Flood Risk Assessment and Reduction Community Guidebook

A PARTNERSHIP BETWEEN

Charlotte-Mecklenburg Storm Water Services and the U.S. Department of Homeland Security, Science and Technology Directorate

[Prepared by]
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ABOUT THE GUIDEBOOK

The Flood Risk Assessment and Reduction Community Guidebook was developed as part of an initiative led by Charlotte-Mecklenburg Storm Water Services (CMSWS) in collaboration with the U.S. Department of Homeland Security, Science and Technology (DHS S&T) Flood Apex Program. Flood Apex is a specialized program that develops and applies new and emerging technologies to improve community resilience from flood disasters. Its goals are to reduce fatalities and property losses from future flood events, increase community resilience to disruptions caused by flooding, and develop better investment strategies to prepare for, respond to, recover from, and mitigate against flood hazards.

This guidebook summarizes the efforts needed to develop a *data-driven framework* that can be used by communities nationwide to assess flood hazards, evaluate and prioritize actions to mitigate risk, and provide a foundation to implement, measure, and track the success of a program over time. It incorporates needs that were initially identified during scoping of the project as well as those identified through a national outreach effort. The national outreach effort, performed in the summer/fall of 2018, included an online survey that yielded nearly 900 responses.

The Community Guidebook aims to lead other communities through obtaining and developing data as well as demonstrate how that data can be used to assess risk and evaluate mitigation options within their community. It also discusses how communities can develop their own mitigation strategy, how to fund and implement that strategy, and how to monitor and communicate the strategy and results within their community. Additional data links and resources, sample checklists and basic calculators, and a case study are also provided.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACRONYMS AND ABBREVIATIONS

ACS	American Community Survey (Census)
ARR	Australian Rainfall and Runoff
BCA	Benefit-Cost Analysis (FEMA)
BCR	Benefit-Cost Ratio
BFE	Base Flood Elevation
CDC	Centers for Disease Control and Prevention
CIP	Capital Improvement Plan
CMSWS	Charlotte Mecklenburg Storm Water Services
DDF	Depth-Damage Functions
DHS	Department of Homeland Security
EC	Elevation Certificate
ESRI	Environmental Systems Research Institute
FEMA	Federal Emergency Management Agency
FFE	First Floor Elevation
FIRM	Flood Insurance Rate Map (FEMA)
FIS	Flood Insurance Study (FEMA)
FPE	Flood Protection Elevation
GIS	Geographic Information System
HCF	Highest Contributing Factor
HEC	Hydrologic Engineering Center (USACE)
HEC-FDA	HEC Flood Damage Reduction Analysis
HEC-RAS	HEC River Analysis System
LAG	Lowest Adjacent Grade

LFE	Lowest Floor Elevation
LiDAR	Light Detection and Ranging
LME	Lowest Mechanical Elevation
MIP	Mapping Information Platform (FEMA)
MSC	Map Service Center (FEMA)
NED	National Elevation Dataset (USGS)
NFHL	National Flood Hazard Layer (FEMA)
NFIP	National Flood Insurance Program (FEMA)
NGOs	Non-Governmental Organizations
NHD	National Hydrography Dataset (USGS)
NHDPlus HR	National Hydrography Dataset High Resolution (USGS)
NLCD	National Land Cover Database
NOAA	National Oceanic and Atmospheric Administration
RARR	Risk Assessment and Risk Reduction
SFHA	Special Flood Hazard Area
SoVI	Social Vulnerability Index
SVI	Social Vulnerability Index (CDC)
TIGER	Topologically Integrated Geographic Encoding and Referencing database (Census)
USACE	United States Army Corps of Engineers
USGS	United States Geological Survey

CHAPTER ONE

Introduction

The goal of this guidebook is to share strategies, resources, and tools that communities can use to develop or enhance their flood mitigation programs and further promote awareness and reduction of risk in their community.

Introduction

This guidebook summarizes the efforts put forth to develop a data-driven framework that can be used by communities nationwide to assess flood hazards, evaluate and prioritize actions to mitigate risk, and provide a foundation to implement, measure, and track the success of a program over time. The goal of this guidebook is to share strategies, resources, and tools that communities can use to develop or enhance their flood mitigation programs and further promote awareness and reduction of risk in their community.

Each community that is impacted by flooding has different characteristics (geography, people, hazards, datasets, financial capabilities, values/priorities, etc.) that make it unique. There is no "one-size fits all" approach to access and reduce flood risk. However, there are common denominators in all of our communities. Flooding causes immense personal and economic damage. Not having a strategy to reduce risk over time will result in continued devastation and hardship.

Although the examples in this guidebook are focused on flood hazards and effective mitigation strategies for Charlotte, North Carolina, the fundamental concepts can be applied to most other communities. This document can serve as your guidebook on how to proactively and strategically become more resilient to flood hazards.

This guidebook was developed in a collaborative effort between Charlotte Mecklenburg Storm Water Services (CMSWS) and the U.S. Department of Homeland Security, Science and Technology Directorate (DHS S&T) for the Flood Apex program under Contract 70RSAT18CB0000022. The Flood Apex program is a specialized program that develops and applies new and emerging technologies to improve community resilience from flood disasters. This guidebook is part of a larger initiative that includes enhancements to a data-driven framework and set of associated tools, referred to as

Risk Assessment / Risk Reduction (RARR), that has been developed and implemented by Mecklenburg County.

1.1 Background

Natural hazards affect communities around the country on an almost daily basis. One of those natural hazards is flooding, which yearly claims more lives and causes more economic damage than any other natural disaster. In recent years, the frequency, intensity, and size of storms leading to significant flooding seems to be increasing and more unpredictable. Many communities have development regulations that limit, but do not completely prohibit, building within the floodplain. In addition, many older structures are already situated in flood-prone areas. As long as structures and other assets are located within flood-prone areas, communities will continue to experience losses due to flooding. In an effort to get ahead of the loss of lives and property due to flooding, it is important that communities minimize flood hazards by reducing the likelihood of detrimental impacts from floodwaters to individuals and buildings. The goal is to accomplish this while also enhancing the natural and beneficial function of floodplains.

In preparation, a national outreach survey was conducted to gather input and needs from communities. The target audience for the outreach study was local communities that deal with flood hazards/losses and have the authority and responsibility to implement flood mitigation measures in order to reduce risk within their community. Secondary audiences included state and federal agencies (e.g., United States Army Corps of Engineers) or other entities that serve a similar role in mitigating flood losses and reducing flood risk. In total, 896 responses were received spanning 46 states and the District of Columbia. A large majority of respondents (93%) work for a community (public employee) with most indicating that they have additional duties other than floodplain management. Feedback from the outreach was used to inform the content of this guidebook.

1.2 Goals and Objectives

The objective/vision for this guidebook is to be a "recipe book" of information that communicates and shares the concepts, methodologies, and templates/tools developed for RARR with other peer-communities in order to provide a baseline for developing or expanding their own risk mitigation strategies. RARR is a data-driven framework and set of tools that dynamically assess, evaluate, and prioritize mitigation strategies at the individual building level.

RARR was developed by CMSWS to assist in expanding upon efforts to understand risks and minimize the consequences from flooding to people and property. The RARR framework integrates information from numerous datasets such as elevation certificates, tax parcels, flood hazard layers, community buffers, and other community planning layers, and includes tools to dynamically update the evaluations to reflect any changes in the source data (e.g., updated floodplain mapping).

This document builds upon experiences and lessons-learned by CMSWS, and provides guidance/information that is scalable to other communities of different sizes, geographies, staff expertise, and data resources. This guidebook also incorporates input gathered from external communities during stakeholder engagement efforts to effectively communicate ideas back out to communities.

