RESILIENT NORTHEASTERN NEW JERSEY

FLOOD IMPACT ASSESSMENT: APPENDIX A

METHODOLOGY AND DATA

May 2022

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INTRODUCTION

This document outlines the methodology for the quantitative analysis and the asset prioritization analysis described in the *Flood Impact Assessment* report, as well as providing the data sources for the analysis and a data gap analysis. The quantitative analysis evaluated consequences of flooding for each building in the project area via a variety of damage metrics. The asset prioritization analysis identified the assets within multiple asset types with the highest impacts. The available data sources, and the associated limitations to the data, affected the methodology and assumptions made during the analysis.

QUANTITATIVE ANALYSIS

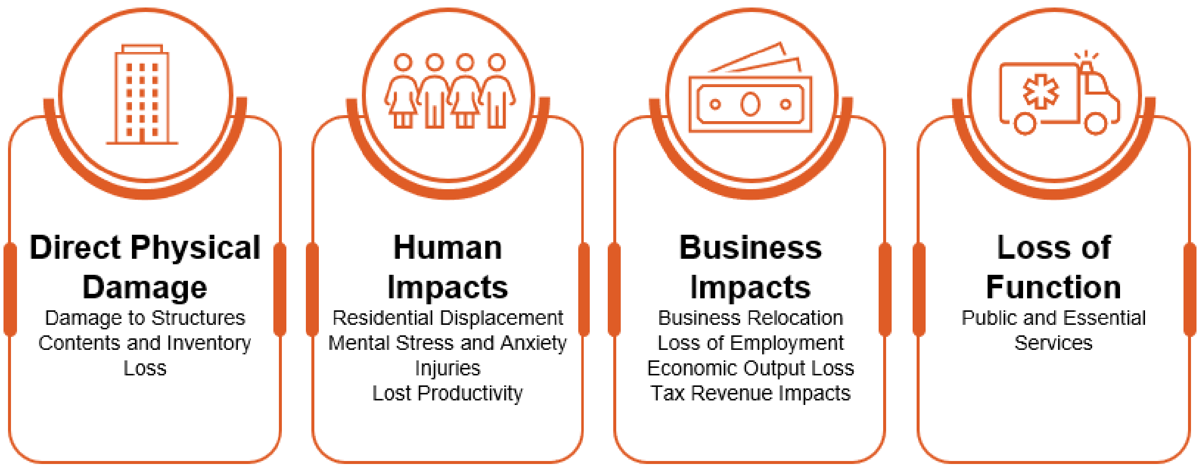

Figure 1: Types of impacts

With a baseline understanding of flood hazards, along with the people, places, and things throughout the region that may be impacted, the Resilient RRBC team quantified the range of impacts flooding has on our region using a variety of metrics. The team used methodologies developed by FEMA and the United States Army Corps of Engineers (USACE) to monetize four types of impacts to buildings and the people, businesses, and services they house:

- **Direct Physical Damage:** Replacement and restoration costs for buildings and their contents that are expected to be damaged by flooding, including retail or wholesale inventory.
- **Human Impacts:** Costs associated with residential displacement, lost productivity, injuries, and mental stress and anxiety treatment for residents in the region as a direct result of impacts to their homes.
- **Direct Business Impacts:** Impacts to tax revenue, economic output, employment, and business relocation as a direct result of impacts to buildings. This only includes losses from businesses expected to be directly impacted by flooding and does not model any reverberating economic impacts.

- **Loss of Function:** Expected impacts associated with the time that public and essential services are out of use, approximated as the portion of annual operating costs associated with the downtime experienced from direct impacts of flooding. For this analysis, public and essential services include libraries, schools, fire stations, hospitals, police stations, nursing homes, rail stations, and electric substations.

This assessment provides **Total Direct Losses**, or the sum of these four types of damage for all buildings within the reporting area. In cases where Total Direct Losses were either unavailable or inappropriate indicators, additional exposure metrics were used to quantify impacts, including **Population Counts, Asset Counts, Building and Contents Values, and Land Values.**

BUILDING INVENTORY

The first step of the quantitative analysis developed a building inventory for the study area. The inventory incorporates data from the following sources:

- **New Jersey Department of Environmental Protection (NJDEP) Building Footprints (2019**): NJDEP provided building footprints for structures in the FEMA 500-year floodplain. Footprint attributes included number of floors and use type.
- **New Jersey Geographic Information Network (NJGIN) Parcels and MOD-IV Composite of NJ (2020):** Parcel boundaries and MOD-IV property tax information was obtained from the New Jersey Office of GIS. The parcel data was used to modify footprints whose polygons represented many buildings with a continuous roofline. Footprints were split along parcel boundaries to delineate individual structures.
- **USGS Coastal National Elevation Database (CoNED) Digital Elevation Model (DEM) (2015):** This DEM provides ground elevations at a 1-meter resolution.
- **RSMeans CostWorks Estimator Replacement Cost Values (2020)**: This publication provides location-specific building replacement square foot costs for a wide range of building occupancy types. The team determined building and contents replacement 2020 RS Means standard replacement cost values, adjusted using RS Means location factors.
- **USACE Generic Depth Damage Functions**: US Army Corps of Engineers (USACE) Generic Depth Damage Functions (DDFs) for residential and non-residential buildings were used to determine the amount of damage to buildings and contents for each flood scenario. This DDF type was used in areas that were not to experience daily tidal flooding, and specific values were chosen based on the hazard and structure type of each building.
- **USACE NACCS Depth Damage Functions**: US Army Corps of Engineers (USACE) NACCS Depth Damage Functions (DDFs) for residential and non-residential buildings were used to determine the amount of damage to buildings and contents for each flood scenario. This DDF type was used in areas that modeling showed to experience daily tidal flooding, and specific values were chosen based on the hazard and structure type of each building.
- **FEMA Contents-to-Structure Ratio Values (CSRVs)**: The 2011 FEMA BCA Reference Guide provides CSRVs based on building type, in the form of a percentage of BRV. This guidance states

that when generic DDFs from USACE are used, 100% of the BRV can be used for residential buildings.

- **HAZUS Occupancy Classes**: HAZUS is a nationally applicable standardized methodology that contains models for estimating potential losses from earthquakes, floods, and hurricanes and is used for structure occupancy classes for applying appropriate DDFs and replacement values.

The team used the building footprints data provided by the New Jersey Department of Environmental Protection (NJDEP) and incorporated additional building attributes necessary for examination, such as number of stories, total area and building use, also from the NJDEP.

The analysis required detailed information on all buildings within the area of interest, such as the first-floor elevation, ground elevation, presence of a basement, first floor footprint and gross square footage and whether the structure was residential versus non-residential. Table 1 below summarizes the primary data source for each of the structure information inputs necessary for the analysis.

Table 1. Building Inventory Data Sources

Structure Attribute	Source
Structure Use	The primary source of the structure use description was the New Jersey Department of Environmental Protection Data. Google StreetView was used to confirm the size of residencies and validate choices of apartment types.
Building Type	Building Type was used to assign depth damage functions to structures. The building type classification follows the HAZUS Occupancy model and was assigned based on the structure use.
First Floor Area	Building floor area data was drawn from NJDEP Data. The values were compared to Google StreetView to ensure that it was reasonable. If it was not reasonable, the value from the NJDEP shapefile was redrawn to better match the Google Imagery.
Number of Stories	The number of floors of the buildings was available in the NJDEP data. When possible, these values were checked against Google StreetView to ensure that these values were reasonable.
First Floor Elevation (FFE)	The first flood elevation (FFE) in North American Vertical Datum of 1988 (NAVD88) of each building was estimated using a variety of sources and methods: • Initially, the first-floor elevation for all buildings was based on the ground elevation for the study area, which was taken from the NJ/DE CoNED (3.28’) 2015 Digital Elevation Model. • Google Streetview was used to ground truth first floor elevations as necessary.

Structure Attribute	Source
Building Replacement Value	The team identified square-foot replacement value estimates using RSMeans Square Foot Costs for Jersey City, New Jersey (in 2021 dollars) based on structure material and size. To ensure these costs were properly valued, all RSMeans cost was adjusted for inflation using the Bureau of Labor Statistics Consumer Price Index Inflation Calculator.[1] Due to the number of buildings analyzed, the project team determined the average gross square footage for each structure type and applied the cost per square foot closest to this determined square footage area. Additionally, to ensure a conservative approach in analysis, the project team applied the lowest cost materials option for each structure use.
Contents Replacement Value	Contents replacement value was estimated as a percent of the entire building replacement value. The contents values for benefitting structures were identified using the applicable USACE Depth Damage Functions. Content values were assigned based on the identified Building Type and Contents Value based on Percentage of Structure Value provided by HAZUS.

Understanding how buildings are used is a key part of understanding how flooding currently impacts and will impact the region. Risk to various building types sheds light on the ability of a community to function, recover, and thrive over time. The Resilient RRBC team categorized buildings in the region with the following use types:

- **Commercial:** Structures providing economic services or goods
- **Education:** Structures providing any form of education, from preschool to universities
- **Emergency Services:** Emergency medical or social services such as EMS, fire and police stations, and hospitals
- **Government:** Judicial, municipal, and other government service buildings
- **Industrial:** Warehouses or buildings within manufacturing campuses or facilities
- **Religious:** Places of worship
- **Residential:** Structures that house community members
- **Transportation:** Structures supporting transportation infrastructure, such as railway stations and ferry terminals

[1] CPI Inflation Calculator. Located at: http://www.bls.gov/data/inflation_calculator.htm

FLOOD DEPTH

For each flood scenario, the mapped extent of the floodplain helped identify buildings that would be flooded. The team flagged flooded buildings as those with at least 10% of their footprint within the floodplain extent. Flood water surface elevations for each building flooded are calculated using the NJDEP flood models.

The NJDEP models provided flood depths. Model development is described in Appendix A and Appendix B. Table 2 outlines the six modeled flood scenarios.

Table 2 Six Modeled Flood Scenarios

Event Name	Modeled Event	Description
Present-day flash flood	2-hour, 2% (50-year) storm	A short duration, high intensity rain event likely to overload storm sewers and cause flooding but will recede quickly, limiting long-term impacts.
Present-day areal flood	24-hour, 1% (100-year)	A longer duration rain event likely to overwhelm available drainage networks and cause widespread inland flooding across low-lying areas.
Future (2070) flash flood	2-hour, 2% (50-year) storm + sea level rise + 10% increase in rainfall	A short duration, high intensity rain event likely to overload storm sewers and cause flooding but will recede quickly, limiting long-term impacts. To account for anticipated climate changes, this event includes the effects of sea level rise and increased
Future (2070) areal flood	24-hour, 1% (100-year) + sea level rise + 10% increase in rainfall	A longer duration rain event likely to overwhelm available drainage networks and cause widespread inland flooding across low-lying areas. To account for anticipated climate changes, this event includes the effects of sea level rise and increased rainfall.
Future (2070) tidal flood	Mean higher high water + sea level rise	Temporary inundation of low-lying areas due to high tides. To account for anticipated climate changes, this event includes the effects of sea level
Future (2070) coastal flood	Hurricane Sandy high water mark + sea level rise	Raised water levels along the coast due to tropical storms, hurricanes and nor'easters. To account for anticipated climate changes, this event includes the

Flood depth is equal to the median water surface elevation, for present and future sea level rise scenarios, at the footprint minus the mean ground elevation plus one foot. This accounts for the variability of the water surface elevations across a single building footprint.

