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Nonstructural and Ringwalls Sub-Appendix

New York – New Jersey Harbor and Tributaries Coastal Storm Risk Management Feasibility Study

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1 Introduction

This technical summary outlines the methodology and assumptions used to develop potential individual structure risk management (ISRM) alternatives for analysis for inclusion in the Tentatively Selected Plan (TSP) for the New York–New Jersey Harbor and Tributaries (NYNJHAT) Coastal Storm Risk Management Feasibility Study. Individual structure protection alternatives developed for analysis in this study include a comprehensive plan, incorporating all structures within the 1% annual chance exceedance (ACE) floodplain, and smaller components intended to supplement the five structural plans[1], which feature storm surge barriers, gates, and shore-based measures (SBMs).

Nonstructural measures are permanent or contingent measures applied to a structure and/or its contents that prevent or provide resistance to damage from flooding. Nonstructural measures differ from structural measures in that they focus on reducing the consequences of flooding instead of focusing on reducing the probability of flooding. Nonstructural measures can be grouped into two categories: physical and non-physical measures. Physical nonstructural measures include actions that require modifications to a property or structure. They include structure elevation, dry and wet floodproofing, basement removal, relocation, and acquisition. Nonphysical nonstructural measures do not modify individual structures, but rather focus on behaviors and plans that reduce flood risk. They include evacuation plans, flood warning systems, flood insurance, floodplain mapping, flood emergency preparedness plans, land use regulations, risk communication, and zoning.

The individual structure protection plans/components have been generated using a decision algorithm that was developed and applied for other projects, including the Fire Island Inlet to Montauk Point General Re-evaluation Study. This algorithm analyzes key structure attributes in order to assign the most appropriate measure to each individual structure and to estimate the construction cost based on reference unit costs derived for typical structure types. While the majority of structures in the study area are of the type and configuration for which the algorithm was originally developed, the study area also contains a number of additional structure types for which the basic array of nonstructural treatments may not be the most appropriate design. Additional measures for these special structure types have been developed for subsequent application to clusters of affected structures at a later stage of the study.

USACE Planning Bulletin 2016-01 defines ringwalls as structural measures. Prior to 2016, USACE considered a ringwall a nonstructural measure. The decision algorithm used in the

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[1] The five structural plans are Plans 2, 3A, 3B, 4, and 5.

analysis includes ringwalls because it was developed prior to this 2016 guidance. The study team determined the algorithm provides utility in decision making when both nonstructural measures and ringwalls, and so it was not modified for this investigation. For this reason, ringwalls are discussed in this appendix. For this reason, this appendix refers to Individual Structure Risk Management (ISRM) measures, which are defined as nonstructural measures and ringwalls.

The nonstructural plans presented in this appendix are preliminary. The decision algorithm outputs are draft and based on best available information. Outputs will be refined as more information is made available and documented in the final version of this appendix.

This appendix includes a preliminary number of structures and nonstructural treatments, as such information was needed for the economic benefit analysis described in Sections 5.4 - 5.9. The number of structures and types of nonstructural treatments are not yet final, and so are not included in the TSP or presented in the main report. The main report includes supplemental information about the alternative plans and the planning process.

2 ISRM Plan Development

2.1 Nonstructural Measures Considered

The full suite of physical and non-physical nonstructural measures was considered during plan formulation. The decision algorithm includes five generic types of measures for application to individual structures, within which more specific treatments are incorporated in order to account for variations in the configuration of the basic structure types.

2.1.1 Wet Floodproofing

Wet floodproofing measures allow flood water to penetrate lower, non-living space areas of the structure via vents and openings in order to reduce the effects of hydrostatic pressure and, in turn, reduce flood-related damages to the structure's foundation. Wet floodproofing may be implemented in conjunction with protection/relocation of utilities and other critical infrastructure. This can involve raising machinery, critical equipment, heating and cooling units, electrical outlets, switches, and panels and merchandise/stock permanently above the estimated flood water height. It can also involve filling subgrade basements, construction of interior floodwalls, utility rooms, or additional living space (to compensate for space lost due to floods), and the use of flood-resistant materials wherever possible to further reduce damages.

2.1.2 Dry Floodproofing

Dry Floodproofing measures allow flood waters to reach the structure but diminish the flood threat by preventing the water from getting inside the structure walls. Dry floodproofing measures considered in this analysis make the portion of a building that is below the flood level watertight through attaching watertight closures to the structure in doorway and window openings.

2.1.3 Elevation

Elevation involves raising the lowest finished floor of a building to a height that is above the flood level. This option was considered both as a stand-alone measure and in conjunction with additional construction. In some cases, the structure is lifted in place and foundation walls are extended up to the new level of the lowest floor. In other cases, the structure is elevated on piers, posts, or piles.

2.1.4 Acquisition

Acquisition involves removal of the structure from the floodplain through purchase and subsequent demolition. Lands are then preserved for open space, recreation, or other uses. Standard policy for the USACE is that acquisition recommendations become mandatory, including the use of condemnation for property if necessary. Acquisition is generally more expensive than retrofits and therefore retrofits have been considered as the least cost approach for screening. It is acknowledged that during implementation there may be occasions where retrofitting a specific property may be more expensive than acquisition and if the property owner accepts voluntary acquisition, it may be to the benefit of the project.

2.2 Structural Approaches (Ringwalls)

Ringwalls are floodwalls or levees constructed to encircle individual structures or small groups of buildings for which other nonstructural treatments are impractical or unfeasible due to their size or configuration. Ringwall systems typically surround the entire building or property with a limited number of access points. They are subject to the same design standards as larger scale floodwalls.

3 Design Criteria

3.1 Regulatory Criteria

The primary regulatory criteria incorporated into the algorithm is the design protection elevation, the elevation to which the main floor of any structure identified for nonstructural treatment must be protected from flood inundation. The design protection elevation is the Base Flood Elevation (BFE) (the 1% annual chance exceedance water surface elevation) at each individual structure, plus freeboard[2] as mandated by local floodplain management regulations. For structures in New Jersey, the mandated freeboard is one additional foot,

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[2] Additional height above the BFE, used as a factor of safety.

while in New York State the mandated freeboard is two additional feet. Additionally, to comply with current Federal Emergency Management Agency (FEMA) regulations and US Army Corps of Engineers (USACE) policy, the design protection elevation for ringwalls in both states must incorporate three feet of freeboard above the base flood elevation.

Design Flood Elevation: New Jersey: BFE + 1 foot
Design Flood Elevation: New York: BFE + 2 feet
Design Flood Elevation: Ringwalls, NJ and NY: BFE + 3 feet

For the purposes of this analysis, the Base Flood Elevations used for all structures were taken to be the 1% annual exceedance elevation in the year 2030, assuming an intermediate sea level rise scenario from the results of hydrodynamic modeling of the study area. While these elevations may not align exactly with BFEs depicted in current effective Flood Insurance Rate Maps for the area, the water surface elevations from the hydrodynamic modeling were used since they are available for every individual structure in the inventory from the damage and benefits estimation component of the overall study, and better represent risks at the time of implementation than the current flood insurance rate maps.

At this stage in the study, the nonstructural design criteria do not account for additional specific local regulations, such as ordinances related to zoning or structure height. It is recognized that some structures may require variances for local approval.

3.2 Engineering Criteria

3.2.1 Nonstructural Treatments

3.2.1.1 Structural Loads

General practice for dry floodproofing is to limit protection to a maximum of 3 feet due to hydrostatic loads, both lateral and vertical (buoyancy), on foundation walls and slabs. This generally accepted standard level of protection includes a maximum of 2 feet of flood protection plus 1 foot of freeboard.

The 3-foot dry floodproofing standard was verified during the application of the algorithm for the Fire Island to Montauk Point Study using the Federal Insurance Administration's (FIA) Manual for the Construction of Residential Basements in Non-Coastal Flood Environs (March 1977). For the verification, the following assumptions were made:

- Foundation walls are 8-inch masonry block, not reinforced;
- Soil type is Silty Sand; saturated working load is 80 pcf;
- Foundation systems are undrained;
- Basement height is 8 feet.

Using construction calculations contained in the FIA’s basement manual, it was determined that the working load (equivalent fluid weight of saturated soil/water) for the typical residential basement is reached at a saturated soil level of 2.8 feet above the basement slab. Therefore, exceeding the working load (i.e., flood depths greater than 3 feet) may result in wall failure. For fully grouted basement walls, the working load is represented by 3.8 feet of saturated soil. These relationships are illustrated in Figure 1.

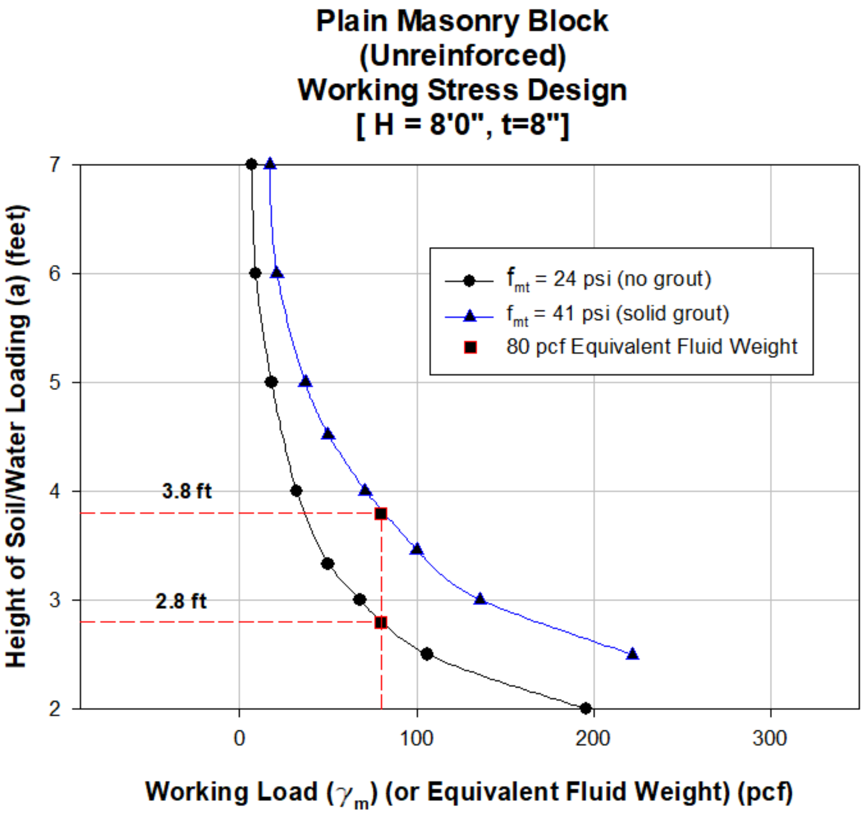


Figure 1. Working Stress Design for Basement of 8′ Height and 8″ Foundation Walls

The results using the FIA basement construction manual were qualitatively confirmed by independent tests conducted by the Waterways Experiment Station (WES) of the USACE for the National Flood Proofing Committee. In tests documented in the USACE’s Flood Proofing Tests – Tests of Materials and Systems for Flood Proofing Structures (August 1988), a concrete block wall failed when subject to 2.4 feet of flooding. Although the concrete wall was constructed without the additional support of roof rafters or ceiling joists, which provide additional lateral wall support, the performance of the wall is consistent with the calculations in the FIA basement construction manual.

The figure depicts analysis results for a water level at grade; that is, there is no freestanding water pressure on the walls. Additional calculations in the FIA basement construction manual demonstrate a similar equivalent weight of soil/water for free standing flood water up to 2 feet in depth. Flood depths of 2 to 6 feet can be represented by a slightly lower equivalent fluid weight (1.15 x 62.4 (pcf)).

As shown in Figure 2, even a basement foundation constructed of 12-inch concrete masonry unit (CMU; ungrouted) has a working load depth of only 3.8 feet. Therefore, a maximum flood depth of 3 feet represents a realistic limit for dry flood proofing.

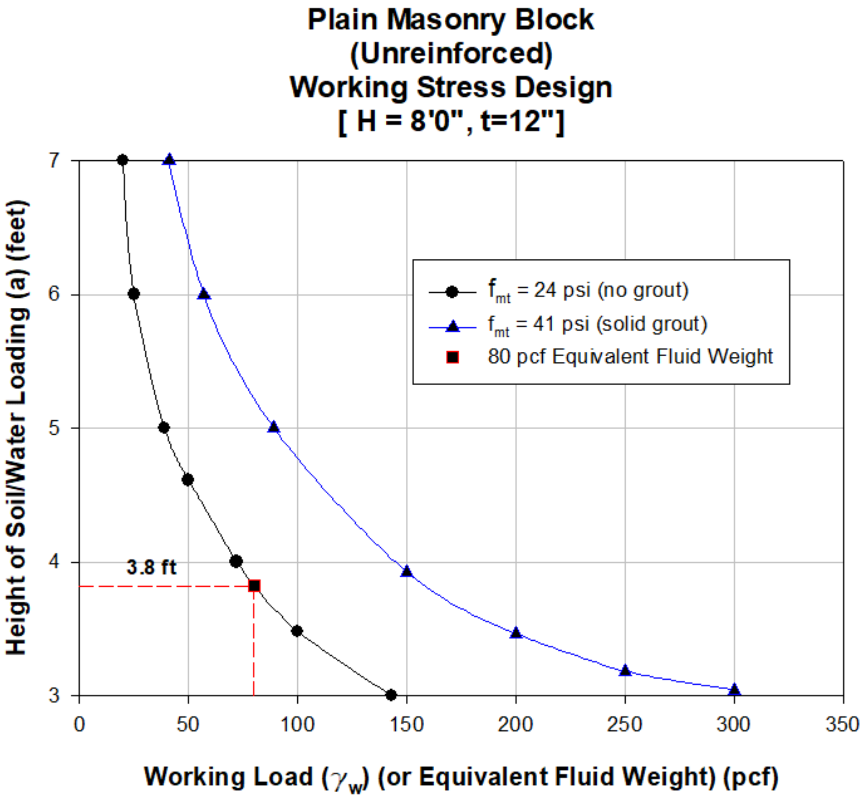


Figure 2. Working Stress Design for Basement of 8′ Height and 12″ Foundation Walls

From the FIA's basement manual, it was determined that the buoyant condition for a 1,500 SF, 1-story structure, with a 4-inch concrete slab, occurs at approximately 3 feet of head above the slab. Likewise, the buoyant condition for a similar 2-story structure is only 3.5 feet, as shown in Figure 3. Buoyant conditions for structures with 6″ slabs are only slightly higher, but still less than 4 feet. Thus, dry floodproofing depth of a structure is also limited by buoyancy effects.