As part of an overall flood mitigation strategy, it may be beneficial for communities to develop a plan that evaluates flood risk and identifies risk reduction opportunities. Together, these evaluations can help assess risks within the community and guide implementation of mitigation strategies with the overall goal of minimizing the consequences to people and property. This plan can vary depending on a community's data availability; however, this guidebook aims to help communities develop a data-driven framework using available data that allows the community to dynamically assess, evaluate, and prioritize mitigation strategies for flood prone buildings/properties. Additionally, the guidebook will provide strategies for closing data gaps and prioritizing data collection efforts. This may be in the form of spreadsheets or, for a more advanced approach, automated tools that assess a community's risk and mitigation options based on available datasets.

CHAPTER TWO

Getting Data

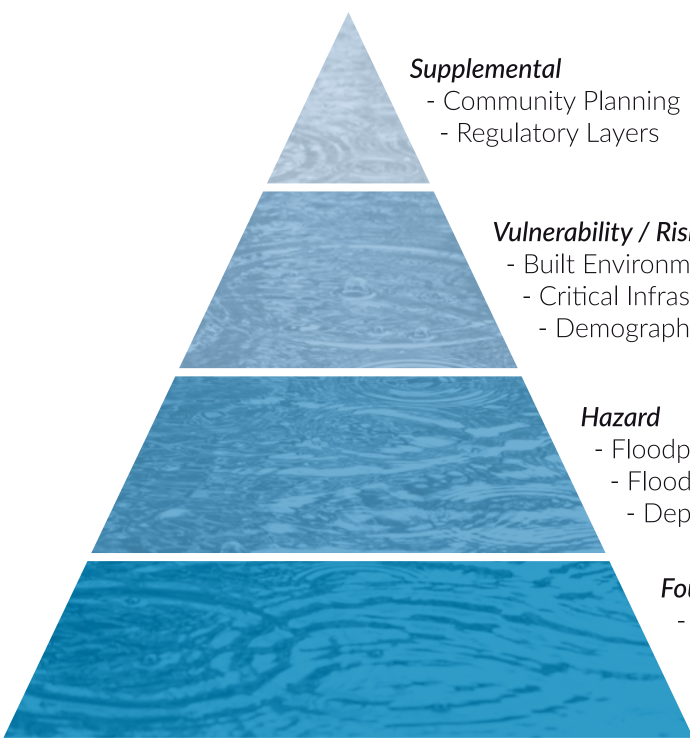
While many communities may not have advanced datasets on their own, there has been a dramatic increase in the availability of data in recent years that communities can leverage when assessing risk within their community.

Getting Data

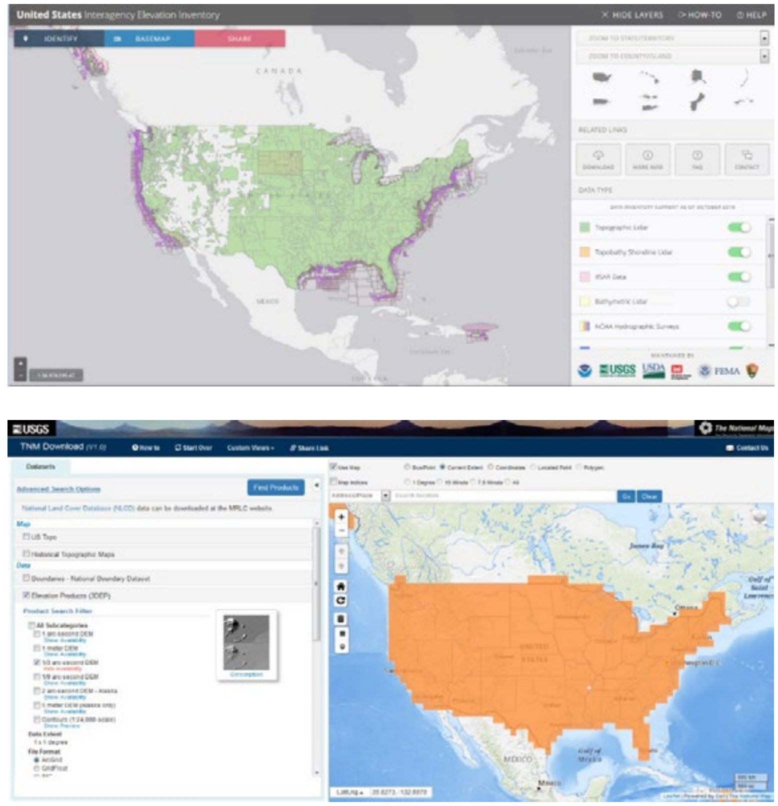
Quality data plays a key role in determining flood risks within a community that can drive better assessments of the risk as well as evaluations of available mitigation options/alternatives. While many communities may not have advanced datasets on their own, there has been a dramatic increase in the availability of data in recent years that communities can leverage when assessing risk within their community. This section provides guidance on data considerations, sources, and applications to support flood risk assessments and mitigation evaluations.

2.1 Types of Data Needed

Various data types are needed to assess flood risk within a community. At a high-level, there are four broad categories that are generally necessary to conduct a risk assessment—foundational, hazard, vulnerability/risk, and supplemental. Additional information on these data categories is provided below.



[Figure 1]
Data categories for risk assessments



[Figure 2]
U.S. Elevation Inventory (above) and USGS National Map (below)

FOUNDATIONAL DATA

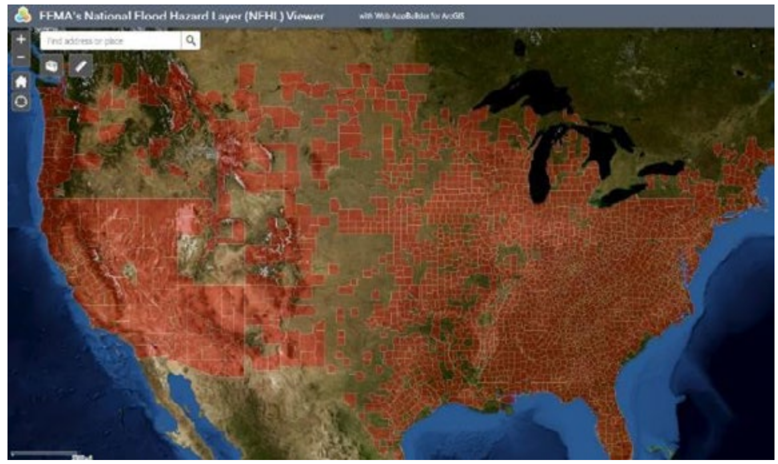
Foundational data elements are building block datasets that are necessary to construct, enhance, or provide essential context to other flood risk related data. One of the most important foundational layers specific to flood risk is ground topography. Topography depicts the "lay of the land," which captures the elevation of the land surface and landform features such as hills, lakes, rivers, valleys, road embankments, and others. As this information largely governs where excess rainfall or coastal surge waters naturally collect and flow by gravity, topography is an essential component in the development of flood hazard data. In the past, the availability of topographic data and the cost to collect/update topographic data were significant challenges in mapping flood hazards and risks. However, with the emergence and continued advances of light detection and ranging (LiDAR) technologies, high-resolution topographic data can be collected/updated for large areas. Currently, there is LiDAR-based topographic data available for much of the U.S. and there are on-going initiatives to collect and update data that will cover essentially the entire country. A centralized repository of LiDAR information is available at the U.S. Interagency Elevation Inventory website. Even in areas where new LiDAR does not exist, reasonable resolution (approximate 10-meter ground spacing) topographic data is available for the continental U.S., which is available on the USGS National Map website. Links and additional information for these topographic data sources are provided in Section 2.3.

