



CURRENT & FUTURE TRENDS IN EXTREME RAINFALL ACROSS NEW YORK STATE

A report from the Environmental Protection Bureau of New York State Attorney General Eric T. Schneiderman

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Eric T. Schneiderman

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EXECUTIVE SUMMARY

New Yorkers are increasingly vulnerable to extreme weather, especially extreme rainfall. Analysis of current trends shows that from Long Island to the North Country to the Southern Tier, the frequency and intensity of extreme rainfall is increasing – and these extreme weather events are damaging communities throughout the State. This new reality demands that we incorporate resiliency planning and response measures into our communities and landscape in order to promote a safer and more sustainable New York.

New York is fortunate to have abundant water resources; the foundations of our State's economy, from agriculture, hydropower and tourism to the Catskill reservoirs that supply drinking water for New York City, are supported by humid continental air masses that pass over our State and drop precipitation in generally consistent patterns. While many other parts of our country are increasingly starved for water, abundance is the norm in New York. Recently, however, the increasing frequency and intensity of extreme rainfall events in New York has resulted in damage to our communities, businesses, and natural systems. Of additional concern, the best-available scientific projections of precipitation trends suggest that extreme rainfall events will continue into the future – more of them, and more often. Our analysis suggests some of these projections may even underestimate the magnitude of future increases.

INTRODUCTION

DEAR NEW YORKER—

There can no longer be any doubt that climate change is more than just a threat – it is a reality. Across the nation and around the world, ecosystems are being altered by warmer temperatures, rising sea levels and severe rainstorms that are striking with growing frequency and intensity.

The effects of this global crisis are being felt locally as well. As documented in this new report by my office, heavy rainfalls and devastating floods are taking an enormous toll on communities across New York State, from Long Island to the Southern Tier to the Capital Region to the North Country.

In recent years, there has been a steep increase in the number of powerful deluges. Extreme rainstorms, and the disastrous floods and soil erosion that result, are wreaking havoc in places that rarely had to contend with these damaging meteorological events.

The pattern and the impacts of more frequent and more extreme rainfall are undeniable – and projections are that these events will likely increase in the future. If we are to overcome the challenges of climate change, we must incorporate resiliency planning and response measures into our communities and our landscape.

I hope you will join me in this essential effort to ensure a safer and more sustainable New York.



ERIC T. SCHNEIDERMAN
NEW YORK ATTORNEY GENERAL



METHODOLOGY

Recently, the increasing frequency and intensity of extreme rainfall events in New York has resulted in damage to our communities, businesses, and natural systems. Of additional concern, the best-available scientific projections of precipitation trends suggest that extreme rainfall events will continue into the future – more of them, and more often. Our analysis suggests some of these projections may even underestimate the magnitude of future increases. As we look to New York’s future, studies on the range of coming climate conditions indicate that current trends of increasing heavy precipitation will continue.

CASE STUDIES

The extreme weather affecting New York over recent years, from intense rainfall to Hurricane Sandy, has put the real and present dangers of climate change into sharp focus for many New Yorkers. Our businesses, governments, and institutions are being challenged to minimize these risks as we move forward – by reducing emissions of heat-trapping greenhouse gases that contribute to a changing climate, while increasing the resiliency of our communities and landscapes to extreme weather.



2014 STALLED WEATHER FRONT LONG ISLAND

On August 13, 2014, a non-tropical weather system that produced about 2 inches of rainfall over much of the northeast United States stalled over the Long Island towns of Islip, Brookhaven and Babylon, resulting in New York's heaviest downpour on record. Preliminary measurements show that 13.57 inches of rain fell, an amount equal to an entire summer's worth of rain for the area and representing what is likely a new state 24-hour rainfall record.¹³ Nearly all the rain fell over the course of a few early-morning hours, where it quickly overwhelmed stormwater and roadway drainage systems, forced waking families to evacuate their homes and compelled drivers on many roadways to abandon their vehicles to escape the rapidly rising water.