DIRECT PHYSICAL DAMAGE

USACE provides DDFs for a variety of building typologies to identify the percent of a building's replacement value (of both the structure itself and the contents within) expected for intervals of flood depths. The DDFs used for direct physical damage are from the U.S. Army Corps of Engineers North Atlantic Coast Comprehensive Study (USACE NACCS) for buildings in the coastal and tidal flood zones, and the USACE Generic DDFs used by FEMA in the Hazus tool were used for all other buildings exposed to rainfall flooding. The team uses information about a building's use, number of floors, and basement presence to determine the appropriate DDF.

Structure uses for each building are mapped to HAZUS occupancy classes (Table 3), which in turn correspond to building replacement values (BRV) per square foot and contents-to-structure value ratios (CSVRs), as shown in Table 4. For this analysis, the standard replacement values developed by FEMA for the HAZUS model were replaced with replacement costs from RS Means for Jersey City in 2021 for improved accuracy. The 2011 FEMA BCA Reference Guide Supplement provides CSRVs based on building type, in the form of a percentage of BRV. This guidance states that when generic DDFs from USACE are used, 100% of the BRV can be used for residential structures.

Table 3. Occupancy Mapping and Building Use Categorization

Use Code	Structure Use Description	Freshwater DDF	IMPLAN Group	Occupancy Class (Lower Floors)	Occupancy Class (Upper Floors)	Reporting Category
AG	Agriculture	1-Story Without Basement	Agriculture	AGR1	AGR1	Agriculture
APTA	Apartment: 1-2 units	Residential	Residential	RES3A	RES3A	Residential
APTB	Apartment: 3-4 units	Residential	Residential	RES3B	RES3B	Residential
APTC	Apartment: 5-9 units	Residential	Residential	RES3C	RES3C	Residential
APTD	Apartment: 10-19 units	Residential	Residential	RES3D	RES3D	Residential
APTE	Apartment: 20-50 units	Residential	Residential	RES3E	RES3E	Residential
APTF	Apartment: Over 50 units	Apartment	Residential	RES3F	RES3F	Residential
ARPRT	Airport	Industrial Light	Transportation	IND2	IND2	Transportation
AUD	Auditorium	Recreation	Public Places, Fitness, Sports, Amusement, and Recreation	COM8	COM8	Commercial
AUTO	Auto Repair	Service Station	Retail, Personal Services, Restaurants	COM3	COM3	Commercial
BANK	Bank	Office One-Story	Office	COM5	COM5	Commercial
CEM	Cemetery	Religious Facilities	Religious	REL1	REL1	Religious
CHR	Places of Worship	Religious Facilities	Religious	REL1	REL1	Religious
CLB	Clubs/Organizations	Recreation	Public Places, Fitness, Sports, Amusement, and Recreation	COM8	COM8	Commercial
CLG	College	Schools	Education	EDU2	EDU2	Education
CLRG	Clergy Housing	Religious Facilities	Religious	RES1x2	RES1x2	Religious
CMTY	Community Center	Recreation	Public Places, Fitness, Sports, Amusement, and Recreation	COM8	COM8	Commercial
CNVT	Convent	Residential	Religious	RES5	RES5	Religious
COMGEN	Commercial - General	Retail-Clothing	Retail, Personal Services, Restaurants	COM1	COM1	Commercial
COMGRO	Commercial - Grocery	Grocery	Retail, Personal Services, Restaurants	COM1	COM1	Commercial
COMRET	Commercial - Retail	Retail-Clothing	Retail, Personal Services, Restaurants	COM1	COM1	Commercial
COMSER	Commercial - Service	Office One-Story	Retail, Personal Services, Restaurants	COM3	COM3	Commercial
CONDOA	Condo: 1-2 units	Residential	Residential	RES3A	RES3A	Residential
CONDOB	Condo: 3-4 units	Residential	Residential	RES3B	RES3B	Residential
CONDOC	Condo: 5-9 units	Residential	Residential	RES3C	RES3C	Residential
CONDOD	Condo: 10-19 units	Residential	Residential	RES3D	RES3D	Residential
CONDOE	Condo: 20-50 units	Residential	Residential	RES3E	RES3E	Residential
CONDOF	Condo: Over 50 units	Residential	Residential	RES3F	RES3F	Residential
CULT	Event/Cultural Center	Recreation	Public Places, Fitness, Sports, Amusement, and Recreation	COM8	COM8	Commercial
DAYC	Day Care	Schools	Health, Care, and Rehabilitation Services	EDU1	EDU1	Commercial
DORM	Dormitory	Residential	Education	RES5	RES5	Education
DPLX	Duplex	Residential	Residential	RES3A	RES3A	Residential
EMERG	Emergency Services	Protective Services	Government	GOV2	GOV2	Emergency Services
FIRE	Fire Station	Protective Services	Government	GOV2	GOV2	Emergency Services
FIREPOL	Fire / Police Station	Protective Services	Government	GOV2	GOV2	Emergency Services
FUNRL	Funeral Home	Office One-Story	Retail, Personal Services, Restaurants	COM3	COM3	Commercial

Use Code	Structure Use Description	Freshwater DDF	IMPLAN Group	Occupancy Class (Lower Floors)	Occupancy Class (Upper Floors)	Reporting Category
GOVT	Government/Municipal	Office One-Story	Government	GOV1	GOV1	Government
GRG	Garage	Service Station	Retail, Personal Services, Restaurants	COM3	COM3	Commercial
HOSP	Hospital	Hospital	Health, Care, and Rehabilitation Services	COM6	COM6	Emergency Services
HOTL	Hotel	Hotel	Hotels and Other Accommodations	RES4	RES4	Commercial
INDGEN	Industrial - General	Industrial Light	Industrial and Utility	IND2	IND2	Industrial
INDLT	Industrial - Light	Industrial Light	Industrial and Utility	IND2	IND2	Industrial
INDMAN	Industrial - Manufacturing	Industrial Light	Industrial and Utility	IND1	IND1	Industrial
LIBR	Library	Schools	Education	EDU1	EDU1	Education
LTCF	Long-Term Care Facility	Medical Office	Health, Care, and Rehabilitation Services	RES6	RES6	Commercial
MEDC	Medical Clinic	Medical Office	Health, Care, and Rehabilitation Services	COM7	COM7	Commercial
MOBH	Manufactured House	Mobile Home	Residential	RES2	RES2	Residential
MUCRA	Mixed Use - Commercial and Residential: 1-2 units	Retail-Clothing	Retail, Personal Services, Restaurants	COM1	RES3A	Commercial
MUCRB	Mixed Use - Commercial and Residential: 3-4 units	Retail-Clothing	Retail, Personal Services, Restaurants	COM1	RES3B	Commercial
MUCRC	Mixed Use - Commercial and Residential: 5-9 units	Retail-Clothing	Retail, Personal Services, Restaurants	COM1	RES3C	Commercial
MUCRD	Mixed Use - Commercial and Residential: 10-19 units	Retail-Clothing	Retail, Personal Services, Restaurants	COM1	RES3D	Commercial
MUCRE	Mixed Use - Commercial and Residential: 20-50 units	Retail-Clothing	Retail, Personal Services, Restaurants	COM1	RES3E	Commercial
MUCRF	Mixed Use - Commercial and Residential: Over 50 units	Retail-Clothing	Retail, Personal Services, Restaurants	COM1	RES3F	Commercial
MUORA	Mixed Use - Office and Residential: 1-2 units	Office One-Story	Office	COM4	RES3A	Commercial
MUORB	Mixed Use - Office and Residential: 3-4 units	Office One-Story	Office	COM4	RES3B	Commercial
MUORC	Mixed Use - Office and Residential: 5-9 units	Office One-Story	Office	COM4	RES3C	Commercial
MUORD	Mixed Use - Office and Residential: 10-19 units	Office One-Story	Office	COM4	RES3D	Commercial
MUORE	Mixed Use - Office and Residential: 20-50 units	Office One-Story	Office	COM4	RES3E	Commercial
MUORF	Mixed Use - Office and Residential: Over 50 units	Office One-Story	Office	COM4	RES3F	Commercial
MUPRC	Mixed Use - Parking and Residential: 5-9 units	Garage	Retail, Personal Services, Restaurants	COM10	RES3C	Commercial
MUPRF	Mixed Use - Parking and Residential: Over 50 units	Garage	Retail, Personal Services, Restaurants	COM10	RES3F	Commercial
MURSRA	Mixed Use - Restaurant and Residential: 1-2 units	Non-Fast Food	Retail, Personal Services, Restaurants	COM8	RES3A	Commercial
MURSRB	Mixed Use - Restaurant and Residential: 3-4 units	Non-Fast Food	Retail, Personal Services, Restaurants	COM8	RES3B	Commercial
MURSRC	Mixed Use - Restaurant and Residential: 5-9 units	Non-Fast Food	Retail, Personal Services, Restaurants	COM8	RES3C	Commercial
MURSRD	Mixed Use - Restaurant and Residential: 10-19 units	Non-Fast Food	Retail, Personal Services, Restaurants	COM8	RES3D	Commercial
MURSRE	Mixed Use - Restaurant and Residential: 20-50 units	Non-Fast Food	Retail, Personal Services, Restaurants	COM8	RES3E	Commercial
MURSRF	Mixed Use - Restaurant and Residential: Over 50 units	Non-Fast Food	Retail, Personal Services, Restaurants	COM8	RES3F	Commercial
MURTRA	Mixed Use - Retail and Residential: 1-2 units	Retail-Clothing	Retail, Personal Services, Restaurants	COM1	RES3A	Commercial
MURTRB	Mixed Use - Retail and Residential: 3-4 units	Retail-Clothing	Retail, Personal Services, Restaurants	COM1	RES3B	Commercial
MURTRC	Mixed Use - Retail and Residential: 5-9 units	Retail-Clothing	Retail, Personal Services, Restaurants	COM1	RES3C	Commercial
MURTRD	Mixed Use - Retail and Residential: 10-19 units	Retail-Clothing	Retail, Personal Services, Restaurants	COM1	RES3D	Commercial
MURTRE	Mixed Use - Retail and Residential: 20-50 units	Retail-Clothing	Retail, Personal Services, Restaurants	COM1	RES3E	Commercial
MURTRF	Mixed Use - Retail and Residential: Over 50 units	Retail-Clothing	Retail, Personal Services, Restaurants	COM1	RES3F	Commercial
MUS	Museum	Recreation	Public Places, Fitness, Sports, Amusement, and Recreation	COM8	COM8	Commercial
OFF	Office	Office One-Story	Office	COM4	COM4	Commercial
PAHA	Public/Affordable Housing: 1-2 units	Residential	Residential	RES3A	RES3A	Residential