In addition to topography, it is helpful to have base mapping information to provide a fuller context to any flood risk assessment. There are a large number and variety of base mapping layers that can be helpful in supporting flood risk assessments. Examples include aerial imagery, hydrography, transportation, and political boundaries. Often, communities collect and maintain many of these base mapping layers. Community data, when available, is generally preferred since it tends to be refined and directly targeted to the needs of the community. However, if local data is not available, there are many sources that provide data for viewing on the web and/or direct data download, which are listed in Section 2.3.

HAZARD DATA

Flood hazard data is used to identify areas susceptible to flooding and help determine the potential flooding characteristics such as frequency, severity, and nature of flooding. Most flood hazard information is developed from engineering models that estimate flood levels (and other flood characteristics) along targeted streams and coastlines. Although there are a variety of specific modeling techniques and software packages, flood hazard modeling methods can generally be grouped into one of two distinct categories – riverine and coastal. In riverine models, flooding is derived by simulating estimated rainfall over a contributing drainage area and/or long-term analysis of stream gages, which is then routed through the system of rivers, channels, and lakes to determine flood elevations. In coastal models, flooding is derived by determining storm surge from long-term patterns of tides, atmospheric conditions, and historic storms, and then integrating that with physical coastal topography to determine flood elevations.

Flood elevation information and other flood characteristics computed from engineering models (riverine and coastal) are then integrated with ground topography and base mapping to produce flood hazard datasets and mapping products. The most common and widely available flood hazard mapping products are those associated with FEMA Flood Insurance Studies (FISs). These include FIS reports, Flood Insurance Rate Maps (FIRMs), and in many cases, digital GIS layers. FEMA FISs and associated FIRMs are available at no cost for most of the U.S. through the FEMA Map Service Center (MSC). In addition to providing PDF documents of the FIS report and FIRMs, FEMA provides GIS layers of flood hazard areas (and other supporting information) through the National Flood Hazard Layer (NFHL). For areas with more recent FIS studies performed under FEMA's Risk MAP initiative, additional digital GIS layers that provide "point-and-click" water surface elevation, flood depth, or flood probability may also be available through the MSC.



[Figure 3]
FEMA National Flood Hazard Layer (NFHL)

While FEMA is a nationwide resource for regulatory flood hazard information, many areas may not have information and/or the available information available may not be sufficient to support desired risk assessments for a community. There are thousands of miles of streams that do not have FEMA floodplain mapping. Additionally, most existing FEMA floodplain maps show flood hazards for streams that drain one square mile or more. As has been shown, and highlighted in recent major flood events (e.g., Hurricanes Sandy, Matthew, Harvey, etc.), a significant amount of flood damage can occur outside the FEMA mapped floodplain areas. Where sufficient data is not available, the community may need to fill data gaps with other data or studies, data proxies, or directly develop flood hazard information to support desired risk assessments. There are a number of additional direct and indirect sources, as well as tools, that can be used to develop or enhance flood hazard information. Examples of data sources that can be used to supplement or enhance FEMA information include: historic flood and/or damage records (e.g., flood insurance claims, high water marks, stream gages, etc.); local flood studies; and predictive/probabilistic information provided by USGS, NOAA, and other federal agencies. In addition to data/information, there are a number of open-source tools that can be used to directly develop flood hazard information. The FEMA HAZUS program is an example of a sophisticated, open-source software that can be used to develop flood hazard information, perform risk assessments, and estimate impacts in a GIS-based environment, without the use of any separate engineering modeling software. In addition to HAZUS, there are a number of open-source engineering modeling software that can used to develop flood hazard information. The "HEC" suite of modeling software (including HEC-RAS) developed by the USACE is widely used in FEMA flood insurance studies. Potential resources to obtain flood hazard data are listed in Section 2.3.

VULNERABILITY / RISK DATA

Vulnerability data is used to identify elements in the natural and/or built environment that may be vulnerable to, and negatively impacted by, flood hazards. Often, building structures (e.g., residential homes, business, etc.) are a primary focus; however, impacts can include infrastructure, agricultural areas, natural resources, indirect economic impacts, or anything else that could be negatively impacted by flooding. Many municipalities maintain spatial layers of building footprints and other critical infrastructure, although the data may be used for other purposes. If a community does not directly have datasets, related/similar datasets often exist (tax parcels, elevation certificates, building permits, and address points) that can provide adequate information to inform community risk assessments.

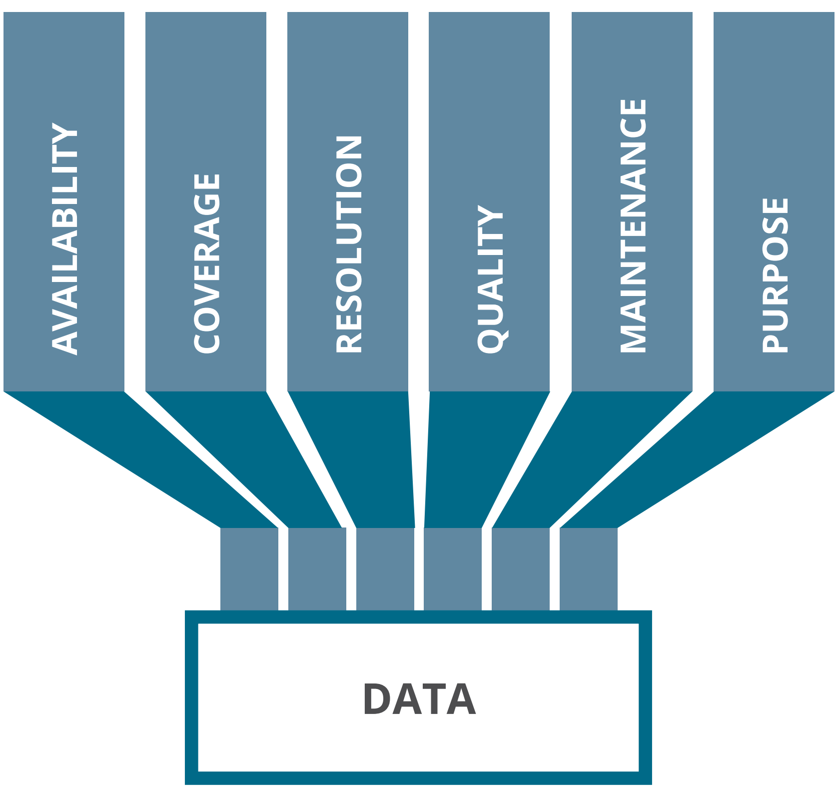
Similar to foundational/base data, with the proliferation of data availability in recent years, there are a number of resources that provide impact related data for essentially the entire country. One relatively recent dataset (released June 2018) is Microsoft Building Footprints. The Microsoft layer, which includes approximately 125 million buildings, is viewable through a number of websites and can be downloaded by state. FEMA's HAZUS program (discussed previously) also includes a number of discrete features and aggregated impact datasets (e.g., critical facilities, building information aggregated to census blocks, etc.) covering the entire United States. Additional discussion of potential resources of hazard data are listed in Section 2.3.

SUPPLEMENTAL DECISION-MAKING DATA

In addition to the core foundation, hazard, and vulnerability datasets discussed above, there may be supplemental datasets that can be used to enhance or further inform risk assessments and mitigation evaluations. These supplemental datasets would often be community-specific layers that reflect aspects of risk assessments and/or mitigation strategies that are important to the community (i.e., "community values"). Examples of supplemental datasets that can provide additional decision-making for risk assessments and mitigation evaluations include: community buffers or other protection zones (water quality, historic, no-build zones, etc.), demographic/quality-of-life area designations, community land use plans, and planned capital improvement project locations (e.g., future greenways, infrastructure projects, etc.). For example, mapped floodways or high-velocity zones may be used as a factor to increase assignment of risk for structures located within them. Similarly, community values that restrict/discourage development in certain areas (e.g. buffer zones) may use those datasets to promote acquisition as a preferred means for mitigating existing structures within them. Additional discussion of potential resources of supplemental data are listed in Section 2.3.

