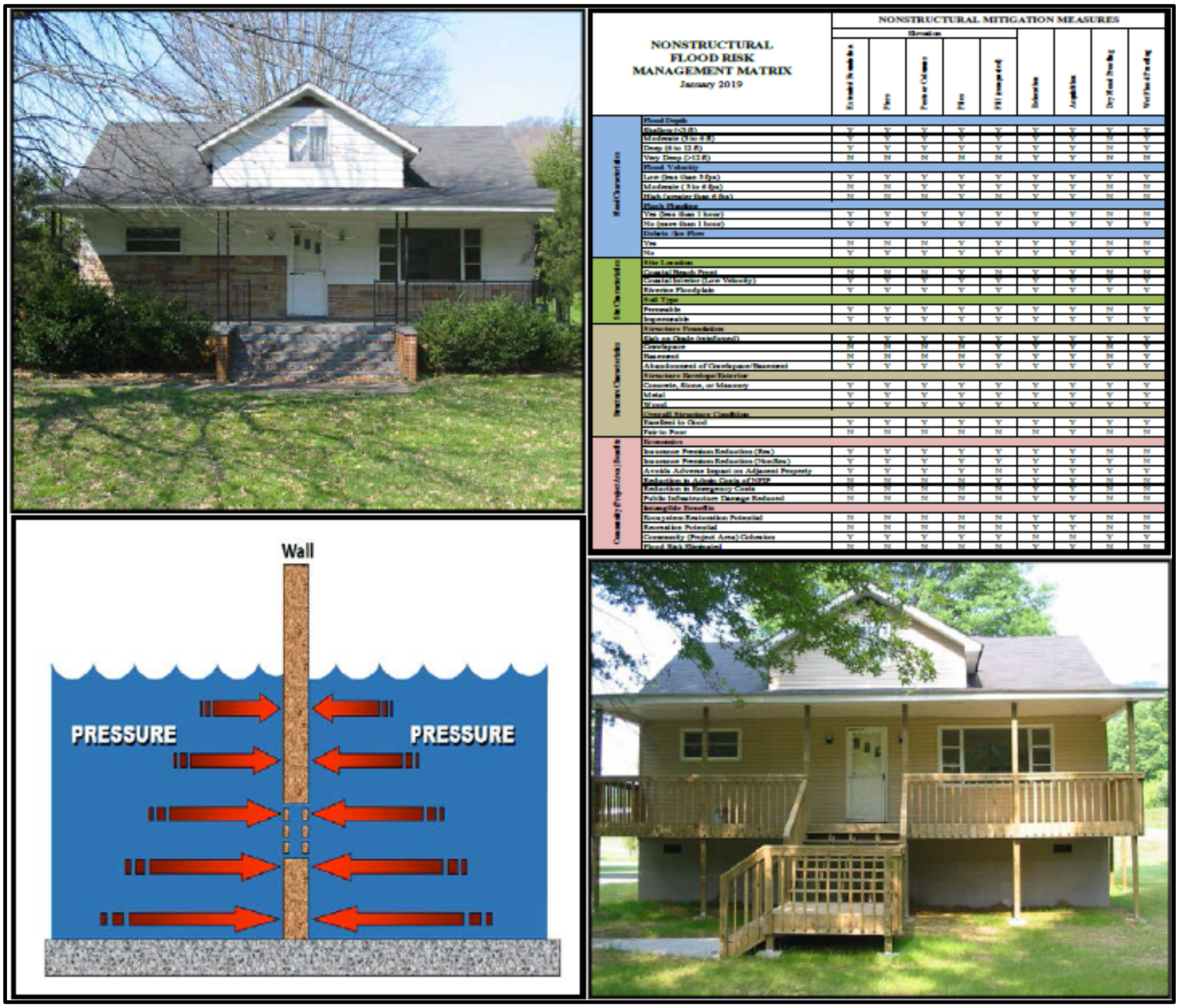
Nonstructural Flood Risk Management Matrix User Guide



May 2019

United States Army Corps of Engineers
National Nonstructural Committee Publication

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Table of Contents

List of Figures

Appendix A

List of Appendix A Figures

List of Appendix A Tables

Nonstructural Flood Risk Management Matrix

1. Objective

The Nonstructural Flood Risk Management Matrix (Matrix) allows the user to determine potential physical nonstructural measures for further evaluation and implementation based upon a series of responses associated with characteristics regarding flood conditions, site conditions, building conditions, potential economic conditions, or recreation and environmental opportunities and challenges. This quick reference guide for the Matrix is for use during initial assessment of nonstructural flood risk management measures.

2. Background

The nonstructural measures described in this document represent techniques commonly utilized in reducing flood risk and the damages associated with flooding. These measures vary from removing an entire structure from the floodplain to insuring a structure which is permanently located within the floodplain. The costs associated with implementing a measure are variable, and the resulting reduction of flood damages is typically proportional to the cost of the measure (i.e. removal of a structure from the floodplain will eliminate all future damages associated with flooding, while purchasing flood insurance for a structure will assist in making the structure whole after a flood event, but does not eliminate future flood damages to that structure).

3. Physical Nonstructural Measures

Nonstructural flood risk management measures are proven methods and techniques for reducing flood risk and flood damages incurred within floodplains. Thousands of structures across the nation benefit from reduced risk and damages or no risk and no damage due to implementation of nonstructural measures. Besides being very effective for both short and long term flood risk and flood damage reduction, nonstructural measures can be very cost effective when compared to structural measures. A particular advantage of nonstructural measures when compared to structural measures is the ability of nonstructural measures to be sustainable over the long term with minimal costs for operation, maintenance, repair, rehabilitation, and replacement.