Use Code	Structure Use Description	Freshwater DDF	IMPLAN Group	Occupancy Class (Lower Floors)	Occupancy Class (Upper Floors)	Reporting Category
PAHB	Public/Affordable Housing: 3-4 units	Residential	Residential	RES3B	RES3B	Residential
PAHC	Public/Affordable Housing: 5-9 units	Residential	Residential	RES3C	RES3C	Residential
PAHD	Public/Affordable Housing: 10-19 units	Residential	Residential	RES3D	RES3D	Residential
PAHE	Public/Affordable Housing: 20-50 units	Apartment	Residential	RES3E	RES3E	Residential
PAHF	Public/Affordable Housing: Over 50 units	Apartment	Residential	RES3F	RES3F	Residential
PKG	Parking	Garage	Retail, Personal Services, Restaurants	COM10	COM10	Commercial
POL	Police Station	Protective Services	Government	GOV2	GOV2	Emergency Services
PRIS	Prison	Correctional Facility	Government	RES5	RES5	Commercial
PSTOF	Post Office	Office One-Story	Government	GOV1	GOV1	Government
PUBL	General Public Property	Office One-Story	Government	GOV1	GOV1	Government
REC	Recreation	Recreation	Public Places, Fitness, Sports, Amusement, and Recreation	COM8	COM8	Commercial
RES	Restaurant	Non-Fast Food	Retail, Personal Services, Restaurants	COM8	COM8	Commercial
SCH	School	Schools	Education	EDU1	EDU1	Education
SFHA	Single Family Home: 1 Story	Residential	Residential	RES1x1	RES1x1	Residential
SFHB	Single Family Home: Over 1 Story	Residential	Residential	RES1x2	RES1x2	Residential
SRVST	Service Station	Service Station	Retail, Personal Services, Restaurants	COM3	COM3	Commercial
STAD	Stadium	Recreation	Public Places, Fitness, Sports, Amusement, and Recreation	COM8	COM8	Commercial
THTR	Theater	Recreation	Public Places, Fitness, Sports, Amusement, and Recreation	COM9	COM9	Commercial
TPLX	Triplex	Apartment	Residential	RES3B	RES3B	Residential
TRNS	Transportation	Industrial Light	Transportation	IND2	IND2	Transportation
TWNA	Townhouse: 1-2 units	Residential	Residential	RES3A	RES3A	Residential
TWNB	Townhouse: 3-4 units	Residential	Residential	RES3B	RES3B	Residential
TWNC	Townhouse: 5-9 units	Residential	Residential	RES3C	RES3C	Residential
TWND	Townhouse: 10-19 units	Residential	Residential	RES3D	RES3D	Residential
TWNE	Townhouse: 20-50 units	Apartment	Residential	RES3E	RES3E	Residential
TWNF	Townhouse: Over 50 units	Apartment	Residential	RES3F	RES3F	Residential
UTLGEN	Utility - General	Industrial Light	Industrial and Utility	IND2	IND2	Industrial
UTLPS	Utility - Pump Station	Industrial Light	Industrial and Utility	IND2	IND2	Industrial
UTLTEL	Utility - Telecom	Industrial Light	Industrial and Utility	IND2	IND2	Industrial
UTLWAT	Utility - Water	Industrial Light	Industrial and Utility	IND2	IND2	Industrial
VET	Veterinary/Animal Shelter	Medical Office	Health, Care, and Rehabilitation Services	COM7	COM7	Commercial
WASTE	Waste Processing	Industrial Light	Industrial and Utility	IND2	IND2	Industrial
WRHS	Warehouse	Warehouse, Non-Refrigerated	Industrial and Utility	COM2	COM2	Industrial

Table 4. Replacement Values by Hazus Occupancy Code

Occupancy Class	Definition	BRV per SF	CSVR
AGR1	Agriculture	$185.30	1
COM1	Retail Trade (Store)	$157.13	1
COM10	Parking (Garages)	$103.35	0.5
COM2	Wholesale Trade (Warehouse)	$185.30	1
COM3	Personal and Repair Services (Service Station/Shop)	$184.84	1
COM4	Professional/Technical Services (Offices)	$266.12	1
COM5	Banks	$287.60	1
COM6	Hospital	$357.19	1.5
COM7	Medical Office/Clinic	$272.58	1.5
COM8	Entertainment and Recreation (Restaurants/Bars)	$255.44	1
COM9	Theaters	$220.90	1
EDU1	Schools/Libraries	$235.99	1
EDU2	Colleges/Universities	$201.66	1.5
GOV1	General Services (Offices)	$208.04	1
GOV2	Emergency Response (Police, Fire Station, etc.)	$322.50	1.5
IND1	Heavy Industrial (Factory)	$180.61	1.5
IND2	Light Industrial (Factory)	$185.30	1.5
REL1	Church/Membership Organizations/Non-Profit	$597.45	1
RES1x1	Single Family (House) - 1 story	$149.57	1
RES1x2	Single Family (House) - 2 stories	$118.64	1
RES2	Mobile Home	$50.50	1
RES3A	Duplex	$110.57	1
RES3B	Apartment/Condo, 3-4 units	$239.28	1
RES3C	Apartment/Condo, 5-9 units	$229.44	1
RES3D	Apartment/Condo, 10-19 units	$216.72	1
RES3E	Apartment/Condo, 20-50 units	$204.25	1
RES3F	Apartment/Condo, 50+ units	$209.84	1
RES4	Temporary Lodging (Hotel/Motel)	$217.43	1
RES5	Institutional Dormitory	$280.03	1
RES6	Nursing Home	$279.05	1
VACANT	Vacant	$0.00	0

The damage percentage identified through a depth-damage function must be applied to the damageable value of the building, which is not always the total building replacement cost. Each DDF provides a maximum number of stories considered “damageable” for the corresponding building type. The number of stories analyzed by the function is related to the structure type and the expected location of mechanical, electrical, and plumbing (MEP) assets in buildings. For example, urban high-rise depth-damage functions from the NACCS report recommend that only the first 10 floors are considered the damageable value of the building, assuming that mechanical and electrical assets are located within the basement or first floor of the building.

Throughout the process, the lower and upper floors of impacted buildings are examined separately, as it is quite possible that the lower floors of the building serve a different purpose than the upper floors. In high rise buildings, lower floors are the first two floors; in all other buildings, the first floor alone is taken as the lower floor. For example, take a building that is eight floors tall with a bodega on the first floor and apartments above. The single lower floor with the bodega would be assigned one depth damage function while the seven upper floors with apartments would be assigned another depth damage function. Results are calculated for lower and upper floors based off their respective depth damage functions and then combined to produce a value for the whole building.

HUMAN IMPACTS

FEMA provides guidance and standard methodologies to quantify human impacts of flooding, including injuries, mental stress, and lost productivity. Standard values were updated and scaled to reflect New Jersey costs and conditions where applicable. Data on the number of residents and workers from the U.S Census American Community Survey was used to derive these results.

Residential Displacement

The following approach was used to calculate residential displacement costs for all events:

1. **Identify Impacted Structures:** The direct physical damages analysis identified structures expected to be impacted for each of the flood events. The impacted structures were those that had at least 10% of their building footprint within the floodplain of the event.
2. **Identify Impacted Square Footage:** The total impacted square footage is the area of the ground floor of the building.
3. **Evaluate Displacement Time:** The estimated flood depth within each structure is correlated to USACE depth displacement table for 2-story residential structures without basements (Appendix E) to estimate displacement time in days for each modeled flood scenario.
4. **Calculate One-Time and Daily Displacement Costs:** For residential buildings, analysts followed the methodology outlined in the 2020 FEMA BCA Standard Economic Value Methodology Report, indicating that displacement costs should represent the per-diem cost of lodging and M&IE, minus the cost of food at home, for the duration of displacement. The census data in each tract was scaled to the structural buildings total square footage to determine the size of each household. These values were then used to determine the number of days in a hotel, making the total residential displacement costs equal:

$$
\begin{aligned}
&Residential\ Displacement\ Costs \\
&\quad = Displacement\ Time\ (days) \times \{Number\ of\ Households \\
&\quad \times Per\ Diem\ Lodging\ (\$\ per\ day) \\
&\quad + Number\ of\ Residents \\
&\quad \times [Per\ Diem\ M\&EI\ (\$\ per\ day\ per\ person) \\
&\quad -\ Cost\ of\ Food\ at\ home\ (\$\ per\ day\ per\ person)]\}
\end{aligned}
$$

Mental Stress and Anxiety

Natural disasters threaten or cause loss of health, social, and economic resources, which leads to psychological distress. Mental stress and anxiety impacts are evaluated as the expected psychological distress that would occur because of property damage or displacement. Mental health treatment costs are based on cost, prevalence, and course. Cost is the cost of treatment for those who seek it. Prevalence is the percentage of people who struggle with their mental health after a disaster event. Course is the rate at which mental health symptoms reduce or increase over time.

FEMA uses cost and prevalence to establish a standard per capita value for mental stress and anxiety costs. The standard per capita value assumes mild to moderate impacts will reduce over time as treatment is provided while severe mental health problems persist. According to the FEMA Benefit-Cost Analysis Toolkit, Version 6.0, $2,443 is the standard per capita cost of mental stress treatment after a disaster. This value assumes that only forty-one percent of the impacted population seeks mental health support. The value does not capture the social impact that results from people who do not seek mental health support. The quantification of this distress is based on the cost of treatment for post-disaster mental health impacts. The final mental stress cost of a flood event is the product of the number of affected residents and the standard cost of treatment for thirty months.

Injuries

The economic value of injuries is calculated based on research from federal agencies on expected injuries from a flood event and their economic valuation. The Center for Disease Control and Prevention (CDC) estimated that 10.4 percent of residents in the Hurricane Sandy inundation zone were injured within the first week of the storm.[2] This percentage is applied to the number of residents in impacted buildings for each flood scenario. The economic value of injuries is calculated based on Willingness to Pay (WTP) values from the Federal Aviation Administration (FAA), which are based on the severity of injuries.

Lost Productivity

Work productivity can be lost due to mental illness as described in research on the impact of psychiatric disorders on work loss days. The historical impacts indicate that mental health issues will increase after a disaster, and this, paired with research related to lost productivity due to mental illness, indicates that economic productivity can be impacted by an increase in mental health issues post-disaster.[3] The impact of mental health on work productivity is calculated based on research into the impact of mental health on earnings. Research from the World Health Organization found that individuals in the United States with mental health illnesses experience as much as a 25.5 percent reduction in earnings.[4] The loss of

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[2] Center for Disease Control, "Nonfatal Injuries 1 Week After Hurricane Sandy — New York City Metropolitan Area, October 2012" Available at https://www.cdc.gov/mmwr/preview/mmwrhtml/mm6342a4.htm

3 Insel, Thomas. Assessing the Economic Costs of Serious Mental Illness. American Journal of Psychiatry. 165:6 June 2008. / Kessler et al. Individual and Societal Effects of Mental Disorders on Earnings on the United States: Results from the National Comorbidity Survey Replication. American Journal of Psychiatry. 165:6. June 2008.

4 Levinson, et al. 2010. Associations of Serious Mental Illness with Earnings: Results from the WHO World Mental Health Surveys. British Journal of Psychiatry. August; 197(2): 114–121. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2913273

productivity cost provided by the FEMA BCA Toolkit Version 6.0 is $8,736 (in 2012 USD) per worker per household, as was escalated to $9,782 (2020 USD) using the Bureau of Labor Statistics Consumer Price Index calculator. The lost productivity value is multiplied by the number of wage earners in the residence. If there is only one person in the residence, the team calculated the lost productivity value for one wage earner. If there is more than one person in the residence, the number of wage earners per household is 1.18, per the 2010 American Community Survey 1-Year Estimates.

BUSINESS IMPACTS

This portion of the methodology models existing economic relationships within New Jersey and expected impacts to those relationships in a post-disaster situation. Damage to buildings can have direct impacts on the economy, including loss of sales and revenues due to business closure. In the context of this analysis, direct economic output losses refer to economic activity that is lost because of functional disruption of a building's use. The analysis measures business interruption through lost output in accordance with FEMA HAZUS methodologies. The direct business interruption approach operates on the assumption that extensive flood damage to buildings affects the ability of businesses to operate because of unsafe working environments or the inability to provide goods and services.

