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STATE OF NEW YORK

PUBLIC SERVICE COMMISSION

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In re:	Case Nos. 13-E-0030,
Con Edison Major Rate Proceedings	13-G-0031, 13-S-0032
(Combined Electric, Gas and Steam)	May 31, 2013

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Report of

Klaus H. Jacob, Ph.D.

on Behalf of the

New York State Office of the Attorney General

Submitted in PSC Proceedings 13-E-0030, 13-G-0031, and 13-S-0032

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I. Introduction

This report is submitted on behalf of the New York State Office of Attorney General, as intervenor party, in Con Edison Company of New York, Inc.'s ("Con Edison" or "Company") Major Rate Proceeding before the New York State Public Service Commission ("PSC"), cases 13-E-0030, 13-G-0031 and 13-S-0032. It is intended to assist the PSC in its review of Con Edison's "storm hardening" proposals set forth in the Company's January 25, 2013 filing and March 25, 2013 update. Con Edison's proposal to spend approximately $1 billion over the next four years represents the Company's effort to identify immediate and longer term system enhancements to protect its electric, gas and steam infrastructure from future damage due to storms and extreme weather events. Based on my review of the proposals described in the Company's filings and information provided in response to interrogatories in this case, and my experience as a disaster risk management expert, it is my opinion that Con Edison has failed to properly identify climate-related risks to its system, such as increased coastal flooding due to sea level rise.[1] Additionally, the Company has failed to provide a cost-benefit analysis of its storm hardening proposals. To ensure continued cost-effective system reliability in the face of increasing climate-risks, I urge the PSC to direct Con Edison to reevaluate its proposals using a comprehensive risk management approach. This approach should identify the full range of climate-related risks based on the best available science and evaluates the cost and feasibility of a range of mitigation and adaptation options.

This report does not offer prescriptions for specific infrastructure retrofits or system design parameters, or suggest a reprioritization of projects proposed by Con Edison to address climate-related hazards. Nor does it assess Con Edison's past performance in preparing for or responding to climate hazards. Rather, this report provides an overview of climate-risk management principles, identifies specific risks to the New York City metropolitan area posed by rising sea levels and other impacts of climate change, and evaluates Con Edison's storm hardening proposals in the context of those risks. It concludes by urging the PSC to require that Con Edison fully consider current and future climate risks,

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[1] As discussed in greater detail in Section II.B.2, scientific data have for some time shown that sea levels are rising. For instance, the NOAA tide gauge at the Battery in NYC (http://tidesandcurrents.noaa.gov/sltrends/sltrends_station.shtml?stnid=8518750) shows sea level rising since 1856 at a rate of 0.91 ft/century. Sea level rise is caused by thermal expansion of oceans, melting ice sheets and glaciers on land, changes in aquifer storage on continents, and changes in coastal land elevations. The New York City Panel on Climate Change (NPCC) projects, based on global climate change models and other research, that the rate of sea level rise will accelerate and that sea levels in the New York City metropolitan area will rise between 2 - 10 inches by the 2020s, 7 - 29 inches by the 2050s, and 12 - 55 inches by the 2080s. See Horton, R. et al. (2010). Climate Risk Information, Appendix to Climate Change Adaptation in New York City: Building a Risk Management Response, New York City Panel on Climate Change 2010 Report. *Annals of the New York Academy of Sciences*, 1196: 147-228 (hereinafter referred to as "NPCC 2010"). The Climate Risk Information Appendix is available at http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2010.05323.x/pdf. The full NPCC 2010 report is available at http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2010.05323.x/pdf. The NPCC is scheduled to release updated and refined estimates in June 2013.

such as rising sea levels, in its development and implementation of storm hardening measures.

II. Discussion

A. Climate-Risk Management

Climate-related hazards pose risks[2] to our natural and built environments. A large body of knowledge has been developed in the area of identifying and quantifying climate hazards.[3] Climate change, which refers to long-term changes in climate conditions due to natural and/or human-induced causes, presents an evolving set of hazards and risks. For example, recent climate data reflect, and climate change models project, current and future increases in air and water temperatures, rising sea levels, and increased coastal storm flood frequency and severity. Among the anticipated impacts of these changing conditions on an urban environment are: increased incidences of damaging floods, overheating of operational systems and materials, and physical damage due to wind, ice and rain.

Over the past two decades science-based organizations like the Intergovernmental Panel on Climate Change (IPCC) have detailed the effects of changing climate. Based on mounting evidence of climate change, groups such as the National Academy of Sciences, the New York State Climate Action Council, and the New York City Panel on Climate Change (NPCC) have called for the adoption of climate-risk management strategies to protect public resources and ensure public safety.

Federal, state and local governments, as well as the business community, have begun to recognize the need to manage the risks posed by changing climate conditions. While climate hazards that are well understood in their effects on engineered structures (*e.g.* wind loads, snow loads) are often readily accounted for in building and engineering codes and/or professional or industry standards, hazards that evolve over time like those related to climate change are harder to incorporate into codes or standards and tend to be incorporated more slowly. For this reason, stakeholders exposed to risks from these changing patterns of hazard must persistently monitor conditions and developments in scientific understanding of

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[2] Risk, in the most general sense, is the potential for future loss. More precisely, risk can be defined as the probability of a hazardous event, multiplied by the consequence should the event occur (i.e., death or bodily injury, physical or financial loss including direct and indirect losses flowing from such injury or loss). In the context of the built environment, hazards posed by the natural environment are a significant source of risk. Risk can also be expressed quantitatively using the following equation: *Risk = Hazards x Assets x Vulnerability*. *Hazard* is expressed as the likelihood, or probability, of a certain event (or set of conditions) to exceed a certain threshold level within a certain time. *Assets* are defined by their current replacement value (in dollars). *Vulnerability* is the fractional loss (varying between 0 and 1) of the asset replacement value and is a function of the severity of a hazard and the unique properties of the asset.

[3] See, *e.g.*, IPCC 2012 report on global climate conditions; Horton et al. (2010), Horton et al. (2011), and Rosenzweig et al. (2011) for the New York region.

changing climate and its impacts, and in turn, incorporate such information into design standards and system operations.[4]

In this rate case, Con Edison has proposed a number of actions to address climate-risks to its infrastructure. However, it does not appear that the Company has considered the full range of risks associated with climate change, particularly increased flooding due to sea level rise. Any effective risk management strategy, including one for climate risks, must first identify and quantify risk before employing mitigation and adaptation measures. Risk assessment entails properly identifying hazards and asset or system vulnerabilities. Once risks are identified and quantified, mitigation and adaptation strategies can be developed based on quantitative benefit-cost assessment methods. Prudent business practices require that Con Edison update its current risk management and capital prioritization processes to identify and address corporate current and future climate risks facing the Company, and by extension, the related risks to its customers and the general public.