3.1 Elevation

This nonstructural measure should be considered for lifting an existing structure to an elevation which is at least equal to or greater than the 1% annual chance flood elevation. The final elevation should place the first floor and associated ductwork, plumbing, mechanical and electrical systems above the design water surface elevation. In many elevation scenarios, the cost of elevating a structure an extra foot or two is less expensive than the first foot, due to the cost incurred for mobilizing equipment. Elevation can be performed using fill material, on extended foundation walls, on piers, post, piles and columns. Elevation is also a very successful measure for reinforced slab on grade structures.

It is possible that the structure being assessed has an existing crawlspace or basement which would require abandoning in order to reduce future flood damages and to implement one of the elevation measures described below. Abandonment would consist of filling in the existing basement or crawlspace with clean run fill material and possibly capping with concrete. With abandonment of the basement or crawlspace, there could be the need to construct a small addition to contain utilities and mechanical equipment and place it onto the side of the structure above the projected water surface elevation. If the addition could not be done because of limited space within the parcel or because the owner did not want it, partial compensation for the lost space would be in order to the owner.

3.1.1 Extended Foundation Walls. Since the foundation is the primary supporting system for a house or other structure, a perimeter of poured concrete is used as a footing from which common masonry units are extended upward to a defined height. If satisfactory, the existing footing and foundation wall may be added onto, or if necessary, a new footing and foundation may be constructed. Because the extended foundation results in an enclosed area, flood vents for equalizing hydrostatic pressure are required to be inserted into the foundation walls.

3.1.2 Piers. An engineered pier foundation (visualize bridge pier) is a collection of large diameter, typically cylindrical columns, to support the superstructure of the building and to transfer large loads to the subsurface ground below. The piers may consist of sections of galvanized or epoxy-coated steel pipe that are driven into the soil with a hydraulic ram until achieving a specified bearing strength. Piers are larger than posts and columns, and designed for most severe velocities and scour potential.

3.1.3 Posts. The engineered post is made of wood and is driven into the subsurface ground to achieve a specified bearing strength. As with a pier, the post is used to transfer the weight of the structure to the ground. Typically, posts are not as large as piers, and therefore even though driven below the frost depth, they are not as resistive as piers or piles to high velocities and generally not resistive to large debris/ice.

3.1.4 Columns. The column is a single-point loading system, such as structural concrete or concrete blocks, supporting the weight of framed structures, where this load is spread by an engineered pad to the bearing layer of soil or rock below. Typically, columns are not as large as piers, and therefore even though driven below the frost depth, they are not as resistive as piers or piles to high velocities and generally not resistive to large debris/ice.

3.1.5 Piles. There are basically two types of cast-in-situ piles; driven (cased or uncased) or bored. The pile is a slender column or long cylinder made of materials such as concrete or steel which are used to support the structure and transfer the load at desired depth either by end bearing or friction. Piles are driven to a greater depth to achieve a higher strength which is more resistive to high velocities and to waves, large debris, and ice. A benefit to elevating onto a pier, post, column, or pile is that the space located under the structure may be used for parking or storage of materials that can be easily moved.

3.1.6 Fill. This elevation measure requires the placement and compaction of clean run material to a height which elevates the structure above the design water surface. Since the amount and placement of fill can take a significant amount of area, this measure is typically relegated to rural settings. The fill material should be in compliance with all aspects of the National Flood Insurance Program (NFIP) and not cause adverse impacts on adjacent properties. During high velocity events, the fill material may erode exposing the structure to additional risk.

3.2 Relocation
This nonstructural measure requires physically moving the existing at-risk structure away from the flood hazard area to a location which is completely outside of the floodplain. The land where the structure had been originally located is purchased, becoming deed restricted in order to prevent development from occurring in the future, and becomes available for open land management as stipulated by the NFIP. It makes the most sense when at-risk structures can be relocated from a high flood risk area to a location of no flood risk.

3.3 Acquisition

This nonstructural measure consists of acquiring the at-risk structure and land that the structure sat upon. The structure is either demolished or is sold to others and relocated to a site external to the floodplain. Development sites for families who have had their structure acquired, if needed, can be part of a proposed project in order to provide parcels where new homes can be constructed within an established community. Keeping the displaced families within their existing community continues to support the local tax structure which could otherwise be adversely impacted by a significant number of acquisitions, and also provides the societal cohesion which many of the displaced families will be in need of. The land where the structure had been originally located is purchased, becoming deed restricted in order to prevent development from occurring in the future, and becomes available for open land management as stipulated by the NFIP.

3.4 Dry Flood Proofing

This nonstructural measure consists of waterproofing the structure and can be done to residential homes as well as commercial and industrial structures. This measure achieves flood risk reduction but is not recognized by the NFIP for any flood insurance premium rate reduction if applied to a residential structure, whereas a commercial structure may achieve insurance premium reduction if dry flood proofed in compliance with the NFIP. Based on laboratory tests, a "conventional" built structure can generally be dry flood proofed up to 3-feet. A structural analysis of the wall strength would be required if it was desired to achieve a higher level of protection. A sump pump and perhaps French drain system should be installed as part of the measure. Closure panels are used at openings. This concept is not recommended for basements or crawlspaces due to excessive costs of reinforcing the exterior walls, preventing seepage, and the possibility of making the whole structure buoyant. Excessive velocities can damage the flood proofing materials, and unless a passive system is incorporated into the design, there may not be adequate time to install closures during a flash flood event.

3.5 Wet Flood Proofing

This nonstructural measure is applicable as either a stand-alone measure or as a measure combined with other measures. Construction materials and finishing materials need to be water resistant and all utilities must be elevated above the design flood elevation. Wet flood proofing is quite applicable to commercial and industrial structures when combined with a flood warning and flood preparedness plan. This measure is generally not applicable to large flood depths which could create large forces on interior walls and high velocity flows or flashy conditions which will not allow hydrodynamic pressures to equalize quickly.

