THE PORT AUTHORITY OF NY & NJ

Engineering Department

Design Guidelines
Climate Resilience

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1.0 CLIMATE RESILIENCE

1.1 OVERVIEW

This chapter is provided as an overview of the Port Authority's climate resiliency design guidelines. Anticipated climate impacts shall be addressed when designing Port Authority infrastructure and buildings. Example design adjustments related to increased temperature, increased precipitation, sea level rise and severe storms include:

- **Higher temperatures:**
  - **Bridges:** Change joint seal design criteria
  - **Rail:** Modify rail for expansion and contraction
  - **Modify Landscape Design:** Provide drought resistant plantings (higher temperatures)
- **Increased precipitation:**
  - **Modify Mechanical Systems:** Provide submersible pumps
  - **Drainage/Utility Design:** Adjust pipe sizes to reflect (increased precipitation)
- **Sea level rise:**
  - **Drainage/Utility Design:** Stormwater outfall water level evaluation
  - **Drainage/Utility Design:** Adjust groundwater table
- **Sea level rise and severe storms:**
  - **Buildings/Infrastructure:** Increase design flood elevation to withstand higher flood levels Design engineers and architects should, as a minimum be familiar with the climate hazards and projections herein and identify any hazards not addressed by these guidelines.

1.2 CLIMATE CHANGE PROJECTIONS

The New York and New Jersey region has several guidance documents concerning the anticipated impacts of future climate conditions. The guidance provided by the New York City Panel on Climate Change (NPCC) are generally applicable to a 100 mile radius around the New York City metropolitan region and therefore have been utilized by PANYNJ for climate risk planning since 2009.

The NPCC released updated climate projections in December 2013. These projections include annual mean changes for the years 2020, 2050, 2080 and select projections to 2100 for air temperature, precipitation and sea level rise and changes to heat waves and cold weather events, intense precipitation and intense hurricanes (see Table 1).

The climate projections were derived utilizing the most recent global climate models, observations about climate trends, and new information about greenhouse gas emissions. It includes a mid-range projection (25th to 75th percentile) and a high-estimate projection (90th percentile).[1]

[1] Percentiles are used by the NPCC to quantify the uncertainty associated with sea level rise estimates. For example, the 2020 90th percentile estimate of 11 inches indicates that 90% of the values produced in the full set of projections do not exceed 11 inches for the 2020s. The 10th percentile represents a "low end" projection, the 25th to 75th percentiles represent "middle range" projections and the 90th percentile represents a "high end" projection.

Table 1 - Regional Climate Projections[2]

Mean Annual Changes

	Baseline (1971-2000)	2020s		2050s		2080s		2100s	
		Mid-Range	High-Estimate	Mid-Range	High-Estimate	Mid-Range	High-Estimate	Mid-Range	High-Estimate
Air Temperature	54°F (annual mean)	+ 2°F to + 2.8 °F	+ 3.2°F	+ 4.1°F to + 5.7°F	+ 6.6°F	+ 5.3°F to + 8.8°F	+ 10.3°F	+ 5.8°F to + 10.3°F	+ 12.1°F
Precipitation	50.1 inches	+ 1 – 8%	+ 11%	+ 4 – 11%	+ 13%	+ 5 – 13%	+ 19%	- 1 – 19%	+ 25%
Sea Level Rise	2000-2004	+ 4 in to 8 in	+ 10 in	+ 11 in to 21 in	+ 30 in	+ 18 in to 39 in	+ 58 in	+ 22 in to 50 in	+ 75 in

Changes to Extreme Events

	Baseline (1971-2000)	2020s		2050s		2080s		2100s	
		Mid-Range	High-Estimate	Mid-Range	High-Estimate	Mid-Range	High-Estimate	Mid-Range	High-Estimate
Temperature									
Days/year at or above 90°F	18 days/year	26 to 31	33	39 to 52	57	44 to 76	87	Not available	Not available
Days/year at or below 32°F	72 days/year	52 to 58	60	42 to 48	52	30 to 42	49	Not available	Not available
Heat waves	2/year	3 to 4	4	5 to 7	7	6 to 9	9	Not available	Not available
Heat wave duration	4 days	5	5	5 to 6	6	5 to 7	8	Not available	Not available
Precipitation									
Rainfall Intensity (Days/year with rainfall ≥ 2 in)	3 days/year	3 to 4	5	4	5	4	5	Not available	Not available
Tropical Cyclones									
Number of Intense Hurricanes (incl. associated Wind/Precipitation)				Greater than 50% probability of increase					