CASE STUDY #1

6200
WITHOUT POWER

1000
HOMES DAMAGED¹⁴



2014 STALLED WEATHER FRONT LONG ISLAND

Damage to public infrastructure was also being reported as extensive, ranging from sinkholes in area roadways to damage to municipal buildings, marinas, parks, MacArthur Airport and train stations. The Federal Emergency Management Agency (FEMA) is assisting the State in a preliminary assessment of damages, which local officials expect to exceed \$30 million

CASE STUDY #1

6200
WITHOUT POWER

1000
HOMES DAMAGED¹⁴

2011 HURRICANE IRENE

Hurricane Irene made landfall in New York as a tropical storm on August 28, 2011, lashing New York City and Long Island with strong winds, storm surge and heavy rain. But what made Irene such a deadly and expensive storm was the intense rainfall it delivered upstate after moving onshore. After making landfall, Irene moved north through the Hudson Valley, eastern Adirondacks and Champlain Valley, dumping over 7 inches of rain in a matter of hours. Record rainfall intensities were measured at many weather stations in the Catskills, where official rainfall gauges measured over 11.6 inches in a 24-hour period.¹⁸ Some unofficial gauges measured over 18 inches in 24 hours.¹⁹

\$1.3B
TOTAL DAMAGES

10
DEATHS²²

CASE STUDY #2



2011 HURRICANE IRENE

Thousands of homes and businesses were damaged by the intense rain and resulting floodwaters, with over 33,000 New Yorkers seeking disaster assistance²¹

Saturated land areas became vulnerable to erosion and tree fall, wreaking havoc on infrastructure.

33000

**DISASTER ASSISTANCE
CLAIMS**

31

**COUNTIES DECLARED
DISASTER AREAS**



CASE STUDY #2

2011 HURRICANE IRENE

Roadway bridges and culverts, many of which were not designed to withstand such heavy rainfall, were overwhelmed by the high waters. The State's transportation infrastructure alone sustained nearly \$300 million in damage.

A week later, the remnants of Tropical Storm Lee delivered another round of intense rainfall to New York, dumping over 7 inches in a 24-hour period – with nearly a foot of rain reported in some spots – along New York's Southern Tier before moving north into many areas still reeling from the effects of Irene's deluge.

\$300M
INFRASTRUCTURE
DAMAGES

CASE STUDY #2



Flood of August 2011, State Route 30 road washout caused by Schoharie Creek at Breakabeen, New York. Photo by Joseph Griffin, courtesy of New York State Department of Transportation (USGS 2014).



2009 SEVERE THUNDERSTORM WESTERN NY

A line of severe thunderstorms produced nearly 6 inches of rain in less than two hours on the night of August 9, 2009, across parts of Cattaraugus, Chautauqua, and Erie counties in Western New York, causing extensive flash flooding and prompting a massive rescue and evacuation effort in the flooded villages of Gowanda and Silver Creek.²³ The stream gauge on Cattaraugus Creek in Gowanda showed a rise from 6 feet to nearly 13 feet in less than an hour (flood stage is 10 feet).²⁴ Moving water 3 feet deep, mud and debris inundated the first floors of village homes, destroying or seriously damaging over 400 structures and leaving even more families homeless.²⁵

CASE STUDY #3

\$45M
DISASTER ASSISTANCE



2009 SEVERE THUNDERSTORM WESTERN NY

In Gowanda, patients and staff of the Tri-County Memorial Hospital had to be evacuated to a temporary medical facility set up at the Gowanda Elementary School. Gowanda's primary drinking water reservoir was so badly damaged that the Village was forced to use backup water supplies for years after the floods.²⁶ More than one-quarter of the roads in Cattaraugus County were damaged. Nearly 18,000 customers lost power due to the storms.

Two deaths occurred during the flood in Gowanda: An 80-year old man was swept away and drowned, and one resident suffered a heart attack when emergency responders were delayed by flooded streets.

CASE STUDY #3

6200
WITHOUT POWER

1000
HOMES DAMAGED¹⁴



2009 SEVERE THUNDERSTORM WESTERN NY

In Silver Creek, several police cars, an ambulance and highway equipment were lost and 35 mobile homes were destroyed as flood waters washed through the heart of the Village. Seven campers had to be rescued by helicopter off the roofs of cars in nearby Zoar Valley, and 90 families of the Seneca Nation were stranded due to road washouts, necessitating the use of ATVs to deliver food and other supplies.²⁷

A federal disaster was declared, and more than \$45 million in federal assistance was distributed to 1,500 individuals and an estimated 1,100 public projects.²⁸