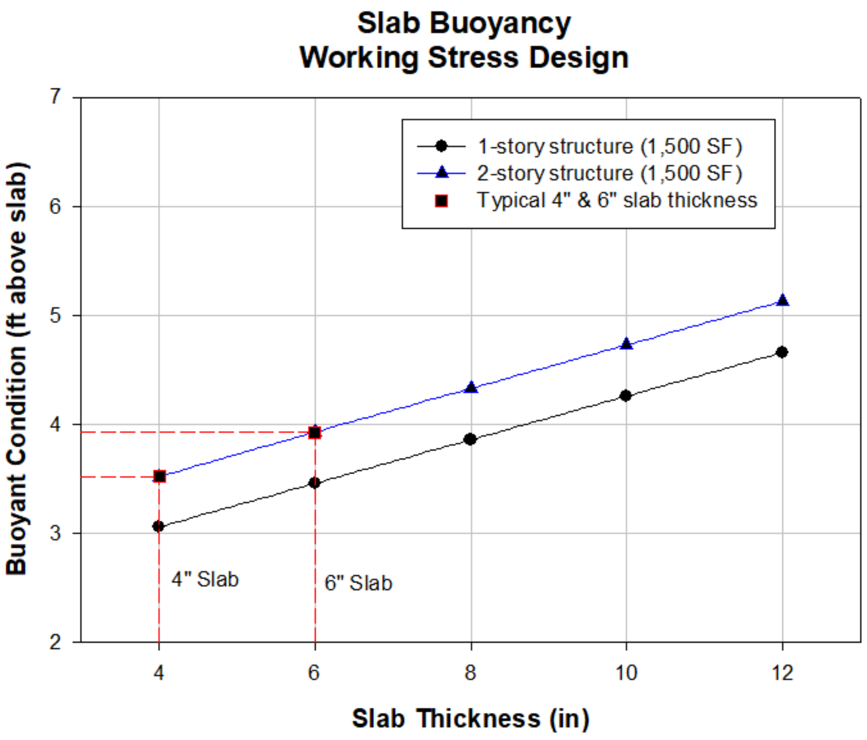


Figure 3. Working Stress Design of Slab Buoyancy

3.2.1.2 Wave Forces

The structures in the study area are generally located away from the immediate shoreline and outside of any areas designated as V or Velocity zones in currently effective FEMA regulatory flood maps. Accordingly, the assessment is based on the expectation that the vast majority of structures to be considered for nonstructural measures are located in mapped A or AE flood zones, and, therefore, not subject to any additional requirements to protect against potential damage from wave action.

3.2.2 Ringwalls

The ringwall design and costs are assumed to be consistent with the floodwall designs documented in the Structural Appendix. This reflects current USACE guidance.

4 Identification of Individual Structure Measures

The evaluation of what measure should be applied to each property in the floodplain utilized the property data compiled for the economic analysis of damages avoided. A decision algorithm was applied to assign a nonstructural measure to residential structures and smaller commercial properties. It was assumed that ringwalls would be applied at large commercial structures with the length of the ringwall estimated based on the size of the building.

4.1 Data Requirements

The main decision algorithm requires the following attributes and physical characteristics of each structure in order to successfully assign nonstructural or ringwall treatments:

- Ground elevation/lowest adjacent grade
- Main floor elevation/height above lowest adjacent grade
- Footprint area
- Foundation/basement type
- Exterior construction material
- Usage type
- Estimated structure replacement value
- Economic reach in which the structure is located
- Design flood elevation

The chief physical structure attribute that governs the selection of individual, feasible, nonstructural treatments, particularly for single family residences and similar structures, is the foundation type. For the purposes of this analysis, the predominant foundation types in the study area are as follows:

- *Slab-on grade:* The structure is constructed on a slab foundation at grade, with no space or structural components between the main finished floor and the foundation slab.
- *Basement (subgrade or walkout):* Typically, one floor equivalent of space is located under the main floor on a slab. The foundation walls may be poured concrete or concrete masonry. The basement may be finished or unfinished. The "Walkout" basement opens at grade, usually in the rear. The basement slab is usually below the front grade elevation. The "subgrade" basement slab is completely below grade on all four sides.
- *Crawlspace:* This structure's main floor is on a raised foundation, typically concrete/masonry, and not high enough for a basement or other usable space. The slab, if present, is at grade. For the purposes of this analysis, this foundation type was assumed to include structures elevated on driven timber piles

Within the residential buildings category, there are also additional structure configurations which, while not representing separate basement types to those listed above, were considered separately when deriving unit costs for nonstructural treatments:

- *Split Level:* This structure consists of three levels: a stacked lower and upper level, with an adjacent main floor between the upper and lower floor levels. Each floor (lower, main, and upper) is at a different elevation, connected by short stairways. The lower level is generally on a slab foundation and the main floor is usually raised. The lower level may be living space and/or a garage. The main entrance is at the main floor level. In some cases, there is a basement below the main level.

- *Bi-level:* This structure consists of two stories. In most cases, the first story is partially below grade, consisting of living space or a garage or both. The main floor tends to be above the first story of the structure, with the main entrance located between the lower and main floor.
- *Raised Ranch:* This structure is similar to the bi-level; however, the lower level is built slab-on-grade and the main entrance is usually at the main floor (second level). Due to the similarities between the characteristics of bi-levels and raised ranches, these structures were considered as the same for flood proofing alternatives screening. Elevation methodology and costs are generally similar to structures with basements.

4.2 Assumptions Inherent to the Baseline Decision Algorithm

The assigned measures vary depending on the structure foundation, the construction type, and flood levels (above or below the main floor). Table 1 summarizes the assumptions that were made during the original development of nonstructural decision algorithm.

Table 1. Assumptions Inherent to the Nonstructural Decision Algorithm

General Assumptions	• Flood velocity is negligible. • Debris impacts will not be considered. • Buildings elevated will be raised (finished floor elevation) to the 100-year water surface elevation plus freeboard as required by state requirements. • Flooding is gradual (no flash flooding).
Foundation Walls	• All basement foundation types are assumed to be unreinforced, 8" CMUs.
Raised Structures (Crawlspace)	• No utilities are located in the crawlspace. • Wet floodproofing requires venting to be installed in the level subject to flooding. The bottoms of the vents are required to be no more than one foot above grade
Slab-On-Grade Structures	• Wet floodproofing is possible if the expected flood elevation is below the main floor (shallow flooding). This alternative includes the elevation of utilities only.

	• Consistent with current floodproofing guidance, structures will not be dry floodproofed for flooding depths greater than 2 feet, with a maximum 3 feet of load including freeboard.
Structures With Basements	• All basements are unfinished and contain major utilities.
Bi-Levels	• The lower portion of the first floor walls is masonry construction. • The foundation is slab-on-grade. • The main floor can be raised separately from the lower level by lifting off the sill of the masonry wall.
Raised Ranches	• The first floor (lower) walls are masonry. • The foundation is slab-on-grade. • The main floor can be raised separately from the lower level (similar to a structure with a basement).
Split-Levels	• The lower level is slab-on-grade. • The lower portion of the lower-level walls are masonry construction. • The main floor level is raised over a crawl space. • The main floor and upper level can be separated from the lower level by raising at the sill.

General practice for dry floodproofing is to limit design flood elevations to a maximum of 3 feet due to hydrostatic loads, both lateral and vertical (buoyancy), on foundation walls and slabs. This includes a maximum of 2 feet of flooding against the foundation plus the required freeboard.

For slab-on-grade structures, wet floodproofing (raising the air conditioning unit) was recommended in cases where the flood level and protection level were both found to be below the level of the main floor. Dry floodproofing (sealant and closures) was recommended any time the flood level or protection level was above the main floor and less than 3 feet. Elevation was recommended only if either the flood level or protection level was above the main floor and more than 3 feet.

For structures with subgrade basements, filling the basement and adding a utility room was recommended if the flood level and the protection level were both below the main floor. Otherwise, the building was identified for elevation.

For raised structures, if both the flood level and protection level were found to be below the level of the main floor, wet floodproofing (raise the air conditioning unit and install flood louvers) was recommended. Otherwise, the building was identified as a candidate for elevation.

For structures with walkout basements, wet floodproofing (construction of an interior floodwall) was initially considered if the flood level and protection level were both below the main floor and less than 3 feet. This approach was determined to not be cost efficient or highly effective in reducing damage. Instead, these structures were identified for filling the lower floor and providing added space above the protection level for utilities. Any time the flood level or the protection level was found to be at or above the main floor, these structure types were recommended for elevation.

For bi-levels and raised ranches, dry floodproofing was recommended if the flood level and protection level were both below the level of the main floor and less than 3 feet. If the first condition was met but the 3-foot threshold was exceeded, it was recommended that the structure be raised.

For split level structures, dry floodproofing was recommended if the flood level and protection level were both below the level of the main floor and less than three feet. Otherwise, the building was identified for elevation.

In addition to the flowcharts representing the algorithm in graphical form, the decision logic for the predominant structure types in the study area is presented in Table 2.

Table 2. Primary Decision Logic

Typical	Flood Level	Decision Condition 1	Decision Condition 2	Treatment
Slab-On-Grade	>= Main Floor	Design Flood Elevation – Ground < 3	n/a	Sealant & Closures
		Design Flood Elevation – Ground >= 3	n/a	Elevate Building
	< Main Floor	< Main Floor	n/a	Raise AC
		>= Main Floor	Protection Level – Ground < 3	Sealant & Closures
			Protection Level – Ground >= 3	Elevate Building
Basement-Subgrade	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor		Fill Basement + Utility Room
		>= Main Floor	n/a	Elevate Building
Raised (Crawlspace)	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor	n/a	Raise AC + Louvers
		>= Main Floor	n/a	Elevate Building
Basement-Walkout	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor	Design Flood Elevation – Ground < 3	Fill Lower Floor + Space
			Design Flood Elevation – Ground >= 3	Fill Lower Floor + Space
		>= Main Floor	n/a	Elevate Building
Bi-Level / Raised Ranch	>= Main Floor	n/a	n/a	Elevate Building
	< Main Floor	< Main Floor	Design Flood Elevation – Ground <= 3	Sealant & Closures
			Design Flood Elevation – Ground >3	Raise Lower Floor + Space
		>= Main Floor	n/a	Elevate Building

Typical Structure Type	Flood Level	Decision Condition 1	Decision Condition 2	Treatment
Split Level	< Main Floor	n/a	n/a	Elevate Building
		< Main Floor	Design Flood Elevation – Ground < 3	Sealant & Closures
			Design Flood Elevation – Ground >=3	Elevate Building
		>= Main Floor	n/a	Elevate Building
Note: Design Flood Elevation includes freeboard.				

The assumptions and decision logic described above were originally developed to apply to single/two-family residential buildings and wood-framed nonresidential structures of similar construction. For additional structure types (apartment buildings and high rises, larger nonresidential structures, and masonry nonresidential structures of any size), the baseline algorithm assumes that elevation is not feasible, and that stand-alone ringwalls will generally be the most appropriate measure. See the flowcharts in Attachment 2 for a full graphical depiction of the baseline algorithm.

4.3 Alternative Strategies for Special Structure Types

An additional evaluation was conducted to identify if there are better approaches to providing flood risk management for some structure types that were not directly considered in prior assessments. The evaluation considered a range of options to provide ISRM for three structure configurations: connected commercial or brownstone type residential buildings; high-rise buildings; and port and marine structures. The current algorithm assigns a standard ringwall to each of these structure types. Table 3 through Table 5 provide a description of the alternative treatments developed for each of the three building types.

Table 3. ISRM Options for Connected Commercial or Brownstone Type Residential Buildings

	Ringwall	Deployable	Ringwall/Deployable Blend	Abandon Lower Level / Fill and Move Utilities	Elevate Building	Do Nothing	Critical Utility Protection	Raise Lower-Level Floor if Ceiling Is High Enough
Feasibility	Yes	Marginal	Yes	Yes. If the flood level is below first floor grade	Generally, not feasible due to the common wall(s) and overall size of these structures.	Yes	Yes	Yes. Limited to structures with high ceilings (say min 3 feet)
Utility Impact	Major Temporary impact. Some Permanent Impact likely.	Major Temporary impact. Some Permanent Impact likely.	Major Temporary impact. Some Permanent Impact likely.	Major Temporary impact. No permanent impact.	NA	NA	Yes	Major Temporary impact. No permanent impact.
Effectiveness	Most applicable with I wall height below 6 ft including 3 feet of freeboard.	Applicable for use on short lengths and openings for access.	Yes. Combines Ringwall and Deployable Options.	Effective	NA	NA	Limited	Limited
Adaptability	Can be used with gates or Deployable at Access locations.	Incorporate with ringwall (See Ringwall - Deployable Blend Option).	No. Combined Concept (see Ringwall and Deployable Options).	N/A	None	NA	No	No
Relative Cost	High	Highest	High	Mid	NA	NA	Low	Low-Mid
Impact on Value (loss of usable space)	Minimal	Minimal	Low	Moderate with the loss of Useable Area.	NA	NA	N/A	Limited loss of storage/volume with floor modification.
Long-term Impact on use and access	Limited	Limited	Limited	Moderate with the loss of Useable Area.	NA	NA	N/A	Limited
Temporary Impact on use and access	High - Relocate tenants during construction.	High - Relocate tenants during construction.	High - Relocate tenants during construction.	High - Relocate tenants during construction.	NA	NA	Limited	High - Relocate tenants during construction.
Life Safety Concern	Moderate. Living space will need to be eliminated at the lower level to avoid a potential life safety threat.	Moderate. Living space will need to be eliminated at the lower level to avoid a potential life safety threat.	Moderate. Living space will need to be eliminated at the lower level to avoid a potential life safety threat.	Minimal	NA	Same as Existing Conditions	No	No
Sufficient Data to Evaluate	Yes. Larger ringwalls could be refined during design level to reflect utility and access requirements.	Yes. If the location requires public access ringwalls could be refined during design level to reflect utility and access requirements.	Yes. Larger ringwalls could be refined during design level to reflect utility and access requirements.	No. More information would be needed regarding basement presence, elevation, and use.	NA	NA	No	No. More information is needed regarding ceiling height.
Recommendation	Continue use as base case for screening.	Consider as part of future design refinements as more data is available for specific structures.	Consider as part of future design refinements as more data is available for specific structures.	Consider as part of future design refinements as more data is available for specific structures.	Not considered further	Not considered further	Consider as part of future design refinements as more data is available for specific structures.	Consider as part of future design refinements as more data is available for specific structures.