[2] New York City Panel on Climate Change (2013). PLANYC - NYC PANEL ON CLIMATE CHANGE [PowerPoint slides]. Retrieved from http://www.nyc.gov/html/planyc/downloads/pdf/publications/NPCC_Climate%20Projections_2013.pdf

1.3 TEMPERATURE CHANGE GUIDANCE

Designs of infrastructure assets should account for the following temperature changes over the assets design life.

	2000	2025	2055	2085
Mean Annual Air Temperature	54˚F	56.5˚F	59˚F	61˚F
Days at or above 90˚F	18	29	45	60
Days at or below 32˚F	72	55	45	36

1.4 PRECIPITATION CHANGE GUIDANCE

Designs of infrastructure assets should account for the following precipitation changes over the assets design life. Current climate projections do not include rainfall intensity curves.

	2000	2025	2055	2085
Mean Annual Precipitation	50.1”	52”	54”	55”
Annual Intense Rain Events (rainfall ≥ 2 inches per day)	3	3	4	4

1.5 SEA LEVEL RISE GUIDANCE

Designs of infrastructure assets should account for the following mid-range estimates in sea level:

	2004	2025	2055	2085
Mean Sea Level	Baseline	+ 6”	+ 16”	+ 28”

2.0 FLOOD RESILIENCE

To establish the flood protection criteria for a project, employ the following steps. Determining this criterion is a collaborative effort led by the Project Engineer or Architect with information and support from various agency departments outlined below.

For large-scale projects (multi-discipline and total project cost over $10M), the Project Engineer or Architect is encouraged to lead a flood risk specific meeting/workshop and to follow the steps below with a Resilience and Sustainability Group’s representative. For smaller scale projects, the Project Engineer or Architect should discuss the following information directly with the project manager and a Resilience and Sustainability Group’s representative. A project team meeting may not be necessary for small-scale projects.

Step 1: Identify Flood Risks to Project Scope
Responsible Group: Engineering

The Engineering Department uses the FEMA 1% annual chance floodplain to determine the current base flood elevation. Each project should determine if the site is within the FEMA 1% annual chance flood plain using the best available FEMA mapping data in conjunction with any available additional sources listed

below. The Assistant Chief, Resilience and Sustainability will provide the project team a link to the current FEMA map.

Additional sources (determined applicable by the Assistant Chief, Resilience and Sustainability) are used to further may be used to inform the project team of flooding hazards:

- Hurricane SLOSH mapping should also be consulted, especially if the project lies outside of the FEMA determined flood map. The SLOSH mapping is used by localities to determine evacuation areas and this information should be evaluated for use in the Basis of Design.
- If the Agency has performed flood modeling to determine current or future flood hazards, this information should be evaluated for use in the Basis of Design.

If the project is determined to be outside of the FEMA 1% annual chance flood plain and any SLOSH Hurricane zones, then the project does not have known flood hazards at this time. Include this information in the stage 1 report. Any projects which have a design life extending past 2025 should evaluate if Sea Level Rise will extend the flood plain such that the project will be at risk after 2025.

The Discipline Specific Design Guidance includes specific project elements to be evaluated based on the project's flood risk and scope.

Step 2: Determine the Influence of Any Area or System-Wide Strategy
Responsible Group: Line Department and Engineering

Discuss any area or system-wide strategies with the Project Manager to determine if the project is sufficiently protected. For example, if a station entrance has flood protection installed, it may not be necessary for internal station components to be elevated. The project team should discuss any high risk consequences of perimeter protection failure before making a final decision not to proceed with the internal flood protection.

Step 3: Identify if project is part of an Emergency Plan or Enterprise Risk Plan
Responsible Group: Line Department
Support: OEM, Enterprise Risk Management

The project may be part of an emergency plan or an enterprise risk mitigation plan. Discuss applicability of these plans with the Project Manager to determine if the plans need to be incorporated into the project. Integrate any functional aspect of the plans related to the project into the Basis of Design. Sample questions to ask are:

- Is this project part of an evacuation route or evacuation plan?
- Does the project provide access or services to an emergency operations center?

