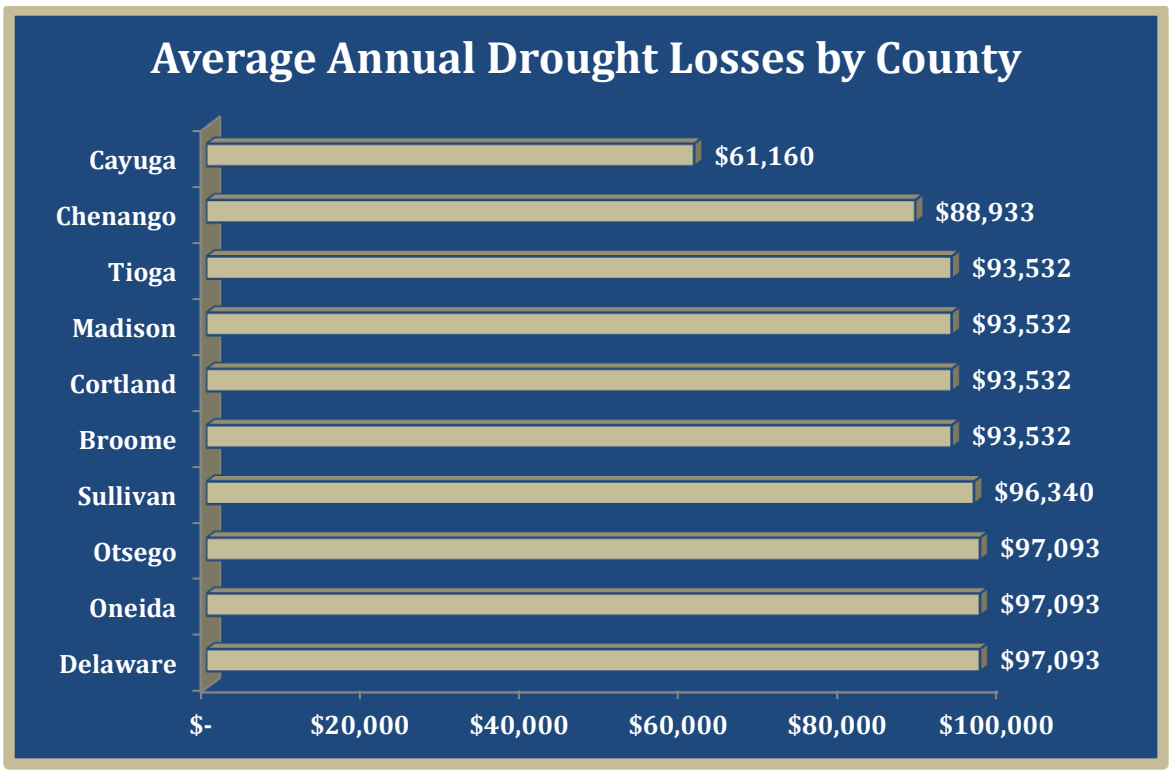
Table 3.6h provides the annualized losses for drought events. The data used was based on SHELDUS records from 1960-2012, with the exception of hurricane, earthquake, and flood hazards which were derived from HAZUS-MH 2.1. For those specific hazards, a probabilistic run was generated to determine the total annual losses for each county found within the State. The information provided by SHELDUS was determined by taking the total economic losses divided by the number of years of record (52) to obtain the losses per year. **Figure 3.6h,** illustrates the top ten counties annualized losses with a total of $2,234,615 in drought losses for the entire State of New York.