B. Climate-Risks to New York City Region

The New York City metropolitan region is, and has always been, exposed to hazards and risks from climate conditions. These hazards include various forms of flooding (*e.g.*, urban flash flooding, river flooding, and coastal storm surge flooding during tropical cyclones/hurricanes, extra-tropical storms, and nor'easter winter storms), extreme temperatures, heat waves, droughts, wind storms including tornados, lightning, heavy snow, freezing-rain and icing, and heavy rain down pours. Tropical cyclones often combine many hazards into a single event (*e.g.*, wind, rain, thunderstorms/lightning, coastal storm surge with resulting coastal flooding). New York City's geographical location, such as its proximity to the Atlantic Ocean and low elevation of parts of the city, a densely built environment, and a large population are the primary reasons for its risk to climate-related perils.

1. Current Climate Hazards

a. ClimAID and New York City Panel on Climate Change Reports

Two recent comprehensive studies summarize the best available scientific information on climate hazards for the New York metro-region. In "Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation,"[5] scientists from Cornell University, Columbia University, and the City

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[4] Smith, L. and N. Stern (2011). "Uncertainty in science and its role in climate policy," Phil. Trans. R. Soc. A. 369: 4818–4841.

[5] Rosenzweig, C., W. Solecki, A. DeGaetano, M. O'Grady, S. Hassol, and P. Grabhorn (2011). Responding to Climate Change in New York State: The ClimAID Integrated Assessment for Effective Climate Change Adaptation. *Annals of the New York Academy of Sciences*, 1244: 2-649. http://onlinelibrary.wiley.com/doi/10.1111/nyas.2011.1244.issue-1/issuetoc http://www.nyserda.ny.gov/climaid

University of New York summarized current climate hazards for the entire State of New York. This report, commonly referred to as the ClimAID report, was commissioned to provide New York State government, business and community leaders and decision makers with the latest information on the State's vulnerability to climate change and to assist in the development of greenhouse gas mitigation and climate change adaptation strategies informed by experience and scientific knowledge. The team of authors consisted of university and research scientists who specialize in climate change science, impacts and adaptation, including this author.[6]

An earlier report, issued by the New York City Panel on Climate Change (NPCC 2010)[7] focused specifically on climate change impacts to the New York City metropolitan area. Modeled after the IPCC, the NPCC was convened by New York City Mayor Michael Bloomberg in 2008 to advise his office on issues related to climate change. It is comprised of climate change scientists, and legal, and insurance risk management experts, including this author. An update of the NPCC 2010 report is expected to be released in June 2013.

These two reports, published well before devastating storms such as Sandy and Irene hit the New York City area, provided compelling evidence that current climate hazards, including hurricanes and nor'easter winter storms, have the capacity to greatly damage critical infrastructure and cause lengthy utility service outages with attendant economic losses potentially ranging from tens of millions to tens of billions of dollars.

As discussed in section II.B.2 below, future climate change will only increase these system vulnerabilities unless they are prudently managed.

b. <u>FEMA Maps</u>

New York City's risk to current flood hazards is reflected, in part, in Federal Emergency Management Agency (FEMA) flood insurance rate maps (FIRMs). Originally developed for the National Flood Insurance Program (NFIP), FIRMs are maps on which are delineated 100-year (1% annual chance) and 500-year (0.2% annual chance) floodplains, base flood elevations and risk premium zones. These maps are designed to enable insurance agents to issue accurate flood insurance policies under the NFIP, thereby protecting homeowners and mortgage-lenders of flood-prone properties. Flood risk information

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[6] The ClimAid report included a case study on potential climate change impacts to a critical component of NYC infrastructure, the transportation system. (Jacob, K. H. et al. (2011). Transportation. Chapter 9 of ClimAID report). It quantified in detail the risks and associated costs for a given severe storm event. These risk estimates were made *before* the recent severe storms (*e.g.*, Irene, Lee and Sandy) affected New York. The ClimAID report's quantitative risk assessments were validated for the New York City area, especially by the occurrence of Sandy. Similarly, risks to the telecommunication infrastructure (and their relation to electric power outages) from extreme weather events, as summarized in Chapter 10 of the ClimAID report (Jacob, K. H. et al. 2011) were validated as well. http://www.nyserda.ny.gov/climaid

[7] NPCC (2010).

presented on FIRMs is based on historic, meteorological, hydrologic, and hydraulic data, as well as open-space conditions, flood-control works, and land development. Among other things, FIRMs identify Special Flood Hazard Areas, which are areas subject to inundation by a flood that has a 1% or greater chance of being equaled or exceeded during any given year. This type of flood commonly is referred to as the 100-year flood or base flood.[8]

Although FIRMs are useful for identifying flood prone areas, FIRMs are not designed for planning and safeguarding infrastructure or critical and public facilities. Because FIRMs are based on past climate, rainfall and land use patterns and do not consider future conditions; they cannot be relied upon exclusively to anticipate current flood risks, and particularly long term risks due to climate change.

i. Digital Flood Insurance Rate Maps and Advisory Base Flood Elevations

FEMA is in the process of updating existing FIRMs across the country, many of which are over 25 years old.[9] The new FIRMs, referred to as Digital FIRMs ("DFIRMs"), include a spatial database for increased functionality. Preliminary DFIRMs for most of the New York City area are planned for release on or around May 31, 2013.[10] In the interim, to assist in rebuilding of communities impacted by Sandy, FEMA issued Advisory Base Flood Elevation ("ABFE") maps in February 2013.[11] These maps provide a more up-to-date picture of current flood risk than the FIRMs currently still on record. The ABFE maps are based on FEMA coastal studies that were completed before Hurricane Sandy. Though the ABFEs are advisory in nature, it is expected that information used to develop the ABFEs will be incorporated into the new DFIRMS.

The ABFEs address some of the deficiencies of prior FIRMs with respect to near-shore wave dynamics, run-up, and overland flooding inland of the shoreline. However, like FIRMs, ABFEs maps do not take into account future storm and sea level rise conditions resulting from climate change. They improve the flood mapping methodology for current climate but cannot be used as a guide of flood severity and frequency under future

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[8] A 100-year flood is not a flood that occurs every 100 years. Rather, the 100-year flood has a 26 percent chance of occurring during a 30-year period, the typical length of a mortgage. The 100-year flood is a regulatory standard, used by Federal agencies and most states, to administer the NFIP and floodplain management programs.

[9] FIRMs for each county in the State, and related information, can be accessed via https://www.rampp-team.com/ny.htm.

[10] For FEMA Flood Map Update Schedule, see http://www.floodsmart.gov/floodsmart/pages/flooding_flood_risks/mapScheduleSearch.action?zipCode=10013

[11] Post-Sandy Advisory Base Flood Elevation (ABFE) maps can be accessed from: http://www.region2coastal.com/sandy/abfe and more specifically http://184.72.33.183/Public/NJ/Index_Sandy_North_Region.pdf

conditions. As a minimum, one would have to add sea level rise projections as a "freeboard" or "margin of safety" on top of the ABFEs. Additional areas of potential inundation not delineated on the ABFE maps may result from climate-related changes in storm frequency, intensity and hurricane track patterns.