4. Matrix

The Nonstructural Flood Risk Management Matrix is presented in Figure 1. This Matrix has been developed to be used as a practical tool in determining effective physical nonstructural mitigation measures for individual at-risk structures based upon relevant flood, site, and structure characteristics, as well as potential community benefits, each of which are described in the following section. As the user becomes more familiar with the criteria supporting a particular measure, the time requirements for stepping through the Matrix should become shorter as the frequency of use increases.

US Army Corps of Engineers ®

Nonstructural Flood Risk Management

National Nonstructural Committee

May 2019

NONSTRUCTURAL FLOOD RISK MANAGEMENT MATRIX

		PHYSICAL NONSTRUCTURAL MITIGATION MEASURES									
		Elevation									
		Extend Foundation	Piers	Posts	Columns	Piles	Fill (Compacted)	Relocation	Acquisition	Dry Flood Proofing	Wet Flood Proofing
Flooding Characteristics	**Flood Depth**										
	Shallow (less than 3 ft)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 6 feet)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Deep (6 to 12 feet)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Very Deep (more than 12 feet)	N	N	N	N	N	N	Y	Y	N	N
	Flood Velocity										
	Low (less than 3 feet per second)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 6 feet per second)	N	Y	Y	Y	Y	Y	Y	Y	N	N
	High (more than 6 feet per second)	N	Y	N	N	Y	N	Y	Y	N	N
	Flash Flooding										
	Yes (less than 1 hour warning)	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	No (more than 1 hour warning)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Debris / Ice Flow										
	Yes	N	Y	N	N	Y	Y	Y	Y	N	N
	No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Site Characteristics	**Site Location**										
	Coastal Beach Front	N	N	N	N	Y	N	Y	Y	N	N
	Coastal Interior (Low Velocity)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Riverine Flood Plain	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Soil Type										
	Permeable	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Impermeable	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Building Characteristics	**Structure Foundation**										
	Slab on Grade (reinforced)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Crawl Space	N	N	N	N	N	Y	Y	Y	N	Y
	Basement	N	N	N	N	N	Y	Y	Y	N	Y
	Abandonment of Crawlspace / Basement	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Structure Construction										
	Concrete, Stone, or Masonry	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Metal	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Wood	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Overall Structure Condition										
	Excellent to Fair	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fair to Poor	N	N	N	N	N	N	N	Y	N	N
Community (Project Area) Benefits	**Economics**										
	Insurance Premium Reduction (Residential)	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	Insurance Premium Reduction (Non-Residential)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
	Avoids Adverse Impact on Adjacent Property	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
	Reduction in Admin Costs of NFIP	N	N	N	N	N	Y	Y	Y	N	N
	Reduction in Emergency Costs	N	N	N	N	N	N	Y	Y	N	N
	Public Infrastructure Damage Reduced	N	N	N	N	N	N	Y	Y	N	N
	Intangible Benefits										
	Ecosystem Restoration Potential	N	N	N	N	N	N	Y	Y	N	N
	Recreation Potential	N	N	N	N	N	N	Y	Y	N	N
	Community (Project Are) Cohesion	Y	Y	Y	Y	Y	Y	N	N	Y	Y
	Flood Risk Eliminated	N	N	N	N	N	N	Y	Y	N	N

The US Army Corps of Engineers National Nonstructural Committee [NNC] is available to assist in any aspect of formulating and implementing nonstructural flood damage reduction measures and realizing the opportunities that exist with nonstructural.

For more information, please contact the NNC Chairman and committee members at: nnc@usace.army.mil
or visit the NNC website at: http://www.usace.army.mil/Missions/CivilWorks/ProjectPlanning/nnc/

US Army Corps of Engineers
National Nonstructural Committee

Figure 1: Nonstructural Flood Risk Management Matrix

5. Matrix Categories

The Nonstructural Flood Risk Management Matrix has been developed utilizing four categories of input data for determining the physical nonstructural measure having the most potential for implementation, excluding costs. The ten nonstructural measures shown on the Matrix in Figure 1 are the most common measures typically employed for reducing flood risk.

In order to start the systematic approach to determining which nonstructural measure is most appropriate for the conditions being investigated, some basic elevation data must be generated or obtained for each structure prior to making a site visit. As highlighted in Figure 2, for existing conditions, the design water surface elevation, the first floor elevation, the lowest adjacent ground elevation, and the basement/crawlspace elevation, shown as a depth, is required. These elevations will allow the user to establish the baseline conditions from which the following Matrix categories will be compared to, in order to determine a potentially implementable nonstructural measure.

Figure 2: Typical Elevation Data Requirements

5.1 Flood Characteristics

This category focuses on the flood characteristics of depth and velocity as well as whether the flooding is flashy and if the flood waters would transport debris or ice. These characteristics are important as some nonphysical nonstructural measures are not suitable for certain flood characteristics. The total depth of flooding is the difference between the water surface elevation and the lowest adjacent ground elevation. It should be noted that while some measures could be designed for flood waters deeper than 12-feet, this Matrix uses 12-feet as the maximum height for implementing several measures. It is generally believed that with depths greater than this, and for moderate to high velocities, as well as debris and ice, structures should not be inhabited in order to reduce the potential for life loss, and that by limiting which measures could be supported for implementation also places caution on the side of first responders who place themselves at greater risk if having to respond to situations where the depth of flooding exceeds 12-feet.

5.2 Site Characteristics

This category focuses on the specific location of the structure being assessed and the type of soil surrounding the foundation of the structure. The location of a structure may also influence the appropriate measure for potential implementation, such as coastal beach front which has significantly higher velocities and wave forces than coastal interior and riverine sites. Additionally, the soil type, permeable or impermeable, will also influence the determination of the appropriate measure for the given site conditions. A structure located on permeable soil will be difficult to dry flood proof without installing a perimeter barrier around the structure both above and below ground to prevent flood water from penetrating the floor of the structure from below.