Table 4. ISRM Options for High-Rise Buildings

	Ringwall	Deployable	Ringwall / Deployable Blend	Abandon Lower Level / Fill and Move Utilities	Critical Utility Relocation or Protection (Dry Floodproof)
Feasibility	Yes – Utility challenge	Marginal	Yes	Yes. If the flood level is below Main (first) level	Yes. If the flood level is below Main (first) level or is combined with Ringwall.
Utility Impact	Yes	Marginal	Yes	Yes. Move utilities which can be raised and protect equipment which likely cannot be raised such as elevators in a watertight chamber	Yes
Effectiveness	Most applicable with I-wall height below 6 ft including 3 feet of freeboard.	Applicable for use on short lengths and openings for access.	Yes. Combines Ringwall and Deployable Options.	Effective	Effective
Adaptability	Can be used with gates or Deployable at Access locations	Incorporate with Ringwall (See Ringwall – Deployable Blend Option)	Combined Concept (see Ringwall and Deployable Options)	N/A	Add – Ringwall
Relative Cost	High	Highest	High	High	Mid
Impact on Value (loss of usable space)	Minimal	Minimal	Low	High – Relocate tenants during construction. Also See note 5.	Low to Moderate – Possible temporary relocation of tenants.
Long-term Impact on use and access	Limited	Limited	Limited	Limited	Limited
Temporary Impact on use and access	Moderate – High	Moderate – High	Moderate – High	Moderate – High	Low to Moderate – Possible temporary relocation of tenants.
Life Safety Concern	Minimal	Minimal	Minimal	Minimal	Minimal
Sufficient Data to Evaluate	Yes. Larger Ringwalls could be refined during design level to reflect utility and access requirements.	Yes. If the location requires public access ringwalls could be refined during design level to reflect utility and access requirements.	Yes. If the location requires public access ringwalls could be refined during design level to reflect utility and access requirements.	Incomplete. Need information on utilities, equipment and building use if Commercial.	Incomplete. Need information on utilities, equipment and building use if Commercial.
Recommendation	Continue use as base case for screening.	Consider as part of future design refinements as more data is available for specific structures.	Consider as part of future design refinements as more data is available for specific structures.	Consider as part of future design refinements as more data is available for specific structures.	Consider as part of future design refinements as more data is available for specific structures.

Table 5. ISRM Options for Port and Marine Facilities

	Ringwall	Deployable	Ringwall / Deployable Blend	Critical Utility Relocation or Protection	No Action
Feasibility	Yes	Marginal	Yes	Yes	N/A
Utility Impact	Possible underground utility impact. Above ground utilities/equipment to be avoided.	Limited. Identify underground and avoid above ground utilities.	Possible underground utility impact. Above ground utilities/equipment to be avoided.	Major during relocation. Low to Moderate if protected.	N/A
Effectiveness	Most applicable with I wall height below 6 ft including 3 feet of freeboard	Applicable for use on short lengths and openings for access	Yes. Combines Ringwall and Deployable Options	Effective	None
Adaptability	Can be used with gates or Deployable at Access locations	Incorporate with Ringwall (See Ringwall - Deployable Blend Option)	No. Combined Concept (see Ringwall and Deployable Options)	Limited	N/A
Relative Cost	High	Highest	High	Moderate	N/A
Impact on Value (loss of usable space)	Low	Minimal	Low	Low	N/A
Long-term Impact on use and access	High	Minimal	High	Low to moderate	N/A
Temporary Impact on use and access	High	Moderate	High	Moderate	N/A
Life Safety Concern	Low to High depending on the type of facility.	Low to Moderate	Low to High depending on the type of facility.	Low to High depending on the type of facility.	Low. increases over time with sea level rise
Sufficient Data to Evaluate	Partially. Need underground utility information.	Partially. Need utility information.	Partially. Need utility information.	No. Need utility information.	N/A
Recommendation	Continue use as base case for screening.	Consider as part of future design refinements as more data is available for specific structures.	Consider as part of future design refinements as more data is available for specific structures.	Not highly effective in most cases, possible specific locations for considerations.	NA

4.3.1 Connected Commercial/Brownstones/Townhouses

At the current stage of the study, the approach applied in the current algorithm assumes risks to those structures in this category will be managed with ringwalls. Alternative approaches identified in Table 3 were considered but there is insufficient data in the current inventory to refine the approach for individual structures. The assumed use of ringwalls for the individual buildings is considered sufficient for screening purposes. Currently, the inventory data for connected residential and commercial structures is not sufficiently detailed to allow for a more granular application of different treatments.

However, it is recommended that this assumption and associated costs be re-visited and refined for structures identified for further assessment in the optimization phase of the study. For such cases, it is recommended that structures subject to flooding below the main floor are most appropriately treated by abandoning and filling the lowest level and moving any utilities located in that level elsewhere in the structure. For flooding above the main floor, it is recommended that structures be assigned ringwalls with access provided via ramps or openings with smaller deployable flood barriers. When structures in this category are assigned ringwalls, any residential space below the main floor (for example, basement apartments that are common in brownstone residences) should be abandoned and either filled or used only for limited storage due to life safety concerns.

The recommended measures would incur costs additional to those currently assumed in the nonstructural algorithm. The average square foot cost to has been developed for fill the lower levels of single-family residences can be used to derive a unit cost to abandon and fill the lower levels of connected structures based on typical sizes of residential and commercial units in this structure category.

Currently, the analysis may over-estimate the ringwall construction cost for some structures where the algorithm interprets connected units as separate structures and calculates the total linear footage of wall accordingly. More detailed inventory data collected for the implementation phase should include confirming the layout and size of connected structures to facilitate a more accurate estimation of the total length of wall required.

Abandoning usable space in a structure as part of nonstructural treatment will very often represent a loss of value to the owner of the structure which is not readily quantifiable as an implementation or construction cost. Detailed assessments of nonstructural treatments for structures in this category in the optimization phase will include a determination of the most appropriate approach to account for the loss of value in the economic analyses.

4.3.2 High-Rise Buildings

Similar to connected structures as described above, the baseline assumption in the current algorithm that high-rise structures are generally to be assigned stand-alone flood protection structures (with a small number subject to elevation and protection of utilities) is considered to be sufficient for screening purposes. However, while no practical changes to the decision algorithm are recommended for these structures, revisions to the estimation of treatment costs are appropriate to refine the analysis for future assessments.

If the designs progress, the ringwall costs should be refined to reflect the public access requirements on a site-specific basis. High-rise structures, especially those in urban areas such as downtown New York City, often feature large public-facing areas not conducive to the construction of permanent ringwall features. Hence, the recommended measure for high-rise structures with flooding above the main floor is a blend of ringwalls and deployable floodwalls, with the exact blend dependent on the amount of public-facing frontage of each individual structure.

During the optimization phase the cost for each high-rise structure is to be refined based on a more detailed assessment of the access requirements and public-facing areas of individual high-rise structures identified for protection.

4.3.3 Port/Marine/Storage Facilities

Port and marine facilities often cover large areas and are frequently most appropriately addressed with SBMs. Ringwalls and alternatives for deployable walls have been assessed, but the need for deployable structures at access points will need to be determined for the individual locations and could not be built into a generalized algorithm.

4.4 Acquisitions

Acquisitions were not included in the current plan formulation since the data is not currently sufficient to evaluate specific locations in detail. Also, a program of acquisitions must comply with the Uniform Relocation Assistance and Real Property Acquisition Act (URA), which requires the provision of equivalent housing in the same area, which is likely to prove challenging in the real estate market in the study area.

4.5 Costs of Nonstructural Measures

Unit costs were developed for the application of all the nonstructural treatments in the array of alternatives to typical structures of varying sizes. Sources used to establish quantities, items and costs for the various measures were:

- Village of Freeport, Nassau County, NY, Elevation of Residential Homes
- McDowell County, WV, Section 202 Acquisition/Demolition/Site Restoration Project
- RSMeans Cost Data

- Homeowner's Guide to Retrofitting (FEMA 312)
- Correspondence with private commercial entities (Davis Brothers Engineering Corp., Smartvent®)

The original costs were developed using MII, a detailed cost estimating software application, and each estimate was revised in detail in 2018 for the final phase of the Fire Island to Montauk Point Study. During this study, costs were updated to 2018 price levels for individual components of the estimates including labor, equipment, and materials escalation. The 2018 unit costs were updated to the March 2022 price level by applying an update factor of 1.22 for Q3 2018 to Q2 2022 derived from the USACE Civil Works Construction Cost Index System.

Table 6 summarizes the assumptions that were applied during the development of detailed unit costs.

Table 6. Assumptions Inherent to the Development of Unit Costs

General Assumptions	• The typical building condition is good. • The typical building foundation is in good condition. • Subgrade basements will be converted to slab-on-grade foundations by filling in the basement to grade. • Exterior utilities will be raised above the BFE. • Living space is located on the lower floor of a split level and bi-level/raised ranch structure. • Additional space is included to relocate utilities when a basement is filled. • Landscaping along the structure perimeter is needed to replace plants, shrubs and trees damaged during construction.
Wet Flood Proofing	• Venting is required below the main floor. • Basement utilities will be relocated to a utility room or protected from flooding with an interior floodwall. • For a slab-on-grade requiring a protection level less than the main floor, the AC unit will be raised. • For flooding below the main floor of a raised structure (crawlspace), raise the exterior AC unit and add flood louvers. • For subgrade basements, fill the basement and add a utility room. • For walkout basements requiring less than 3 feet of protection (below the main floor) use an interior floodwall.

	• For walkout basements requiring protection of 3 feet or more (below the main floor) raise the lower floor and add a utility room. • For bi-levels/raised ranches requiring greater than 3 feet of protection (below the main floor), raise the lower floor and add a utility room.
Dry Flood Proofing	• Utility relocations are not required. • Limited to low level flooding (<= 2 feet). • For slab-on-grades, bi-levels/raised ranches and split-levels requiring less than 3 feet of protection (below the main floor) use sealant and closures. • Watertight closures are required for windows and doorways.
Elevation	• The Finished Floor Elevation will be elevated above the 1% Annual Chance Exceedance (100-year) flood level projected in 2030 using the intermediate sea level change rate. • Wood decks, exterior stairs, and fireplaces will not be evaluated. • Lifting systems include supporting beams, lifting beams, and jacking systems. • Slab-on-grade foundations will be elevated without the slab. The slab will be abandoned in place and broken up to reduce the effect of buoyancy. • Structures lifted without a floor (i.e., slab) need bracing to prevent the walls from buckling. • Interior masonry columns will be used to support the raised structure. • Existing foundation with extended walls will support an elevated structure.

Using the criteria, methodology, and assumptions discussed above, unit costs were developed for a series of floodproofing measures for each typical building type. The unit cost estimates are presented in Table 7. Estimates are based on a March 2022 price level.

Table 7. Unit Reference Cost Estimates for Nonstructural Measures by Structure Type

Structure	Nonstructural Measure	Flood Depth / Elevation Height	Building Footprint (Square Feet)	Description	Estimated Cost	Cost / Square Foot
Slab on Grade	Wet Floodproof	All	All	Raise AC Units	$5,400	Varies
	Dry Floodproof	<=2 Ft	1,000	Sealant & Closures	$88,000	$88
			2,000	Sealant & Closures	$115,600	$58
			5,100	Sealant & Closures	$157,200	$31
			5,100	Sealant & Closures	$166,400	$33
	Elevation	Raise 8 Ft	1,000	Raise 8 Ft	$219,300	$219
			2,000	Raise 8 Ft	$246,200	$123
Basement - Subgrade	Wet Floodproof	All	900	Add utility room, fill basement, raise exterior utilities	$119,500	$133
			1,600	Raise, add utility room, fill basement, raise exterior utilities	$138,300	$86
	Elevation	Raise 4 Ft	900	Raise, add utility room, fill basement, raise exterior utilities	$256,100	$285
			1,600	Raise, add utility room, fill basement, raise exterior utilities	$266,900	$167
		Raise 8 Ft	900	Raise, add utility room, fill basement, raise exterior utilities	$312,500	$347
			1,600	Raise, add utility room, fill basement, raise exterior utilities	$301,900	$189
Basement - Walkout	Wet Floodproof	All	All	Utility Room + Louvers	$89,400	Varies
	Elevation	Raise 4 Ft	900	Raise, Wet Floodproof +Utility room	$205,500	$228
			1,600	Raise, Wet Floodproof +Utility room	$254,500	$159

Structure	Nonstructural Measure	Flood Depth / Elevation Height	Building Footprint (Square Feet)	Description	Estimated Cost	Cost / Square Foot
		Raise 8 Ft	900	Raise, Wet Floodproof +Utility room	$290,100	$322
			1,600	Raise, Wet Floodproof +Utility room	$386,500	$242
Raised / Crawlspace	Wet Floodproof	All	1,000	Raise AC unit + Flood Louvers	$7,900	$8
			1,400	Raise AC unit + Flood Louvers	$8,900	$6
			2,000	Raise AC unit + Flood Louvers	$10,400	$5
	Elevation	Raise 4 Ft	1,000	Raise	$149,300	$149
			1,400	Raise	$163,900	$117
			2,000	Raise	$187,100	$94
		Raise 8 Ft	1,000	Raise	$159,900	$160
			1,400	Raise	$202,900	$145
			2,000	Raise	$230,500	$115
Bilevel /Raised Ranch	Wet Floodproof	>2 Ft	1,200	Raise/Rebuild Floor	$153,800	$128
			1,600	Raise/Rebuild Floor	$168,700	$105
	Dry Floodproof	<=2 Ft	1,200	Sealant & Closures	$111,200	$93
			1,600	Sealant & Closures	$115,900	$72
	Elevation	Raise 4 Ft	1,200	Raise	$153,800	$128
			1,600	Raise	$168,700	$105
		Raise 8 Ft	1,200	Raise	$184,400	$154
			1,600	Raise	$198,400	$124
Split Level	Wet Floodproof	>2 Ft	1,100	Additional space	$99,500	$90
			1,800	Additional space	$110,600	$61
	Dry Floodproof	<=2 Ft	1,100	Sealant & Closures	$65,600	$60
			1,800	Sealant & Closures	$74,700	$42
	Elevation	Raise 4 Ft	1,100	Raise	$209,800	$191
			1,800	Raise	$237,300	$132
		Raise 8 Ft	1,100	Raise	$232,400	$211
			1,800	Raise	$252,700	$140

Structure	Nonstructural Measure	Flood Depth / Elevation Height	Building Footprint (Square Feet)	Description	Estimated Cost	Cost / Square Foot
Structures not suitable for treatments above	Ringwall	All	All	Stand-alone Floodwall	$7,600 / LF	

The reference cost for ringwalls was taken from the cost estimate for a stand-alone floodwall of height 6.5 feet above grade, derived as part of a separate exercise in the to develop standard shore based measure designs and costs. This approach provides consistency for comparing shore based measure alternatives and individual structure protection.