Though FIRMs and ABFEs are helpful tools for flood planning and prevention, FEMA itself warns against over-reliance on such maps:

> *ABFEs are based on the 1% annual chance flood event. ABFEs may show flood elevations lower than Hurricane Sandy in certain areas because Sandy was a more extreme event than the 1% annual chance flood in those areas. The elevations of the 1% annual chance flood are the NFIP standard for floodplain management. It is important to note that buildings constructed to this standard are still vulnerable to the effects of larger events like Hurricane Sandy…Hurricane Sandy demonstrated that BFEs and flood boundaries on the current effective FIRMs may not have provided an appropriate level of protection for new structures and substantially damaged or substantially improved structures in New Jersey and New York coastal areas.*[12]

Consequently, FEMA advises that in areas where observed water levels for Sandy exceeded ABFEs, it is good practice to build higher and use freeboard on top of ABFEs.[13]

2. Increasing Hazards from Future Climate Change

Human activities, predominately in the form of greenhouse gas emissions and land use changes, are altering our climate system. Preeminent scientific institutions confirm that climate change is underway and will accelerate unless global action is taken to dramatically reduce emissions.[14] Planning decisions, engineering design standards and risk based decision-making models are typically based on analysis of historical climate data, assuming

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[12] FEMA ABFE Frequently Asked Questions, § 1.12 and 2.1. (http://www.region2coastal.com/faqs/advisory-bfe-faq) (Emphasis added.)

[13] Id. at § 2.6.

[14] NAS/NRC (2010). Adapting to Impacts of Climate Change. The National Academies Press. Washington D.C. http://www.nap.edu/catalog.php?record_id=12783; USGCRP, United States Global Change Research Program http://www.globalchange.gov/home and http://www.globalchange.gov/resources/reports ; IPCC, Intergovernmental Panel on Climate Change http://www.ipcc.ch/ and http://ipcc-wg2.gov/SREX/ . See also, Parris et al. 2012. Global Sea Level Rise Scenarios for the US Climate Assessment. NOAA Tech. Memo OAR CPO-1 http://cpo.noaa.gov/sites/cpo/Reports/2012/NOAA_SLR_r3.pdf

past conditions are an appropriate proxy to inform future decisions, a concept known in statistics as a “stationary process”. Climate change renders this approach invalid.

Projections of climate change can help inform new decision-making paradigms. More than twenty national and international laboratories have spent decades refining models that project future global climate change. Uncertainty in these projections results from an imperfect understanding of the earth’s climate system and not knowing with exactitude the future rate of change of greenhouse gas emission profiles. Multiple scenarios incorporating future conditions are modeled to generate bounds of future climate conditions.

For individuals, businesses, governments and other organizations that must decide how to build or maintain assets and systems vulnerable to future climate change, the current global climate models project future conditions at a spatial scale (*e.g.*, State or region) that is often not useful to inform local decisions. To provide the level of granularity necessary on a local scale, additional “downscaling” of this output from global climate models is necessary. Fortunately, for Con Edison and other owners and operators of expensive, long-lived, critical infrastructure, downscaled climate projections are available for important climate variables in future decades for all regions of New York State, including the New York City metro area.

For New York City, the NPCC (2010) downscaled the likely changes in climate (relative to a pre-2000 baseline) for a number of climate parameters at three future time horizons: the mid-2020s, 2050s, and the 2080s. It generated mean values of climate parameters, such as temperature, precipitation and sea level rise as shown in Table 1.

TABLE 1.

Baseline Climate and Mean Annual Changes[1]

	Baseline 1971-2000	2020s	2050s	2080s
Air temperature Central range[2]	55° F	+ 1.5 to 3.0° F	+ 3.0 to 5.0° F	+ 4.0 to 7.5° F
Precipitation Central range[2]	46.5 in	+ 0 to 5 %	+ 0 to 10 %	+ 5 to 10 %
Sea level rise[3] Central range[2]	NA	+ 2 to 5 in	+ 7 to 12 in	+ 12 to 23 in
Rapid Ice-Melt Sea Level Rise[4]	NA	~ 5 to 10 in	~ 19 to 29 in	~ 41 to 55 in

[1] Based on 16 GCMs (7 GCMs for Sea Level Rise) and 3 emissions scenarios. Baseline is 1971-2000 for temperature and precipitation and 2000-2004 for sea level rise. Data from National Weather Service (NWS) and National Oceanic and Atmospheric Administration (NOAA). Temperature data are from Central Park; Precipitation data are the mean of the Central Park and La Guardia Airport values; and sea level data is from the Battery at the southern tip of Manhattan (the only location in NYC for which comprehensive historic sea level rise data are available).

[2] Central range = middle 67% of values from model-based probabilities; temperatures ranges are rounded to the nearest half-degree, precipitation to the nearest 5%, and sea level rise to the nearest inch.

[3] The model-based sea level rise projections may represent the range of possible outcomes less completely than the temperature and precipitation projections. For more information, see the "sea level rise" paragraph in the "mean annual changes" section.

[4] "Rapid ice-melt scenario" is based on acceleration of recent rates of ice melt in the Greenland and West Antarctic Ice sheets and paleoclimate studies. See Annex C for further description.

Source: NPCC 2010

While the average projected values for temperature, precipitation and sea level rise set forth in Table 1 are useful for general planning purposes, the vulnerability of critical infrastructure systems may be better ascertained by examining projected weather *extremes* as outlined in Table 2.

a. <u>Increasing Frequency and Severity of Coastal Flooding Due to Sea Level Rise.</u>

The NPCC projections for changes in future coastal flood frequency and flood heights due to storm events (bottom six rows in Table 2) were based on the lower range sea level rise forecasts developed using the methodology of the IPCC in 2007.[15] These projected values are lower than what would be expected under the rapid-ice melt (RIM) scenario referenced in Table 1. Although not published in its 2010 report, NPCC made additional flood computations for the RIM sea level rise scenario. The changes in coastal floods and storms using this RIM model are shown in Table 3. Significantly, the increase in flood frequency using either sea level rise scenario identified in Tables 2 and 3 is attributable to projected sea level rise only. Increased storm frequency and intensity, which are expected as a result of climate change, would further reduce flood recurrence intervals or, conversely, increase the annual exceedance probabilities.[16]

The coastal flood frequency increase (or reduction in storm average recurrence period) due to the IPCC-model based sea level rise scenario for the 1-in-100 year coastal flood (or 1%/yr flood) approximately doubles for the 2050s compared to the current base line (Table 2, fourth row from the bottom). By contrast, the equivalent increase in coastal flood frequency for the RIM scenario is much higher (1 in 100 yr. return period, Table 3).[17] For this 1%/yr coastal flood, the amplification factor ranges from about 5 to 10 for the 2050s. That is to say, a critical infrastructure that historically would flood, on average, with an annual chance of 1%/yr prior to 2000, will have a 5 to 10%/yr annual chance of flooding in the 2050s (or an average recurrence period of about 10 to 20 years).

[15] The IPCC methodology has been criticized for failing to accurately account for melting land-based ice sheets which contribute significantly to rising sea levels. The IPCC has reported that it will be producing revised sea level rise estimates using a modified methodology, to be released in the fall of 2013.

[16] Flooding determinations and probabilities are based on recurrence intervals. The United States Geological Survey (USGS) defines a recurrence interval as the average number of years between floods of a certain size.

[17] Note that the forecasts (Tables 2 and 3) apply only for the Battery Park area in New York City. Other areas of the City may be affected differently.

TABLE 2.