CASE STUDY #3

6200
WITHOUT POWER

1000
HOMES DAMAGED¹⁴

FINDINGS

EXTREME PRECIPITATION EVENTS ARE INCREASING IN FREQUENCY & INTENSITY

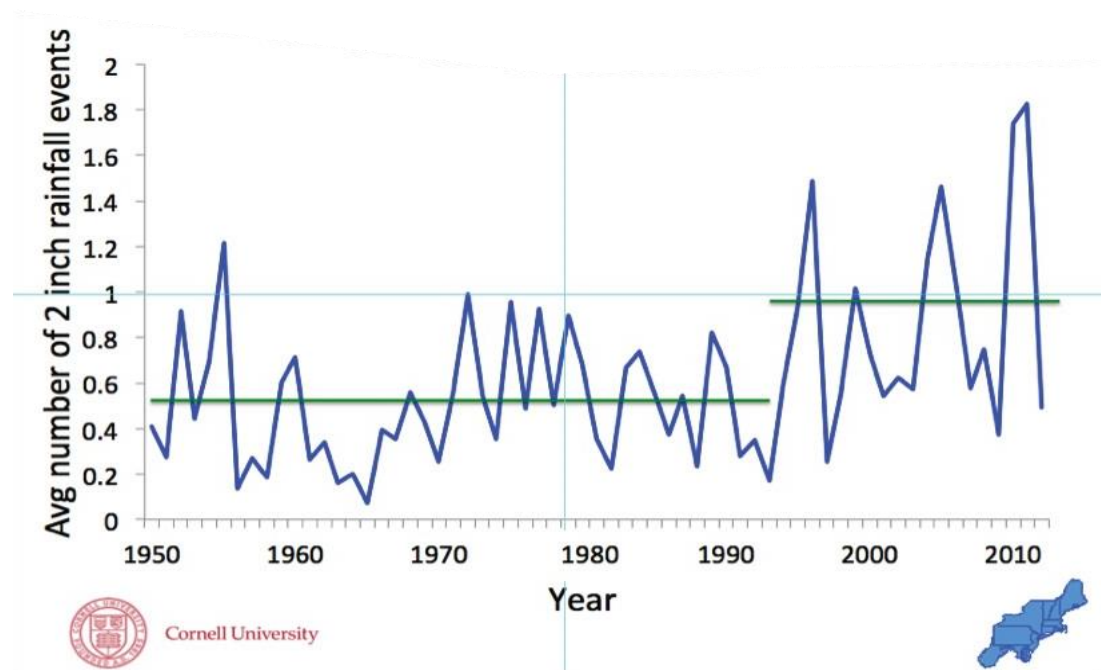
Researchers at the National Oceanographic and Atmospheric Administration (NOAA) Northeast Regional Climate Center at Cornell University have long studied changes in extreme rainfall patterns, including how recurrence intervals of extreme rainfall events may be changing over time.³ In one recent study of 100-year 24-hour rainfall for the Northeastern United States, recurrence intervals based on years 1978 to 2007 were found to have shortened dramatically, to a frequency of only 60 years, as compared with a 1950-to-1979 baseline.⁴ Engineers and other professionals rely on estimates of recurrence intervals of climate phenomena, such as extreme rainfall and stream flows, for designing and locating critical infrastructure, such as bridges and buildings, and for developing land use and zoning regulations. Using outdated recurrence intervals that rely upon extreme rainfall data from a period that ends in 1960 for such projects could potentially result in inadequate design of important structures. The Office of the Attorney General has highlighted this issue in comments regarding the construction of appropriately sized stormwater retention basins around New York.⁵

“Heavy downpours are increasing nationally, especially over the last three to five decades, with the largest increases in the Midwest and Northeast. Increases in extreme precipitation are projected for all U.S. regions.” (2014 U.S. National Climate Assessment)



2-INCH RAINFALL AVERAGES INCREASING AT NY STATIONS

Analysis of 2-inch, 24-hour rainfall events in New York, for example, shows a substantial increase in frequency beginning in the mid-1990s and continuing to the present.