To generate treatment costs for individual structures in the study area, adjustment factors were applied to the unit costs, to account for where sizes and protection/elevation heights varied from those of the structures and treatments on which the unit reference costs were based. The unit costs and adjustment factors were applied within the SAS program and output for each individual structure, along with the assigned treatment and associated modifications to the structure attributes.

4.6 Derivation of the Structure Inventory

The structure inventory to which the decision algorithm was applied was derived from the inventory generated for the estimation of damages and benefits in a separate component of the overall study. Data sources for the original inventory are provided in the NYNJ HAT Study Interim Report Economics Appendix of February 2019. At that stage of the study, the inventory was primarily generated from available tax parcel data for the study area, and where the sources did not include certain structure characteristics listed above that are required by the damage modeling approach, typical attributes drawn from detailed inventory surveys conducted in areas of similar building stock were assumed. Subsequent to that effort, the inventory was refined based on a windshield survey of sample structures in the study area, following which detailed attribute data for approximately 6,000 sample structures was added to the inventory. For the purposes of the nonstructural treatment analysis, for those structures not surveyed in detail, further assumptions were applied to populate all the data required by the decision algorithm. Since the data coverage and detail was not consistent between the sources used to generate the inventory, there was some variance by state/city in the assumptions used to refine the data input to the algorithm. These assumptions are presented in detail in Attachment 1.

5 Individual Structure Risk Management Plan Development

5.1 Stand-alone Plan

A high-level screening was performed to compare the larger structural plans to the use of ISRM only. The total implementation cost for a comprehensive ISRM plan covering the whole of the 1% annual chance exceedance floodplain is estimated to be $155 billion. This is greater than the currently estimated cost of Alternative 2, the largest structural plan under consideration. Since current economic analyses indicate that Alternative 2 is not cost-effective, it is considered that the comprehensive ISRM plan would be even less cost-effective: in addition to the higher cost, the comprehensive ISRM plan would realize fewer total benefits. While it would reduce the risk of damage to individual structures in the same coverage area as Alternative 2, it would not provide additional benefits such as those related to infrastructure and business disruption that would be associated with the structural alternative. Additionally, a comprehensive ISRM plan would very likely face significant challenges in implementation and participation that would greatly hinder the plan's feasibility and further reduce its ultimate effectiveness.

5.2 Integration with Structural Plans

Nonstructural alternatives developed and evaluated also included stand-alone plans for a smaller floodplain area that could be implemented independent of any structural measures. These plans were developed and screened for potential benefit and cost viability based on aggregate values for each economic reach. In addition to stand-alone plans, ISRM measures were developed for buildings as supplemental measures to address gaps in Risk Reduction Feature (RRF) limits associated with the alternative Storm Surge Barriers (SSBs). The assessment of these supplemental RRF measures was not subject to incremental benefit cost justification since their economic performance is hydraulically connected to the operation of the SSBs. It is expected that the inter-relationship of costs and benefits associated with SSB operation and RRF design levels will be evaluated jointly as part of the optimization stage. Nonstructural measures have been developed in order to assess their effectiveness as stand-alone components to supplement gaps in the coverage of structural plans, as RRFs in conjunction with structural plans, and as adaptive management measures to mitigate the potential impact of future changes in barrier operating scenarios.

Preliminary analyses were based on the current SSB gate operation. Structural Plans 2 through 4 would be closed when the water surface elevation reaches 7 feet NAVD at the Battery, the southernmost point of Manhattan. Under this operating scenario there remain some developed areas behind the barriers with ground elevations sufficiently low that they would be subject to flooding prior to the closure of the barriers, or that remain vulnerable to flood damage because they are outside the areas covered by the barriers. To mitigate damages in reaches behind barriers, residual risk reduction features in the form of either structural floodwalls or nonstructural treatments to the affected structures have been proposed to supplement the structural plans. To mitigate damages in reaches outside the barriers, nonstructural treatments have been analyzed as stand-alone measures covering vulnerable low-lying areas. Additionally, nonstructural treatments have been considered for individual structures nominally protected by storm surge barriers but located in low-lying areas outside those protected by residual risk features.

5.3 Derivation of Floodplains for Nonstructural Plan Coverage

Locations (nodes) used for hydrologic modeling during the North Atlantic Coast Comprehensive Study (NACCS) have been assigned to each economic reach in the study to be used as representative stage frequency data. These nodes provide water surface elevations for the 50%, 20%, 10%, 5%, 2%, 1%, 0.5%, and 0.2% annual chance exceedance storm events for 1992 (the "2, 5, 10, 20, 50, 100, 200, and 500-year" events). The data was then adjusted for sea level rise for the initially selected base year (2030) using the USACE/NOAA Low Sea Level Change (SLC) Curve. Full details of the assignment of NACCS nodes to economic reaches can be found in the NYNJ HAT Study Interim Economic Appendix, February 2019. These stage-frequency curves provided the design protection elevation for each affected structure, and were also used to define the floodplains, corresponding to levels of protection associated with first added risk reduction features, varying storm surge barrier operating scenarios, and a comprehensive nonstructural plan covering the entire 1% annual chance floodplain.

Since there is significant variation across the study area in the frequency at which the water surface elevation reaches 7 feet NAVD, the floodplains affected by these features have been derived by using the water surface elevation in each reach which occurs at the same frequency as that which generates the 7 feet NAVD stage at the battery. An example of the derivation of the equivalent stage for a single reach is shown in Figure 4.

In the future, as sea level change increases, the frequency which generates a stage of 7 feet NAVD at the Battery will increase, and the barrier closure stage may need to be raised to avoid obstructions to shipping and to reduce operations and maintenance costs. Under such circumstances, the coverage of structural or nonstructural residual risk would need to be expanded, and Figure 4 also shows the derivation of floodplains at frequencies equivalent to stages of 8 feet NAVD and 9 feet NAVD at the Battery to represent two possible future operating scenarios, for which nonstructural plans have also been compiled.

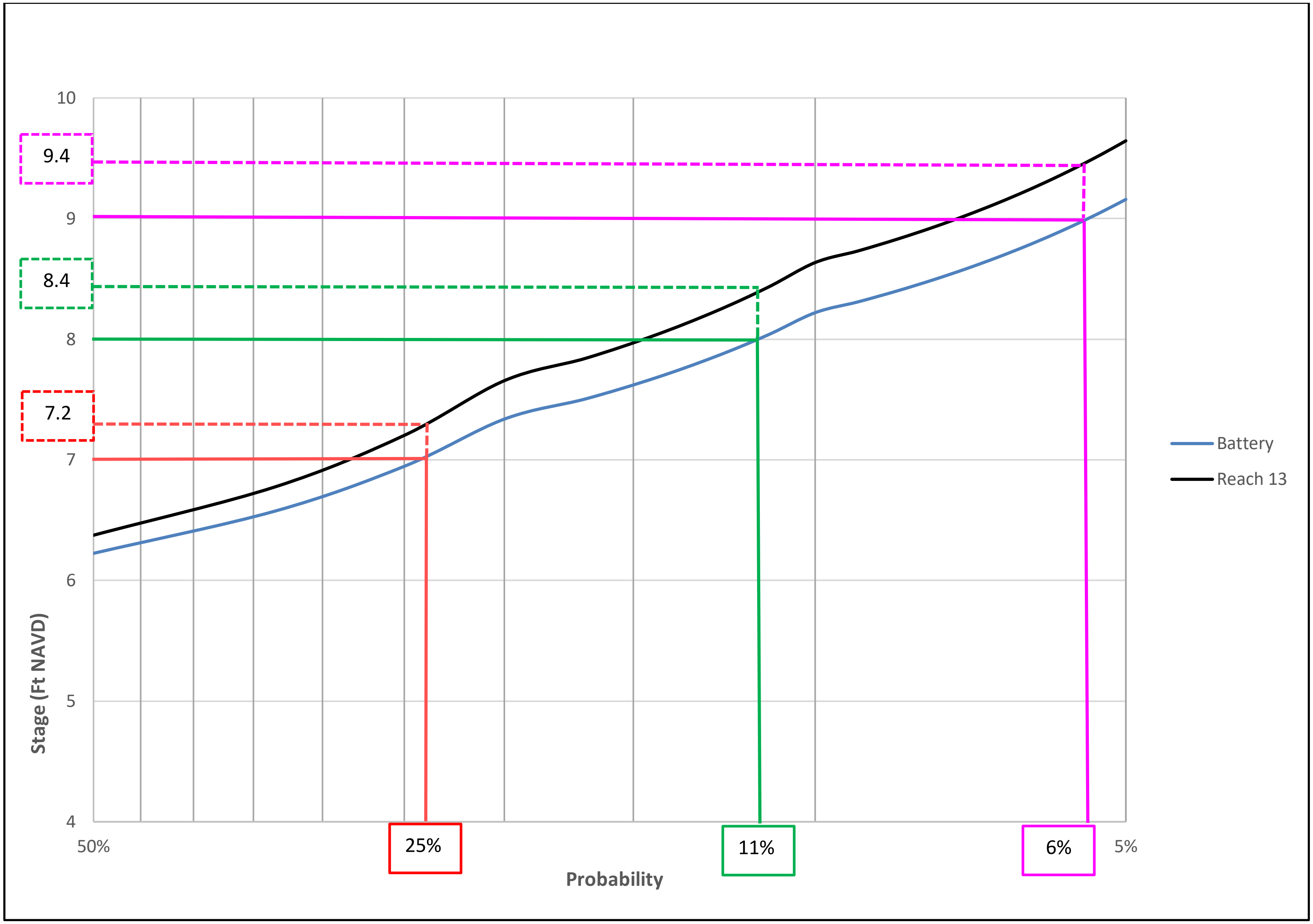


Figure 4. Derivation of Equivalent Floodplain Stages

5.4 Benefits Analysis Approach

The benefits accruing from nonstructural measures (i.e., the reduction in flood damages to structures and their contents) have been evaluated both on a first added and a second added basis. The benefits analysis concept is illustrated in Figure 5 below.

In cases where no structural measures (i.e., storm surge barriers or shore-based structures) are proposed, the benefits of stand-alone nonstructural plans covering the 7-foot equivalent floodplains as described above have been evaluated on a first-added basis. The benefits of a nonstructural plan in any reach in this scenario correspond to Area A in Figure 5.

In cases where nonstructural measures are intended to supplement the protection provided by structural plans (storm surge barriers and shore-based structures), the function of nonstructural measures is to act as residual risk features providing protection to structures in low-lying areas (i.e., the 7-foot equivalent floodplains) behind the gates from potential flooding before the barriers are closed and from flooding caused by interior runoff after the gates have closed. In this scenario, nonstructural measures have been evaluated on a second added basis (i.e., they include benefits from when the barriers are closed in addition to pre-closure flooding). The benefits for nonstructural plans evaluated using this approach correspond to Area A plus Area B in Figure 5. Area C represents the benefits of storm surge barriers implemented on a first-added basis.

The benefits of the nonstructural plans, whether they were considered as first or second added measures, were drawn from the comprehensive benefit analysis conducted for the five structural plans. This analysis took the damages calculated using HEC-FDA for each plan component at various increments of sea level rise and entered them into a lifecycle spreadsheet to calculate damages and benefits accruing over the project appraisal period as total present worth and annualized values. Residual risk features were assumed to provide protection to all low-lying areas vulnerable to high frequency flooding in each reach, and the benefits calculated for structural RRFs were used as a surrogate for the benefits of nonstructural measures covering the same areas. It is acknowledged that this approach is likely to slightly overestimate the total benefits of a nonstructural plan in any given reach since the structural option eliminates all damages below the applied level of protection, while the approach typically used to estimate damages of buildings with nonstructural treatments implemented allows for a small amount of residual structural damage to treated structures.

For this analysis, benefits for nonstructural measures in each reach were uniformly computed assuming completion in 2044 and accruing benefits over a 50-year analysis period. In reality, the completion year and period of benefits accrual for any given reach may vary with the structural plan in which it is included.

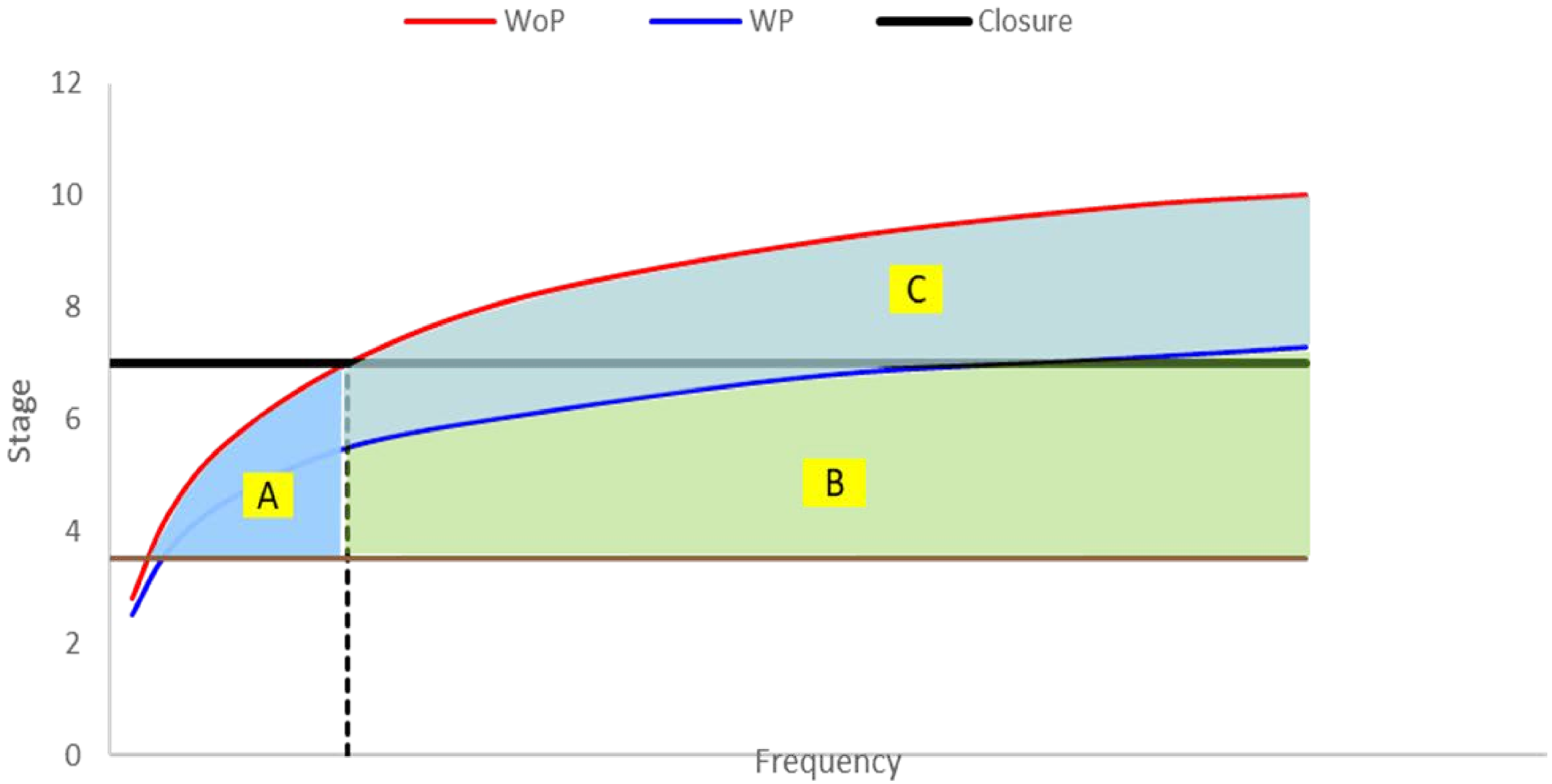


Figure 5. Benefits Analysis Concept

5.5 Initial Decision Algorithm and Cost Outputs

The nonstructural algorithm was executed for the study area inventory to identify the most feasible treatment and assign an associated construction cost for every structure in the floodplains equivalent to stages of 7, 8, and 9 feet NAVD at the Battery and for the 1% annual chance floodplain across the whole study area.