Quantitative Changes in Extreme Events

Note: Extreme events are characterized by higher uncertainty than mean annual changes. The central range (middle 67% of values from model-based probabilities) across the GCMs and greenhouse gas emissions scenarios is shown. See Appendix B for the full range of values

	Extreme Event	Baseline (1971-2000)	2020s	2050s	2080s
Heatwaves & Cold Events	# of days/year with maximum temperature exceeding:				
	90° F	14	23 to 29	29 to 45	37 to 64
	100° F	0.4[1]	0.6 to 1	1 to 4	2 to 9
	# of heat waves/year[2]	2	3 to 4	4 to 6	5 to 8
	Average duration (in days)	4	4 to 5	5	5 to 7
	# of days/year with minimum temperature at or below 32° F:	72	53 to 61	45 to 54	36 to 49
Intense Precipitation & Droughts	# of days per year with rainfall exceeding:				
	1 inch	13	13 to 14	13 to 15	14 to 16
	2 inches	3	3 to 4	3 to 4	4
	4 inches	0.3	0.2 to 0.4	0.3 to 0.4	0.3 to 0.5
	Drought occurs, on average[3]	~once every 100 yrs	~once every 100 yrs	~once every 50 to 100 yrs	~once every 8 to 100 yrs
Coastal Floods & Storms[4]	1-in-10 yr flood to reoccur, on average	~once every 10 yrs	~once every 8 to 10 yrs	~once every 3 to 6 yrs	~once every 1 to 3 yrs
	Flood heights associated with 1-in-10 yr flood (in feet)	6.3	6.5 to 6.8	7.0 to 7.3	7.4 to 8.2
	1-in-100 yr flood to reoccur, on average	~once every 100 yrs	~once every 65 to 80 yrs	~once every 35 to 55 yrs	~once every 15 to 35 yrs
	Flood heights associated with 1-in-100 yr flood (in feet)	8.6	8.8 to 9.0	9.2 to 9.6	9.6 to 10.5
	1-in-500 yr flood to reoccur, on average	~once every 500 yrs	~once every 380 to 450 yrs	~once every 250 to 330 yrs	~once every 120 to 250 yrs
	Flood heights associated with 1-in-500 yr flood (in feet)	10.7	10.9 to 11.2	11.4 to 11.7	11.8 to 12.6

1. Decimal places shown for values less than 1 (and for all flood heights), although this does not indicate higher precision/certainty. More generally, the high precision and narrow range shown here are due to the fact that these results are model-based. Due to multiple uncertainties, actual values and range are not known to the level of precision shown in this table.

2. Defined as three or more consecutive days with maximum temperature exceeding 90° F.

3. Based on minima of the Palmer Drought Severity Index (PDSI) over any 12 consecutive months. More information on the PDSI and the drought methods in general can be found in Appendix B.

4. Does not include the rapid ice-melt scenario.

Source: NPCC 2010

TABLE 3: Preliminary estimates of coastal flood heights and frequencies using the Rapid Ice Melt Scenario (RIMS) sea level rise estimates.[1]

Extreme event	Baseline flood (1971-2000)	2020s	2050s	2080s
1-in-10 yr flood ht, ft	6.3 ft	6.7 to 7.1 ft	7.9 to 8.7 ft	9.7 to 10.9 ft
1-in-10 yr return Period changes to	10 y	4.6 to 6.9 y	<1 to 2.2 y	<1 y
1-in-100 yr flood ht, ft	8.6 ft	9.0 to 9.4 ft	10.2 to 11.0 ft	12.0 to 13.2 ft
1-in-100 yr return period changes to	100 y	42 to 63 y	9 to 20.5 y	1.1 to 3.4 y
1-in-500 yr flood ht, ft	10.74 ft	11.2 to 11.6 ft	12.3 to 13.2 ft	14.2 to 15.3 ft
1-in-500 yr return period changes to	500 y	290 to 375 y	72 to 159 y	8.8 to 27 y

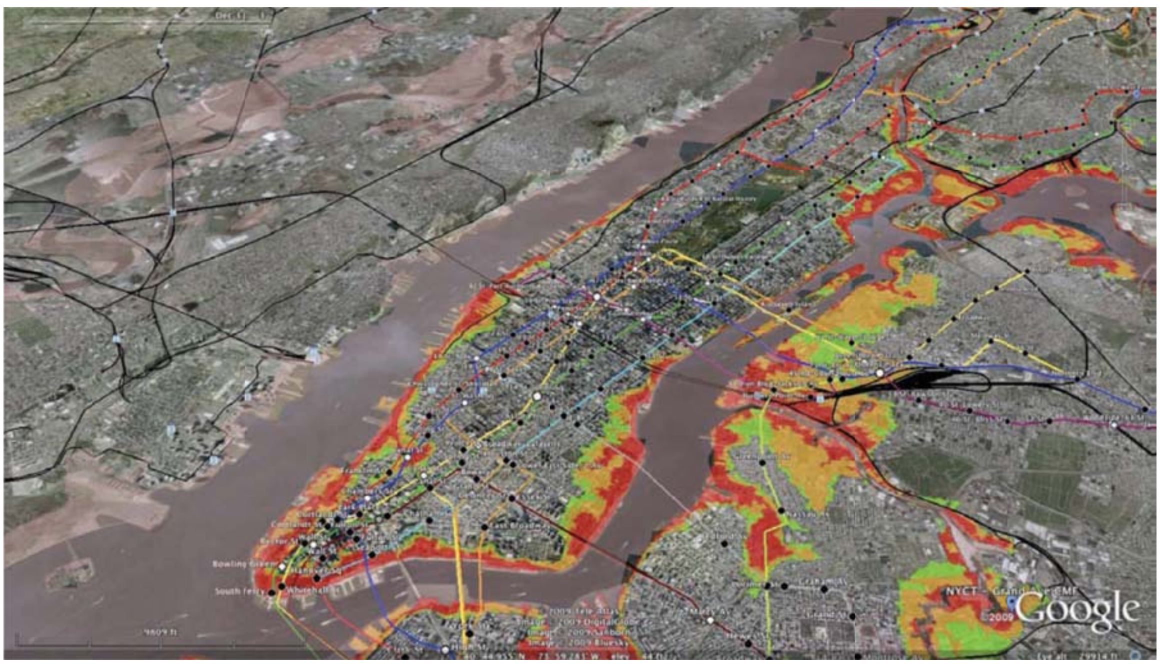
[1] Due to incomplete understanding of ice sheet melt dynamics, there are large uncertainties associated with these estimates that must be incorporated into decision-making models for capital expenditures and project prioritization.

Projected sea level rise for the rapid ice melt scenario (*see Horton*, *et al*., in NPCC 2010 report) for the indicated decades (mean of 2020-2090 etc.) relative to base period (mean of 2000-2004). Flood heights and return periods are for combined nor'easters and hurricanes at high tide, wave setup not included (*Gomitz* in *Rosenzweig* and *Solecki* 2001). Datum is NAVD88.