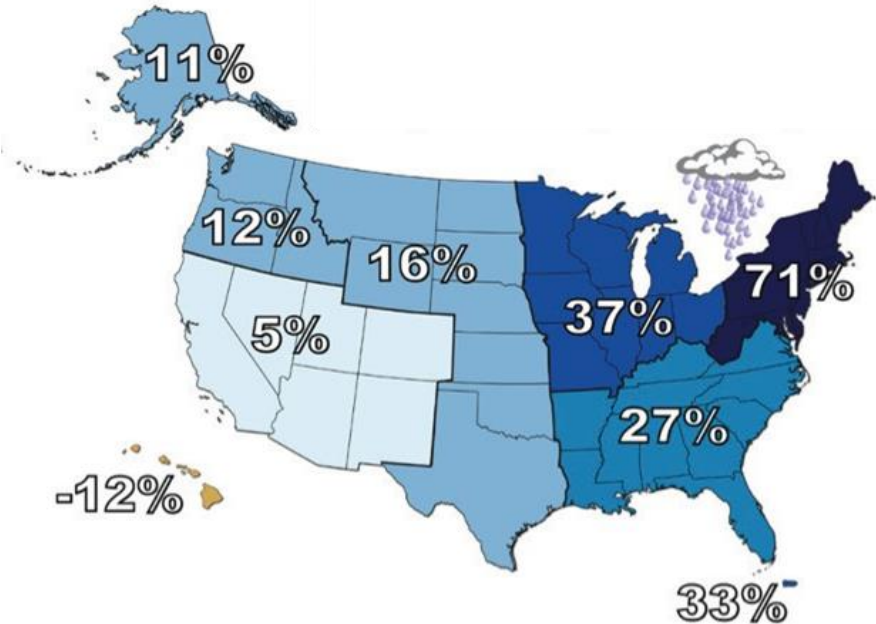
EXTREME PRECIPITATION EVENTS ARE INCREASING IN FREQUENCY & INTENSITY

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“Heavy downpours are increasing nationally, especially over the last three to five decades, with the largest increases in the Midwest and Northeast. Increases in extreme precipitation are projected for all U.S. regions.” (2014 U.S. National Climate Assessment)

CHANGES IN VERY HEAVY PRECIPITATION OBSERVED

In 2014, the United States National Climate Assessment (Assessment) measured trends in extreme rainfall for different regions of the country, quantifying the amount of rainfall occurring in the heaviest 1% of all rain events. The Assessment found a 71% increase in the amount of rain in those events in the Northeast United States, including New York, from 1958 to 2012.



EXTREME RAINFALL EVENTS EXPECTED TO INCREASE

As we look to New York's future, studies on the range of coming climate conditions indicate that current trends of increasing heavy precipitation will continue. Understanding exactly how much more frequent and intense these storms will become is affected by several factors, including the amount of additional greenhouse gases released into the atmosphere. Generally, the more greenhouse gases emitted, the greater the likelihood of more frequent and intense extreme precipitation events.

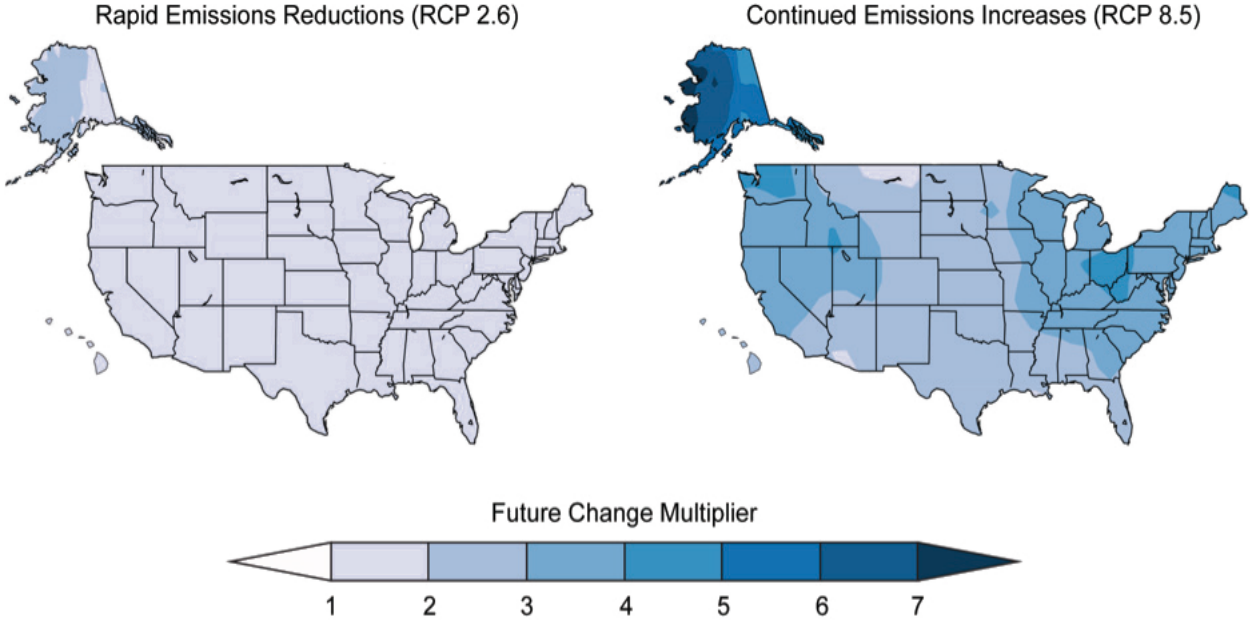
The recent United States National Climate Assessment evaluates and compares different global greenhouse gas emission scenarios and their potential influence on future trends in extreme rainfall. Figure 3 illustrates the expected increases for the 20-year daily storm that typically produces between 4 and 6.5 inches of rain in New York. The report finds that if the current trend in global greenhouse gas emissions remains high for the remainder of the century (such a trend is designated in Figure 3 as emission scenario RCP 8.5)⁷, the frequency of extreme rainfall as measured by the 20-year daily storm event may increase significantly, on the order of 300% to 400% by the latter part of this century.⁸ This means that storms that are currently expected to occur every 20 years will occur every 5 to 7 years. Such an increase in extreme rainfall events would have significant consequences for New York.