Following the initial calculation based on the algorithm, the total output costs for nonstructural treatments in the nominal 7 ft floodplain in each reach were converted to implementation costs. The implementation costs were then compared to the present worth first-added benefits for structural RRFs in each reach to derive a benefit-cost ratio for a stand-alone nonstructural flood risk management measure covering the nominal 7-foot floodplain in each reach.

5.6 Secondary Costs

Unit costs presented in Table 7 and the individual structure costs output by the algorithm include overhead and contractor profit but do not include contingencies, or costs associated with real estate administration, preconstruction design and engineering, permits, and temporary accommodation for homeowners/residents. These secondary costs were based on those previously applied in the development of nonstructural plans elsewhere in the New York metropolitan region and are presented in Table 8. These costs were added separately to the output from the algorithm on an aggregated reach-by-reach basis to compute a total implementation cost for the nonstructural treatments in each reach.

Table 8. Secondary Costs Applied to Nonstructural Plans

Secondary Cost Component	Elevate	Floodproof	Ringwall
Contingency (New York City)	60%	60%	60%
Contingency (New Jersey, New York State)	40%	40%	40%
Real Estate Administration[1]	$9,500	$9,500	$9,500
Preconstruction Design & Engineering	15%	15%	12%
Supervision, Inspection & Administration	12%	12%	12%
Temporary Accommodation[2]	$12,000	$6,000	$6,000
Permits[3]	$2,000	$1,000	$1,500

Notes: 1. Includes access negotiations, required easements, and deed restrictions
2. Assumes $3,000 per month; four months for elevation and two months for floodproofing or ringwalls
3. Assumes no variances required

It is acknowledged that while the secondary costs presented above do not exactly match the factors used in the final cost estimate for the tentatively selected plan, they are appropriate for the initial screening process.

5.7 Algorithm Adjustments

A general review of the initial algorithm output identified several concerns regarding the assignment of treatments and the assumptions that were utilized to format the structure inventory for input to the algorithm. As a result, the following modifications were made to the SAS® programs used to apply the algorithm:

- A footprint size limit for the elevation of single-family residential structures was added to ensure that elevations were not assigned to unfeasibly large structures. This was occurring in some cases where initial interpretations of the tax code data had led to multi-dwelling structures being treated as single family houses.
- The general assumption that smaller non-residential structures that had not been individually surveyed were of wood frame construction was modified to make them masonry in the most densely urbanized reaches of the study area. This was based on a limited review of individual structures initially proposed for elevation in these areas.
- Individual Port Authority of New York and New Jersey structures were removed from the dataset input to the algorithm. These structures are not eligible for consideration in the nonstructural plans since they are subject to the Port Authority's own risk mitigation programs, and for the analysis of flood damages they have been assigned site-specific damage functions that reflect these ongoing programs.

The impact of these modifications to the output of the algorithm was a net increase in the number of ringwalls assigned and an associated increase in the overall costs.

5.8 Analysis Results

The algorithm was executed following the adjustments described above and the results were again output for post-processing and the application of secondary costs.

The total number of structures identified for potential ISRM treatments and the associated costs output from the algorithm for all floodplains considered during the analysis are summarized by state/city in Table 9 through Table 11 below. The total number of structures identified for treatments as part of a comprehensive plan covering the 1% ACE floodplain are summarized separately in Table 12.

Table 13 then summarizes the number of buildings evaluated for ISRM within different floodplain extents for all economic reaches. The screening level costs include preliminary assumptions regarding secondary cost considerations, including contingencies, costs associated with real estate administration, preconstruction design and engineering, permits, and temporary accommodation for homeowners/residents.

Table 9. Summary of Structures Identified for ISRM Treatments in New Jersey

Treatment/Cost Component	Floodplains Covered							
	7 Ft (Equivalent)		8 Ft (Equivalent)		9 Ft (Equivalent)		1% ACE	
	#	Cost	#	Cost	#	Cost	#	Cost
	7,666	$1,883,757,000	11,179	$2,716,292,000	14,370	$3,468,745,000	16,927	$4,070,306,000
Floodproof	56	$2,180,000	77	$2,754,000	88	$3,413,000	8,708	$1,284,653,000
Ringwall	2,028	$13,281,988,000	3,175	$19,771,758,000	4,173	$25,419,945,000	5,445	$31,650,619,000
Estimated Construction Cost	9,750	$15,167,924,000	14,431	$22,490,804,000	18,631	$28,892,102,000	31,080	$37,005,578,000
Contingency		$6,067,170,000		$8,996,322,000		$11,556,841,000		$14,802,231,000
Total Construction Cost		$21,235,094,000		$31,487,125,000		$40,448,943,000		$51,807,809,000
Real Estate Administration		$92,625,000		$137,095,000		$176,995,000		$295,260,000
Preconstruction Design & Engineering		$2,627,421,000		$3,892,655,000		$4,999,704,000		$6,441,845,000
Supervision, Inspection & Admin		$2,548,211,000		$3,778,455,000		$4,853,873,000		$6,216,937,000
Temporary Accommodation		$104,496,000		$153,660,000		$198,006,000		$288,042,000
Permits		$18,430,000		$27,198,000		$35,088,000		$50,730,000
Implementation Cost	9,750	$26,626,277,000	14,431	$39,476,187,000	18,631	$50,712,608,000	31,080	$65,100,623,000

Price Level: March 2022

Table 10. Summary of Structures Identified for ISRM Treatments in New York City

Treatment/Cost Component	Floodplains Covered							
	7 Ft (Equivalent)		8 Ft (Equivalent)		9 Ft (Equivalent)		1% ACE	
	#	Cost	#	Cost	#	Cost	#	Cost
	13,499	$3,015,723,000	22,837	$5,099,645,000	31,936	$7,164,112,000	38,547	$8,648,399,000
Floodproof	260	$13,500,000	393	$25,916,000	666	$43,578,000	25,621	$2,806,161,000
Ringwall	1,722	$6,721,483,000	3,122	$12,651,565,000	4,494	$18,672,317,000	7,336	$29,993,492,000
Estimated Construction Cost	15,480	$9,738,177,000	26,351	$17,764,596,000	37,095	$25,867,476,000	71,504	$41,448,051,000
Contingency		$5,850,424,000		$10,666,275,000		$15,528,003,000		$24,868,831,000
Total Construction Cost		$15,588,601,000		$28,430,872,000		$41,395,481,000		$66,316,882,000
Real Estate Administration		$147,070,000		$250,345,000		$352,413,000		$679,288,000
Preconstruction Design & Engineering		$2,017,538,000		$3,659,235,000		$5,314,930,000		$8,507,845,000
Supervision, Inspection & Admin		$1,872,136,000		$3,413,208,000		$4,968,961,000		$7,958,026,000
Temporary Accommodation		$173,880,000		$295,134,000		$414,192,000		$660,306,000
Permits		$29,841,000		$50,750,000		$71,279,000		$113,719,000
Implementation Cost	15,480	$20,147,890,000	26,351	$36,770,311,000	37,095	$53,697,097,000	71,504	$85,682,999,000

Price Level: March 2022

Table 11. Summary of Structures Identified for ISRM Treatments in New York State (Outside of New York City)

Treatment/Cost Component	**Floodplains Covered**							
	7 Ft (Equivalent)		**8 Ft (Equivalent)**		**9 Ft (Equivalent)**		**1% ACE**	
	#	**Cost**	**#**	**Cost**	**#**	**Cost**	**#**	**Cost**
	294	$67,686,000	409	$93,798,000	507	$115,522,000	569	$128,886,000
Floodproof	1	$126,000	2	$131,000	11	$1,318,000	303	$40,705,000
Ringwall	317	$959,882,000	393	$1,319,421,000	473	$1,711,398,000	609	$2,232,127,000
Estimated Construction Cost	612	$1,027,694,000	804	$1,413,350,000	991	$1,828,238,000	1,481	$2,401,719,000
Contingency		$411,078,000		$565,340,000		$731,295,000		$960,687,000
Total Construction Cost		$1,438,771,000		$1,978,690,000		$2,559,533,000		$3,362,406,000
Real Estate Administration		$5,814,000		$7,638,000		$9,415,000		$14,070,000
Preconstruction Design & Engineering		$175,501,000		$241,388,000		$312,051,000		$410,612,000
Supervision, Inspection & Admin		$172,653,000		$237,443,000		$307,144,000		$403,489,000
Temporary Accommodation		$5,436,000		$7,278,000		$8,988,000		$12,300,000
Permits		$1,065,000		$1,410,000		$1,735,000		$2,355,000
Implementation Cost	612	$1,799,239,000	804	$2,473,846,000	991	$3,198,865,000	1,481	$4,205,230,000

Price Level: March 2022

Table 12. Summary of Structures Identified for ISRM Treatments – Comprehensive Plan (1% ACE Floodplain)

	Study Area Region							
Treatment/Cost Component	**New Jersey**		**New York City**		**New York State**		**Total**	
	#	**Cost**	**#**	**Cost**	**#**	**Cost**	**#**	**Cost**
	16,927	$4,070,306,000	38,547	$8,648,399,000	569	$128,886,000	56,043	$12,847,591,000
Floodproof	8,708	$1,284,653,000	25,621	$2,806,161,000	303	$40,705,000	34,632	$4,131,519,000
Ringwall	5,445	$31,650,619,000	7,336	$29,993,492,000	609	$2,232,127,000	13,390	$63,876,238,000
Estimated Construction Cost	*31,080*	*$37,005,578,000*	*71,504*	*$41,448,051,000*	*1,481*	*$2,401,719,000*	*104,065*	*$80,855,348,000*
Contingency		$14,802,231,000		$24,868,831,000		$960,687,000		$40,631,749,000
Total Construction Cost		*$51,807,809,000*		*$66,316,882,000*		*$3,362,406,000*		*$121,487,097,000*
Real Estate Administration		$295,260,000		$679,288,000		$14,070,000		$988,618,000
Preconstruction Design & Engineering		$6,441,845,000		$8,507,845,000		$410,612,000		$15,360,302,000
Supervision, Inspection & Admin		$6,216,937,000		$7,958,026,000		$403,489,000		$14,578,452,000
Temporary Accommodation		$288,042,000		$660,306,000		$12,300,000		$960,648,000
Permits		$50,730,000		$113,719,000		$2,355,000		$166,804,000
Implementation Cost	***31,080***	***$65,100,623,000***	***71,504***	***$85,682,999,000***	***1,481***	***$4,205,230,000***	***104,065***	***$154,988,852,000***

Price Level: March 2022

Table 13. Individual Structure Risk Management – Screening Level Costs

Treatment/Cost Component	**Floodplains Covered**							
	7 Ft (Equivalent)		**8 Ft (Equivalent)**		**9 Ft (Equivalent)**		**1% ACE**	
	#	**Cost**	**#**	**Cost**	**#**	**Cost**	**#**	**Cost**
	21,459	$4,967,166,000	34,425	$7,909,735,000	46,813	$10,748,379,000	56,043	$12,847,591,000
Floodproof	317	$15,806,000	472	$28,801,000	765	$48,309,000	34,632	$4,131,519,000
Ringwall	4,066	$20,963,353,000	6,689	$33,742,744,000	9,139	$45,803,660,000	13,390	$63,876,238,000
Estimated Construction Cost	25,842	$25,933,795,000	41,586	$41,668,750,000	56,717	$56,587,816,000	104,065	$80,855,348,000
Contingency		$12,328,672,000		$20,227,937,000		$27,816,139,000		$40,631,749,000
Total Construction Cost		$38,262,466,000		$61,896,687,000		$84,403,957,000		$121,487,097,000
Real Estate Administration		$245,509,000		$395,078,000		$538,823,000		$988,618,000
Preconstruction Design & Engineering		$4,820,460,000		$7,793,278,000		$10,626,685,000		$15,360,302,000
Supervision, Inspection & Admin		$4,593,000,000		$7,429,106,000		$10,129,978,000		$14,578,452,000
Temporary Accommodation		$283,812,000		$456,072,000		$621,186,000		$960,648,000
Permits		$49,336,000		$79,358,000		$108,102,000		$166,804,000
Implementation Cost	***25,842***	***$48,573,406,000***	***41,586***	***$78,720,344,000***	***56,717***	***$107,608,570,000***	***104,065***	***$154,988,852,000***

Price Level: March 2022

The benefits (first and second added), costs, and resulting benefit-to-cost ratios for each economic reach are presented for the nonstructural plan covering the 7-foot equivalent floodplain in Table 14 through Table 16 below. For this analysis, benefits for ISRM measures in each reach were uniformly computed assuming completion in 2044 and accruing benefits over a 50-year analysis period. In reality, the completion year and period of benefits accrual for any given reach may vary with the structural plan in which it is included.

Incremental benefits arising from treating additional structures in the 8- and 9-foot equivalent floodplains as adaptive management measures are also not available for direct comparisons with the additional costs.