Step 4: Review Current Codes
Responsible Group: Engineering

Analyze the current codes to determine the minimum flood projection or elevation level required by code. QAD can assist in providing a code review (current list of resiliency codes in Appendix A). This information will be used in Step 8.

Step 5: Determine Funding Source Requirements/Guidelines
Responsible Group: Line Department
Support: Storm Mitigation and Resiliency Office

Projects receiving federal, state or local funding may need to incorporate specific flood resiliency criteria. Line Department Project Managers should identify the funding program and assist in determining project-specific funding requirements or guidelines. The Engineering Department's contacts for the Sandy

program are the Assistant Chief, Resilience and Sustainability and the EOP for Sandy Program. If the project is receiving any FEMA or FTA Sandy funding, these individuals should be invited to the kick off meeting and can assist the project team with design requirements related to federal funding.

Step 6: Identify Critical Infrastructure
Responsible Group: Line Department/Engineering
Support: OEM, Enterprise Risk Management

Building code (ASCE-24) provides essential building flood protection requirements (Category IV), however critical infrastructure flood protection requirements are not defined by the building code. For Port Authority Infrastructure the flood protection elevation for the following infrastructure types shall follow ASCE-24 freeboard requirements (BFE + 2 feet) for a Category IV structure:

- PATH Tunnels (entrances, penetrations)
- Vehicular Tunnels (entrances, penetrations)
- Power distribution facilities (electrical substations, switch houses)
- Emergency generators
- Fire Protection Systems (mechanical, electrical, civil)
- Aircraft Fueling Systems

Any additions or subtractions of assets to the list above, require mutual agreement between the respective Line Department Director and the Chief Engineer.

Step 7: Determine Life Expectancy
Responsible Group: Line Department/Engineering

The life expectancy of a critical infrastructure asset can be directly tied to the risk of occurrence. For example, the risk of an occurrence of a flood with a 1% annual probability of occurrence over the life of building with a 50-year life expectancy is 39.5%. A sample list of asset design life can be found in Engineering Management Services Division "Asset Class Reference Manual (December 2011)". The asset design life will be used to determine the level of flood protection (Step 8) and will factor into the project's benefit cost analysis (Step 9).

Step 8: Determine Flood Protection Level
Responsible Group: Engineering

The Engineering Department has developed flood protection levels (Table 2 below) which adjust for anticipated sea level rise based on the design life and criticality of the asset. The project team should utilize these elevations unless the project is proven to be cost prohibitive based on the cost benefit analysis (Step 9).

Table 2 – Flood Protection Levels

	Non Critical Assets			Critical Assets		
Asset Design Life	Code Requirement	Sea Level Rise Adjustment	Final Flood Protection Elevation	Code Requirement	Sea Level Rise Adjustment	Final Flood Protection Elevation
Up to 2020	12”	6”	FEMA 1% Elevation + 18”	24”	6”	FEMA 1% Elevation + 30”
2021-2050	12”	16”	FEMA1% Elevation + 28”	24”	16”	FEMA1% Elevation + 40”
2051-2080	12”	28”	FEMA1% Elevation + 40”	24”	28”	FEMA1% Elevation + 52”
2080+	12”	36”	FEMA1% Elevation + 48”	24”	36”	FEMA1% Elevation +60”

Step 9: Perform Benefit Cost Analysis
Responsible Group: Line Department/Engineering
Support: Planning

Utilizing the information from Steps 7 & 8, perform a benefit cost analysis to weight the capital investment, the benefits associated with the mitigation strategy and the costs of not performing the investment over time (generally measured by direct loss and operational revenue). All projects with a TPC greater than $10M must perform a benefit cost analysis. Additionally, for a project of any size, this may be required for FEMA and FTA funded projects.

The Port Authority Planning Department will perform the benefit cost analysis. A project with a benefit-cost ratio greater than 1 is considered to be a positive return on the capital investment made.

Step 10: Establish Flood Resilience Criteria
Responsible Group: Line Department/Engineering

Based on the conclusions drawn from all steps of the process, the project team should review all information and agree upon an acceptable level of flood protection at a reasonable cost. The result is incorporated into the Basis of Design.