5.3 Structure Characteristics

This Matrix category considers the structure foundation, the structure envelope (exterior), and the overall structure condition. All three categories can influence the determination of a potential measure for implementation. If a structure is determined to have a slab on grade, there could be potential restrictions regarding which physical nonstructural measures may be considered for implementation depending upon if the slab is reinforced or not. For non-reinforced slabs, there could be significantly higher costs for any of the elevation measures as the existing slab would be required to be retrofitted with a new reinforced slab. Slabs which are not reinforced do not possess the appropriate tension requisites for maintaining stability when elevated. These slabs may crack, then fail when elevated.

It is also important to determine if the structure being assessed contains a crawlspace or basement. Either feature can pose a limitation to any of the elevation measures unless abandoned. If the existing feature was used to house utilities and appliances, the abandonment of the feature may require the modified structure to contain a utility addition in order to compensate for lost space. Crawlspaces or basements are not elevated unless the measure to elevate is by placement of compacted fill material.

In general, any envelope (exterior) can be incorporated into a physical nonstructural mitigation project, but some envelopes may require modification depending upon the measure being considered. For instance, the exterior of a structure may require modification if dry flood proofing were being proposed. Additionally, the overall condition of the structure, external and internal, may influence the determination of which measure is considered for implementation.

5.4 Community Benefits

This category considers economics and intangible benefits. While the category is illustrated with Y's and N's similar to the rest of the Matrix, the purpose for this category is to assist in determining which measure should be specifically considered for implementation. When assessing a structure using the other three categories of the Matrix, it is possible that two or more measures may appear to be equal in their potential for implementation. When this happens, it is suggested that the user examine the Community Benefits category to identify the most preferential measure for implementation. For example, a community may be fully supportive of removing flood risk and would support relocation or acquisition. However, a different community may have good reason to maintain community cohesion, and would prefer utilizing a different measure.

5.5 Costs to Mitigate

Costs for mitigation measures were not supported as a category of the Matrix, as unit costs can vary across the country and are dependent upon overall structure size, the number of structural corners, as well as each of the individual categories illustrated in the Matrix. For comparison purposes, the user should consider that if two or more measures appear to be equal for potential implementation, there are several inherent factors which may assist in selecting the preferred measure. For instance, when considering elevation, generally due to the confined parcel space within an urbanized environment, elevation on fill will not be acceptable. Or when considering reducing flood damages for a commercial structure, which is impacted by shallow flooding, it would probably be most cost effective to consider dry flood proofing versus elevation of any type, particularly if the structure has a slab on grade foundation, not reinforced, and surrounding structures are remaining at grade. There would be a significant cost to replace the non-reinforced slab with a reinforced slab and then the aesthetics of elevating one structure when surrounding structures remain a their existing grade would suggest that dry flood proofing would be the most economical solution. The costs should be estimated after the specific nonstructural measure has been determined from the criteria identified within the Matrix.

6. Directions for Matrix Use

The user should have a thorough knowledge and understanding of the aforementioned characteristics which the targeted structure will be exposed to during a flood event. The user will consider these characteristics and determine if the targeted structure has those characteristics by denoting responses with a "Y" for yes, and an "N" for no. The objective is to work through as many of the specific characteristics as possible, responding to each one with a "Y" or "N". After completing responses, the user will tally all of the "Y" responses for each nonstructural measure. The measure with the most "Y" responses should be considered for additional evaluation. There could be more than one measure to consider for implementation.

7. Matrix Use Examples

Two step by step examples, the first for a residential structure and the second for a commercial structure, are provided for the user to become familiar with the Matrix in Appendix A. The examples provide baseline conditions and information which can be registered within the appropriate category of the Matrix characteristics. The examples illustrate that in some instances more than one nonstructural measure may be applicable for the conditions being assessed. Information is generated by the Matrix to the user so that an informed decision can be made as to which measure would be most appropriate when considering all characteristics and potential community benefits.

8. Summary

The Nonstructural Flood Risk Management Matrix is a quick reference guide for use during initial assessment of a targeted structure for identification of potential nonstructural flood risk adaptive measures for implementation. The Matrix was developed based upon relevant flood, site, and structure characteristics, as well as potential community benefits, with the objective of guiding the user toward potentially implementable nonstructural measures. By using the Matrix it is possible for more than one potential measure to be identified for implementation. In those circumstances, the user must evaluate the potential economic and intangible benefits, as well as the desires of the structure owner and community officials, and make a determination of what represents the most reasonable and prudent measure for further consideration. Costs were not supported as a category of the Matrix, as unit costs can vary across the country and are dependent upon overall structure size, the number of structural corners, and specific flood, site, and structure characteristics.

Appendix A

Nonstructural Flood Risk Management Matrix User Guide Examples

A.1 Example 1

For this example, the targeted structure, which is residential within an urbanized area, is shown with pertinent elevations highlighted in Figure A1. Additional pertinent data regarding the structure and categories of the Matrix are illustrated in Table A1. The user should consider the elevation information provided in Figure A1 and the data illustrated in Table A1 and then determine the appropriate "Y" responses to enter into the Matrix.