Economic Output Loss

Analysis steps used to estimate direct business interruption are as follows:

1. **Identify impacted buildings, impacted square footage, and estimate restoration times**.
   A. **Impacted buildings:** Like restoration costs, output losses are estimated under the assumption that a building is damaged and unusable, not just exposed to flood hazards. For this reason, output losses are only applied to buildings that experience at least 1 foot of flooding. It is assumed that damage incurred by flood depths below 1 foot can be repaired while the building is still in use.
   B. **Impacted square footage:** For many buildings, the analysis assumes that restoration and subsequent disruption of building use is applicable only to damaged floors, which is only the first floor in any water level evaluated in this study. However, as noted above, access to upper levels may be compromised in urban high-rise buildings when only the first floor is flooded. Therefore, output loss is assessed for the entire building for urban high rises (as modified by service interruption multipliers as described below). All other buildings assume that output loss only impacts the first floor.
   C. **Restoration time.** The estimated flood depth within each building is correlated to FEMA HAZUS software depth-restoration timetables to estimate restoration time for each flood event. Restoration time is the time needed for physical restoration of building damage, including time for cleanup, inspections, permits, and delays due to contractor availability. FEMA's restoration time estimates are specific to different structure occupancies and flood depth intervals. Values from HAZUS were converted to depth damage functions using the Maximum Total Time for each depth threshold and interpolating values for flood depths in between. These curves were then applied to specific depths in the same manner as other depth-damage functions.
2. **Apply Service Interruption Multipliers to Restoration Time**
   Restoration time is adjusted for businesses that can rent alternative space or use spare industrial/commercial capacity elsewhere using service interruption multipliers, which

convert restoration time to economic functional downtime for the business interruption calculation. Business interruption multipliers are assigned to a specific building based on its assigned HAZUS occupancy class and damage state. For example, some businesses can rent alternative space or use spare industrial or commercial capacity elsewhere. For other types of buildings whose revenue or continued service depends on the existence and continued operation of the facility, repair time more closely relates to the duration of business or service interruption; these buildings include residential areas and entertainment venues.[5]

According to FEMA (HAZUS Earthquake Technical Manual), the time modifiers represent median values for the probability of business interruption across occupancy classes and for various states of structure damage. These median values consider that a portion of the businesses impacted will suffer longer outages and even fail completely under extensive and complete damage states. A few of the service interruption modifiers have trends that indicate a reduction of economic functional downtime with higher damage states. This assumes that moderate to extensive building damage incurred for those occupancies; therefore, longer restoration times may influence an occupant's owner to relocate instead.

3. **Identify output per building.**
   Output data from IMPLAN zip code-level data was used in the assessment. IMPLAN is a proprietary economic impact assessment modeling software that brings in economic data from many sources, including the U.S. Bureau of Economic Analysis, the U.S. Bureau of Labor Statistics, and the U.S. Census Bureau. IMPLAN has over 500 individual economic industries and logs industry production value (output), regional gross domestic product (value added), labor income (employee and proprietor compensation), and employment data (jobs). IMPLAN data at the zip code level was used to extract output specific to the study area, which is then further distributed to buildings. This was done using an aggregation and grouping method that links structure use with an economic industry. Different structure uses and IMPLAN industries were aggregated into "sectors" that represent related building uses and economic activity. Total building areas within the study area were then summed by sector and used to identify average output per square foot. These average values were then applied to the disrupted area of flood-damaged buildings to identify the amount of economic activity (in output) in each building.
4. **Calculate output loss.**
   Output loss is equal to impacted square footage *times* restoration time in days *times* service interruption multiplier *times* average output loss per day per square foot.

Business Relocation

The HAZUS Flood Technical Manual provides guidance to calculate relocation costs to building occupants based on occupancy type. Relocation costs consist of one-time relocation costs, lost income experienced by property owners who lease their buildings, and rental costs for property owners who live in their buildings. These costs are a function of monthly rent and building restoration time.

[5] While the research and development of service interruption multipliers pre-dates current COVID-19 related practices of work-from-home, to some extent these multipliers account for how remote work can avoid total loss of business activity while offices are not accessible.

1. **Identify impacted buildings.** Displacement costs are estimated under the assumption that a building is damaged and unusable, not just exposed to flood hazards. For this reason, displacement costs are only applied to buildings that experience at least 1 foot of flooding. It is assumed that damage incurred by flood depths below 1 foot can be repaired while the building is still in use.
2. **Identify impacted square footage.** For many buildings, the analysis assumes that displacement is applicable only on damaged floors. However, some of the area consists of urban high-rise buildings, where structure type and height may be a greater contributing factor to restoration time than occupancy. The structure damage methodology assumes that buildings with more than three stories likely have complex mechanical, electrical, and plumbing equipment located in basements or lower floors (that is, elevators, and heating, ventilation, and air conditioning [HVAC]) that would prohibit access to higher floors regardless of flood depth. Therefore, for high-rise buildings, relocation costs are calculated for the whole building for time it takes to restore the first floor. All other buildings assume that restoration only impacts the first floor.
3. **Estimate displacement time.** The estimated flood depth within each building is correlated to displacement time for each flood event. Displacement time estimates are specific to different structure occupancies and flood depth intervals.
4. **Identify and apply percent owner-occupancy rate:** The owner-occupancy rate is used to distinguish between lost income experienced by property owners and rental costs for displaced property owners.
5. **Calculate one-time disruption costs.** FEMA HAZUS methodology assumes that every building incurs one-time disruption costs for accommodating the interruption and potentially moving to a new location when the building is damaged. All buildings with flood depths of 1 foot or more have estimated disruption costs calculated based on a cost per square foot and the square footage of disrupted space.
6. **Identify rental costs.** Expected daily rental costs were calculated per building, regardless of owner occupancy. Daily rental costs in this calculation represent both the rental income a property owner can lose if a tenant is displaced, and the amount an owner would spend to rent comparable space while repairing their building.
7. **Process relocation costs.** The HAZUS Flood Technical Manual provides guidance to calculate relocation costs to building occupants based on occupancy type (FEMA, 2015). If buildings experienced physical damage and had over 1 foot of flood depth, relocation costs are the sum of one-time damage loss, rental income loss for property owners, and rental costs for property owners.

Table 3 provides a record of mapping by use code and structure use to depth damage functions, IMPLAN group, occupancy classes, and reporting category for the flood impact assessment.

LOSS OF FUNCTION

A subset of the asset data was given more specific loss of function values because of their criticality from a health and safety perspective as well as having large, readily accessible datasets. These specific assets and the data used in their loss of function calculations are as follows:

Table 5. Asset Type and Loss of Function Value Type

Asset Type	Data used for Loss of Function[6]
Libraries	Total Operating Budget for libraries in municipality per library per day
Fire Stations	Total Operating Budget for fire stations in municipality per station per day
Police Stations	Total Operating Budget for police stations in municipality per station per day
Hospitals	Total Operating Budget per center per day
Nursing Homes	National average cost of care per day for the total beds in the facility
Hospitals with Emergency Departments or Trauma Level I or II Centers	FEMA’s Benefit-Cost Analysis (BCA) Toolkit
Train Stations	Total Operating Budget of the specific transit system per station per day
Substations	Total impact per capita per day was multiplied by the total population of the municipality.

For the value per day amounts that are explained in the following sections, each is multiplied by the restoration time for that structure to determine the total loss of function per flood event.

Fire Stations

Because operating budgets for individual stations were not available, the most recent annual fire department operating budgets for each municipality were collected and distributed over the total number of stations per department, as summarized in Table 6. To determine loss per day, the annual operating budget per station was divided by 365. Volunteer fire stations were excluded in the analysis unless otherwise specified with an asterisk.

[6] All values identified were escalated to 2021 US Dollars.

Table 6. Annual Operating Budgets for Fire Stations per Municipality

Municipality	Total Stations	Total Annual Operating Budget	Annual Operating Budget per Station	Source Year	Data Source
Bayonne	9	$21,350,047	$2,372,227	2019	QuickFacts: Bayonne, New Jersey (U.S Department of Commerce 2019)
Hoboken	4	$16,864,286	$4,216,072	2020	Hoboken Fire Department (Hoboken City Hall 2021)
Jersey City	14	$68,967,213	$4,926,230	2019	Division of Fire (Jersey City, City Hall 2021)
Newark	19	$76,281,261	$4,014,803	2020	2020 Municipal Data Sheet (City of Newark 2020)
Carteret	2	$3,229,500	$1,614,750	2019	2019 Municipal Data Sheet (Borough of Carteret 2019)
Old Bridge	9	$7,652,800	$850,311	2020	Fire District Budget (Old Bridge Township #3 2020)
Perth Amboy	1	*No data available*			
Sayreville	4	$593,742	$148,436	2020	2020 Municipal Budget (Borough of Sayreville 2020)
South Amboy*	5	$225,000	$45,000	2020	2020 Municipal Data Sheet (City of South Amboy 2020)
South River*	3	$130,000	$43,333	2020	2020 Municipal Data Sheet (Borough of South River 2020)
Woodbridge	11	$54,914	$4,992	2019	SFY 2019 Municipal Data Sheet (Township of Woodbridge 2018)

Police Stations

LOF for police stations was calculated in a similar manner to fire stations. The most recent annual police department operating budgets for each type of police station in the project area (municipal, county, and state) were collected and distributed over the total number of stations per department, as summarized in Table 7. Daily operating budgets per station were divided by 365 to determine the loss per day. University police departments were excluded in this calculation.

Because there was no available data, the loss of function value for transit police stations was calculated by taking the average loss of function for all other police stations. Since Perth Amboy also did not have available data, analysts took the average of all municipal police budgets to determine its loss of function.

Table 7. Annual Operating Budgets for Police Stations per Municipality

Municipality	Total Stations	Total Annual Operating Budget	Annual Operating Budget per Station	Source Year	Data Source
Bayonne	1	$25,592,000	$25,592,000	2019	2019 Municipal Data Sheet (City of Bayonne 2019)
Hoboken	2	$18,265,853	$18,265,853	2020	Year: 2020 Municipal User Friendly Budget (Hoboken City 2020)
Jersey City	5	$111,383,303	$22,276,661	2020	Year: 2020 Municipal User Friendly Budget (Jersey City 2020)
Newark	12	$142,704,636	$15,856,071	2020	2020 Municipal Data Sheet (City of Newark 2020)
Carteret	1	$8,602,500	$8,602,500	2019	2019 Municipal Data Sheet (Borough of Carteret 2019)
Old Bridge	1	$14,300,000	$14,300,000	2020	Recycling Costs Biggest Driver of 2020 Old Bridge Municipal Budget (Chang 2020)
Perth Amboy	1	$16,444,800	$16,444,800	2021	*Average; No data available*
Sayreville	1	$13,227,529	$13,227,529	2020	2020 Municipal Budget (Borough of Sayreville 2020)
South Amboy	1	$4,374,697	$4,374,697	2020	2020 Municipal Data Sheet (City of South Amboy 2020)
South River	1	$4,000,000	$4,000,000	2020	2020 Municipal Data Sheet (Borough of South River 2020)

Municipality	Total Stations	Total Annual Operating Budget	Annual Operating Budget per Station	Source Year	Data Source
Woodbridge	1	$31,870,072	$31,870,072	2019	SFY 2019 Municipal Data Sheet (Township of Woodbridge 2018)
Hudson County	1 in project area	$35,323,327	$11,774,442	2021	2021 County Data Sheet (County of Hudson 2021)
New Jersey State	1 in project area	$583,652	$145,913	2021	Analysis of New Jersey Budget (Department of Law and Public Safety 2021)
Transit	2 in project area	$36,000,000	$18,000,000	2021	**Sourced from averaging all other values.*
Essex County	1 in project area	$48,030,831	$48,030,831	2020	2021 County Budget (County of Essex 2021)

Hospitals and Medical Centers

LOF for most hospitals and medical centers was calculated in a similar manner to fire and police stations. The most recent annual operating budgets for each hospital or hospital system were collected and distributed over the total number of facilities within each system as summarized in Table 8. Volunteer fire stations were excluded in the analysis unless otherwise specified.

There were some hospitals and medical centers that did not have available information and the following assumptions were used; all hospitals and medical centers without available budgets used the loss of function value calculated for the Newark Community Health Center system; The loss of function value for school based health centers was calculated by taking the mean budget for schools from the "Economic Evaluation of School-based Health Centers: A Community Guide Systematic Review" (Chattopadhyay et al, 2016).