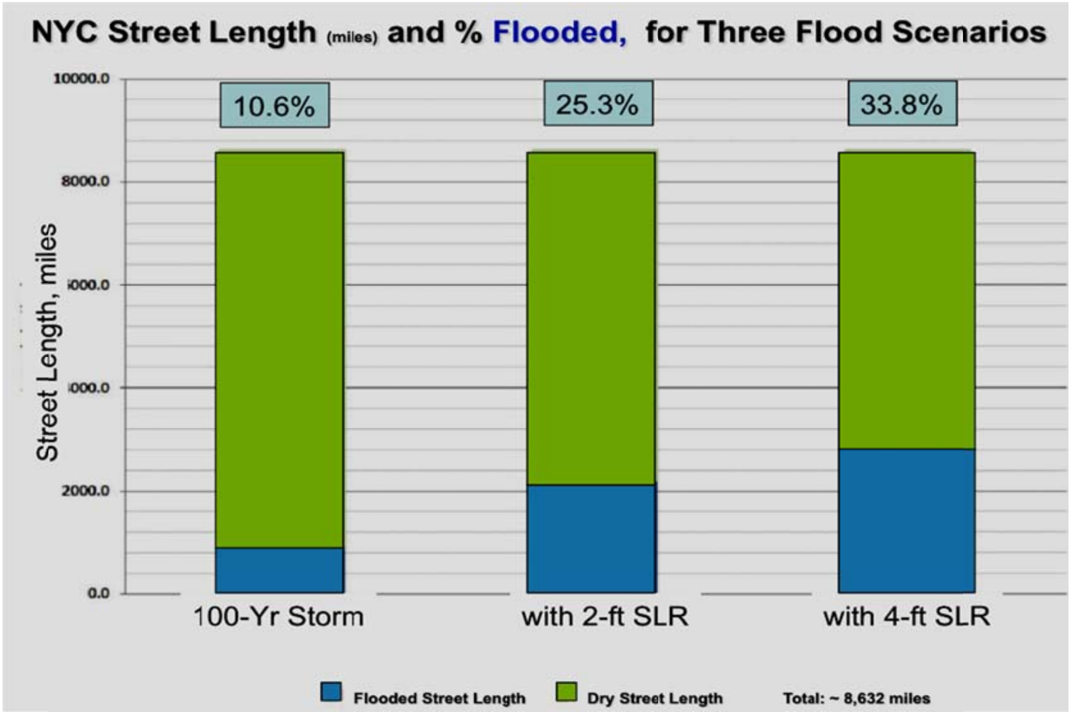
Source: Center for Climate Systems Research, Columbia University

Updated Tables 1 and 3 from the NPCC, as part of New York City's post-Sandy Special Initiative for Rebuilding and Resilience (SIRR) may combine the two distinct sea level rise projections into a single new forecast based on new scientific findings and methods. Regardless of which sea level rise forecast is used for future planning, however, one thing is clear: sea level rise exerts a strong influence on coastal flood frequencies and flood heights. These forecasts must therefore be taken into account when planning for flood risk reduction and their consequences for infrastructure services, business continuity, and sustainability in the New York City metropolitan area.

A visualization of how the flood risks in Manhattan and parts of Queens and Brooklyn will increase with sea level rise is shown in Figure 1. It shows the increasing landward reach of the 1%/year FEMA flood zones as defined and mapped pre-2012 (red areas), and how this 1%/year flood zone laterally extends inland for a two foot sea level rise (yellow zone) and for a four foot sea level rise (green zone). It is expected that NPCC will update such maps for the NYC area in June 2013, using the latest FEMA flood zone maps and the latest NPCC sea level rise projections for the 2020s and 2050s.



<u>Figure 1:</u> Growth of the FEMA 1%/year flood zone (red) for portions of NYC and its landward growing extent for a 2ft (yellow) and 4ft (green) sea level rise, respectively. Source: ClimAID, Chapter 9, Jacob et al. (2011).



<u>Figure 2:</u> Increase of the total length of streets in New York City flooded by the 1%/yr flood at sea level elevation in year 2000(left), and with 2ft (center) and 4ft (right) sea level rise. Source: ClimAID, Chapter 9, Jacob et al. (2011).

Figure 2 illustrates how flood hazards for New York City streets increase with sea level rise. It depicts the increasing percentage of streets that will be flooded by the 1%/year flood for the pre-2000 base line sea level, and for two foot and four foot sea level rise, respectively. The amount of flooded streets increases from about 1/10 to 1/4 to 1/3 of the total street length in New York City (approximately 8,600 miles). This street level inundation may result in flooding of subgrade and grade level basements and floors, manholes, and electrical installations. Such flooding can result in significant damage and widespread service interruptions unless the equipment and systems are designed to be submersible, raised to higher elevations and/or made resistant to saltwater exposure.

In summary, by the mid-2050s, climate change induced sea level rise could increase the hazard exposure of the built assets of New York City and its infrastructure by factors 3 to 10 (compared to the pre-2000 base line). The expected annualized economic losses may increase by similar multipliers unless the vulnerability of assets and systems is reduced by carefully designed engineering and risk reduction measures.

My assessment focuses largely on the combined effect of sea level rise and coastal storm surge floods. For example, it reveals the risk posed to low-lying areas near the waterfront and, the encroaching threat over time, to areas further inland. There are several other climate change effects to consider, such as the increase in number of days per year with extreme hot temperatures (Table 2). Such heat waves can increase peak demand for power to satisfy additional needs for air conditioning, stressing the grid's ability to provide sufficient power to all customers. Other climate related threats to the power grid may also increase due to change in wind, snow and ice storms,[18] but the likelihood for these changes are less clear than those related to sea level rise and coastal flood hazards. Utilities will need to continuously track the NPCC or other authoritative climate forecasts to ensure operation and planning decisions are based on the best available information.

C. <u>Climate-Risks to the Con Edison System</u>

Given the location of Con Edison's critical infrastructure and service territory, current and future coastal flooding associated with sea level rise due to climate change poses serious risks to Con Edison's ability to deliver safe, reliable and cost-efficient service to its customers. As the tables above illustrate, frequency and severity of flooding due to coastal storms is likely to increase manifold over the duration of this century. The projected rate of increased flooding is slow initially (less than a factor of 2 by the mid-2020s) but progresses rapidly in the years 2050s and beyond. Due to the rising risk of damage to infrastructure and service interruptions over the next several decades, Con Edison is faced with a race against time to reduce system vulnerabilities in a cost-effective manner.

D. <u>Climate Change Adaptation and Coastal Flood Risk Reduction</u>

To adapt to rising sea levels and coastal storm surge risks, there are fundamentally three basic options available: (i) Defend and Protect, (ii) Accommodate, and (iii) Managed Retreat. Although they involve distinct approaches to reducing risk, each of these options require planning, and to a large extent, coordination of public and private resources.

<u>Defend and Protect</u>. This mode of adaptation comes in two forms: as *centralized protection* (for example, a system of storm surge barriers, levees and pumping systems like the New Orleans, LA, system; the Dutch 'Delta' water works; or the London Thames River barriers). It is designed to protect an entire region or estuary from inundation. This centralized version of protection involves largely the public sector, large investments in time and capital, and inter-governmental coordination and integration over many jurisdictions, interests and stakeholders. Time horizons are from one to several decades after commitment to this approach before the centralized protection measure becomes effective, and the measure has a limited life-time of effectiveness because of continued sea level rise. An additional limitation of barriers is that they cannot be closed permanently due to the need for local rivers (*e.g.*, the Hudson, Raritan, Passaic Rivers in the NY/NJ estuary) to drain into the ocean. In the wake of Superstorm Sandy, the U.S. Army Corps of Engineers is conducting a feasibility study for estuary wide protection in the tri-state area that could include barriers. Until this study is completed, no published estimates are available for how long a barrier system could be effective and sustainable. Depending on future rates of sea level rise, a barrier system may function sustainably for one to two centuries.