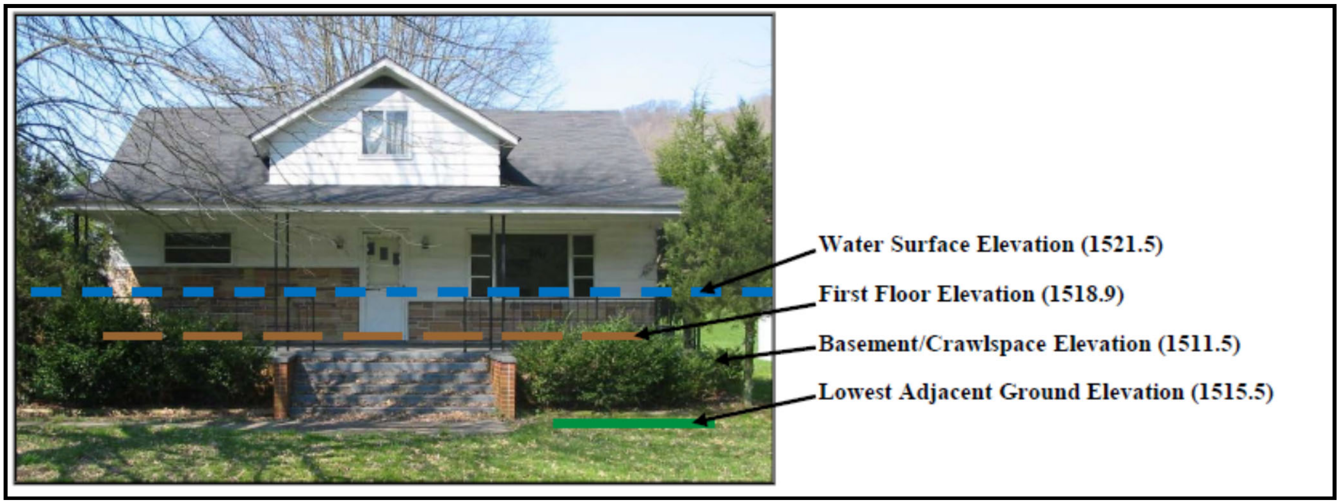

Figure A1: Example 1 Structure Data

The structure contains a basement with a floor elevation which is located approximately 4-feet below the lowest adjacent ground elevation of 1515.5 feet. Even though the first floor is elevated above the lowest adjacent ground elevation of 1515.5 by 3.4 feet, the design water surface elevation of 1521.5 feet exceeds the first floor elevation of 1518.9 feet by 2.6 feet. The total depth of flooding is the difference between the water surface elevation, 1521.5 feet, and the lowest adjacent ground elevation, 1515.5 feet, which is equal to 6.0 feet.

Table A1: Example 1 Structure Assessment Data

Structure Characteristics
First Floor Elevation – 1518.9
Lowest Adjacent Grade Elevation – 1515.5
Design Water Surface Elevation – 1521.5
Basement Floor Elevation – 1511.5
Flood Depth - Moderate (3 to 6 feet)
Flood Velocity – Low (less than 3 feet per second)
Flash Flooding – No (more than 1 hour warning)
Debris/Ice Flow - No
Site Location – Riverine Floodplain
Soil Type - Permeable
Structure Foundation – Crawlspace
Structure Envelope/Exterior – Wood
Overall Structure Condition – Excellent to Fair

With the information provided in Figure A1 and Table A1, the user will now begin to populate the Matrix by going through each of the Matrix categories and denoting the "Y's" which support the data provided for the targeted structure. For instance, the flood depth has been established as being 6.0 feet, which would be equivalent to the category represented by "Moderate (3 to 6 feet)". The user should highlight each "Y" in the row corresponding to this category. See Figure 4 which has been highlighted for this category and all other categories associated with the structure information provided. If a category does not have information, just skip it and move on to the next category.

As you work through this example, highlighting the "Y's" corresponding to the specific Matrix category, note that many of the nonstructural measures appear to be supported for further consideration. After identifying the "Y's" associated with the Overall Structure Condition, tally each vertical column. As shown in Figure A2, nine of the measures have the same number of "Y's". Only the dry flood proofing measure is eliminated, as its tally is less than the others.

At this point, the user should next consider the categories of Economics and Intangible Benefits under Community (Project Area) Benefits. Again, the "Y's" within each row which pertain to the structure are highlighted. For this example they are highlighted in "blue" to separate them from the other Matrix categories. Again, tally the responses denoted with a "Y". This time both dry flood proofing and wet flood proofing have a lower tally than the other measures. Relocation and acquisition appear to have the highest tally, with 8 each. This would suggest that either measure would reduce future flood damages and provide the most intangible benefits. However, in this situation, the user needs to be aware of the desires of the structure owners and community officials. If relocation or acquisition were to be implemented, community cohesion could be disrupted. Unless structure owners and community officials are supportive, these measures could result in the loss of an established tax base, and if the structure is part of a larger relocation or acquisition proposal, the result could be a checkerboard pattern of empty lots requiring deed restrictions and long-term upkeep and maintenance by the community with the loss of tax revenue previously generated by the structures. For this reason, the Community (Project Area) Cohesion is highlighted in "yellow" for relocation and acquisition, as a cautionary marker for both measures.

Additionally, the structure is known to have a basement, which would require abandonment in order for the elevation measures to be implemented, other than elevation by placement on compacted fill material. Since this is an urbanized area, the placement of fill would not be appropriate as it could adversely impact adjacent properties. For this reason the Crawlspace category under Structure Characteristics is highlighted in "yellow" for the Elevation with Fill measure, as a cautionary marker for both measures.

This results in the elevation measures of Extended Foundation, Piers, Posts, Columns, and Piles for consideration for implementation. Since the existing structure was determined to have existing solid and intact foundation footings, it was determined that elevation on extended foundation would be the most effective and cost efficient nonstructural measure for implementation. For this climate, not having the underside of the first floor exposed to the elements (cold air) was an additional consideration for elevating on extended foundation.