Note that in Table 14 through Table 16 several reaches exhibit positive benefit cost ratios for stand-alone nonstructural plans but have not been reviewed in detail or recommended for inclusion in the TSP. In structural plans where these reaches are not protected by storm surge barriers, they are covered by shore-based measures and there is no potential for nonstructural plans in these reaches.

Table 14. Summary of Nonstructural Benefits, Costs and BCRs, 7 Ft Equivalent Floodplain, New Jersey

Reach	First Added Benefits	Second Added Benefits	Total PW Benefits	Costs	1st Added (Stand-alone) BCR	2nd Added (as RRF) BCR
2 NJ Shrewsbury/Navesink River	$418.443	$1,105.836	$1,524.280	$2,515.643	0.2	0.6
3 NJ Raritan & Sandy Hook Shore	$255.709	$975.794	$1,231.503	$942.997	0.3	1.3
4 NJ Raritan River Basin	$342.055	$520.742	$862.798	$600.799	0.6	1.4
8A North Arthur Kill	$303.444	$493.843	$797.287	$686.453	0.4	1.2
8B Arthur Kill South	$95.301	$167.386	$262.687	$413.785	0.2	0.6
9 NJ Rahway River Basin	$179.645	$244.664	$424.309	$627.639	0.3	0.7
10 NJ - Newark Bay	$130.015	$295.556	$425.571	$418.361	0.3	1.0
11 NJ Passaic River Basin	$1,695.767	$4,014.329	$5,710.097	$3,437.757	0.5	1.7
12 Hackensack/Meadowlands Basin	$1,083.471	$3,165.272	$4,248.743	$2,270.158	0.5	1.9
12 RBDM	$4,646.024	$14,629.675	$19,275.700	$6,123.150	0.8	3.1
12 RBDMSL	$309.491	$910.289	$1,219.780	$538.992	0.6	2.3
12 RBDMSM	$134.351	$422.106	$556.457	$504.979	0.3	1.1
12 RBDMSU	$2,539.609	$7,954.439	$10,494.048	$4,969.294	0.5	2.1
13 NJ Shoreline Kill Van Kull	$117.756	$22.158	$139.914	$185.274	0.6	0.8
14 NJ Shoreline along Upper Bay[1]	$577.761	$1,230.868	$1,808.630	$352.801	1.6	5.1
14S Jersey City SBM	$790.709	$1,266.594	$2,057.303	$1,677.194	0.5	1.2
15 NJ Shoreline - Hudson River[1]	$534.646	$1,548.556	$2,083.202	$361.003	1.5	5.8

Price Level: March 2022, Completion/base year 2044, 50-yr analysis period

Notes: 1. Not considered appropriate for inclusion in the TSP following review
2. Benefits and Costs in Millions, Present Worth

Table 15. Summary of Nonstructural Benefits, Costs and BCRs, 7 Ft Equivalent Floodplain, New York City

Reach	First Added Benefits	Second Added Benefits	Total PW Benefits	Costs	1st Added (Stand-alone) BCR	2nd Added (as RRF) BCR
5 SSSI	$15.592	$734.844	$750.436	$112.418	0.1	6.7
6 WSSI	$40.647	$152.369	$193.015	$131.279	0.3	1.5
7E NSSI East of KVK Gate	$7.868	$31.680	$39.548	$66.429	0.1	0.6
7W NSSI West of KVK gate	$48.321	$84.884	$133.206	$194.935	0.2	0.7
17 NYC Bronx Shoreline – Hudson	-	-	-	-	-	-
18 Manhattan Shore along Hudson	-	-	-	-	-	-
18S NYC West Side SBM[1]	$600.105	$1,317.826	$1,917.931	$569.526	1.1	3.4
19 Manhattan Shore East River	$632.023	$943.703	$1,575.726	$888.682	0.7	1.8
19S NYC West Side SBM E[1]	$1,190.940	$1,752.103	$2,943.043	$728.591	1.6	4.0
20A Manhattan Shore HarlemR North	$1.111	$8.630	$9.741	$54.071	0.0	0.2
20B Manhattan Shore HarlemR South[1]	$2,806.929	$4,644.737	$7,451.666	$1,047.955	2.7	7.1
21 NYC Bronx HarlemR North	$2.700	$16.426	$19.126	$16.829	0.2	1.1
21 NYC Bronx Shore-HarlemR South	$16.741	$75.890	$92.630	$51.664	0.3	1.8
22A Bronx Shore West of TN br	$365.832	$436.004	$801.837	$449.061	0.8	1.8
22AS Bronx & Westchester Creek	$84.332	$143.242	$227.574	$402.891	0.2	0.6
22PB N of Pelham Barrier	$24.331	$57.993	$82.324	$35.830	0.7	2.3
25A Queens west of Throgs Neck B	$48.947	$126.454	$175.402	$72.164	0.7	2.4
25AF Flushing Creek Gate & SBM	$176.513	$286.118	$462.631	$715.383	0.2	0.6
25AS Astoria SBM	$28.151	$45.256	$73.407	$35.401	0.8	2.1
26 NYC Queens shore East River[2]	$1,187.011	$1,874.786	$3,061.797	$323.085	3.7	9.5
26S Long Island City SBM[2]	$108.315	$246.567	$354.882	$81.340	1.3	4.4
27 Queens/Brooklyn Newtown Crk	$252.047	$476.200	$728.247	$498.769	0.5	1.5
28 NYC Brooklyn along East River	$373.301	$1,168.377	$1,541.678	$604.878	0.6	2.5
29 NYC Brooklyn shore Upper Bay	$47.940	$152.957	$200.897	$57.148	0.8	3.5

Reach	First Added Benefits	Second Added Benefits	Total PW Benefits	Costs	1st Added (Stand-alone) BCR	2nd Added (as RRF) BCR
30 NYC Gowanus Canal Basin	$302.153	$510.094	$812.246	$950.144	0.3	0.9
31 Brooklyn Lower Bay, Coney Isld	$1,569.771	$3,275.130	$4,844.901	$4,604.980	0.3	1.1
32 NYC Brooklyn shore JamaicaBay	$62.250	$379.919	$442.169	$434.540	0.1	1.0
33 Queens shore/isld JamaicaBay	$588.608	$1,303.042	$1,891.650	$7,019.899	0.1	0.3

Price Level: March 2022, Completion/base year 2044, 50-yr analysis period

Notes:
1. Protected by shore-based measure in plans where this reach is outside barrier line of protection
2. Not considered appropriate for inclusion in the TSP following review
3. Benefits and Costs in Millions, Present Worth

Table 16. Summary of Nonstructural Benefits, Costs and BCRs, 7 Ft Equivalent Floodplain, New York State (Outside of New York City)

Reach	First Added Benefits	Second Added Benefits	Total Benefits	Costs	1st Added (Stand-alone) BCR	2nd Added (as RRF) BCR
16 NY - Shoreline along Hudson River	$167.834	$510.651	$678.485	$1,722.862	0.1	0.4
16SO Ossining SBM	$1.920	$6.175	$8.095	$26.799	0.1	0.3
16SP Stony Point Perimeter SBM	$3.577	$12.072	$15.650	$36.094	0.1	0.4
16SS Stony Point Shore SBM	-	-	-	-	-	-
16ST Tarrytown SBM	$2.285	$7.965	$10.250	$13.483	0.2	0.8
16SYN Yonkers North SBM	-	-	-	-	-	-
16SYS Yonkers South SBM	-	-	-	-	-	-

Price Level: March 2022, Completion/base year 2044, 50-yr analysis period

Notes: Benefits and Costs in Millions, Present Worth

Review of the comparison of the benefits to costs for stand-alone ISRM features did not identify reaches that are not included in a structural (SSB or SBM) plan that were economically justified with a Benefit to Cost Ratio (BCR) greater than 1.0. This assessment of the high frequency floodplain suggests that larger ISRM plans would also not be cost-effective, and they were deleted from further assessment as part of the TSP.TSP

5.9 ISRM to Supplement RRF Reaches

The TSP includes measures identified to address localized areas where there are buildings potentially exposed to flooding at some gaps in the residual risk features for Alternative 3B. The number of properties impacted, and the aggregate construction costs (without contingency or other secondary costs) are presented in Table 17.

Table 17. Summary of Supplemental ISRMs for Inclusion in TSP

Reach		**Tentatively Selected Plan: 3B**			
		Nonstructural		**Ringwall**	
		#	**$**	**#**	**$**
NYC	6	5	$1,027,000	2	$14,264,000
NYC	7W	6	$1,285,000	6	$27,588,000
NJ	8N	10	$2,069,000	8	$39,844,000
NJ	8S	28	$6,286,000	11	$60,692,000
NJ	9	24	$5,874,000	7	$32,815,000
NJ	11	22	$4,750,000	11	$44,560,000
NJ	12	8	$1,748,000	11	$31,748,000
Total by Account		103	*$23,039,000*	56	*$251,511,000*
TSP Plan Total		**159**		**$491,926,561**	

Note: Costs in this table exclude contingencies, costs associated with real estate administration, preconstruction design and engineering, permits, and temporary accommodation for homeowners/residents

The principal areas in each reach where supplemental ISRMs are located are shown in Figure 6 to Figure 13.

Figure 6. Principal Area of Supplemental ISRMs of Reach 6

Figure 7. Principal Area of Supplemental ISRMs of Reach 7W

Figure 8. Principal Area of Supplemental ISRMs of Reach 8N

Figure 9. Principal Area of Supplemental ISRMs of Reach 8S

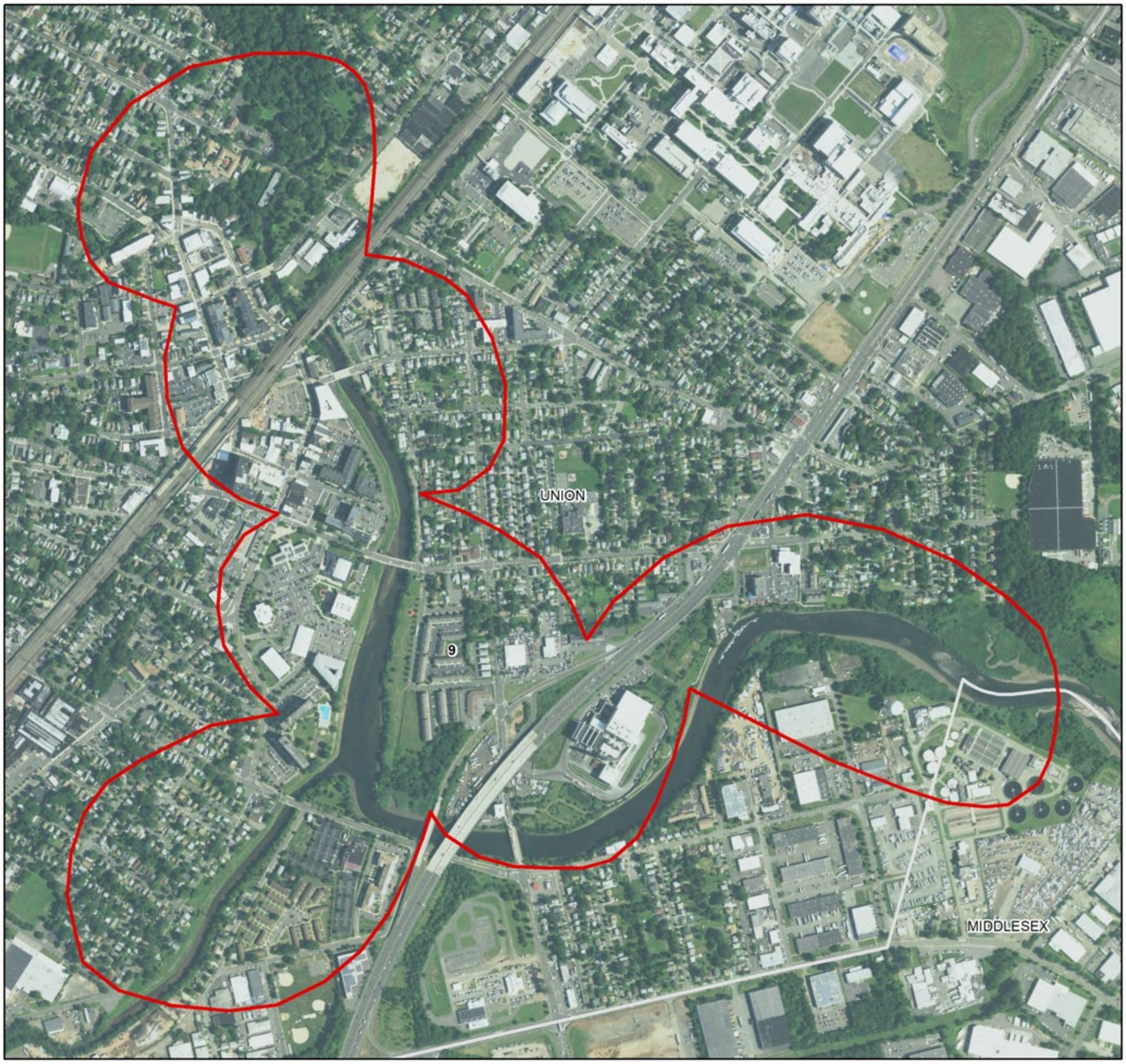


Figure 10. Principal Area of Supplemental ISRMs of Reach 9

Figure 11. Principal Area of Supplemental ISRMs of Reach 11MS (Passaic Main Stem)