The NPCC study projects that 1-, 2-, and 4 inch 24-hour rainfall events are expected to increase in frequency, intensity, and duration in New York City.⁹



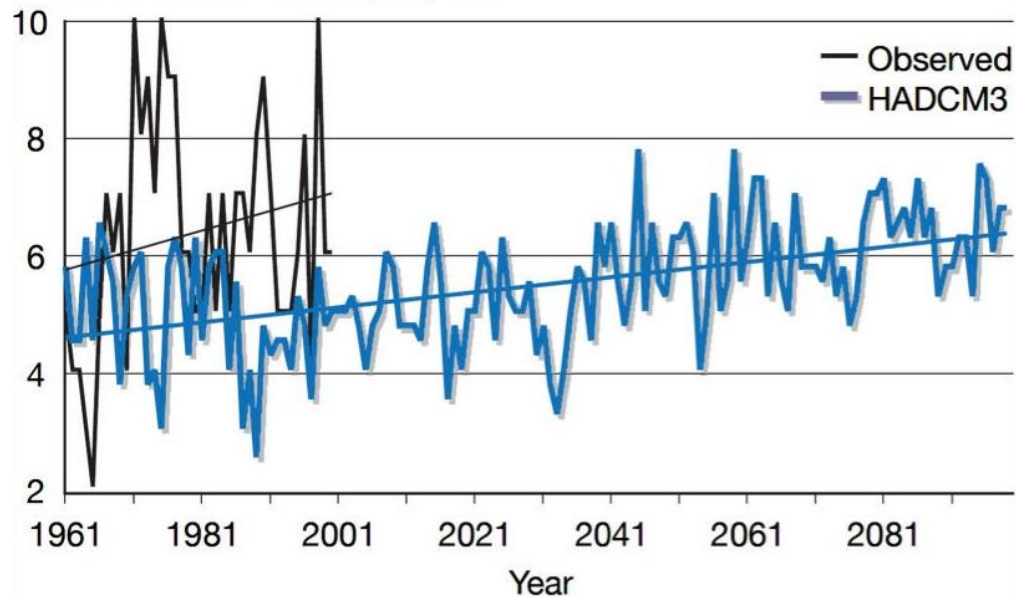
RAPID EMISSIONS REDUCTIONS & INCREASES

The frequency of extreme daily precipitation events (a daily amount that now occurs once in 20 years) is expected to increase by the latter part of this century (2081-2100) compared with the latter part of the last century (1981-2000) everywhere in the United States. The magnitude of the increase is greater if global greenhouse gases emissions continue on their current trajectory, as represented by scenario RCP 8.5.10



1960-2100 NUMBER OF RAINFALLS 1+ INCH

The observed number of rainfall events exceeding one inch from 1960 to 2000 in New York is shown by the black line, and the projected number of such events, using the HadCM3 global climate model, is shown by the blue line. These results are broadly consistent with those of the other 15 global climate models used by ClimAID for a high greenhouse gas emission scenario.