May 2019		PHYSICAL NONSTRUCTURAL MITIGATION MEASURES									
NONSTRUCTURAL FLOOD RISK MANAGEMENT MATRIX		Elevation									
		Extend Foundation	Piers	Posts	Columns	Piles	Fill (Compacted)	Relocation	Acquisition	Dry Flood Proofing	Wet Flood Proofing
Flooding Characteristics	**Flood Depth**										
	Shallow (less than 3 ft)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 6 feet)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Deep (6 to 12 feet)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Very Deep (more than 12 feet)	N	N	N	N	N	N	Y	Y	N	N
	Flood Velocity										
	Low (less than 3 feet per second)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 6 feet per second)	N	Y	Y	Y	Y	Y	Y	Y	N	N
	High (more than 6 feet per second)	N	Y	N	N	Y	N	Y	Y	N	N
	Flash Flooding										
	Yes (less than 1 hour warning)	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	No (more than 1 hour warning)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Debris / Ice Flow										
	Yes	N	Y	N	N	Y	Y	Y	Y	N	N
	No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Site Characteristics	**Site Location**										
	Coastal Beach Front	N	N	N	N	Y	N	Y	Y	N	N
	Coastal Interior (Low Velocity)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Riverine Flood Plain	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Soil Type										
	Permeable	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Impermeable	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Building Characteristics	**Structure Foundation**										
	Slab on Grade (reinforced)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Crawl Space	N	N	N	N	N	Y	Y	Y	N	Y
	Basement	N	N	N	N	N	Y	Y	Y	N	Y
	Abandonment of Crawlspace / Basement	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Structure Construction										
	Concrete, Stone, or Masonry	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Metal	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Wood	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Overall Structure Condition										
	Excellent to Fair	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fair to Poor	N	N	N	N	N	N	N	Y	N	N
Community (Project Area) Benefits	**Economics**										
	Insurance Premium Reduction (Residential)	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	Insurance Premium Reduction (Non-Residential)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
	Avoids Adverse Impact on Adjacent Property	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
	Reduction in Admin Costs of NFIP	N	N	N	N	N	Y	Y	Y	N	N
	Reduction in Emergency Costs	N	N	N	N	N	N	Y	Y	N	N
	Public Infrastructure Damage Reduced	N	N	N	N	N	N	Y	Y	N	N
	Intangible Benefits										
	Ecosystem Restoration Potential	N	N	N	N	N	N	Y	Y	N	N
	Recreation Potential	N	N	N	N	N	N	Y	Y	N	N
	Community (Project Are) Cohesion	Y	Y	Y	Y	Y	Y	N	N	Y	Y
	Flood Risk Eliminated	N	N	N	N	N	N	Y	Y	N	N
	Total Y's (Red)	9	9	9	9	9	9	9	9	7	9
	Total Y's (Blue)	3	3	3	3	3	3	8	8	2	2

Figure A2: Example 1 Matrix Solution

The structure is shown post-elevation in Figure A3. As illustrated in the figure, the first floor elevation for this example is located 1.5 feet above the design water surface elevation, which for this example is the 1% ACE flood event. Flood vents and air vents have been incorporated into the foundation to allow for the equalization of hydrostatic forces on the exterior of the foundation walls. The elevation of the first floor above the water surface also allows for the inclusion of mechanical systems and ductwork to be in place without risk of flooding. The existing crawlspace was abandoned and filled to the adjacent grade elevation. A small utility addition was constructed at the rear of the structure to house utilities and appliances which were previously contained within the basement. Flood vents having 1 square inch per 1 square foot of floor area are incorporated into the foundation in order to equalize external flood forces with the interior. This space is not to be habitable. Access can be from the first floor or exterior wall.

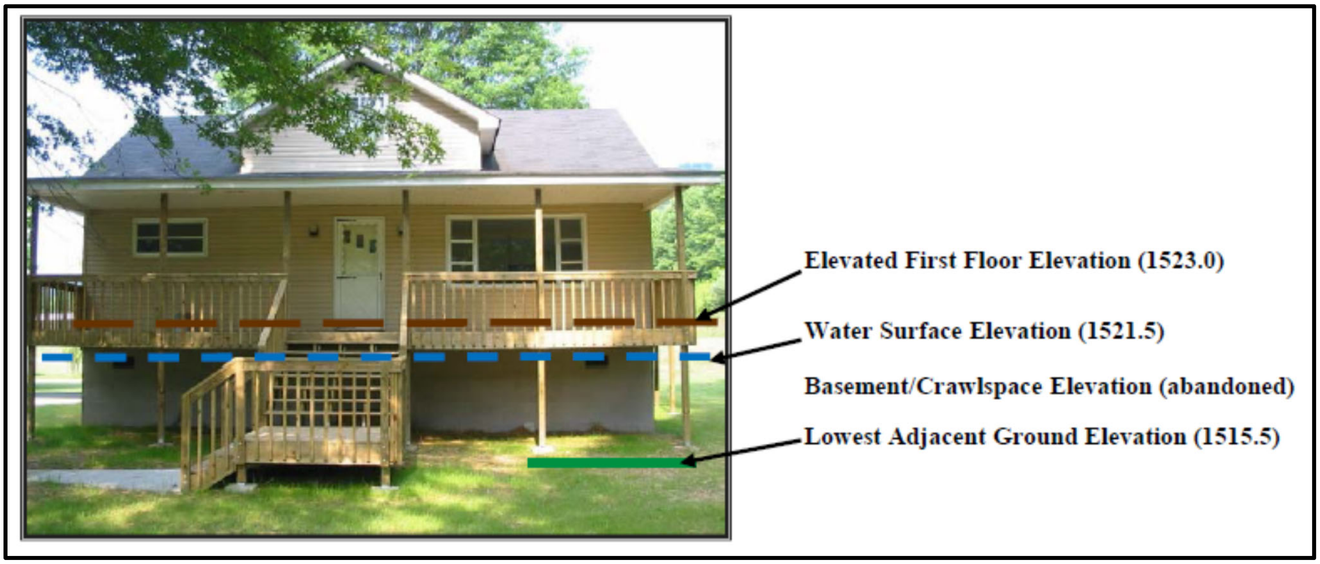

Figure A3: Example 1 Modified Structure

The user will find that in many instances, several nonstructural measures will appear to be supported for implementation based upon flood and structure data. And while one of the other elevation measures may have worked as well for this example, the objective is to identify a measure which qualifies based upon the data, fits the needs of the owners and the community officials, blends well with existing architecture and construction, and is cost effective.