Table 3.6h: Average Annual Drought Losses by County 1960-2012

County	Drought	County	Drought	County	Drought
Delaware	$ 97,093	Rensselaer	$ 51,959	Rockland	$ 3,561
Oneida	$ 97,093	Ulster	$ 51,959	Westchester	$ 3,561
Otsego	$ 97,093	Fulton	$ 40,532	Allegany	$ -
Sullivan	$ 96,340	Hamilton	$ 40,532	Bronx	$ -
Broome	$ 93,532	Herkimer	$ 40,532	Cattaraugus	$ -
Cortland	$ 93,532	Montgomery	$ 40,532	Chautauqua	$ -
Madison	$ 93,532	Schoharie	$ 40,532	Erie	$ -
Tioga	$ 93,532	St Lawrence	$ 40,532	Genesee	$ -
Chenango	$ 88,933	Orange	$ 35,933	Kings	$ -
Cayuga	$ 61,160	Putnam	$ 35,933	Livingston	$ -
Chemung	$ 61,160	Saratoga	$ 35,933	Monroe	$ -
Onondaga	$ 61,160	Schenectady	$ 35,933	Nassau	$ -
Schuyler	$ 61,160	Warren	$ 35,933	New York	$ -
Seneca	$ 61,160	Washington	$ 35,933	Niagara	$ -
Tompkins	$ 61,160	Clinton	$ 32,372	Ontario	$ -
Steuben	$ 56,561	Essex	$ 32,372	Orleans	$ -
Yates	$ 56,561	Franklin	$ 32,372	Queens	$ -
Albany	$ 51,959	Jefferson	$ 8,160	Richmond	$ -
Columbia	$ 51,959	Lewis	$ 8,160	Suffolk	$ -
Dutchess	$ 51,959	Oswego	$ 8,160	Wyoming	$ -
Greene	$ 51,959	Wayne	$ 4,599	**Total**	**$ 2,234,615**

Source: SHELDUS, 2013

Figure 3.6h: Average Annual Drought Losses by County 1960-2012



Source: SHELDUS, 2013

3.6.5 Estimating Potential Losses of State Facilities

Although state agencies maintain internal databases that identify location and value of properties within their areas of responsibility, New York State does not currently have a comprehensive data set of state-owned and operated assets that can be integrated into the GIS methodology for analysis. However, a state facilities inventory project was initiated in August 2013, which will gather information that can be used to build a comprehensive data set. The pilot phase, which will look at a specific critical facility category and develop the methodology for the project, is expected to be completed in mid-2014. At that time, the next phase of the project will be developed for what is anticipated to be a multi-year project.

3.6.6 Data Limitations and Other Key Documents

The drought hazard in New York State is often underestimated because other natural hazards occur more frequently (e.g., hurricanes, tornadoes, flooding) and are much more visible. The Mitigation Planning Team researched the drought hazard as it affects the State. Contents of this section result from research and outreach from the following sources:

- The New York State Department of Environmental Conservation, Bureau of Water Resources Management, Division of Water, staff and website, http://www.dec.state.ny.us
- New York State Climate Office, Department of Earth and Atmospheric Sciences at Cornell University web site, http://www.nrcc.cornell.edu/drought/
- The National Drought Mitigation Center http://droughtmonitor.unl.edu/monitor.html
- National Weather Service, Climate Prediction Center, http://www.cpc.ncep.noaa.gov/products/monitoring_and_data/drought.shtml
- The National Climatic Data Center, http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwevent~storms
- United States Department of Agriculture, Natural Resource Conservation Service, http://www.nrcs.usda.gov/
- The United States Geological Survey, http://ny.water.usgs.gov/projects/duration/
- The New York State Disaster Preparedness Commision. (2012). *New York State Comprehensive Emergency Management Plan: Drought Management Coordination Annex.* Disaster Preparedness Commission .

Please note: *data obtained from the Spatial Hazard Events and Losses Database for the United States (SHELDUS™) is a county-level hazard data set for the U.S. for 18 different natural hazard event types such thunderstorms, hurricanes, floods, and tornados. For each event the database includes the beginning date, location (county and state), property losses, crop losses, injuries, and fatalities that affected each county. The data derives from the national data source, National Climatic Data Center's monthly Storm Data publications. Using the latest release of SHELDUS™ 12.0, the database includes every loss causing and/or deadly event between 1960 through 1992 and from 1995 onward. Between 1993 and 1995, SHELDUS™ reflects only events that caused at least one fatality or more than $50,000 in property or crop damages.*