NEW YORKERS HARMED FROM RECENT EXTREME PRECIPITATION EVENTS

A review of New York's top ten 24-hour rain events of the past five years (August 2009 to August 2014) demonstrates that extreme precipitation events have occurred in a variety of geographic locations and weather contexts. As shown in the following, four of these top ten rainfalls, including the most recent record-breaking event on Long Island in August 2014, arose from typical low pressure weather systems. Four of the rain events were related to moisture from tropical systems, such as Hurricane Irene and Tropical Storm Lee in 2011. The remaining two extreme precipitation events were generated from an unstable air mass that also spawned a tornado, as well as a winter nor'easter.

“As New York continues to recover, we must also turn our attention to the future. We live in a world of increasing volatility, where natural disasters that were once anticipated to occur every century now strike with alarming regularity. Our response capabilities to this new level of instability and the ability to bounce back stronger must be developed and strengthened. Our efforts must be rooted in robust structural underpinnings as well as expanded operational capacities.” (NYS 2100 Commission Report, January 2013)

TOP 10 RAINFALL EVENTS

4

**LOW PRESSURE
SYSTEMS**

4

**TROPICAL
SYSTEMS**

2

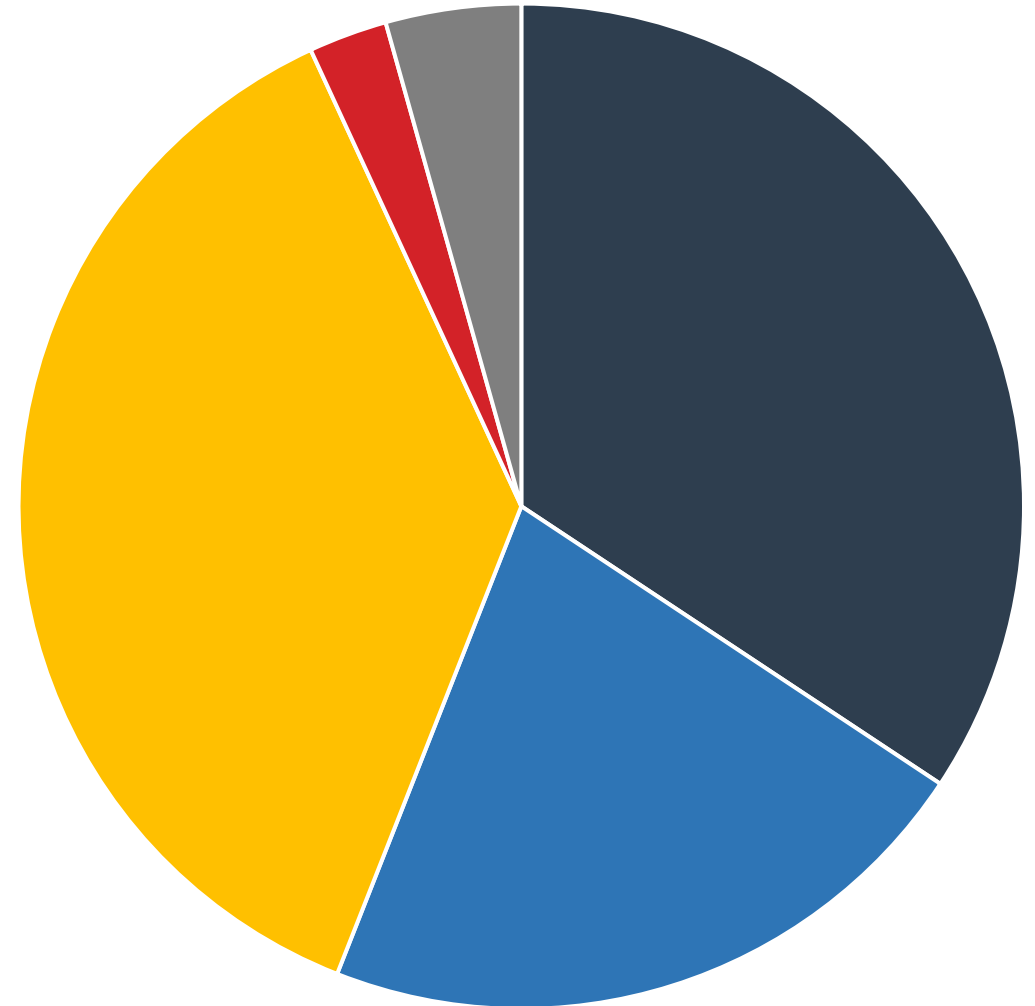
**UNSTABLE
AIR MASSES**

Date of Storm	Type of Storm	Highest Recorded 24-Hour Rainfall (inches)	Region(s) of Greatest Impact
08/13/14	Complex upper-level disturbance with surface low-pressure area	13.57	Long Island
08/28/11	Hurricane Irene	11.6	Southeastern NY Catskills Schoharie Valley Capital District Adirondacks Champlain Valley
08/23/10	Slow moving low pressure system	10.80	Central NY (Herkimer, Montgomery, Fulton Counties)
09/8/11	Remnants of Tropical Storm Lee	10.40	Southern Tier Central NY Mohawk Valley
08/14/11	Slow moving low pressure	9.62	New York City Long Island
10/1/10	Upper-level low pressure with moisture from remnants of Tropical Storm Nicole	8.25	Catskills Capital District
09/12/12	Low-pressure system	7.35	Catskills Capital District
08/10/09	Severe thunderstorms with tornado activity	7.27	Lake Erie / Niagara Western Southern Tier (Erie, Cattaraugus, Chautauqua)
06/8/13	Remnants of Tropical Storm Andrea	6.44	Long Island New York City
03/30/10	Winter Nor'easter	6.23	Long Island

Source: NOAA's Northeast Regional Climate Center

2011 GREENHOUSE GAS EMISSION BY SECTOR

- Transportation & Land Use
- Power Supply & Delivery
- RCI (Buildings)
- Agriculture
- Water & Wastewater



CONCLUSION

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The extreme weather affecting New York over recent years, from intense rainfall to Hurricane Sandy, has put the real and present dangers of climate change into sharp focus for many New Yorkers. Our businesses, governments, and institutions are being challenged to minimize these risks as we move forward – by reducing emissions of heat-trapping greenhouse gases that contribute to a changing climate, while increasing the resiliency of our communities and landscapes to extreme weather.