2.2 Data Considerations

The term “data” is a general term for essentially any type of information related to a particular theme. For example, flood hazard data could take many forms (flood hazard boundaries, a list of properties with previous flood damage, a drainage study report, etc.). There are a number of considerations that should be evaluated and understood in applying data to support flood risk assessments. A graphic of key data considerations is shown in Figure 4, followed by descriptions of each.



[Figure 4]
Data considerations

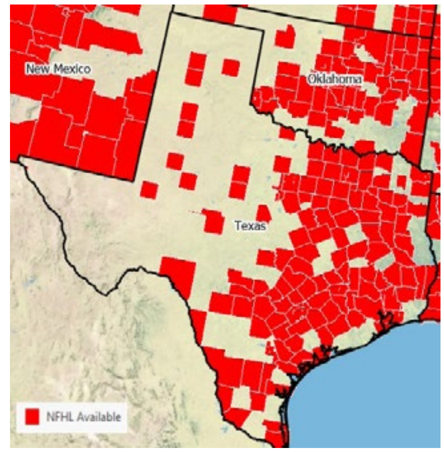
Data obtained from public sources often includes metadata ("data about the data") or have other general information about the data provided. Metadata (when available) may be helpful in evaluating the considerations below for a given dataset.

DATA AVAILABILITY

The availability of data relates to if, and how readily, a certain type of data can be obtained. The availability of data depends on many factors including the source, type, and resolution of data. Generally, data captured/created by a community or regional entity will tend to be more detailed, and thus would be preferable. Examples of common community-maintained datasets that can be valuable for flood mitigation planning include: parcels, elevation certificates, and land use/zoning layers. However, there are a number of datasets that are important for flood risk assessments and mitigation evaluations, such as elevation data and building footprints, that may be cost-prohibitive for some communities to develop or maintain. In these cases, communities may explore external sources such as state and federal agencies (e.g., USGS, FEMA, etc.). With advances in data capture, processing, and sharing technologies over the past 15 years, there are now many sources of quality data that can be used to fill data gaps and/or to enhance local datasets. For example, if a community does not have local topographic data, 10-meter elevation data is available for the entire continental U.S. through the USGS National Map web portal. Similarly, if a community does not have local flood hazard data or building footprints, this information is available for much of the country through the NFHL and Microsoft, respectively.

When developing a strategy for assessing risk and evaluating mitigation options, a community should develop a list of relevant data types it wishes to use and then identify potential sources of data and data gaps. In most cases, data gaps can be filled with external datasets; however, there may be times when a community uses data proxies or makes the business decision to capture data to fill gaps.

[Figure 5]
Scattered NFHL availability in Texas and Oklahoma



DATA COVERAGE

Data coverage is similar to availability; however, it is more refined in the sense that a dataset may be known to exist and be available, but it may not cover a specific area of interest. The lack of coverage may be due to gaps in the data or cases where the data is constrained to a smaller extent. For example, the NFHL is considered to be a “nationwide” dataset; however, there are gaps in the dataset, particularly in the central-western region of the country (see example in Figure 5). It is estimated that there are roughly 25% of counties nationwide in which NFHL is not available. For those counties, floodplain boundaries may only be available in static map form, which may be much more difficult to use for community level risk assessments and evaluations.

DATA RESOLUTION

Data resolution refers to the scale that the data represents and/or the level of detail/granularity in the data. Overall, data developed for large areas (i.e., small map scales) tend to be generalized and much coarser. A common example would be municipal boundaries. A dataset covering the entire nation may represent municipalities as points or generalized polygons. However, the same dataset generated at the local or state level would likely have much more detail and precision in the boundary. Another example that may be more directly related to flood mitigation is demographic data, which may be used to identify at risk populations and social vulnerabilities within those populations. Some demographic data, such as population, number of households, and similar, are available at the census block level (areas often 2 – 20 acres in urbanized areas). Data on social vulnerability (income, ownership, etc.) is often only available at the census block group or census track level, which can be hundreds of acres in size.

When evaluating data sources for flood mitigation, it is important to understand the resolution of the source data with respect to the resolution of the intended analysis. Some datasets (e.g., building footprints, floodplain boundaries, etc.) may have the resolution to directly support building level evaluations; however, others may only provide data at a neighborhood or larger level. In these cases, lower resolution data can still be used, but assumptions about applying or de-aggregating it may have to be made.

DATA QUALITY

Data quality refers to the accuracy of the data. Accuracy may be related to a number of factors including resolution, age, and consistency. Larger-area datasets with aggregated data may not provide information that is accurate at a more granular level. Similarly, datasets representing features that are subject to frequent change (e.g., property values) may become inaccurate simply from being out of date. However, it is not uncommon for datasets to have errors/discrepancies that result from issues with data capture, development, or processing. Most datasets are not "perfect" and have errors, discrepancies, or other issues that may lead to erroneous results.

Any datasets (internal or external) that are being used to support flood mitigation planning should be checked for reasonableness in quality. Data issues can often be identified by querying the dataset for missing values and/

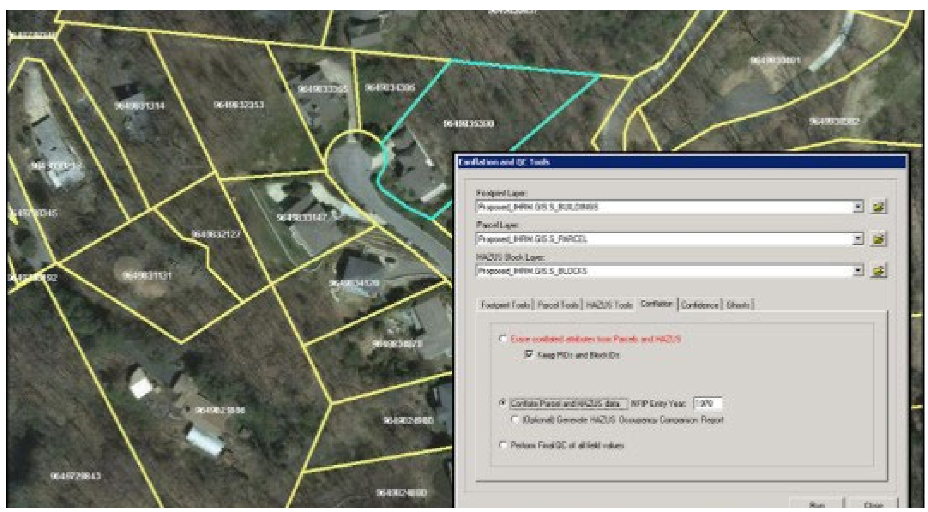
or “outliers” (i.e., values that are far outside of typical ranges found in the data). Missing/erroneous data can be replaced with proxy information such as average values or estimates for similar samples to help reduce erroneous results from inaccurate data.

DATA MAINTENANCE

Data maintenance is related to both the age (i.e., how current is the data) of a given dataset and how often it is updated/maintained. There are many datasets and conditions related to flood hazard mitigation that are subject to change, especially in urban areas. Many areas are experiencing development/re-development, infrastructure changes, demographic shifts, and other factors that may change flood hazards themselves, or the vulnerabilities exposed to flood hazards.