A.2 Example 2

For this example, the targeted structure, which is a commercial business located in a flood zone, is shown with pertinent elevations highlighted in Figure A4. Additional pertinent data regarding the structure and categories of the Matrix are illustrated in Table 2. The user should consider the elevation information provided in Figure 6 and the data illustrated in Table A2 and then determine the appropriate "Y" responses to enter into the Matrix.

Figure A4: Example 2 Structure Data

The commercial structure is a slab on grade (not reinforced) and does not contain a crawlspace or basement. The area where the structure is located is a mix of commercial and residential structures. Utilities and other equipment are located within the structure at floor elevation or on the roof. There are a total of three entrances into the structure and 14 windows, with a lower sill elevation of being approximately 4-feet above the first floor. The first floor elevation is 0.5 feet higher than the lowest adjacent ground elevation of 1208.5 feet. The water surface elevation of 1210.5 feet exceeds the first floor elevation of 1209.0 feet by 1.5 feet. The total depth of flooding is the difference between the water surface elevation, 1210.5 feet, and the lowest adjacent ground elevation, 1208.5 feet, which is equal to 2.0 feet.

Table A2: Example 2 Structure Assessment Data

Structure Characteristics
First Floor Elevation – 1209.0
Lowest Adjacent Grade Elevation – 1208.5
Design Water Surface Elevation – 1210.5
Crawlspace Floor Elevation – None Exist
Flood Depth - Shallow (< 3 feet)
Flood Velocity – Low (less than 3 feet per second)
Flash Flooding – No (more than 1 hour warning)
Debris/Ice Flow - No
Site Location – Coastal Interior
Soil Type - Impermeable
Structure Foundation – Slab on Grade
Structure Exterior – Wood/Brick Laminate
Overall Structure Condition – Excellent to Fair

With the information provided in Figure A4 and Table A2, the user will now begin to populate the Matrix by going through each of the Matrix categories and denoting the "Y's" which support the data provided for the targeted structure. For instance, the total flood depth has been established as being 2.0 feet, which would be equivalent to the category represented by "Shallow (< 3 feet)". The user should highlight each "Y" in the row corresponding to this category. See Figure A5 which has been highlighted for this category and all other categories associated with the structure information provided. If a category does not have information, just skip it and move on to the next category.

As you work through this example, highlighting the "Y's" corresponding to the specific Matrix category, note that many of the nonstructural measures appear to be supported for further consideration. After identifying the "Y's" associated with the Overall Structure Condition, tally each vertical column. As shown in Figure A5, all of the measures have the same number of "Y's". This is not unusual as the depth of flooding is shallow and the flood velocity is low, which on surface would support all of the measures.

At this point, the user should next consider the categories of Economics and Intangible Benefits under Community (Project Area) Benefits. Again, the "Y's" within each row which pertain to the structure are highlighted. As with the previous example, they are highlighted in "blue" to separate them from the other Matrix categories. Again, tally the responses denoted with a "Y". This time wet flood proofing has a lower tally than the other measures, which is not surprising since the structure is a restaurant and should not allow flood waters to enter. Wet flood proofing is highlighted in "yellow" under the Slab on Grade (reinforced) category as a cautionary marker for this measure.

The other measures each have three "Y's" except for relocation and acquisition which have the highest tally, with 8 each. This would suggest that either measure would reduce future flood damages and provide the most intangible benefits. However, in this situation, the user needs to be aware of the desires of the structure owners and community officials. The structure is not located in a floodway and if relocation or acquisition were to be implemented, community cohesion could be disrupted. Unless structure owners and community officials are supportive, these measures could result in the loss of an established tax base, and if the structure is part of a larger relocation or acquisition proposal, the result could be a checkerboard pattern of empty lots requiring deed restrictions and long-term upkeep and maintenance by the community with the loss of tax revenue previously generated by the structure. For this reason, the Community (Project Area) Cohesion is highlighted in "yellow" for relocation and acquisition as a cautionary marker for both measures.

Additionally, the structure is known to not have a reinforced slab, which would dictate that while elevation is not impossible, it would be difficult and likely very expensive to implement. The structure would have to be separated from the existing slab and then another slab, with reinforcement, formed and poured at a higher elevation. For this reason the Slab on Grade (reinforced) category under Structure Characteristics is highlighted in "yellow" for all of the elevation measures as a cautionary marker for these measures.

Finally, after reviewing the Matrix categories and taking into account the cautionary markers (highlighted in "yellow" on Figure A5), as well as the potential economics and intangible benefits, it appears that dry flood proofing would benefit the structure by reducing future flood damages. The depth of flooding is shallow. If the structure were to be dry flood proofed in compliance with National Flood Insurance Program regulations, the flood insurance premiums could be reduced on the structure. The structure and business remain as a viable part of the community, providing services and generating tax revenues for the community.

The structure is shown post-dry flood proofing in Figure A6. Dry flood proofing in the form of water resistant sealant has been applied to the exterior surface of the structure to a height of approximately 3-feet. A brick veneer siding is applied over the sealant in order to protect it from being damaged. With this application, none of the windows had to be modified. The hard surface parking lot which extends away from the structure on all sides also decreases the permeability of the surrounding area, preventing flood waters from penetrating into the structure from beneath the slab.