Table 8. Annual Operating Budgets for Hospital Systems

Hospital System	Total Facilities	Total Annual Operating Budget	Annual Operating Budget per Facility	Source Year	Data Source
Bayonne Medical Center	1	$155,307,142	$155,307,142	2017	Hospital Charges. (CarePoint Health, 2017).

Hospital System	Total Facilities	Total Annual Operating Budget	Annual Operating Budget per Facility	Source Year	Data Source
Hoboken University Medical Center	1	$179,429,356	$179,429,356	2017	Hospital Charges. (CarePoint Health, 2017).
Jewish Renaissance Medical Center	9	$13,708,754	$1,523,195	2020	Return of Organization Exempt From Income Tax. (Jewish Renaissance Medical Center, 2018).
Metropolitan Family Health Network	3	$13,340,201	$4,446,734	2019	Tax Filings and Audits by Year (Metropolitan Family Health Network, 2019).
Newark Community Health	8	$33,605,372	$4,200,672	2017	Tax Filings and Audits by Year (Newark Community Health Centers Inc, 2017)
Rutgers Community Health Center	1	$6,165,000	$6,165,000	2020	FY2021 Revised Budget Proposal (Office of the Governor, 2020)
Raritan Bay Medical Center - Perth Amboy	3	$1,404,420,282	$468,140,094	2021	Identification and Characteristics (Raritan Bay Medican Center, 2021)
RWJ Barnabas Health at Bayonne	11	$161,500,000	$14,681,818	2019	*Source not available*
School Based Health Centers	3	$633,572	$633,572	2013	Chattopadhyay et al. *Economic Evaluation of School-based Health Centers: A Community Guide Systematic Review*, 2016.
Additional Unknown Hospital Budgets	12	$4,200,672	$4,200,672	2017	Tax Filings and Audits by Year (Newark Community Health Centers Inc, 2017)

Nursing Homes

For nursing homes and assisted living facilities, the national average cost of care per day for a semi-private room of $225 (Long Term Care, 2020) was multiplied by the number of beds in each facility, which were obtained from the Homeland Infrastructure Foundation-Level Data (HIFLD) Nursing Home Dataset (HIFLD, 2020) to obtain the total potential loss per day.

Schools

Because individual school operating budgets were not available, the average annual cost per student was collected for each municipality and applied to the total enrollment for all public, private, and charter schools as a proxy for annual operating budgets.

Table 9. Average Annual Costs per Student for each Municipality

Municipality	Average Annual Cost per Student	Source Year	Data Source
Bayonne	$17,049	2017	The Most - And Least - Expensive School Districts in New Jersey (Bichao 2017).
Hoboken	$27,899	2019	The Most - And Least - Expensive School Districts in New Jersey (Bichao 2017).
Jersey City	$17,621	2018	Interactive Map: Cost of Education in Each School District, 2017 - 2018 (O'Dea 2019).
Newark	$18,016	2018	Interactive Map: Cost of Education in Each School District, 2017 - 2018 (O'Dea 2019).
Carteret	$16,250	2017	Taxpayers' Guide to Education Spending 2017 (Department of Education 2017).
Old Bridge	$17,503	2017	Taxpayers' Guide to Education Spending 2017 (Department of Education 2017).
Perth Amboy	$25,507	2017	Perth Amboy Public School District (Public School Review 2017).
Sayreville	$15,739	2017	Sayreville Public School District (Public School Review 2017).
South Amboy	$17,822	2017	The Most - And Least - Expensive School Districts in New Jersey (Bichao 2017).
South River	$16,352	2017	The Most - And Least - Expensive School Districts in New Jersey (Bichao 2017).
Woodbridge	$16,941	2017	The Most - And Least - Expensive School Districts in New Jersey (Bichao 2017).

Libraries

Library loss of function was calculated in a similar manner to fire and police stations. The most recent annual library operating budgets for each municipality were collected and distributed over the total number of branches per municipality, as summarized in Table 10.

Table 10. Annual Operating Budgets for Library Branches per Municipality

Municipality	Total Branches	Total Annual Operating Budget	Annual Operating Budget per Station	Source Year	Data Source
Bayonne	1	$2,116,781	$2,116,781	2019	Hours and Location (Bayonne Public Library 2019)
Hoboken	3	$5,846,247	$1,948,749	2020	QuickFacts: Hoboken, New Jersey (U.S Department of Commerce 2019)
Jersey City	10	$11,175,536	$1,117,554	2019	New Jersey Public Library Data and Analyses (NJ State Library 2019)
Newark	8	$10,539,582	$1,317,448	2020	2020 Municipal Data Sheet (City of Newark 2020)
Carteret	1	$839,867	$839,867	2019	2019 Municipal Data Sheet (Borough of Carteret 2019)
Old Bridge	1	$2,788,823	$2,788,823	2020	2020 Municipal Data Sheet (Old Bridge Township 2020)
Perth Amboy	1	$1,059,259	$1,059,259	2018	Perth Amboy Free Public Library: Budget Breakdown (IMLS for Perth Amboy 2018)
Sayreville	1	$1,662,795	$1,662,795	2020	2020 Municipal Budget (Borough of Sayreville 2020)
South Amboy	1	$328,000	$328,000	2020	2020 Municipal Data Sheet (City of South Amboy 2020)
South River	1	$480,181	$480,181	2020	2020 Municipal Data Sheet (Borough of South River 2020)
Woodbridge	4	$5,471,500	$1,367,875	2019	SFY 2019 Municipal Data Sheet (Township of Woodbridge 2018)

Rail Stations

Rail station LOF was calculated by collecting the total operating budget for each transit service and distributing over the number of stations in each service, as summarized in Table 11. Daily operating budgets per station were derived by dividing the value per station by 365.

The Amtrak budget was scaled according to the number of riders at both stations in the project area (15,338 and 168,581) relative to the 2.7 billion riders that Amtrak sees each year.

Table 11. Annual Operating Budgets for Rail Stations per Transit Service

Service	Total Stations	Total Annual Operating Budget	Annual Operating Budget per Station	Source Year	Data Source
Amtrak	2	$40,813,783	$20,406,892	2021	US Passenger Railroad Amtrak asks Congress for $5.4 billion (Reuters and David Shepardson 2021).
NJ Transit	166	$2,390,000,000	$14,397,590	2020	NJ Transit Adopts Fiscal Year 2020 Operating, Capital Budgets (Staff 2019).
PATH	13	$389,000,000	$29,923,077	2020	Port Authority Releases Proposed 2020 Operating and Capital Budgets for Public Review and Comment (Port Authority of NY NJ 2019).

Electrical Substations

The loss of function value for electrical substations was calculated using FEMA Standard Values methodology to determine the total economic impact. Economic impact was determined to be the sum of total impact on economic activity and economic impact to residential customers per capita per day. The methodology is as follows:

Economic activity was estimated using Gross Domestic Product (GDP) dollar values combined with FEMA's "importance factors" for each economic sector from a study by the Applied Technology Council on the impact of power outages due to earthquakes. While FEMA used national GDP values for their analysis, state GDP data was used to determine the impact to economic activity per capita per day of $139.86. (FEMA Standard Economic Value Methodology Report, 46, Table 17, 2020).

Economic impacts to residential customers was calculated by estimating willingness-to-pay (WTP) to avoid power outages. FEMA recommends using estimates from a 2003 Department of Energy study that analyzed five major electric utilities over 15 years to determine that the average WTP to avoid a 12-hour outage was $26.27 in 2002 dollars. This value was adjusted for a 24-hour outage in 2020, becoming

$76.05 per household. Using the approximate of 2.68 people per household in New Jersey, the cost per day became $28.38 per capita. The impact on residential customers was added to the impact on economic activity for a total impact per capita per day of $168.24. This value was then multiplied by the population in each municipality to determine the total economic impact and was divided by the total number of substations in each municipality to get the total economic impact per substation per day.

This calculation assumes that the substations in each municipality serve the population within that municipality, they have the same capacity, and the total collective capacity for the substations in each municipality is large enough to provide adequate electrical power for every household per day (approximately 1.22 kW).

ASSUMPTIONS

As a modeling exercise, many uncertainties are inherently part of the losses avoided analysis. These uncertainties largely come from assumptions that are made during the analytic process. The assumptions are in line with best practices for methodologies throughout the industry and the results presented herein reflect those best practices. However, results presented herein should be taken as estimates of the cause of no action and the value of losses avoided. Assumptions include:

1. Changes in present-day demographics are not considered; future demographics are taken as reflective of current demographics.
2. Current conditions represent the 2020's.
3. First floor elevations are taken as the ground elevation except where other information, such as building codes and known mitigation projects, allowed for more specific values. First floor elevations are the basis for flood exposure and flood depth.
4. Building replacement values are derived from HAZUS, a FEMA tool, and RSMeans, a construction cost-estimating resource published yearly, and are scaled to New York City values, as appropriate. These tools represent the industry standard for replacement value estimation but do correlate precisely to the costs of repairs for any specific building in the study area.
5. The NACCS depth-damage functions used to link damage percentages to flood depths represent the best available data for the project area, but do not correlate precisely to the damage percentages experienced by any specific buildings in the study area.
6. Economic data for many sectors are aggregated and then distributed to buildings based on size and structure use type of the building. Because the building use types are not perfectly matched to economic sector, there is inherent error associated with this methodology. Results for any specific building may over- or under-represent the actual economic activity impacted but are more accurate when aggregated at the scale of the study area. Additionally, this method captures average annual estimates of economic impacts for sectors present in the study area but does not capture the seasonal variation in sales and activity that may occur. This methodology represents an industry standard and best practice for economic impact estimation.

ASSET PRIORITIZATION

What are Assets?

Assets are infrastructure, transportation, natural areas, and facilities that provide essential function to a community. They hold regional significance while contributing to a community's identity and future vision. While not all assets are structures, they can be assigned a location to examine the flood risk exposure.

Why Do We Prioritize Assets?

The Resilient RRBC region encompasses thousands of assets, 850 of which are at risk of flooding. Some assets flood more frequently but with mild flooding, some flood under fewer conditions, but when they flood the higher flood depths cause greater impacts. In order to help identify which assets are more closely examined in the flood impact assessment, the Resilient RRBC team has developed an objective ranking methodology in order to help decision makers identify assets that are more heavily impacted than other similar assets.

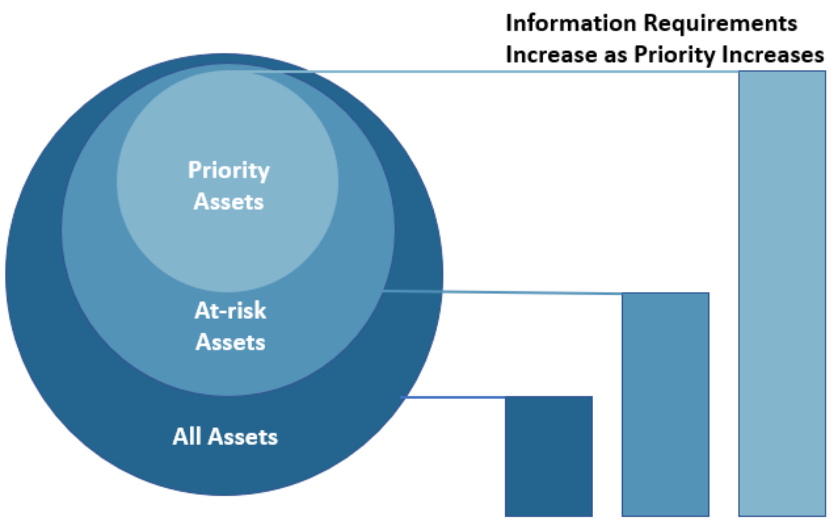

Figure 2: Asset prioritization and data requirements

Using the Flood Risk Calculator, we calculate a wealth of information for At-risk Assets.