DATA PURPOSE

Data purpose refers to the intent, purpose, and context that drives why a dataset is created. Base mapping datasets generally have broader applications as their purpose is to provide uniform “themed” content (topography, land use, imagery, etc.) over larger areas. However, many other datasets are created to support specific initiatives and are thus often created with a specific application in mind. One common example is land use/land cover datasets. A community planning agency may produce an existing land use dataset that categorizes tax parcels by “functional” uses. A stormwater agency may



[Figure 6]
Example tool to conflate parcel data to buildings

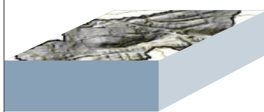
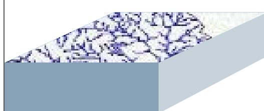
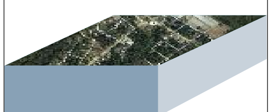
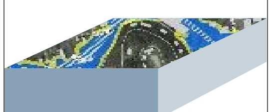
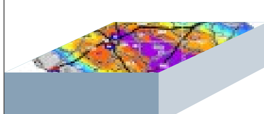
create an existing land use that is built with the mindset to estimate impervious cover, whereas, for natural resources or agricultural applications, an existing land use/cover (e.g., National Land Cover Dataset (NLCD)) may be structured around vegetation categories.

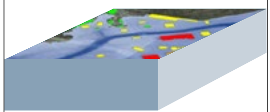
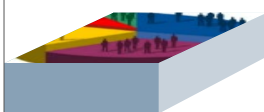
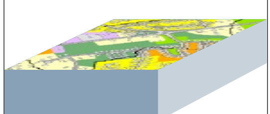
When using any dataset, it is important to be aware of the purpose/context for which it was created and to confirm that the purpose of the source data aligns (or can be adjusted to align) with the intended application. In cases where there is misalignment between source data and intended application, it may be necessary to process/refine source data to improve alignment and/or establish assumptions. In all cases of using external data, it is recommended that any "post-processing," data limitation, and data application assumptions be documented.

2.3 Data Sources

Performing flood risk assessments and mitigation evaluations for a community can be a data intensive exercise. In general, data developed by a community will often be the best source as the considerations discussed in the previous section will be known and controlled by the community. However, it will often be necessary to fill data gaps and/or supplement/enhance local data with data developed by others outside the community. There is a tremendous amount of data developed, maintained, and provided at no cost by a variety of entities and agencies, which can be used to support/enhance flood hazard mitigation planning at the community level. Table 1 provides a summary of data source/uses, categorized by data type. Appendix A includes a more complete listing of data sources with weblinks to directly view/download data.

[Table 1]
Summary of example data uses and sources

	Information Type	*Application*	*Example Source*
FOUNDATIONAL	 **TOPOGRAPHIC DATA**	– Products include raw digital elevation models (DEMs), LiDAR, and topographic maps. 10-meter resolution is available for continental U.S. Higher resolution datasets available for portions of U.S. – Elevation data is key dataset used in the development of flood hazard areas, as well as identifying risk.	U.S. Interagency Elevation Inventory USGS NED Digital Coast Community/ Regional Sources
	 **HYDROGRAPHIC DATA**	– Products includes networked stream lines, water bodies, dams, and watershed boundaries for the continental U.S. – Local products may include drainage inventories. – Shows locations and connectivity of streams and waterbodies where flooding is more likely to occur. NHD Plus and Plus HR provides cumulative drainage area and other watershed/stream characteristics.	USGS NHD / NHD Plus / NHD Plus HR FEMA NFHL Census TIGER Community/ Regional Sources
	 **GENERAL BASE MAPPING**	– Includes general base layers such as aerial photography, streets, political boundaries, points of interest, and many others. – Local data may include more recent aerials and more community specific base layers. – Provides context to put flood hazards and risks in perspective.	USGS National Map FEMA NFHL ESRI Google/Bing Community/ Regional Sources
HAZARD	 **FLOOD HAZARD MAPPING**	– Products include regulatory floodplain boundaries, non-regulatory boundaries and enhanced risk products (e.g., depth rasters). – Engineering models and supporting information that provide details of mapping can often be obtained through FEMA MIP or requested from FEMA. – Used to assess location, extent, and magnitude of flood risks.	FEMA FIS / NFHL FEMA Risk Database FEMA MIP USGS Community/ Regional Sources
	 **STORM EVENT MAPPING**	– Provides flood hazard (hydrologic, hydraulic, mapping) data specific to historic storm events. – Can be used to identify and evaluate flood prone areas that may not be in regulatory mapping.	USGS Gages / Reports USACE Community/ Regional Sources FEMA Disaster Portals

	Information Type	*Application*	*Example Source*
VULNERABILITY / RISK	 **BUILT ENVIRONMENT**	– Products include building footprints, infrastructure, critical facilities / key resources, and similar. – Local data that may provide information include tax parcels, elevation certifications, building permits, and similar. – Can be used to identify and quantify vulnerabilities to specific features/areas from flooding and to assess beneficial impacts from mitigation projects.	Microsoft Buildings HAZUS Community/ Regional Sources
	 **COMMUNITY / DEMOGRAPHIC**	– Products typically include demographic data aggregated to census feature (block, block group, tract) or neighborhood level. – Local data may include quality of life estimates, housing information, and other refined demographic information. – Provides information on populations that may be more vulnerable to flood events and less able to recover.	Census ACS SoVI CDC (SVI) HAZUS Community/ Regional Sources
SUPPLEMENTAL	 **REGULATORY LAYERS**	– May include local (or regional) regulatory buffers, overlays, or other features that prohibit/restrict activity in flood prone areas. – These layers may be used to influence risk assessments and/or mitigation evaluations based on community values.	Community/ Regional Sources
	 **LOCAL PLANNING LAYERS**	– Products may include comprehensive master plans, zoning, planned CIPs, and similar that provide guidance/vision where the community wants to go. – These layers may be used to influence risk assessments and/or mitigation evaluations based on community values.	Community/ Regional Sources

2.4 Getting the Most Out of Data

As indicated above, there are many potential individual datasets that contribute to flood hazard mitigation planning. While the individual layers provide valuable information, it is the collection of data together that provides a clearer picture of flood risks and appropriate mitigation strategies.

To aid in the evaluation and communication of the data, it is beneficial to integrate information from key datasets. Often, standard geoprocessing techniques, such as spatial overlays, tabular joins, and data translations, can significantly increase the value of data. For example, building footprint data can be used in conjunction with parcel information and topographic data to estimate building characteristics such as occupancy type, foundation type, first floor elevation, lowest adjacent grade, etc.

While individual datasets/information are helpful, together they can be very powerful tools for hazard assessment and mitigation planning.