REDUCE GREENHOUSE GAS EMISSIONS

Emissions of carbon dioxide, methane, and other greenhouse gases in New York are produced primarily from electric power generation, heating and cooling buildings, industrial processes, and transportation and land use (Figure 5). Reaching New York's aggressive goal of reducing greenhouse gas emissions by 80% from 1990 levels by the year 2050²⁹ will require replacing the fossil fuels that power large parts of our economy with low- or zero-carbon energy sources.³⁰ In addition, energy efficiency must be increased in all applications including deep- energy retrofits for our existing building stock.

New York has multiple programs to help reduce greenhouse gas emissions from the sectors of the economy mentioned above and to move the State toward a more-efficient, clean energy economy based on wind, solar, hydroelectric, and other renewable energy resources. These efforts include the Regional Greenhouse Gas Initiative a multistate agreement that puts a price on carbon emissions from electricity generation, encouraging cost-effective reductions in carbon emissions from electricity producers; the Renewable Portfolio Standard that requires that a certain portion of the State's electricity come from low-carbon, renewable sources; and the Energy Efficiency Portfolio Standard. The NY Green Bank was recently established in order to facilitate additional investments in renewable energy within the state.

RESPONSE CHALLENGE #1





CONSIDER CURRENT & FUTURE RAINFALL PROJECTIONS

As this report has explained, extreme rainfall events are occurring more frequently and with more intensity throughout New York State. At a minimum, this information must be incorporated into the design of our built environment. Architects, civil engineers, and building code developers are but just a few of the professionals who must reject outdated information that does not represent current climate risks and instead begin incorporating best available data. Projections of future climate conditions must be considered as well, as they suggest even greater increases of extreme rainfall in the future. Coastal communities in New York are especially challenged, as they must also consider, the compounding effect that sea level rise, in addition to increasing extreme rainfall, will have on coastal flooding.

RESPONSE CHALLENGE #2

ENGAGE ON CLIMATE CHANGE BEYOND NEW YORK STATE LINES

Because greenhouse gases have the same climate-forcing effect no matter where they are emitted around the world, New York must expand its engagement in national and international efforts to limit emissions of climate change pollution. Through leading by example, and engaging in multi-state, national and international advocacy, New York can play a key role in reducing climate change risks and building communities that are more resilient to extreme weather.

RESPONSE CHALLENGE #3



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³If rates of extreme rainfall increase, the length of the associated storm recurrence intervals will decrease.

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