But based on the additional needs for the qualitative assessment, we need to create a Priority Asset List that includes selected assets based on community priorities.

Why Can't We Just Use Damage Estimates to Prioritize?

The costs of associated with flooding are certainly important. But if we only looked at the monetary costs, assets that support other important functions would not be considered. During the COVID-19 pandemic, for example we saw how critical assets like schools are to the overall ability of a family to function. We also saw how open space use increased, as people sought spaces that improved their mental health and supported their quality of life. We use the prioritization as a way to make sure the importance of these types of assets is acknowledged.

How Do We Prioritize Assets?

The prioritization methodology ranks assets within different *asset types* and associates them with *community benefit categories*. By prioritizing assets within an asset type, decision makers can see which assets within a type are more impacted by flooding. This also keeps the prioritization objective as ranking across asset types would require someone to say, for example, that a school is more important than a hospital or vice versa – and there's no fair way to make that comparison.

By considering their community benefit categories, we ensure that decision makers can make decisions knowing how the assets support the community. That way, assets that are often not considered during a typical risk assessment, like those supporting quality of life and the impact on ecosystems. The figure below provides an overview of the asset prioritization process. Specific details are provided in sections discussing assigning asset scores and prioritizing within categories.

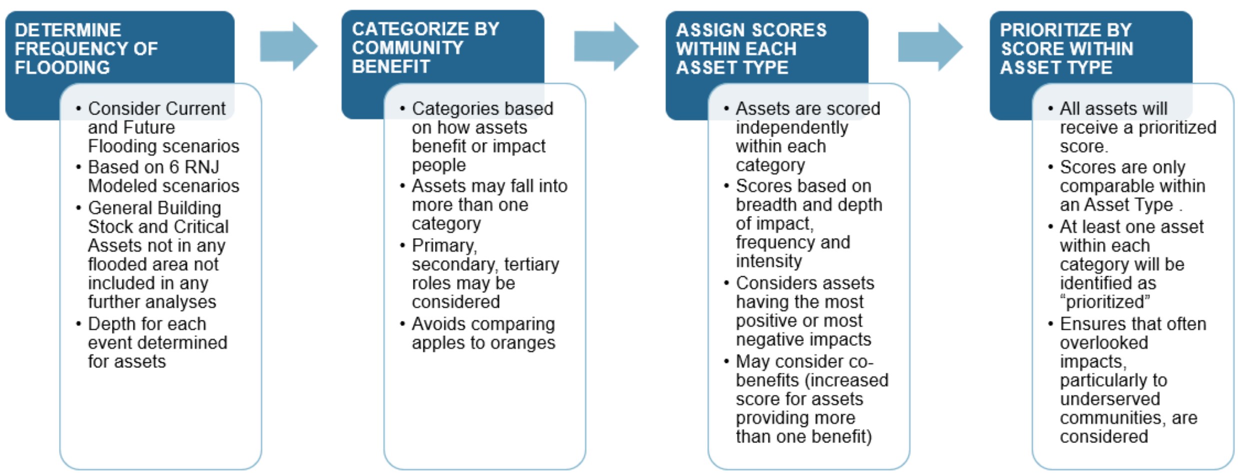

Figure 3: Overview of asset prioritization methodology

ASSET TYPES

Asset types include items which are considered important due to their role in community safety, their contribution to critical utilities, or their importance being highlighted by community member input.

Asset types in Resilient RRBC include:

- Airports
- Bike Lanes
- Bus Routes
- Cell towers
- Cemeteries
- Child care centers
- Commuter Rail
- EMS
- Fire stations
- Hospital and medical centers
- Hurricane Evacuation Routes
- Landfills
- Libraries
- Local emergency operations centers
- Municipal Buildings
- Natural Gas Pipelines
- Nursing Homes
- Parks
- Parks and Forest Trails
- Places of Worship

- Police Stations
- Power Generation
- Primary and Secondary Roads
- Prisons
- Public Housing
- Public Open Space
- Pump stations
- Rail stations
- Schools
- Shelters
- State Parks
- Substations
- Transmission Lines
- Vegetation
- Wastewater Treatment

COMMUNITY BENEFIT CATEGORIES

Assets may fit in one or many of following five benefit categories that consider the different ways that the community interacts with assets and the how the assets affect their lives:

- **Infrastructure:** Assets that ensure or impact movement of goods, services, information, and function of society on an average day, including ***Transportation*** assets that enable the movement of people and goods and ***Utility*** assets that impact the movement of essential resources, services, and information. Examples include roads, bus routes, wastewater treatment plants, and electrical substations.
- **Emergency Response:** Specific infrastructure or other assets that ensure or impact the functioning of society in an emergency or time of crisis. Examples include emergency shelters, fire stations, and hospitals with emergency rooms.
- **Public Health:** Additional assets that ensure or impact basic health, safety, and the well-being of people that are not specifically identified as infrastructure or emergency response assets, including groups of ***Vulnerable Populations*** or specific areas that provide housing and shelter for the elderly, unhoused, or other economically disadvantaged populations as well as educational institutions, such as K-12 schools. Additional examples include prisons, childcare centers, local parks, and municipal buildings. Contaminated sites also fall into this category.
- **Quality of Life:** Assets that ensure or impact people's positive relationships with themselves, one another, their community, and their environment. Examples include libraries, places of worship, and local festivals.
- **Ecosystem Health:** Assets that ensure or impact the functioning of the natural environment. Examples include state parks, landfills, and combined sewer outfalls

FEMA categorizes assets by Community Lifelines[7], which were developed to support response planning and operations. Planning that protects these lifelines can help foster resilience. Many of our community benefits align with FEMA's Lifelines. Note, however, that the FEMA Lifelines does not include assets falling into the "Quality of Life" category. See Table 12 for a mapping of community benefit categories to FEMA lifeline categories.

Table 12 Community benefit category mapping to FEMA lifeline

Community Benefit Category	FEMA Lifeline

[7] https://www.fema.gov/emergency-managers/practitioners/lifelines

Infrastructure	Energy	Communications	Transportation
Emergency Response	Safety and Security	Communications	
Public Health, Safety, Physical Well Being	Food, Water, Shelter	Health and Medical	Hazardous Materials
Quality of Life			
Ecosystem/ Environmental Health	Hazardous Materials		

COLLECT ASSET DATA

The initial list of asset data came from inputs and consideration by the project team of what would be deemed an asset to the community. The list expanded from community member input and defining what assets were important to the community. All these assets are run through a flood risk assessment to put a monetary cost on the loss of function of the assets.

The datasets used were pulled from federal, state, county, and local open data sites. The economic values connected to these assets to facilitate in creating a prioritization list for what is at the higher risk were taken from HAZUS, FEMA BCA analysis, and open source data. Additional data were requested from regional team partners. A complete list of asset types, sources and detailed methodology for the loss of function calculations can be found in this appendix in the section on Quantitative Analysis. A complete list of data sources used for the Resilient RRBC project is located as Attachment A to this appendix.

ASSIGN SCORES WITHIN EACH ASSET TYPE

Consequence scores within each category are based on the breadth and depth of flooding and the anticipated frequency of impacts:

Breadth indicates how far the impacts of flooding reach and is intended as a proxy to indicate how many people will be impacted if the asset is affected by flooding. Because each asset type serves different populations and because there generally isn't a specific count of how many people use every asset, surrogate information is used to estimate the breadth of flood impacts. For example, we estimate the population that might use a neighborhood park by estimating a reasonable distance people would likely be willing to travel to get to the park and determining the population that live within that distance. The method and assumptions used to estimate breadth depend on what information is available with the source dataset for each asset type. For example, information on the number of beds in a hospital was provided with the hospital data and is a good indicator of how many people the hospital can admit and treat. That information can be readily used to determine breadth. Table 13 lists the metrics used for each asset type to determine a breadth value. Because each asset type has a different type of breadth metric, we simplify the scoring by normalizing the values to a score between zero and ten.

Table 13. Breadth Metric Calculation

Asset Type	Metric	Calculation Method	Units
Airport	Total Area	Area of Airport polygon from GIS Database	Square Feet
Bridges	Traffic Count	Traffic Count from Nearest Road	Number of Cars
Bus Routes	Population within X miles	Use Census Data to calculate the population within a 0.5 mile radius of bus routes.	Persons
Cell Towers	Population within X miles	Use Census Data to calculate the population within a 5 mile radius of cell towers.	Persons
Cemetery	Total Area	Area of Cemetery polygon from GIS Database	Square Feet
Child Care Centers	Total Area	Area of Child Care Center connected to critical asset point	Square Feet
Colleges	Enrollment	Use number of students enrolled from college website	Persons
Emergency Medical Services	Distance to next Critical Asset	Calculate the direct distance to the nearest emergency medical service building	Miles
Ferry Terminal	Departure Count	Use average weekly departures	Number of Departures
Fire Stations	Distance to next Critical Asset	Calculate the direct distance to the nearest fire station	Miles
Gas Stations	Distance to next Critical Asset	Calculate the direct distance to the nearest gas station	Miles
Heavy Rail	Route Length	Calculate the length of the rail line	Miles
Hospitals and Medical Centers	Number of Beds	Determine the number of beds in each hospital	Persons
Hospitals with Emergency Rooms	Number of Beds	Determine the number of beds in each hospital	Persons
Landfills	Total Area	Use the area of the landfill polygon from GIS Database	Square Feet
Light Rail/Commuter Rail	Route Length	Calculate the length of the rail line	Miles

Asset Type	Metric	Calculation Method	Units
Local Emergency Operating Center	Population within Jurisdiction	Determine jurisdiction the center serves and using that population	Persons
Municipal Buildings	Default Assigned	All received the same breadth score	None
Nursing Homes	Number of Beds	Determine the number of beds in each nursing home	Persons
Parks	Population within X miles	Use Census Data to calculate the population within a 0.5 mile radius of parks.	Persons
Parks and Forest Trails	Trail Length	Calculate the length of the trail	Miles
Places of Worship	Population within X miles	Use Census Data to calculate the population within a one mile radius of each place of worship	Persons
Police Stations	Distance to next Critical Asset	Calculate the direct distance to the nearest police station	Miles
Port Facilities	Total Area	Use the area of port facility polygon from GIS Database	Square Feet
Power Generation	Plant Capacity	Determine the average weekly power output of each power generation plant	Megawatts
Primary and Secondary Roads	Route Length	Calculate the length of each road	Miles
Prisons	Prison Population	Determine the capacity of each prison	Persons
Public Housing	Number of Residents	Determine the population per building	Persons
Public Open Space	Total Area	Use the area of the open space polygons from GIS Database	Square Feet
Pump Stations	Capacity	Determine the capacity of each pump station	CFS
Rail Stations	Population within X miles	Use Census Data to calculate the population within a 0.5 mile radius of each rail station	Persons

Asset Type	Metric	Calculation Method	Units
Schools	Total Enrollment	Determine the number of students in each school	Persons
Shelters	Total Capacity	Determine the maximum capacity for each shelter	Persons
State Parks	Population within X miles	Use Census Data to calculate the population within a 5 mile radius of each state park	Persons
Transmission Lines	Line Length	Calculate the length of each transmission line	Miles
Wetlands	Total Area	Use the area of the wetland polygons from GIS Database	Square Feet
Wastewater Treatment	Default Assigned	All received the same breadth score	None