The second Defend/Protect mode is *decentralized protection* and could be implemented on a neighborhood basis (*e.g.*, block-by-block, street-by-street, or asset-by-

[18] Jacob et al. (2011), ClimAID Chapter 10.

asset). For this mode of adaptation, the private sector assumes a larger proportion of the costs as the size of the unit to which the protective measures are applied decreases. One example of this approach is the "HafenCity" project[19] in Hamburg, Germany; it is a publicly guided multi-street-block rejuvenation project with private partners designed to waterproof an entire streetscape in an historic harbor exposed to sea level rise and storm surges.

Accommodate. This second option, to accommodate flood waters, can be designed on various spatial urban scales but in most cases needs implementation on an individual asset scale (unless appropriately combined with the above decentralized defend/protect option). For individual buildings this requires, in FEMA terminology, "wet-proofing," a strategy of allowing water to flood portions of an asset with minimal physical damage while retaining the ability to quickly return to full functionality after the flood waters retreat. This is also referred to as resiliency. This requires all utility connections inside the customer's assets to be either submersible and resistant to salt water corrosion, or installed above minimum flood elevation levels.

Managed Retreat. Managed retreat on an urban scale is a slow, politically unpopular (at least on the short term), and seemingly costly option, but may, over extended periods of time (a hundred or more years), be the safest and most cost-beneficial option. It only is possible where areas with sufficiently high topography are available or can be made available over time by rezoning for appropriate densities. New York City, in contrast to New Orleans, Miami, or Rotterdam has the benefit of areas with high topography that, due to sea level rise, sooner or later will see the need for densification, while some low-lying areas with low or modest asset investment density may see a thinning out of asset densities over time. On an individual asset basis, such as for a utility, managed retreat can be in two forms: *laterally* moving assets to higher ground, if available, or *vertically* raising assets in place to higher elevations by an engineered solution.

While the above approaches of mitigating and adapting to flood risk are available to a utility provider like Con Edison in varying degrees, a utility's need to physically connect to its customers, where ever they are located, requires consideration of customers' decisions as to whether they will defend/protect their individual assets, accommodate or vertically retreat (elevate assets) from flood waters.

[19] http://www.hafencity.com/en/overview.html and http://www.hafencity.com/en/overview/facts-figures.html

E. Con Edison's Storm Hardening Proposal

> *"It's clear that weather patterns are changing. Severe storms are becoming more frequent and destructive. In August 2011, Hurricane Irene knocked nearly 204,000 Con Edison customers out of service. At the time, that was the largest storm-related outage in our long history. Just 14 months later, Superstorm Sandy knocked five times as many customers out of service." – Excerpt, Con Edison 2013 Rate Case Q&A*[20]

Con Edison has proposed to invest approximately $1 billion in hardening measures because it is all too well aware that the increasing frequency and intensity of storms pose significant risks to its infrastructure and system reliability.[21] Con Edison has acknowledged that Superstorm Sandy was the most damaging storm to hit the Company in its 120 year history, resulting in approximately 1,115,000 customer outages in its electric system.[22] Even prior to Sandy, the Company had begun to implement initiatives to harden its system against extreme storm and flood events.[23] Con Edison now proposes to continue and expand its hardening program over the next three years.[24]

According to Company filings, a corporate System Design Task Force was established in December 2012 to develop and recommend both short and long-term hardening initiatives and system design changes that would mitigate the impacts of future

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[20] http://www.coned.com/documents/2013-rate-filings/2013-rate-case-qa.pdf

[21] In its 2013 Corporate Coastal Storm Plan (CCSP), Con Edison states that the Company: "faces a variety of threats to providing reliable service to its customers, including natural hazards such as storms. Under certain conditions, a significant coastal storm can cause large-scale and wide-spread disruptions to our customers throughout the region, and can impact our energy system infrastructure and facilities". CCSP p. 3. The CCSP is accessible at: http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={347A2FB6-6DAF-40F4-BE6C-501B2171A87A}

[22] Electric Infrastructure and Operations Panel Testimony (EIOPT), pp. 14-15; accessible at http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={A3EFED44-5E61-42B6-9348-7AB59BAA8CB5}. The vast majority of service outages was due to flooding and associated salt water corrosion of equipment. According to the January 11, 2013 Con Edison Part 105 Report to PSC on Sandy Preparation and System Restoration, "Sandy's relentless winds and unprecedented storm surge caused damage across the region unlike anything we've ever seen. Catastrophic flooding and corrosive salt water destroyed electrical equipment and downed trees ravaged our overhead system, making repairs difficult and time-consuming." Report, p. 2. The report is accessible at http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={2D1BF3D9-95DC-4C2D-9F24-6DE65926275B}

[23] EIOPT, p. 15.

[24] Id., pp. 22-42.

weather-related events, such as the damage which resulted from flooding and high winds during Superstorm Sandy.[25] Proposed initiatives include a range of flood prevention measures at power generation facilities, transmission substations, area substations and unit substations. For example, to protect vulnerable equipment from flood waters, the Company has proposed elevation of pumps, relays, control panels and control rooms, and emergency diesel generators, together with enhanced sealing of connection and termination points. Further measures include installing flood barriers, watertight doors, sluice gates, and flood pumps to prevent the migration of water into stations. To address flooding concerns for its distribution system and customer facilities, which include damage to non-submersible installations and stray voltage, Con Edison has proposed among other things, relocation of equipment to higher elevations, installing barriers and pumps, and development of submersible equipment. Also proposed is reconfiguring network boundaries to align with hurricane flood impact areas and sectionalizing switches to facilitate isolation of a network to minimize outages in the event of a preventive shutdown. Enhancements to the Company's electric transmission system and generation facilities have also been proposed. These include physical flood barriers around the perimeter of facilities, elevation of critical equipment, and increased use of fiber-optic based salt water-resistant equipment. The Company intends to implement these and other measures in two phases: the immediate hardening phase, beginning June 2013, and the second, full hardening phase over the next three years, ending in 2016. Con Edison's specific proposals to harden its electric system are discussed in greater detail in the Electric Infrastructure and Operations Panel's Exhibit IIP-6 and March 25, 2013 Revised Exhibit IIP-6.[26]

While the Company's list of hardening proposals is extensive, the design basis for the proposals do not appear to take into consideration increased coastal flooding risk due to rising sea levels. For example, the Company has indicated in its March 25, 2013 update that the design standard for its proposed area and transmission station upgrades is: "based on the flood levels considered and anticipated by the Company under the 'Immediate Storm Hardening' phase, which considers the higher of the (1) observed Sandy level at each of the facilities, (2) the 2010 Category I levels as predicted by the National Weather Service's SLOSH[27] Maps, and (3) the 2007 FEMA Maps.[28] The Company is designing (as a

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[25] Id., pp. 21-29.