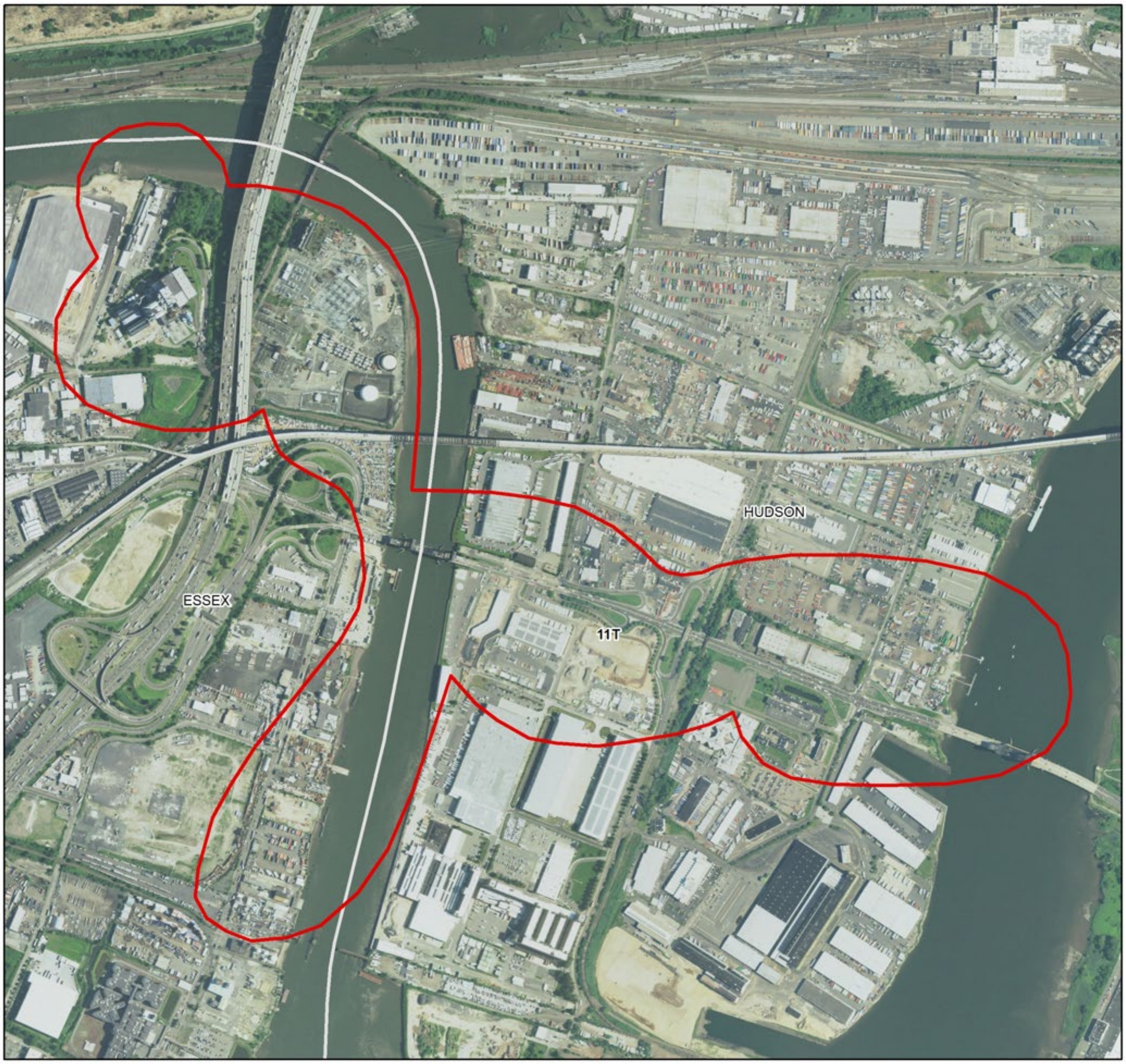


Figure 12. Principal Area of Supplemental ISRMs of Reach 11T (Passaic Tidal)

Figure 13. Principal Area of Supplemental ISRMs of Reach 12

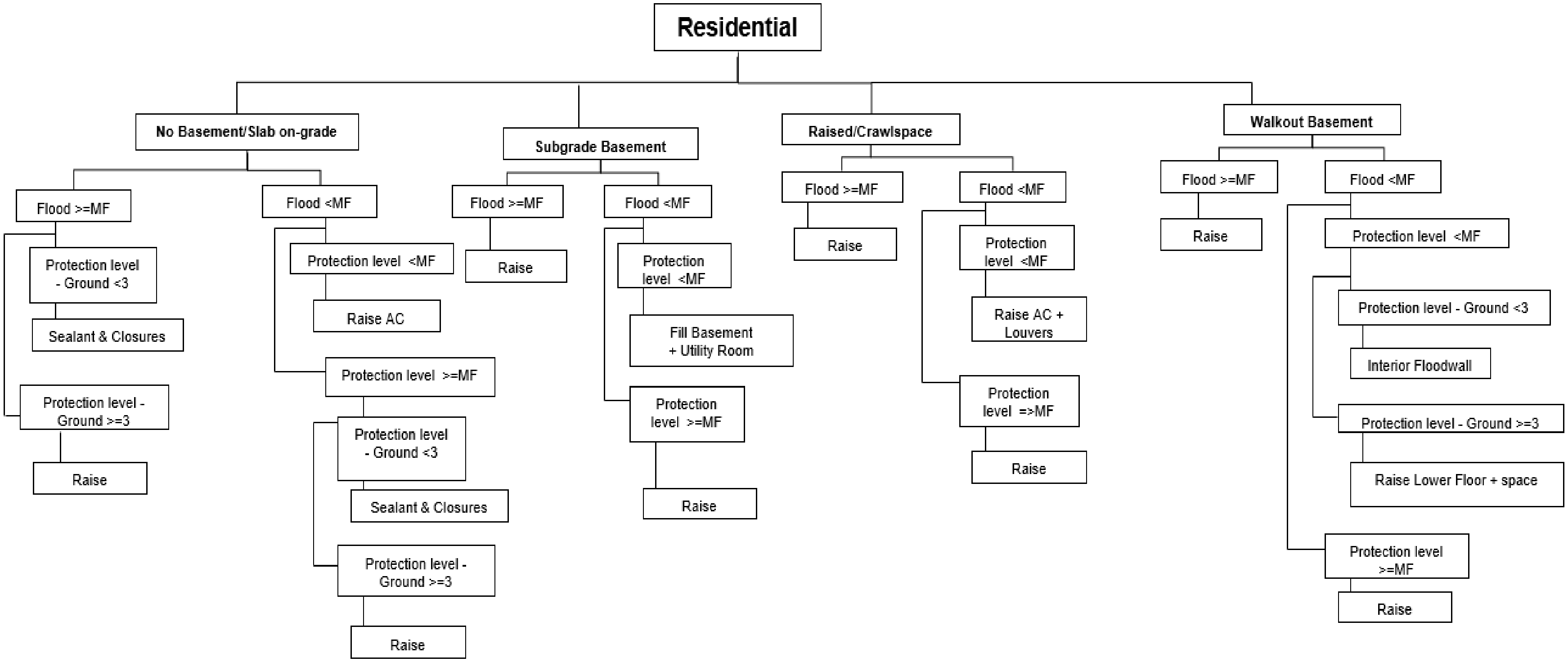
6 Attachment 1: Data Overview and Assumptions for Decision and Cost Algorithm

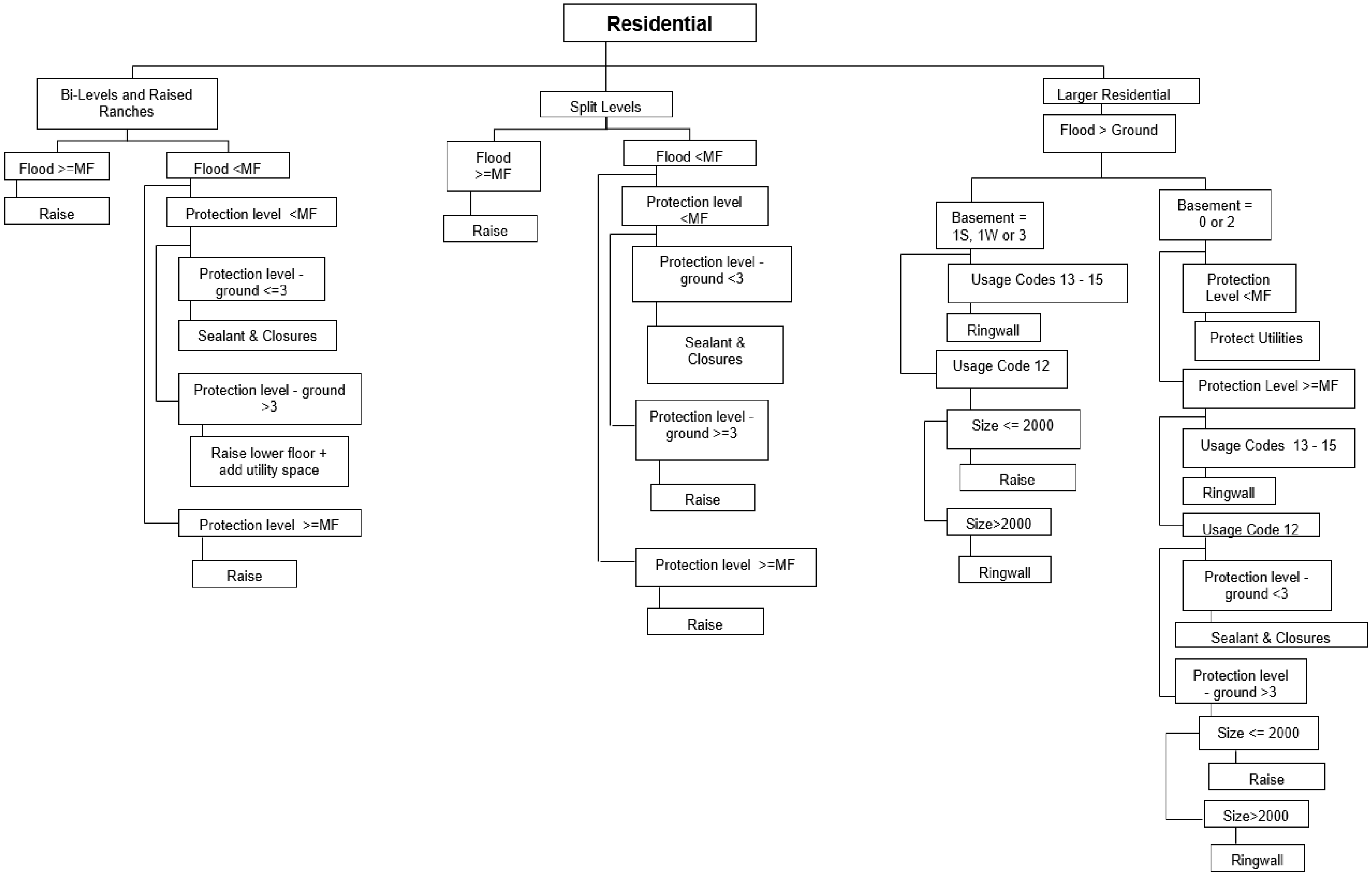
New York-New Jersey Harbor and Tributaries Coastal Storm Risk Management Feasibility Study					
Nonstructural Plan Development					
Data Overview and Assumptions for Decision and Cost Algorithm					
Attribute	Cost/Risk implications of Assumptions	Parcel/Structure Data Source			
		Windshield Survey	New Jersey: MOD IV	New York City: MapPLUTO	New York State: County Tax Databases
Building Footprint Size	Elevations subject to size limits	Drawn from sources listed at right.	Available for about 67% of structures from NJDEP/Microsoft Building Footprints Dataset. Remainder estimated based on average/typical survey structure value per square foot by assigned damage function, capped at area of host parcel and with 700 sq ft minimum.	Available for about 95% of structures from NYC Open Data. Remainder estimated based on average/typical survey structure value per square foot by assigned damage function, capped at area of host parcel and with 700 sq ft minimum.	Manually created for sample structures based on aerial photography
Ground Elevation	Determines presence of structure in various floodplains, eligibility for treatment	Drawn from digital terrain sources listed at right, adjusted as necessary based on field observations.	North Atlantic Coast Comprehensive Study (NACCS) 1m Digital Elevation Model	North Atlantic Coast Comprehensive Study (NACCS) 1m Digital Elevation Model	USGS/NYS 10m/1m Digital Elevation models, varies with county
Finished Floor Elevation (FFE) / Height above grade	Affects treatment options since basement types are partially driven by FFE	Based on field observation.	In development of the inventory, structures were grouped into 13 basic usage codes, each code was assigned typical values from prior structure inventory surveys, adjusted based on results of sample survey.	In development of the inventory, structures were assigned typical values from prior structure inventory surveys for a full range of usage codes (usage/type data for NYC/NYS was found to be more detailed than for other areas), adjusted based on results of sample survey.	In development of the inventory, structures were assigned typical values from prior structure inventory surveys for a full range of usage codes (usage/type data for NYC/NYS was found to be more detailed than for other areas), adjusted based on results of sample survey.
Foundation/Basement Type	Structures with basements are more expensive to elevate than those without. For structures without subgrade basements, costs to elevate structures with slab on grade foundation are generally greater than for those with crawlspaces. Costs.	Based on field observation.	Inventory development assumed uniform basement types by category: all single-family residences were assumed to have subgrade basements, all other structures assumed to have no basement. Assumed that all structures with FFE below eight feet do not have subgrade basements. To account for the proportion of these structures that are of slab on grade construction rather than crawlspace, an adjustment factor was derived from the proportions of surveyed no basement structures with slab on grade versus crawlspace foundations, which was used to increase the unit costs for elevation of crawlspace structures in the algorithm.	Presence or absence of subgrade basements for most individual single-family residences was derived from parcel data. All other structures assumed to have no basement. Assumed that all structures with FFE below eight feet are on crawlspaces rather than subgrade basements. To account for the proportion of these structures that are actually slab on grade rather than crawlspace, an adjustment factor was derived from the proportions of surveyed no basement structures with slab on grade versus crawlspace foundations, which was used to increase the unit costs for elevation of crawlspace structures in the algorithm.	Inventory development assumed uniform basement types by category: all single-family residences were assumed to have subgrade basements, all other structures assumed to have no basement. Assumed that all structures with FFE below eight feet do not have subgrade basements. To account for the proportion of these structures that are of slab on grade construction rather than crawlspace, an adjustment factor was derived from the proportions of surveyed no basement structures with slab on grade versus crawlspace foundations, which was used to increase the unit costs for elevation of crawlspace structures in the algorithm.