Exposure is a combination of two factors, depth of flooding and frequency of flooding. Again, to simplify the scoring process, we assign assets a frequency score based on the number of modeled events that causing flooding at the asset and a depth score based on a range of depths, as shown in Table 14 **and** Table 15**.** The Exposure Score is calculated as the sum of the products of the frequency scores and the depth scores across all events:

$$Exposure\ Score = \Sigma\ (Frequency\ Score\ X\ Depth\ Score)_{\text{For all events}}$$

Table 14: Exposure Ranking Table for each Flood Event

Event	Individual Event Frequency Score	Notes
Present day 2-hour, 50 year	3	Higher scores associated with Current flooding than future flooding
Present day 24-hour, 100 year	3	Higher scores associated with Current flooding than future flooding
MHHW + SLR	3	Higher score for high frequency of flooding under future conditions
Future 2-hour, 50 year	2	
Future 24-hour, 100 year	2	

Event	Individual Event Frequency Score	Notes
MHHW + SLR + Sandy	1	Sandy event is less likely to occur

Table 15. Depth Scoring

DEPTH RANGE	SCORE
Not Flooded	0
0-6 inches	1
6-12 inches	2
12-24 inches	3
24-60 inches	5
60-120 inches	7
> 120 inches	10

The overall **prioritized score** is **calculated by multiplying the exposure score by the breadth score. Note that this score cannot be compared across asset types (i.e. a score of 120 for a hospital is not the same thing as a score of 120 for a school). This is driven by the fact that the breadth score is based on relative ranking and is not a true count of population affected. The breadth is estimated based on differing types of information, some of which cannot be converted to population count.**

PRIORITIZED ASSET LIST

The prioritized asset list included by municipality in the Impact Assessment represents a selection of assets. They include the highest-ranking asset in each benefit category for each study area within the municipality. These assets represent a wide cross-section of asset types and are intended to highlight the diversity of assets that are exposed to flooding. This list also covers the geography of the municipality. It is not, however, a comprehensive list of assets exposed to flooding. While the list is useful to highlight some of the exposed assets, the listed assets should not be the only assets considered in planning and decision-making process.

The full list of all assets in the municipality that are impacted by flooding is included in Appendix D. This list is grouped by benefit category and asset type, with assets listed in order of score (high priority to lower priority). Additionally, the list includes the breadth score, exposure score, and prioritization score for each asset.

DATA GAP ANALYSIS

Why is Data Important?

Complete and quality data are the foundation on which sound decisions can be made. They have value because the decisions they support affect lives; they can be processed and analyzed from individual observations into relevant information, which used in context can lead to knowledge-based recommendations and wise decisions (see Figure 4)[8].

Complete, sound, accurate, current information and data are the root of all wise decision making

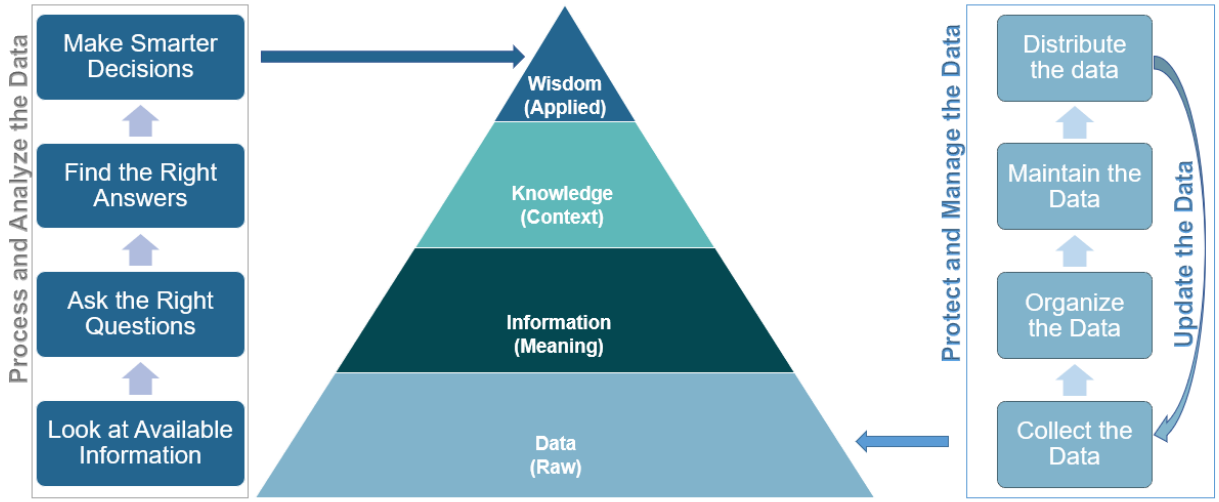

Figure 4: Data Foundation Supporting Decision Making

The reality the data represents is constantly changing - new buildings and developments are going up, people are moving, roads are built, land uses change, and land is filled during development. Data completeness and accuracy, or quality, must be kept current and accessible in order to maximize benefit over time. A robust data plan can establish a routine to maintain and update data can minimize efforts to update analyses as conditions change over time.

Alignment with New Jersey Climate Change Resilience Strategy

The New Jersey Department of Environmental Protection has identified developing and maintaining quality information as a key aspect of its climate strategy. "Priority 4: Invest in Information…" of the strategy closely aligns with the need for data improvement-related actions, and much of the recommendations could fall under this priority, though there are recommendations under other priorities (3 and 6, for example) that also align and are complementary to the findings of the data gap analysis. All recommendations could support the integrity of the Decision Support System outlined in the strategy. Alignment of our specific recommendations with the strategy is noted throughout.

[8] Louisiana Watershed Initiative

Potential future steps that further support the goal of investing information include:

- Complete a statewide assessment of data needs for reliable resilience-related planning and implement, develop, and fund an implementation strategy. Louisiana Watershed Initiative (LWI) has a possible model for review. LWI followed the below process:
  1. Develop and prioritize the list of data needed to effectively plan and implement resilience strategies (this can be done in categories)
  2. Complete an initial data gap analysis
  3. Recommend an implementation process by which detailed data gathering and development will occur
- Define data storage, maintenance, and update methods (this aligns with Action 3.1.4 of the NJ state resilience plan, Share data across agencies through an interagency web portal)

SUMMARY OF DATA TO UNDERSTAND FLOODING AND FLOOD IMPACTS

Datasets relevant to floodplain management are used in modeling the relationship between rainfall and flooding, making decisions, or engaging the community. Generally, datasets that are critical to understanding flooding and flood risk include:

- **Topographic Elevation** (Light Detection and Ranging [LiDAR]) data help in estimating flooded areas when compared to measured, predicted, or modeled water surface elevations. These data were used extensively by the Resilient RRBC team in model development and in the impact assessment.
- **Bathymetry** data consists of elevations in coastal areas and along river bottoms. They help define how water flows within the flood models. The use of this data is described in Appendix C.
- **Hydrography** data represent the locations of streams and lakes, depicting where water flows. In addition to showing these features on maps, the Resilient RRBC team used these data to develop the model.
- **Historical Flood** data **provides information on where flooding has occurred, what buildings or properties were affected, and what kinds of services were lost. Descriptions of past flooding were collected from the community.**
- **Assessor** data indicate how a property is used and who owns the property. The data help us understand what the impacts and damages are if a property is flooded. The Resilient RRBC team used this data in the impact assessment.
- **Buildings/Structures** typically consist of a building footprint. These data are compared to flood extents to determine which structures are impacted by flooding.
- **Critical Asset** data help us understand what assets may be impacted by flooding. These may include both buildings and non-building assets, like parks, pipelines, train lines, roads, power plants, and a variety of other assets. For more information on critical assets, see Appendix D.

- **River Flow and Stage** are measured at stream gages that may record flow or stage (an indicator of flood depth). They help us understand the relationship between rainfall and flood elevations. For Resilient New Jersey, these data were used to compare observed flood depths from Hurricane Irene to predicted flood depths from the flood model.
- **Rainfall** data drives the amount of flooding that occurs. For the Resilient NJ (RNJ) study, the models use design storm data rather than measured rainfall. But we also look at historical rainfall data and observed flooding as a point of comparison.
- **Conveyance Structures, Hydraulic Structures, and Roads and Bridges** affect how water behaves as it flows through the region. The RNJ models do not represent these structures in detail. The effects of stormwater conveyance are approximated, as discussed in Appendix D. A few major hydraulic structures (e.g. bridge openings and culverts under roads) are included in the models, but generally these are approximated. While this is appropriate for a regional, planning scale model, this adds some level of uncertainty to the models.

DATA GAP EVALUATION

In working toward development of the RNJ strategies, we have identified gaps that have increased the level of effort and decreased the certainty and quality of our analyses. This data gap evaluation briefly discusses the quality of the data available, identifies if it is appropriate for a regional, planning level study, and identifies relevant shortcomings to the data, including when data is not available or incomplete. For significant data shortcomings, potential steps to correct the data are provided. We also provide recommendations on data updates in the future.

TOPOGRAPHIC ELEVATION DATA

As described in Appendix B, U.S. Geological Survey (USGS) Coastal National Elevation Database Applications (CoNED) data were used as the basis for the RNJ evaluations. These data were acquired in 2014 and generally represent a suitable level of detail for a regional analysis. Some errors, however, were found locally in the data when reviewing model results. These errors appear to be based on application of an incorrect coastline in merging topographic and bathymetric data layers. The original dataset was updated with post-Sandy LiDAR data.

The corrected elevation dataset developed for the RNJ project may be used for model creation and flood inundation mapping in the near future. However, as time progresses, it may be superseded by any updated, high quality LiDAR that meets the USGS 3DEP data quality standards. Additionally, if localized projects are implemented that significantly alter the elevations, manual updates to the dataset would be recommended.

BATHYMETRY

The multiple data sources used to enhance the USGS CoNED data are described in Appendix D. This update was implemented in areas where improved bathymetry were available. This update to the bathymetry improved the model and the data are considered appropriate for a regional planning level study. The bathymetry data used to update the model extended up the Raritan River. No significant issues were found in the current bathymetry dataset that would affect their use in the RNJ study.

HYDROGRAPHY DATA

Two separate layers were used by the Resilient RRBC team. The USGS National Hydrography Dataset (NHD) represented streamlines during model development. The FEMA hydrography layers provided additional information on potential paths of flooding and guided model updates. Both are suitable for use in a regional, planning level study. No significant issues were found in the current hydrography datasets that would affect their use in the RNJ study.

HISTORICAL FLOOD DATA

Data on historical flooding provided through community outreach was incorporated into the Impact Assessment. This data, while informative, does not include flood depths or high-water marks, nor specific information on damages. More comprehensive provided by FEMA would enhance the analysis of flood impacts.

FEMA gathers a significant amount of site-specific data on impacts to communities. Not only can this information be used to justify funding from FEMA and other federal sources, it can also be used to complete loss avoidance assessments, detailed vulnerability assessments, and develop a myriad of strategies to reduce risk. The Resilient RRBC team, through NJDEP, requested this data but did not receive the information. These data should be readily available to the State of New Jersey for planning purposes. Some of the data, namely Small Business Administration (SBA), Individual Assistance (IA), and National Flood Insurance Program (NFIP) claims data are subject to privacy laws, but Public Assistance (PA) data are not. While FEMA makes some information available through its website[9], the publicly available data does not provide the level of detail. Either the spatial coordinates are too imprecise, or the key attribute data are not included:

- **NFIP claims** - location is very approximate (city or Zip code. Coordinates are DD to 1 decimal point only)
- **Housing Assistance (Renters and Owners)** - Location is to city or zip code
- **Public Assistance Applications** - includes address, but no amounts. Does include applicant ID and disaster number.
- **Public Assistance funded Projects** - includes amounts, applicant ID and disaster number. Duplicate applicant id's exist for multiple addresses, difficulties in matching with applications data.
- **Individual Households Programs (Valid Registrations)** - location is to city/zip code
- **Individual Households Programs (large disasters)** - location is to census block

The Resilient RRBC team recommends that the State consider meeting with NJOEM to determine whether there is an easier path to data acquisition through their relationships. The State could meet

[9] OpenFEMA Datasets, https://www.fema.gov/about/openfema/data-sets

with FEMA PA, IA, and SBA program leads to discuss a pathway for the state to receive direct access to these data. Additionally, the State could meet with the State Floodplain Manager to discuss use and availability of NFIP claims data for planning purposes, then potentially hold a meeting with FEMA Region II to discuss the same to speed access.