NONSTRUCTURAL FLOOD RISK MANAGEMENT MATRIX

May 2019		PHYSICAL NONSTRUCTURAL MITIGATION MEASURES									
		Elevation									
		Extend Foundation	Piers	Posts	Columns	Piles	Fill (Compacted)	Relocation	Acquisition	Dry Flood Proofing	Wet Flood Proofing
Flooding Characteristics	**Flood Depth**										
	Shallow (less than 3 ft)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 6 feet)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Deep (6 to 12 feet)	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Very Deep (more than 12 feet)	N	N	N	N	N	N	Y	Y	N	N
	Flood Velocity										
	Low (less than 3 feet per second)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Moderate (3 to 6 feet per second)	N	Y	Y	Y	Y	Y	Y	Y	N	N
	High (more than 6 feet per second)	N	Y	N	N	Y	N	Y	Y	N	N
	Flash Flooding										
	Yes (less than 1 hour warning)	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	No (more than 1 hour warning)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Debris / Ice Flow										
	Yes	N	Y	N	N	Y	Y	Y	Y	N	N
	No	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Site Characteristics	**Site Location**										
	Coastal Beach Front	N	N	N	N	Y	N	Y	Y	N	N
	Coastal Interior (Low Velocity)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Riverine Flood Plain	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Soil Type										
	Permeable	Y	Y	Y	Y	Y	Y	Y	Y	N	Y
	Impermeable	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Building Characteristics	**Structure Foundation**										
	Slab on Grade (reinforced)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Crawl Space	N	N	N	N	N	Y	Y	Y	N	Y
	Basement	N	N	N	N	N	Y	Y	Y	N	Y
	Abandonment of Crawlspace / Basement	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Structure Construction										
	Concrete, Stone, or Masonry	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Metal	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Wood	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Overall Structure Condition										
	Excellent to Fair	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
	Fair to Poor	N	N	N	N	N	N	N	Y	N	N
Community (Project Area) Benefits	**Economics**										
	Insurance Premium Reduction (Residential)	Y	Y	Y	Y	Y	Y	Y	Y	N	N
	Insurance Premium Reduction (Non-Residential)	Y	Y	Y	Y	Y	Y	Y	Y	Y	N
	Avoids Adverse Impact on Adjacent Property	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
	Reduction in Admin Costs of NFIP	N	N	N	N	N	Y	Y	Y	N	N
	Reduction in Emergency Costs	N	N	N	N	N	N	Y	Y	N	N
	Public Infrastructure Damage Reduced	N	N	N	N	N	N	Y	Y	N	N
	Intangible Benefits										
	Ecosystem Restoration Potential	N	N	N	N	N	N	Y	Y	N	N
	Recreation Potential	N	N	N	N	N	N	Y	Y	N	N
	Community (Project Are) Cohesion	Y	Y	Y	Y	Y	Y	N	N	Y	Y
	Flood Risk Eliminated	N	N	N	N	N	N	Y	Y	N	N
	Total Y's (Red)	9	9	9	9	9	9	9	9	9	9
	Total Y's (Blue)	3	3	3	3	3	3	8	8	3	2

Figure A5: Example 2 Matrix Solution

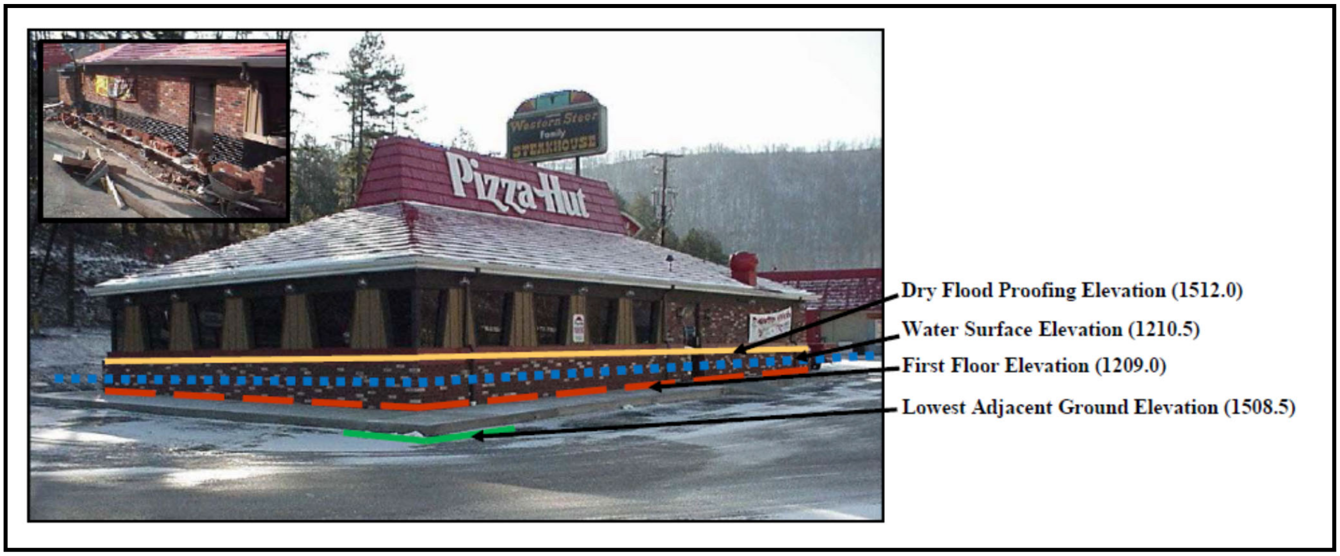

Figure A6: Example 2 Modified Structure

As previously described, the structure has three entrances. In addition to a water resistant sealant being applied to the walls of the structure, with a masonry veneer cover, the entrances must be retrofitted with flood proof barriers. The barriers could be incorporated as a passive system, where the doors are flood proof, or as separate barriers which must be placed prior to the flood event. While many flood barriers and closures are marketed nationally, it is highly recommended that flood barriers which have been tested and certified through the National Flood Barrier Testing and Certification Program (http://nationalfloodbarrier.org) be incorporated into project implementation.