[26] Id., p. 36. EIOPT Exhibit IIP-6 is accessible at http://documents.dps.ny.gov/public/Common/ViewDoc.aspx?DocRefId={1BA71027-19F1-4DB4-8F83-F8629C717721}.

[27] SLOSH stands for Sea, Lake, and Overland Surge from Hurricanes. It is a computer model developed by the National Weather Service (NWS) to estimate storm surge heights associated with a particular storm category, storm track and wind field of a forecast hurricane. It can be used to estimate the potential flooding from storm surge for a given location from an approaching hurricane. Accuracy for the SLOSH model is generally within plus or minus 20% of the actual peak storm surge. When large ensembles of historical, hypothetical or predicted storms with different tracks, wind fields and forward-speed are computed by multiple SLOSH computer runs, SLOSH maps produce, for any given shore location, the maximum surge height from all SLOSH runs for hurricanes of a given category. But one cannot directly assign probabilities to the SLOSH map surge elevations. Other procedures are required to achieve probabilistic surge elevations. SLOSH maps provide some general

minimum) to the higher of these 3 levels."[29] Notably lacking is any reference to free-board or extra margin of safety to be added to the design minimum to account for rising seas or storms more powerful than Sandy.

Elsewhere, in what appears to be a post-Sandy analysis of flood protection approaches by its System Design Task Force [30] Con Edison considers the addition of freeboard to its flood elevation design benchmarks. According to this document, the factors the Task Force considered to determine its design basis consisted of the higher of: 1) Observed Sandy flood levels; 2) Base Flood Elevations (2007 FEMA map) **+ 2 feet** (emphasis added); 3) Con Edison Flood Control Design, and 4) 2010 SLOSH maps for a Category 1 hurricane. To the extent Con Edison is basing its design standard in part on FEMA base flood elevations (BFEs), it is unclear whether the Company is considering adding freeboard as referenced in the Task Force document. [31]

The Task Force apparently also developed design flood elevations for various facilities based on SLOSH maps for a Category 2 hurricane but excluded them as criteria for final flood design consideration. No explanation was given for this decision, even though the Company itself acknowledges that Category 1 and 2 hurricanes affect the region once every 19 years and the effects of such storms would be "devastating" to the Company's southerly networks in Brooklyn and Queens, as well as those in Manhattan.[32]

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guidance, for instance have been used by emergency services for evacuation planning, but generally are not used for design and construction or code purposes. For more details see for instance: http://slosh.nws.noaa.gov/sloshPub/pubs/Vol-33-Nu1-Glahn.pdf

[28] Also referred to as a FIRM.

[29] EIOPT, Revised Exhibit IIP-6, p. 94.

[30] Con Edison System Design Task Force, "Central Engineering Flood Protection Approaches and Control Level Determination for Generating Station and Substation Facilities – Immediate Hardening Measures to be completed by Hurricane Season of 2013 (Draft)," provided by Con Edison in response to New York City Interrogatory No. 181.

[31] Not only is it unclear which flood elevation benchmarks Con Edison is proposing to use for its storm hardening measures, but it also appears that Con Edison's approach to storm surge is inconsistent with the storm hardening the company requires of some of its customers. In its January 11, 2013 Part 105 report, the Company states that after Hurricane Katrina (August 2005) it has required that "all new distribution transformer installations at large customer facilities within a Category 3 Hurricane storm surge zone" either be "submersible designs when equipment is installed in the sidewalk at street level" or in "interior transmission vault structures at the second floor or higher" if the equipment is non-submersible (Con Edison Part 105 Report, p. 19). Con Edison points to IKEA in Brooklyn, Goldman Sachs headquarters in Battery Park City in Manhattan, and the Hunters Point Development in Queens as completed projects built to its Category 3 Hurricane storm surge zone design standard. (*Id.*, p. 20). In effect, the Company seems to require certain customers to prepare for a Category 3 hurricane storm surge but itself prepares for only a Category 1 hurricane storm surge.

[32] EIOPT, Revised Exhibit IIP-6, p. 178.

Regardless of whether Con Edison considers FEMA BFEs with or without a 2-foot freeboard, or a Category 1 or 2 hurricane, the fact of rising sea levels has been entirely ignored. This omission is critical, since the FEMA and SLOSH maps relied upon by the Company as flood elevation benchmarks also do not incorporate rising sea levels.

Con Edison's reliance on the observed flood levels during Superstorm Sandy, together with FEMA and SLOSH maps, for establishing flood design standards engenders significant risk. Using Sandy flood levels as a benchmark for system enhancements reflects a deterministic approach which relies exclusively on past experience. However, if anything, Sandy has shown that history is a poor predictor of the future. Reliance on observed water levels from a single storm is an overly simplistic means of setting a design standard, is unlikely to be efficacious, and is inconsistent with standard probability-based risk management principles and best practices.

Similarly, designing to base flood elevations on FIRMs -- particularly outdated, 2007 FIRMs -- may not sufficiently protect against increasing flood risks. As discussed earlier, ABFEs are now available with more up to date information as to current flooding hazards for the New York City area. SLOSH maps do not adequately account for near-shore wave dynamics and run-up, significant considerations along a coast line such as New York City's. Most importantly, neither FEMA maps nor SLOSH maps account for future sea level rise.

Con Edison has by and large presented a single-option for each of its storm hardening/mitigation measures without explaining what risk levels it is guarding against, and what the costs and benefits would be if other options were pursued and implemented. Rather, Con Edison should evaluate multiple alternative adaptations to current and future flood hazards to optimize cost effectiveness, technical feasibility, and long-term sustainability. Providing information about the various incremental costs associated with constructing a storm surge barrier at different heights, for example, would allow the Company and the PSC to identify the incremental cost associated with increasing margins of safety.

Although the evolving nature of climate-related risk poses planning challenges, it is not a basis for lack of foresight and action.[33] Indeed, the benefits of a well-planned mitigation or adaptation strategy can far exceed the costs. In one celebrated example of a wise investment in flood mitigation, FEMA issued a grant to the coastal town of Freeport, New York to regrade and raise streets well above the base flood elevation. While the total cost of the project was $2.76 million, the benefits from reducing the town's flood risk was estimated to be $6.52 million.[34] In another example of prudent planning, the designers of the

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[33] Smith and Stern (2013).

[34] Major et al. (2011), "Mainstreaming Climate Change Adaptation Strategies into New York State Department of Transportation's Operations. Final Report, October 31, 2011. https://www.dot.ny.gov/divisions/engineering/technical-services/trans-r-and-d-repository/C-08-09_synthesisfinalReport1.pdf , citing Multihazard Mitigation Council, 2005, p. 107. *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings from Mitigation Activities*, vol.