ASSESSOR DATA

Assessor data in the State of New Jersey is based on the MOD-IV data structure that was established in 1966 and last updated in 1982. There are nearly 100 unique data fields characterized in the data, but rules for populating data do not appear to be enforced, and fields have widely inconsistent data across (and even within) municipalities. MOD-IV data is best linked to parcels using a parcel identification field called “LEADLOT”. The state-wide Parcels and MOD-IV Composite of NJ GIS dataset[10] seems to have joined MOD-IV data based on the PAMS_PIN field rather than LEADLOT, which leaves many parcels missing the appropriate MOD-IV information.

Further, this composite dataset does not actually include all the information available from MOD-IV, such as the EPL use, description, or definition fields that contain the most detailed and well-populated use data for tax-exempt properties.

These data are incredibly valuable for multiple resilience-related planning purposes. We use these data to distribute demographic data for assessments, conduct assessments of direct physical damage and displacement from storm events, identify potential human impacts from climate related hazards, and more. Poor quality data both increase the cost and level of effort to complete quality assessments while simultaneously reducing the reliability of the outputs of the assessment. Parcel and assessor data are regularly gathered, and this may be an opportune time to integrate collection of fields for public safety purposes in addition to assessment.

Potential steps to make the assessor data more usable include:

- Join the state-wide composite parcel dataset by LEADLOT
- Make more resilience-relevant MOD-IV fields available and integrate these fields into the regular data collection and confirmation process for economies of scale
- Review the MOD-IV format to determine if a more streamlined data collection process would be beneficial
- Implement a robust QAQC process to ensure consistent compliance with rules for each MOD-IV data field

As MOD-IV is a state-wide standard, modifications to this standard would require action at the State level.

These recommendations would complement NJ Office of Emergency Management and Rutgers University efforts to collect high resolution elevation data for coastal floodplains. They constitute a

[10] Parcels and MOD-IV Composite of NJ, https://njogis-newjersey.opendata.arcgis.com/documents/newjersey::parcels-and-mod-iv-composite-of-nj-download/about

recommended enhancement to action 4.3.1 “Collect and maintain elevation information for existing buildings and critical infrastructure” in the NJ state resilience strategy.

- A complete asset inventory requires that each building have:
- A unique ID for each building
- A link to the associated parcel and assessor ID
- A feature type (classifying things like storage tanks vs proper buildings)
- Occupancy type
- Land use category
- Building height or number of floors
- Square footage (or other measure of area)
- Whether basements exist, if the basements are finished/occupied
- Elevation or height above ground level of the first occupied floor (perhaps merged from the Rutgers / NJOEM study or provided as a separate dataset for merging)
- Foundation height / grade elevation
- Data should also include location as either latitude/longitude or northing/easting (at a minimum), or GIS centroid points or polygons.

The State could consider which of these data might be possible to collect alongside the annual property assessment (and other data collection) processes.

Note that ownership and use of properties change over time. While in the short term the use of the current datasets is appropriate, if significant development occurs in the region, updating the analysis based on more recent datasets is recommended.

BUILDINGS/STRUCTURES

A large data gap is the lack of robust building footprints. Data for RNJ were compiled from footprints in the 500-year floodplain used in the Hazard Mitigation Plan along with footprints autogenerated by Microsoft. While the Microsoft dataset is a good start, it lacks local input or QAQC and is not regularly updated to reflect changes in development. Neighboring buildings that share a roofline are often identified as a single building, which skews building counts and other aspects of our flood risk analysis. It is difficult to reliably quantify risk with incorrect, overlapping, and unreliable building footprint data.

We recommend maintaining a state-wide dataset of building footprints, modeled after NYC[11] or Philadelphia[12] footprint data.

For simple properties, such as properties with a single building on a parcel, one can easily transfer data from assessor data to buildings. Nevertheless, for more complex properties, such as university campuses, industrial campuses, or office parks, the presence of multiple buildings of various heights and uses on a single parcel makes it more difficult to assign attributes. Building footprint data should separate buildings, where appropriate. In some cases, the data provide one solid, very long structure

[11] https://github.com/CityOfNewYork/nyc-geo-metadata/blob/master/Metadata/Metadata_BuildingFootprints.md
[12] https://metadata.phila.gov/#home/datasetdetails/5543864f20583086178c4ea5/

that complicates risk calculation. The State could consider requiring separation of buildings in footprint data as part of the data collection process and update process, where possible.

This recommendation will complement NJ Office of Emergency Management and Rutgers University efforts to collect high resolution elevation data for coastal floodplains, and is a recommended enhancement to action 4.3.1 “Collect and maintain elevation information for existing buildings and critical infrastructure” in the NJ state resilience strategy.

Due to the large effort currently required to correct/modify the datasets and transfer information from the assessor to the building data to support the flood impact assessment, our current recommendations are that updates to this dataset be carefully evaluated. Unless improved building datasets and/or improved coordination between building and assessor data are implemented, the best approach to updating the building dataset may be to identify changes from the dataset used by Resilient RRBC and make updates based on those changes, rather than re-creating the analysis performed to develop the current dataset.

CRITICAL ASSETS

Data on critical assets is important to understand interdependencies and cascading impacts of climate related hazard events. Arcadis has been quantifying risk to critical assets, but accurately mapping interdependencies (upstream and downstream relationships) is not currently possible without extensive further engagement.

- We found that there were many layers available for *some* municipalities, but not all – such as bike lanes, evacuation routes, trails.
- Other layers, specifically stormwater and wastewater features, that are necessary to understand, were inconsistent in their completeness across municipalities.
- Data on community-based assets, such as grocery stores (could be used to identify food deserts, for example), was not usually differentiated. These data are valuable in efforts to truly understand the cost of risk to the social fabric and resilience of a community

These are important datasets that should be available and maintained, though not all fields necessary for risk assessments will be appropriate for public download. It may not be feasible in the near-term to maintain these data at the state level, but the State could consider maintaining a list of all critical asset types and provide a status on whether information is available for each county/municipality/contact information for the information. This could also help provide oversight on data quality control.

Likewise, the State could consider setting / providing a standardized process for acquiring these data. For example, set up a memorandum of agreement (MOA) with counties and providers like Middlesex County Utilities Authority (MCUA) such that, for contractors working for the state or for people participating in the MOA, a simple data agreement can be signed to provide access to the data and at the same time set confidentiality / use restrictions.

Brownfields are specific asset type where we identified additional data gaps. Due to their prevalence and impacts in the state of New Jersey, it is necessary to understand the location, nature (source, extent, exposure risk), and status of contaminated sites and brownfields in order to analyze the associated near- and long-term climate-related risks associated with these sites, as well as the potential opportunities to integrate these sites into broader climate resilience strategies. There is also recent legal precedent for lawsuits including, in part, a failure to adequately consider sea level rise in the development of solutions (See example here. A source close to the issue indicated a key issue was impacts from sea level rise and associated groundwater rise).

A significant amount of data on contaminated and brownfield sites are currently available on NJGIN Open Data, NJ Mart Webpage, and NJDEP Data Miner. The data sets we explored are as follow:

- NJ Known Contaminated Sites – GIS
- NJ Classification Exception Areas (CEAs) – GIS
- NJ Deed Notice Extents – GIS
- Chromate Sites in New Jersey – GIS
- NJ Brownfield Development Areas (BDAs) – GIS
- NJ Site Mart Brownfields – GIS
- NJ Site Mart Brownfield Listings
- Individual Site Reports

NJDEP known contaminated sites are given a preferred ID number (PI number), and the PI number is key to linking known contaminated sites with their CEAs and deed notices. The chromate sites and brownfield development area layers can also be linked to known contaminated sites using the PI number.

Contaminant type details are only available for CEAs and deed notices (and inherently for chromate sites), and the details are missing for several sites within these data sets. Information on engineering / institutional controls are also only available through the CEA, deed notice, and chromate site data sets. Therefore, these details (contaminant type, method of remediation) are only publicly available for a subset of the full known contaminated site list. This information would be helpful to track performance against climate related hazards over time, as well as identify sites with potential risk to groundwater rise, etc.

Individual sites can be searched through NJ Brownfields Site Mart (for an individual report on general site info, remediation status) or the Data Miner (for various reports such as enforcement actions, permits). Neither of these sites appear to provide information on the climate-relevant attributes such as contaminant type and remediation method, and the reports that are available appear to be missing information for many sites. Additionally, the site numbers used on the NJ Brownfields Site Mart do not appear to match the PI_number.

Arcadis has completed some preliminary work to identify which fields and data are important to have to both assess risk and resilience-related opportunities at the portfolio level for contaminated and brownfields sites. We intend to refine the assessment approach through stakeholder engagement.

Some data needed to assess risk and opportunities are already available through existing data sets. As part of its development of the Decision Support System (or not) mentioned in the state Resilience Strategy, NJDEP could take the lead in assessing what data are necessary to understand risk and opportunity, support data improvements to improve availability of information, and complete a statewide assessment to identify and prioritize contaminated and brownfields sites for action based on climate-related risk and potential opportunities.

RIVER FLOW AND STAGE

While examining river flow and stage data supports a robust understanding of flooding, these data are often used to compare models for historical events to field measurements for those events as a way of validating the model. This is typically done during for studies done at a higher level of detail than the RNJ evaluations. While we use this data to provide context in comparing our model results to historical events, they were not used for model validation.

However, any future work that involves changes to the model with the intent to use the model for more localized studies should more fully incorporate any available flow and stage data. While a complete review of the available flow and stage data was not performed as part of this data gap analysis, the availability of flow and stage data should be considered for more detailed modeling, especially any modeling done to support detailed design.

RAINFALL

Design storm data from NOAA's Precipitation Frequency Data Server (PFDS)[13] was used to develop rainfall layers for the RNJ model, as described in Appendix B. These data were used to develop a single rainfall depth for each modeled scenario, which was distributed over the entire watershed with a uniform distribution. In reality, rainfall would likely have a spatially varying distribution over an area as large as the watersheds represented in the models. We recommend that this methodology be revisited for updates to the model in future, particularly if the intent is to use the model for more detailed analysis.

CONVEYANCE STRUCTURES, HYDRAULIC STRUCTURES, AND ROADS AND BRIDGES

The natural flow of rivers is affected by structures that are built to control flooding, allow navigation, or enable transportation. With an understanding of how the structures were designed or specifics on their size, shape, and other physical characteristics, the amount of flow that is carried by these structures can be included in a model that can then help predict flow and flooding patterns. Based on the regional planning scale of the modeling for RNJ, accurate representation of these structures is not included in the current model. Representing these structures would require design drawings or field surveys in order to determine opening sizes and invert elevations. This is an area where model improvements may be made and improvements are highly are recommended if updates to the model are being made with the intent of doing more detailed analysis or evaluations supporting detailed design.

[13] https://hdsc.nws.noaa.gov/hdsc/pfds/

Note that some large structures were incorporated in the model, however even for the included structures, engineering judgment was applied to develop an estimate of size and invert elevations. This does represent some uncertainty in the model results.