APPENDIX A - CODE CHANGES DUE TO RECENTLY ENACTED RESILIENCY LEGISLATION

All the code changes due to Resiliency Legislation were introduced through NYC Local Laws and have been incorporated into the new 2014 Construction Codes.

NYC Administrative Code –Title 28
PC: Plumbing Code
BC: Building code
EC: Electrical Code
MC: Mechanical Code
NYCRR: New York City Rules and Regulations

Survey Data and Flood Maps (Local Law 96/13)

28-104.7.6 City datum

- For new projects on or after January 6, 2014, all elevations must now refer to North American Vertical Datum of 1988(NAVD 1988) regardless of whether the project is located in a flood zone or not.

BC Appendix G

- All projects must comply with the more stringent of either the 2007 FEMA FIRMs, or the 2013 FEMA PFIRMs.

Prevention of Backflow (LOCAL LAW 83/13)

BC Appendix G, G501.1-Modifications to ASCE 24-05(Ref. PC 715.1 and PC 1101.9)

- Section 7.3.3 - Plumbing Systems Installed below Minimum Elevations: Plumbing systems shall be provided with backwater valves in the building drain at its point of exit from the building and downstream of the building trap.
- Section 7.3.4 - Sanitary systems shall be provided with backwater valves at the point of exit from the building and downstream of the building trap.

Emergency and Standby Power Systems and natural Gas Usage (Local Law 111/13)

2008 New York City Building Code Chapters 4, 9, 10, 17, 27, 30, and 31; MC Chapter 5

- Optional standby power systems must power the following loads:
  - Emergency lighting
  - Fire alarm systems
  - Elevators as follows:
    - R2 occupancies in building greater than 125 feet in height
    - All other buildings with occupied floors 75 feet above lowest level of FDNY access
  - Fuel cells are permitted as a source of power for Standby systems
- Construction Codes and the NYC Electric Code permit natural gas from a public utility as a sole fuel supply for:
  - Emergency systems serving R-2 occupancies
  - Standby systems in all buildings

Cabling & Fuel Oil Storage in Flood-Prone Areas (Local Law 99/13)

NYC Electrical Code

- Unlisted conductive and nonconductive outside plant optical fiber cables entering buildings may exceed 15m (50 ft) length in the 100-year and 500-year flood plains, for locating equipment above potential floodwaters.

BC 202, BC Appendix G, G201.2 Definitions

- 500-YEAR FLOOD ELEVATION. The elevation of the flood having a 0.2-percent chance of being equaled or exceeded in any given year, as specified on FEMA FIRM 360497 or FEMA FIS 360497.
  When 500-Year Flood elevation is not specified, elevation must be determined by Registered Design Professional based on available information or analysis, as per BC Appendix G, Section 103.3.1
- SHADED X-ZONE. The land in the floodplain delineated as subject to a 0.2-percent or greater chance of flooding, but less than one percent chance of flooding, in any given year. Such areas are designated on the Flood Insurance Rate Map (FIRM) as shaded X-Zones

BC Appendix G, G307.4

- Fuel-oil storage increases permitted above the design flood elevation in Special Flood Hazard Areas and Shaded X-zones:
  - 3,000 gallons total on lowest story having its floor above DFE
  - Each tank limited to lesser of 1,500 gallons per tank or 24-hour supply
  - Tanks shall be enclosed in a vault with a 3-hour fire-resistance rating
  - Vault shall be located in a dedicated room/area separated from other areas by 2-hour fire-resistance rated construction
  - Vault shall be protected with alternative automatic fire-extinguishing system.

Flood Barriers (Local Law 109/13)

BC 32 Encroachments into the Public Right-of-Way

BC Appendix G, Flood-Resistant Construction

- BC G308.6 Temporary flood shields: Temporary flood shields permitted
- BC G308.7.1 Temporary Stairs in Evacuated Buildings: Temporary stairs and ramps permitted
- BC G308.7.2 Temporary Stairs in Existing Buildings:
- BC Appendix G, G501 Modifications to ASCE 24 Section 6.2.2 Dry Flood proofing: Requires 1 exit above the DFE for each required exit