Confederation Bridge, which links Prince Edward Island and New Brunswick, Canada, made the bridge "one meter higher than it would otherwise have been" in order to accommodate rising sea levels.[35]

Given that Con Edison's proposal involves hardening of assets to a standard with undefined safety margins against future sea level rise, or against storms potentially stronger than Sandy, the question arises: are Con Edison's measures safe enough, and for what criticality of asset? Why does Con Edison fail to account for sea level rise in its flood design parameters even though data regarding rising sea levels and its anticipated impacts have been widely available to the public? Why does Con Edison reject from consideration FEMA's February 2013 ABFEs, pending the establishment of a "consistent design basis" by "all affected utilities, agencies and other organizations which have a direct impact on the steam and electric infrastructure"?[36] Flood maps, building codes and industrial codes can, and will, change over time and Con Edison must, at a minimum, keep abreast of such changes. But since these codes are not yet updated to take into account rising sea levels, Con Edison's internal design programs need to factor in rising sea levels now, and do so with a long-term vision.

Effective management of climate-related risk requires that the Company evaluate potential mitigation options in the context of climate risks over various time horizons (*e.g.*, to a 2050-time horizon), for a range of hazard probabilities (*e.g.*, 1%/yr vs. 0.2%/year flood probability), and the expected life span, cost, and criticality of the assets to be protected. In assessing criticality, the Company should consider both the criticality and value of its own assets, as well as the criticality to the public (*e.g.*, service to hospitals, emergency services, financial markets, etc.). Although the Company's own "enterprise risk management" and "capital project optimization" processes[37] call for thorough assessments of risks and benefits using quantitative methods, because of Con Edison's failure to incorporate future climate risks and perform cost benefit analyses, it does not appear that Con Edison has done so for its storm hardening proposals.

III. Conclusion

Con Edison has proposed a series of storm hardening and other measures to protect its system against damage due to future storms and to increase system resiliency. However, Con Edison has failed to engage in a robust evaluation of the full range of climate-related risks and potential risk mitigation/adaptation measures. More specifically, by failing to consider

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2: Study Documentation. Washington DC: National Institute of Building Sciences.

[35] Major et al. (2011), citing Titus, J., "Does Sea Level Rise Matter to Transportation Along the Atlantic Coast?" in United States Department of Transportation Center for Climate Change and Environmental Forecasting, 2002, *The Potential Impacts of Climate Change on Transportation*. Federal Research Partnership Workshop Summary and Discussion Papers, p. 141.

[36] EIOPT, Revised Exhibit IIP-6, p. 95.

[37] EIOPT, pp. 54-57.

recent data and reports regarding rising sea levels and their potential to significantly increase coastal flooding, Con Edison has ignored available information essential to identifying risk to a vast segment of its critical infrastructure. Moreover, the company's proposals detail specific storm hardening measures but fail to identify alternative design/retrofit options and their cost effectiveness.

Based on my professional experience as a disaster risk management expert, it is my opinion that in order to ensure Con Edison's investment in future storm hardening efforts are prudent and cost-effective, the PSC should require that Con Edison develop and employ a comprehensive and transparent risk management strategy that sufficiently takes into account current and forecast climate change impacts for the NYC metropolitan area, including increased coastal flooding due to rising sea levels. The PSC should further require that such management strategy identify and evaluate the costs and benefits of proposed mitigation and adaption measures and of alternatives not only to itself, but also to its customers and for the public at large.

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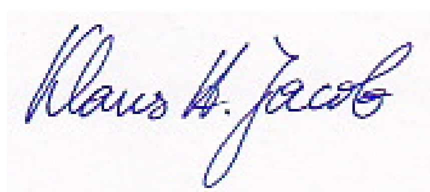
New York State Office of Attorney General,



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V. Addendum – Curriculum Vitae of Klaus H. Jacob, Ph.D.

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1999-2005: Adj. Professor, Department of Environmental Sciences, Barnard College.
1973-2001: Senior Research Scientist, LDEO of Columbia University.
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1968-1969: Post-Doctoral Scientist, LDEO of Columbia University
1964-1968: Research Assistant, Meteorology & Geophysics, Goethe Univ. Frankfurt, Germany.
1963-1964: Visiting Research Scientist, BP Research Center, Sunbury on Thames, UK.

Dr. Jacob is a geophysicist with Columbia University where he carried out basic and applied research in the Earth Sciences for more than 44 years. Currently he is a Special Research Scientist / Emeritus Research Professor at Columbia's Lamont-Doherty Earth Observatory, and Adjunct Professor at Columbia's School of International and Public Affairs where he teaches Disaster Risk Management; he also taught at the Department of Environmental Sciences at Barnard College, and Disaster Resilient Urban Planning at Columbia's Graduate School of Architecture, Planning and Preservation. His recent research focus is climate change and sea level rise, and impacts on infrastructure of major coastal cities. He serves on the Mayor's *New York City Panel on Climate Change* (NPCC), the state's *ClimAID* study; prepared a MTA climate change adaptation plan; and coauthored the National Academy / Transportation Research Board's report on *Potential Impacts of Climate Change on U.S. Transportation*. Prior activities included seismic hazard and risk analysis for large dams and nuclear power plant sites; he was a cofounder of the National Center for Earthquake Engineering Research. He is a coauthor of the NYC and national seismic building code and has performed seismic modal analysis of large New York City bridges and buildings; and seismic and volcano studies in Alaska's Aleutian Islands, and on 6 continents.

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Synergistic Activities:

- Invited Speaker at numerous organizations, panels, and government agencies on Climate Change Risk Assessment and Adaptation; including: NYC DDC, FTA, FHWA, HUD, AIANY, NYASLA, NYSDOT, NYSATE, others.
- 2009-2012: Team Member of NYSERDA/ClimAID study: Lead author on Transportation (Chapter 9) and Telecommunication (Chapter 10).
- 2008-current: Member New York Panel on Climate Change, NPCC: Lead author on Chapter 7 (Indicators and Monitoring).
- 2007-Current Member, Board of Directors, Scenic Hudson Inc.
- 2007-2009: MTA Blue Ribbon Commission on Sustainability. Working Groups on TOD, and Adaptation Strategies to Climate Change. Wrote CC Adaptation Chapter.
- 2005 - 2008: Executive Committee Member of the US National Academies' Transportation Research Board's Committee on Climate Change and U.S. Transportation; see: http://onlinepubs.trb.org/onlinepubs/sr/sr290summary.pdf
- 1999-2008: Member, Board of Direction, Multihazard Mitigation Council (MMC) of the National Institute of Building Sciences, Washington D.C. see: http://www.nibs.org/MMC/mmcleads.html
- 1999-2002: Editorial Board of *Earthquake Spectra,* EERI
- 1980-1990: Co-PI and Co-Founder of National Center on Earthquake Engineering Research (NCEER). Team Leader for Engineering Seismology and Strong Ground-Motions.
- 1991-1992: NY Academy of Sciences: Chairman, Div. Geolog. Sciences.
- 1987-1992: Committee on Seismology, National Academy of Sciences.
- 1992-1997: NY City Seismic Building Code (Chair, Geotechnical Section), and NEHRP National (Seismic) Building Model Code Update Committees.
- 1989-1992: Chairman, Technical Advisory Committee, NYS Emergency Management Office.

Recent Honors:

In 2012 *Time* Magazine named Dr. Jacob as one of globally 50 "people that mattered in 2012", for his correct forecast of the consequences of a SANDY-like storm on the NYC metropolitan area and its infrastructure, just one year before SANDY hit the area validated these assessments.