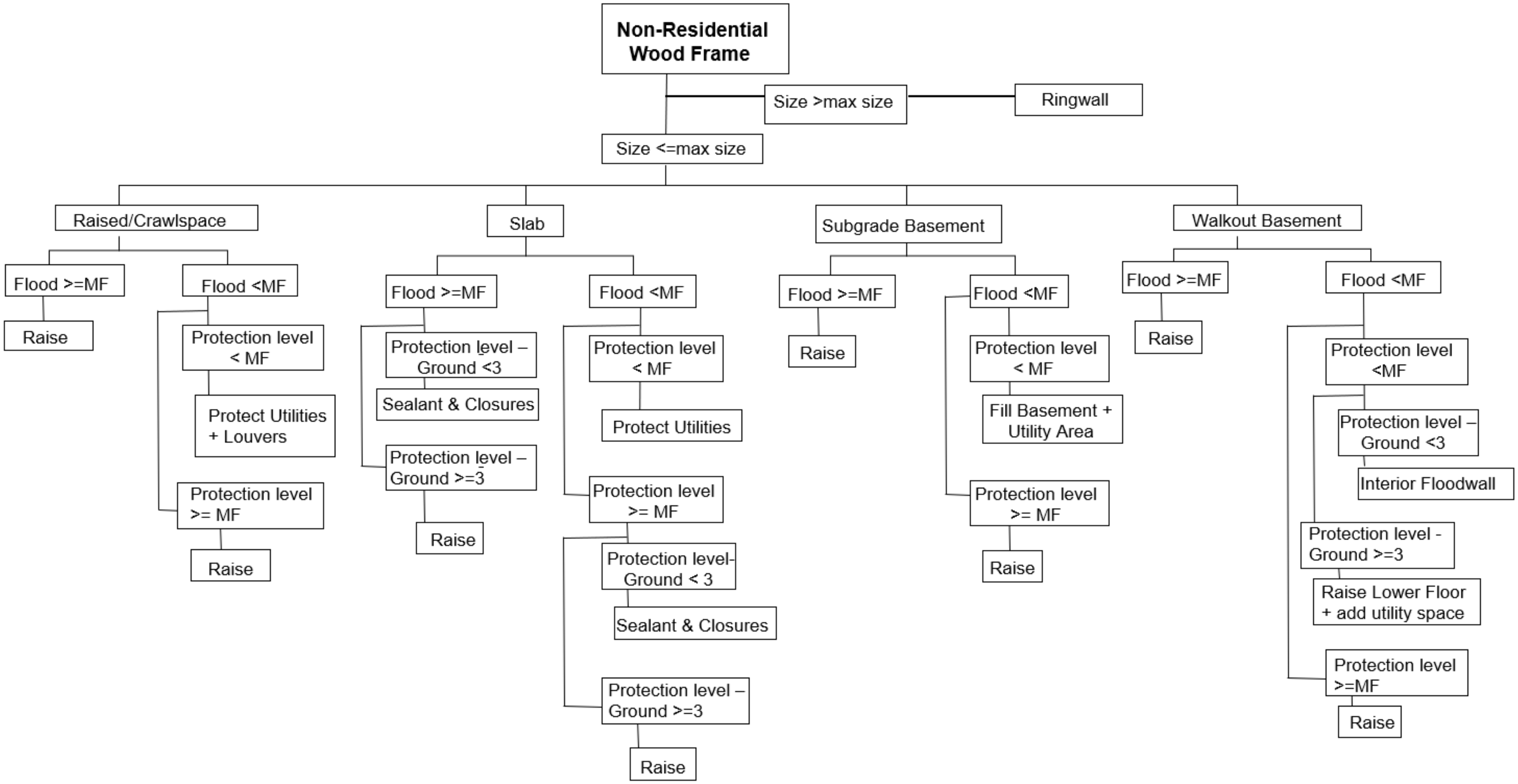
New York-New Jersey Harbor and Tributaries Coastal Storm Risk Management Feasibility Study					
Nonstructural Plan Development					
Data Overview and Assumptions for Decision and Cost Algorithm					
Attribute	Cost/Risk implications of Assumptions	Parcel/Structure Data Source			
		Windshield Survey	New Jersey: MOD IV	New York City: MapPLUTO	New York State: County Tax Databases
Construction/Exterior Material	Masonry non-residential structures are not typically cost-effective to elevate: Ringwall, dry floodproofing, and protection of utilities are typically more feasible. Blanket assumptions regarding construction of non-residential structures could impact costs since it influences selection of treatment for smaller structures.	Based on field observation.	Single family residential structures and non-residential structures with footprint less than 2,500 square feet assumed to be wood frame. Larger nonresidential, multifamily / apartment / high rise residential structures assumed to be of masonry construction.	Single family residential structures assumed to be wood frame. Larger nonresidential, multifamily / apartment / high rise residential structures assumed to be of masonry construction. Initial assumption re: smaller non-residential structures with footprint less than 2,500 square feet having masonry construction revised to masonry for most densely urbanized portions of the study area.	Single family residential structures and non-residential structures with footprint less than 2,500 square feet assumed to be wood frame. Larger nonresidential, multifamily/apartment/high rise residential structures assumed to be of masonry construction.
Condition	Assumed aligned with building age: typically, older structures are more expensive to elevate. Not considering age may lead to underestimation of elevation costs, however, most older buildings in the study area are likely to be connected structures and not subject to elevation.	Based on field observation, used to assign depreciation factor in computation of structure value.	Not available in parcel data.	Not available in parcel data.	Not available in parcel data.
Structure Value	Used in assessment of total value of property for acquisition in comparison with first assigned treatment. No current risk implications since acquisition is not currently included in nonstructural treatment options.	Depreciated structure replacement value computed from survey data and RSMeans Square Foot Costs.	Parcel improvement values from tax data, converted to estimate of replacement value using published equalization rates. Values and uncertainty parameters adjusted using index factors resulting from statistical analysis of assessed/equalized values versus values computed from survey data.	Parcel improvement values from tax data, converted to estimate of replacement value using published equalization rates. Values and uncertainty parameters adjusted using index factors resulting from statistical analysis of assessed/equalized values versus values computed from survey data.	Parcel improvement values from tax data, converted to estimate of replacement value using published equalization rates. Values and uncertainty parameters adjusted using index factors resulting from statistical analysis of assessed/equalized values versus values computed from survey data.
Land value	Used in assessment of total value of property for acquisition in comparison with first assigned	Not assessed in windshield survey, see entries at right.	Total assessed value by parcel is available in original data but not currently linked directly to inventory values by building polygon. Based on prior studies, assume	Total assessed value by parcel is available in original data but not currently linked directly to inventory values by building polygon. Based on prior studies, assume	Total assessed value by parcel is available in original data but not currently linked directly to inventory values by building polygon. Based on

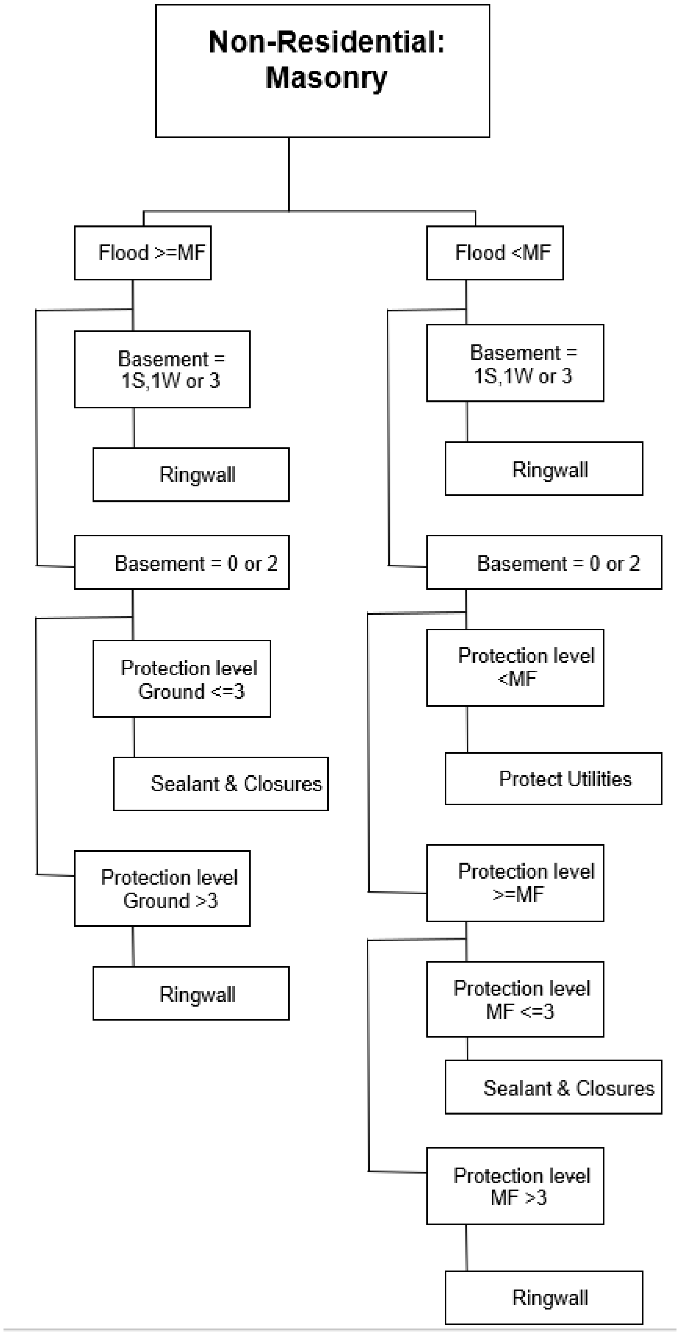
New York-New Jersey Harbor and Tributaries Coastal Storm Risk Management Feasibility Study					
Nonstructural Plan Development					
Data Overview and Assumptions for Decision and Cost Algorithm					
Attribute	Cost/Risk implications of Assumptions	Parcel/Structure Data Source			
		Windshield Survey	New Jersey: MOD IV	New York City: MapPLUTO	New York State: County Tax Databases
	treatment. No current risk implications since acquisition is not currently included in nonstructural treatment options.		typical land value is two thirds of total value, i.e. 50% of structure value	typical land value is two thirds of total value, i.e. 50% of structure value	prior studies, assume typical land value is two thirds of total value, i.e. 50% of structure value
Design Flood Elevation	Elevation relative to first floor impacts selection of treatments. Use of modeled water stages in place of mapped Base Flood Elevations may have cost/risk implications which require additional study beyond the current scope to determine the magnitude.	See state standards and sources at right	Use NJ state standard of base flood elevation plus one foot of freeboard for elevations and floodproof treatments . Use base flood elevation plus three feet of freeboard for ringwalls. Base flood elevation assumed as 1% annual exceedance water surface elevation in the year 2030 under intermediate sea level rise scenario, from NACCS hydrodynamic modeling.	Use NY state standard of base flood elevation plus two feet of freeboard for elevations and floodproof treatments . Use base flood elevation plus three feet of freeboard for ringwalls. Base flood elevation assumed as 1% annual exceedance water surface elevation in the year 2030 under intermediate sea level rise scenario, from NACCS hydrodynamic modeling.	Use NY state standard of base flood elevation plus two feet of freeboard for elevations and floodproof treatments . Use base flood elevation plus three feet of freeboard for ringwalls. Base flood elevation assumed as 1% annual exceedance water surface elevation in the year 2030 under intermediate sea level rise scenario, from NACCS hydrodynamic modeling.

7 Attachment 2: Nonstructural Algorithm Flowcharts


Residential
No Basement/Slab on-grade
Flood >=MF
Protection level - Ground <3
Sealant & Closures
Protection level - Ground >=3
Raise
Flood <MF
Protection level <MF
Raise AC
Protection level >=MF
Protection level - Ground <3
Sealant & Closures
Protection level - Ground >=3
Raise
Subgrade Basement
Flood >=MF
Raise
Flood <MF
Protection level <MF
Fill Basement + Utility Room
Protection level >=MF
Raise
Raised/Crawlspace
Flood >=MF
Raise
Flood <MF
Protection level <MF
Raise AC + Louvers
Protection level =>MF
Raise
Walkout Basement
Flood >=MF
Raise
Flood <MF
Protection level <MF
Protection level - Ground <3
Interior Floodwall
Protection level - Ground >=3
Raise Lower Floor + space
Protection level >=MF
Raise


Residential
Bi-Levels and Raised Ranches
Flood >=MF
Raise
Flood <MF
Protection level <MF
Protection level - ground <=3
Sealant & Closures
Protection level - ground >3
Raise lower floor + add utility space
Protection level >=MF
Raise
Split Levels
Flood >=MF
Raise
Flood <MF
Protection level <MF
Protection level - ground <3
Sealant & Closures
Protection level - ground >=3
Raise
Protection level >=MF
Raise
Larger Residential
Flood > Ground
Basement = 1S, 1W or 3
Usage Codes 13 - 15
Ringwall
Usage Code 12
Size <= 2000
Raise
Size>2000
Ringwall
Basement = 0 or 2
Protection Level <MF
Protect Utilities
Protection Level >=MF
Usage Codes 13 - 15
Ringwall
Usage Code 12
Protection level - ground <3
Sealant & Closures
Protection level - ground >3
Size <= 2000
Raise
Size>2000
Ringwall


Non-Residential Wood Frame
Size >max size
Ringwall
Size <=max size
Raised/Crawlspace
Flood >=MF
Raise
Flood <MF
Protection level < MF
Protect Utilities + Louvers
Protection level >= MF
Raise
Slab
Flood >=MF
Protection level – Ground <3
Sealant & Closures
Protection level – Ground >=3
Raise
Flood <MF
Protection level < MF
Protect Utilities
Protection level >= MF
Protection level- Ground < 3
Sealant & Closures
Protection level – Ground >=3
Raise
Subgrade Basement
Flood >=MF
Raise
Flood <MF
Protection level < MF
Fill Basement + Utility Area
Protection level >= MF
Raise
Walkout Basement
Flood >=MF
Raise
Flood <MF
Protection level <MF
Protection level – Ground <3
Interior Floodwall
Protection level - Ground >=3
Raise Lower Floor + add utility space
Protection level >=MF
Raise


Non-Residential: Masonry
Flood >=MF
Flood <MF
Basement = 1S,1W or 3
Ringwall
Basement = 0 or 2
Protection level Ground <=3
Sealant & Closures
Protection level Ground >3
Ringwall
Basement = 1S,1W or 3
Ringwall
Basement = 0 or 2
Protection level <MF
Protect Utilities
Protection level >=MF
Protection level MF <=3
Sealant & Closures
Protection level MF >3
Ringwall

Notes on Flowcharts:

Assumptions for Typical Structure Types

- Raised (Crawl Space): 1. No utilities are located in the crawl space.
- Raised (Crawl Space): 2. Wet Flood Proofing includes exterior utilities only.
- Slab: Wet Flood Proofing is possible when flood depth is below the MF. Typically exterior utilities only (e.g. AC).
- Basement: All basements are unfinished.
- Bi-level/Raised Ranch: 1. The lower floor is a minimum of 4-ft of masonry wall.
- Bi-level/Raised Ranch: 2.The lower level is slab on grade; walkout.
- Split-Level: 1. The lower level is slab on grade; the main floor is raised over a crawl space.
- Split-Level: 2. The Main Floor and the upper level can be separated from the lower level in order to raise the structure.

Basement Codes

No basement/slab on grade	0
Subgrade basement	1S
Walkout basement	1W
Raised/crawlspace	2
Partial Subgrade basement	3

Larger Residential Building Codes

Multi-family	12
Garden Apartments	13
High Rise Apartments	14
Townhouses	15