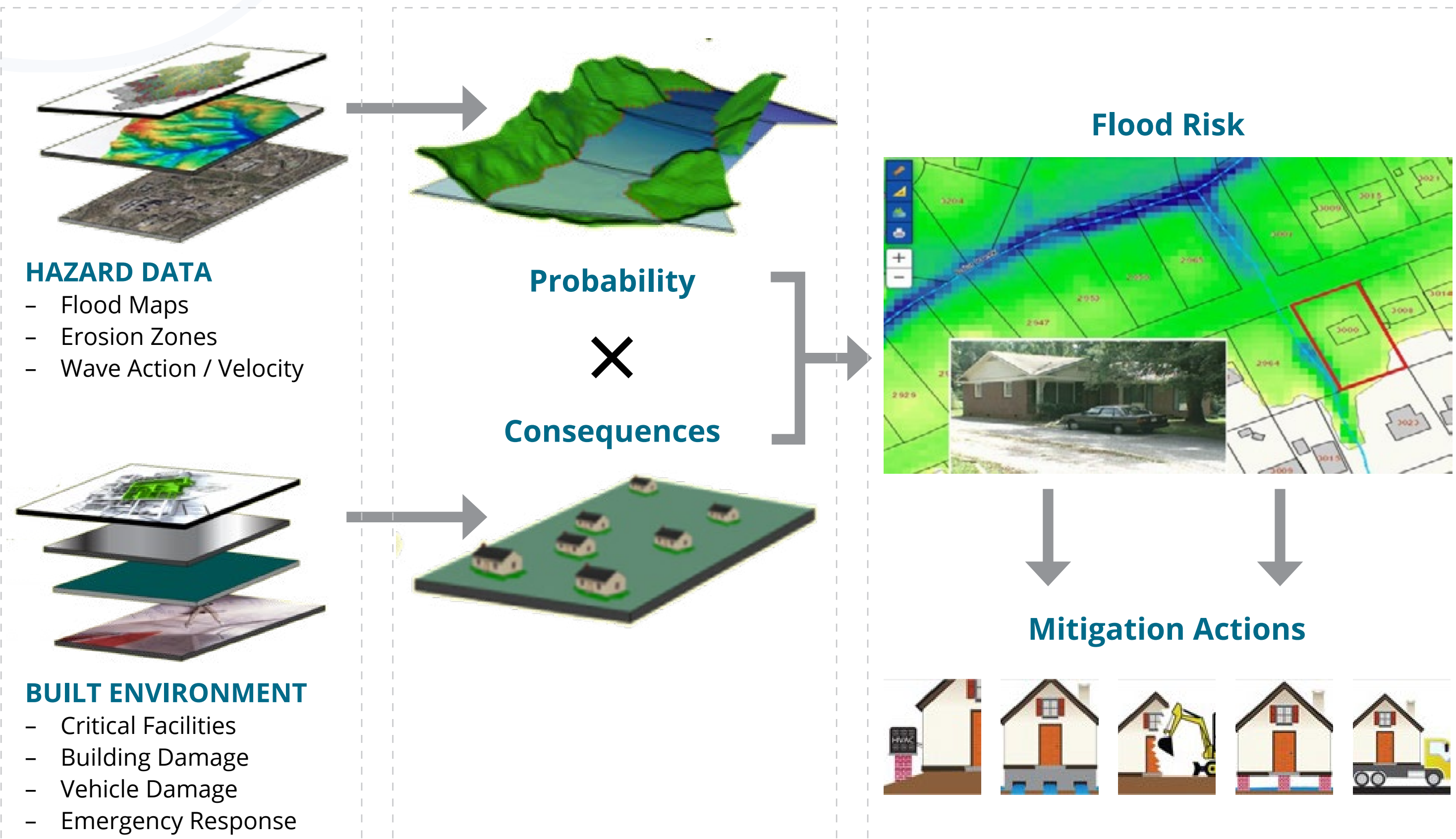
CHAPTER THREE

Assessing Risk

Risk can be defined as the product of the likelihood (or probability) of a detrimental incident/ event occurring and the consequences (or impacts) that are incurred as a result of the event.

Assessing Risk

Risk can be defined as the product of the likelihood (or probability) of a detrimental incident/event occurring and the consequences (or impacts) that are incurred as a result of the event. Specific to flooding, risk is associated with the frequency and magnitude of flooding along with impacts to people or the built and/or natural environment (Figure 7). Flood risk is generally lower in areas that are less prone to flooding and/or are more undeveloped. Conversely, flood risk tends to be higher in developed areas that are more prone to flooding.



[Figure 7]
Flood risk concept

Since the concept of risk integrates probability and consequence, two areas may exhibit similar long-term risk profiles, but have very different flood hazard characteristics. For example, the probability of flooding for a neighborhood behind a levee or downstream of a dam may be very low, but should the levee/dam fail, the severity and consequence of flood would be very high. Conversely, a neighborhood near the banks of a river may be prone to more frequent flooding; however, the severity and consequence of flooding would likely be much less.

Understanding the nature of both the hazard's probability and consequences that define flood risk are essential in identifying and implementing informed strategies to mitigate the risk. The subsections below provide additional context and identify considerations that may help a community in assessing its flood risk. Considerations for mitigating risk are discussed in Section 4.0.

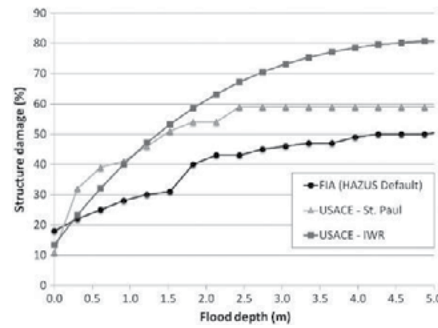
3.1 Anatomy of a Risk Assessment

Once the hazard is defined, the next step is to identify what items of interest may be vulnerable to the hazard. Items of interest usually include people, buildings, commerce, and infrastructure, but can also include any asset, resource, or feature of value or interest. Identifying vulnerabilities associated with flood hazards typically involves overlaying delineated flood hazard boundaries (i.e., floodplains) with layers of building footprints, critical facilities, roadways, and other features of interest. Leveraging available datasets with GIS software can greatly expedite identifying and quantifying vulnerabilities in an area associated with a given hazard.

The last step in a risk assessment is to assess the consequences the hazard poses to the vulnerabilities.

[Figure 8]
Steps in a risk assessment

Consequences are most often reported in context of direct physical damage or loss (e.g., physical damage to a building structure or infrastructure); however, there can also be non-physical or other indirect impacts (e.g., loss of use/access) that should be considered in a risk assessment.



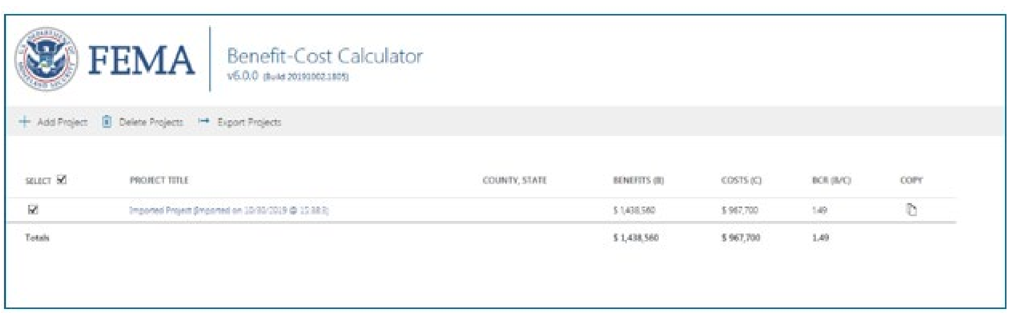
[Figure 9]
Example depth-damage curves

QUANTIFYING CONSEQUENCES

In order for communities to more fully determine greatest risk areas and prioritize mitigation strategies, it is necessary to be able to quantify risk consequences. There are two general types of systems that are often used to quantify impacts—absolute and relative scoring systems. For absolute system consequences, damages or losses are usually quantified in a dollar ($) value. Specific to flooding, FEMA, USACE, and others have developed "depth-damage-functions" (DDFs that provide a means to assign a dollar value impact for a number of physical and indirect impacts (e.g., structural damage, content damage, disruption, etc.) based on depth of flooding.

There are also publicly available tools such as the FEMA BCA Toolkit, HAZUS, and HEC-FDA that incorporate these DDFs and can be used to calculate damage estimates. An absolute scoring system would be useful for driving mitigation funding decisions, as well as educating property owners of the flood risk they face in terms of dollars to provide additional context for considering the benefits of mitigation.

[Figure 10]
FEMA Benefit-Cost tool



As an alternative to associating impacts to an absolute dollar value, some communities may associate impacts through a relative scoring system. There are several approaches to relative scoring systems. One common approach is to assign a maximum total risk score. The total risk number can be arbitrary (e.g., 100, 1000, etc.), as it just establishes the range for relative scoring. The total risk score is then proportioned amongst all the risk factors. Risk factors deemed to be more important receive a higher portion of the total risk score, while those with lower risk receive lower scores. This method essentially "weights" various risk components based on perceived risk as opposed to monetary risk. The main benefit of a relative scoring system is that it provides additional flexibility in being able to potentially capture a broader range of impacts, particularly indirect benefits that do not favor larger, more expensive buildings. A drawback to this method is that it does not provide a direct indication of the magnitude (e.g., depth) or financial losses associated with a given flood event. As a third method, these two general types of impact assessments can be combined to use a point based system that also includes a cost component. The next section provides specific items that may be appropriate to consider in conducting a risk assessment.

