5) Vulnerability Assessment Methodology

To address the requirements of the Disaster Mitigation Act of 2000 and better understand the potential vulnerability and losses associated with hazards of concern, New York City used standardized tools including the HAZUS-MH modeling software, combined with local, state, and federal data to conduct the vulnerability assessment.

a) HAZUS-MH Methodology

HAZUS-MH is a nationally applicable standardized methodology and software program, developed by FEMA, which is under contract with the National Institute of Building Sciences. The program estimates potential losses from earthquakes, hurricane winds, and floods. In HAZUS-MH, current scientific and engineering knowledge is coupled with Geographic Information Systems (GIS) technology to produce estimates of hazard-related damage before, or after, a disaster occurs.

Potential loss estimates analyzed in HAZUS-MH include:

- **Physical damage** to residential and commercial buildings, schools, critical facilities, and infrastructure.
- **Economic loss**, including lost jobs, business interruptions, repair and reconstruction costs.

HAZUS-MH is designed to generate estimates of hazard-related damage to a city or a region for a specific "hazard event" (that is, an earthquake, hurricane, or flood of a given severity and location, also known as a deterministic event) or it can model the effects of probabilistic events. Probabilistic events are modeled by looking at the damage caused by an event that is likely to occur over a given period of time, known as a return period. For example, HAZUS-MH can estimate the damage caused by an earthquake that is likely to occur once every 500 years (which has a 1 in 500 or 0.2% chance of occurring in a given year).

HAZUS-MH uses demographic and general building stock (GBS) data, which is used to estimate hazard-related damage. New York City supplemented this default data with a refined set of GBS data because an initial review found that for the City as a whole, the default GBS data provided with HAZUS-MH did not adequately reflect actual conditions. In order to refine the default GBS dataset, OEM provided an updated set of building data to Applied Research Associates, Inc. (ARA). ARA converted this dataset to a format that was usable by HAZUS-MH, classifying all structures according to the building type and occupancy classes required by the software. The resulting census block-based dataset provided a much more accurate starting point for subsequent analyses.

i) HAZUS-MH for Earthquakes

A probabilistic earthquake model incorporating a locally refined version of the National Earthquake Hazards Reduction Program's (NEHRP) soil data was used to estimate building damage from earthquakes over the 100, 250, 500, 1,000, and 2,500-year return periods. Additionally, HAZUS-MH generated an estimate of annualized capital-stock losses due to earthquakes.

ii) HAZUS-MH for Hurricane Winds (Coastal Storms)

A probabilistic hurricane wind-model was used to estimate building damage resulting from 10, 20, 50, 100, 200, 500, and 1,000-year return period storms. Additionally, HAZUS-MH generated an estimate of annualized capital-stock losses due to hurricane winds.

iii) HAZUS-MH for Floods

A scenario-based, or deterministic, flood model was used to estimate capital-stock losses (including building damage, contents damage, and inventory) from a 100-year flood. A 100-year flood is calculated to be the level of floodwater expected to be equaled or exceeded every 100 years on average. The extent of a 100-year flood was delineated horizontally using FEMA Digital Flood Insurance Rate Map boundaries and vertically using a New York City digital elevation model.

iv) HAZUS-MH for Coastal Erosion

Although coastal erosion is not one of the hazards directly modeled by HAZUS-MH, HAZUS-MH data was used to estimate loss. The extent of the coastal erosion loss area was delineated horizontally using New York State Department of Environmental Conservation (NYSDEC) Coastal Erosion Hazard Area (CEHA) boundaries. Because HAZUS-MH estimates loss on the census block level, the value of all buildings within the CEHA were calculated manually and then reduced based on the percentage of building footprints within the CEHA.

v) Data Limitations

While the results of the HAZUS-MH analysis provide a good starting point for loss and damage estimation, the results are approximate predictions. There is uncertainty inherent in any predictive model and HAZUS-MH is no exception. For example, the use of general-engineering data supplied with the software combined with building-stock data that has been compiled to the census-block level means that, as a rule, site-specific damage analysis is not practical. However, the use of HAZUS-MH as a tool for more macro-level citywide analysis can provide a good overall view of potential exposure to various hazards based on the best available local data.

vi) Role of HAZUS-MH in Future Hazard Mitigation Planning

OEM is considering the following options for HAZUS-MH in the future:

- Refine and update data sets for GBS, essential facilities, vegetation, vehicle distribution, and population, and update the earthquake, hurricane wind (coastal storm), and flood models.

- Pilot the use of HAZUS-MH with inputs from actual events, as they are about to occur, to affect pre-event mitigation and preparedness. Work with planning, preparedness, and operations personnel to design useful HAZUS-MH outputs for these events.

b) Methodology for Assessing Hazards Not Covered by HAZUS-MH

i) Approach

Non-HAZUS-MH hazards include drought, extreme temperatures, winter storms, and windstorms/tornadoes. Vulnerable populations and infrastructure were mapped and evaluated using the best available data to assess vulnerability to these natural hazards and to help identify appropriate mitigation efforts.

ii) Limitations

While this risk assessment relies on the best available data and methodologies, uncertainties are inherent in any loss-estimation methodology and arise in part from incomplete scientific knowledge concerning natural hazards and their effects on the built environment. Uncertainties also result from the following:

- Incomplete or dated inventory, demographic, or economic parameter data
- The unique nature, geographic extent, and severity of each hazard

These factors can result in a range of uncertainties in loss estimates. Therefore, potential exposure and loss estimates are approximate.