3.2 Risk Assessment Considerations

In conducting a risk assessment, there are a number of considerations that may be important in evaluating risk in a community and prioritizing mitigation needs. As indicated in the previous sub-section, there are direct damages as well as indirect losses/impacts associated with flooding. Direct damages are often attributed to physical contact with flood waters. Indirect losses/impacts can be associated with physical contact, but may also include other considerations. Common physical contact and other considerations associated with flood risk assessments are listed below, followed by additional context for each consideration.

Physical Contact Considerations	*Other Considerations*
– Flood frequency – Flood depth – Velocity – Duration	– Access – Type/use of impacted facility – Social vulnerability / resiliency – Other community considerations

[Table 2]
Direct and indirect risk considerations

PHYSICAL CONTACT CONSIDERATIONS

Frequency of Flooding

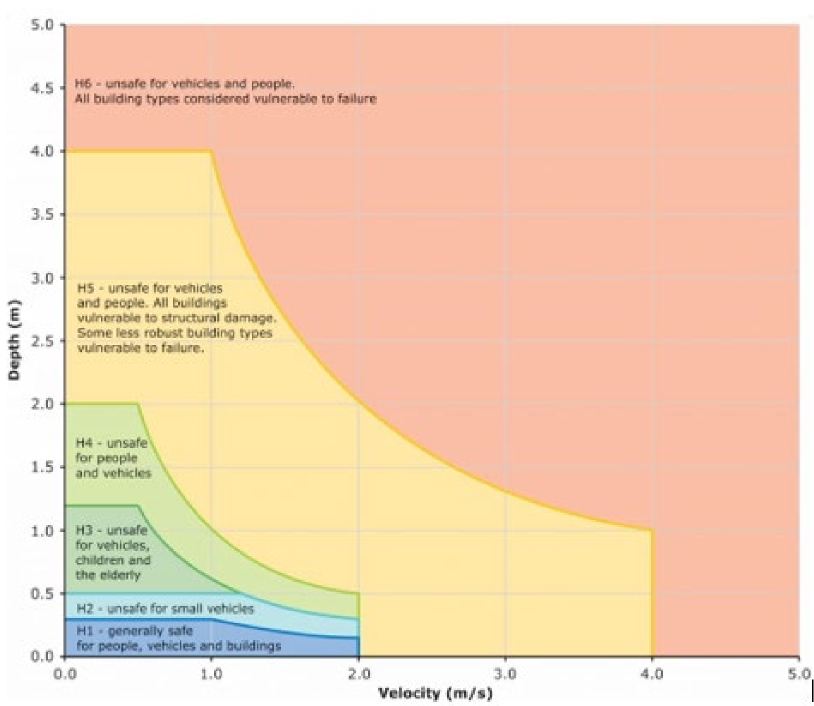
A storm recurrence interval or annual exceedance probability are the most common ways to communicate the frequency that a given amount of precipitation will fall or a certain flood level will rise during a year. A storm recurrent interval (also known as a return period) is the estimated average time between events of a given magnitude.

The recurrence interval is calculated as the inverse of the annual exceedance probability, which is defined as the probability that an event will be exceeded any one-year period. The 100-year recurrence interval (i.e., "100-year storm") is the most common event used for floodplain mapping in the U.S. The 100-year recurrence interval corresponds to the 1% (= 1 / 100) chance event. A 100-year recurrence interval suggests that the event will occur on average once every 100 years. However, it is important to note that the 100-year storm can occur much more frequently, as has been seen with numerous areas in the U.S. getting multiple "100+-year" storms over a span of just a few years (e.g., eastern Carolinas receiving greater than "100-year" rainfall in Hurricanes Matthew and Florence in 2016 and 2018, respectively). To reduce misinterpretation, there has been a shift in recent years for using annual exceedance probability to communicate estimated probability and frequency.

A longer recurrence interval (100-year versus 2-year) indicates that there is a lower probability that a flood impact will occur. Traditionally, the 100-year recurrence interval is used to evaluate risk (i.e., this is the FEMA regulatory event); however, using multi-return recurrence intervals, such as the 2-, 5-, 10-, 50-, and 500-year events, can give a better understanding of the risk for a particular building.

Depth of Flooding

A majority of flood risk assessments prioritize the analysis of evaluating flood depths in and around structures. Flooding above the lowest floor of a building can cause varying levels of damage to a structure. However, even if the living space is not flooded, any depth of flooding of the crawlspace or building foundation can still cause cracking or potential damage from subsidence or shifting soil. Many provide a more complete picture to the risk of people, vehicles, or buildings being swept away in a flooding event, as shown in the figure below.



[Figure 11]
Depth-Velocity Hazard Zones (Source: WRL Technical Report 2014/07)

Duration of Flooding

Flood waters can provide a variety of risks, but long-term standing water that does not drain quickly can also present significant damages. In and around structures, downed power lines and shorted electrical outlets are some of the most common issues. However, stagnant water can cause major ecological issues due to chemical and agricultural releases. Long-term flooding can result in mold and mildew that can lead to serious health issues. Warped wood in flooring and other areas of a structure could create hazardous areas.

Long-term flooding of yards is also worthy of consideration for a variety of reasons. Flood water on the property may pose a safety hazard to children and pets; flood water standing for long periods of time can become a habitat for mosquitoes, snakes, and possibly other forms of wildlife; and yard flooding can hinder access to the structure and cause damage to landscaping and other property improvements.

OTHER CONSIDERATIONS

Access

During a flood event, flood waters can restrict access to or from properties, which may not allow for safe evacuation if conditions worsen and emergency service vehicles are unable to reach a residence to render assistance. If flood waters stand for long periods of time, prolonged isolation can lead to serious needs related to food, drinkable water, medicines and medical support, etc.

In times of crisis, people need access to critical facilities to gain emergency assistance and help with recovery. A critical facility is a building used to house a function that is essential to the community. Flood water surrounding a critical facility poses the additional concerns of emergency vehicles not being able to access the facility, the facility may not be able to perform its designated function, and employees and staff may not be able to access the facility.

Type/Use of Impacted Facility

The type and use of a facility (or asset) affected by a hazard directly influences the level of risk posed to a community. Although flooding of any facility/structure can present significant consequences to a property owner, family, or individual business, direct damage or the loss of use or function of facilities that provide services to the community generally pose a much greater consequence to a community as a whole, and thus are often given a higher priority in risk assessments and mitigation evaluations. Hospitals, treatment plants, nursing homes, emergency response, child and adult daycare facilities, nursing homes, schools, and other facilities that provide essential functions to a community (or otherwise deemed "critical") are often given the highest priority. A community might also want to consider other entities that are "woven" into the community and may cause additional financial stress if affected. This may include structures/areas such as major employers and financial centers. Conversely, accessory buildings or other secondary use buildings such as storage/maintenance facilities are usually given lower priority as the consequences of flooding are smaller and often contained to fewer individuals/entities.

Social Vulnerability / Resiliency

As previously discussed, there are significant factors that influence the severity of a flooding event. The initial damage to structures and the direct financial impact to property owners can be devastating; however, there are other impacts that can impact the socio-economic condition of an individual property owner, as well as the local community. The consequences of injury and loss of life and property are often immediate, but longer-term impacts to livelihoods in impacted neighborhoods have a real potential to affect a community. Property owners affected by damages are often unable to immediately return to work, which can delay the recovery of consumer purchasing power and the ability to get back into the workforce. With larger flood events, property owners often leave impacted neighborhoods, moving out of the region which can negatively impact the economic recovery of that area. Reinvestment in public and private infrastructure and new development are often felt by communities cleaning up from a flooding event. As indicated in Section 2.0, the Social Vulnerability Index (SVI) is one metric that can be used to facilitate the examination of the differences in social vulnerability to environmental hazards. Applications of SVI are further described in subsequent sections. Additional information and resources on social vulnerability are provided in Appendix A.

Community Values

Community values are also a consideration in risk. Different communities may have differing levels of risk that are considered acceptable, prioritization of those risks, and responsibilities for mitigating the risks. For example, one community may view flooding of personal property (e.g., swimming pools, garages, etc.) as either an acceptable risk or more of a responsibility of a private property owner, whereas, another community may view it as a resource that needs to be specifically protected.

How a community defines and addresses risks is typically shaped by community values, the types and severity of risks present in a community, and the resources/funding available to a community for addressing risks. One litmus test of community values may be local regulations and ordinances. A community that employs "higher standards" related to floodplain development may have a lower tolerance to flood risk and/or be more likely to place a higher emphasis on reducing risk than those communities that employ minimum standards.

3.3 Performing a Risk Assessment

Risk assessments take into account how the hazard and risk considerations, described above, may affect features and resources. While risk assessments can be performed for a variety of features/resources (i.e., infrastructure), this guidebook focuses on risk assessments for building structures. Assessment elements can be grouped by building flooding, access issues, and secondary flooding. Within each element group, various factors are taken into consideration. In general, risk assessments are used to quantify the risk at an individual building by determining the severity and frequency of hazards along with the potential consequences. The sub-sections below provide specific elements that may be considered for building-level risk assessments. As described in Section 3.1, the two general options for risk assessments are relative scoring systems and direct damage calculations. For relative scoring systems, there are several options for implementation. One approach is to assign a component risk score by evaluating which flood event "triggers" a certain risk factor and then multiplying the probability of that flood event times a base score (determined by the community based on their hierarchy of all risk factors) for that risk factor. The individual component risk scores can be summed up to compute a total building risk score. Further details and considerations for the three basic element groups are described below, and a link to an example flood risk score calculator is provided in Appendix A.

BUILDING FLOODING

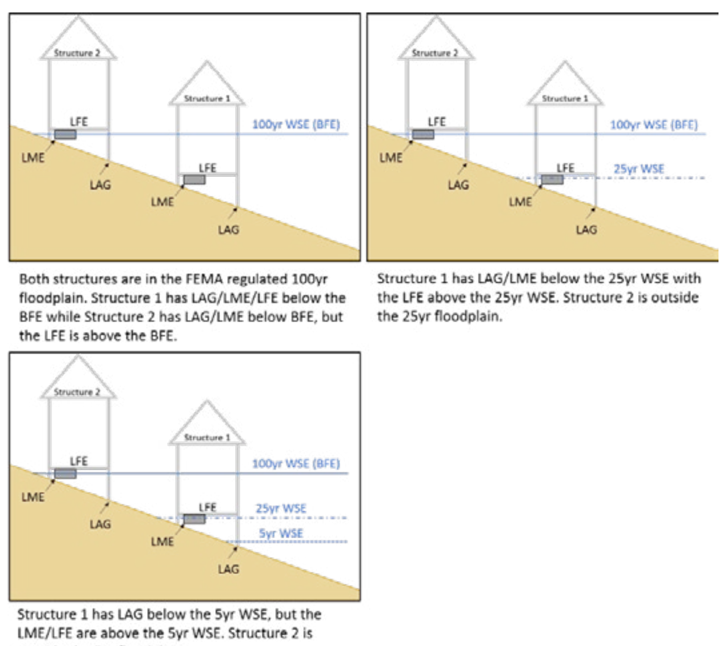
Flooding Above the Lowest Floor Elevation

Flooding above the lowest floor elevation (LFE) of a building can cause varying levels of damage to a structure. This risk factor can be evaluated by determining the recurrence interval of the flood event that exceeds the lowest floor elevation of a building. To account for this, use the probability of the trigger flood event (where the water surface elevation is higher than the LFE) times the base score for this risk factor to calculate the risk score for flood water above the lowest floor. Datasets that can be used for this evaluation include buildings (attributed with LFE) and multi-return water surface elevation rasters. If the elevation of the lowest floor is not available or is unknown, an assumed elevation can be determined based on the foundation type and the elevation of the lowest adjacent grade.

Flood Water Touching a Portion of the Building

Flood water, even if touching only a corner or portion of a building, can cause structural damage and/or pose a risk to inhabitants. This risk factor can be evaluated by determining which recurrence interval flood event water surface elevation exceeds the lowest adjacent grade (LAG) elevation of a building. To account for this, use the probability of the trigger flood event (where the water surface elevation is higher than the LAG) times the base score for this risk factor to calculate the risk score for flood water touching a building. Datasets that can be used for this

[Figure 12]
Examples of building elevation based risk assessments



Both structures are in the FEMA regulated 100yr floodplain. Structure 1 has LAG/LME/LFE below the BFE while Structure 2 has LAG/LME below BFE, but the LFE is above the BFE.

Structure 1 has LAG/LME below the 25yr WSE with the LFE above the 25yr WSE. Structure 2 is outside the 25yr floodplain.

Structure 1 has LAG below the 5yr WSE, but the LME/LFE are above the 5yr WSE. Structure 2 is outside the 5yr floodplain.

evaluation include buildings (attributed with LAG) and multi-return water surface elevation rasters.

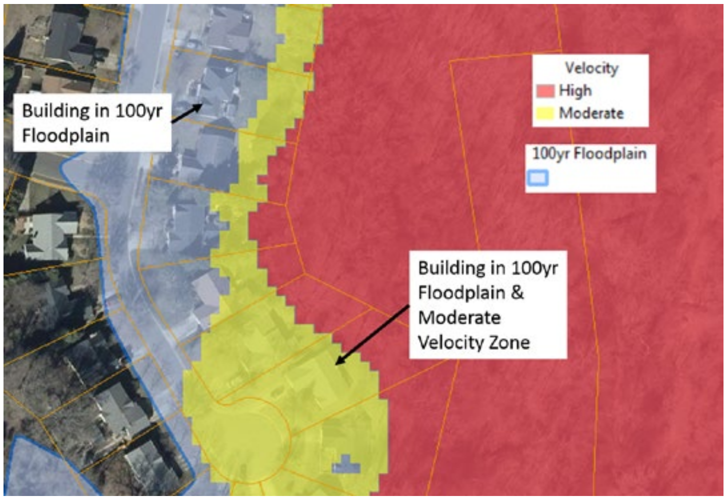
FLOODING OF ELECTRICAL AND/OR MECHANICAL EQUIPMENT

Flooding of electrical and/or mechanical equipment can lead to costly repairs, render a residence temporarily uninhabitable, pose a fire hazard, and lead to other serious problems for a structure. This risk factor can be evaluated by determining which storm event flood water elevation exceeds the lowest mechanical elevation (LME) of a building. To account for this, use the probability of the trigger flood event (where the water surface elevation is higher than the LME) times the base score for this risk factor to calculate the risk score for flooding of electrical or mechanical equipment. Datasets that can be used for this evaluation include buildings (attributed with LME) and multi-return water surface elevation rasters. If the elevation of the electrical or mechanical equipment is not available or is unknown, an assumed elevation can be determined based on the foundation type, finished floor elevation, and the elevation of the lowest adjacent grade.

Building Located in High/Medium Danger Depth-Velocity Zone

It is an accepted principal that high velocity storm water creates hazardous conditions. Depth-Velocity Zones can either be incorporated into risk scoring using location-based factors (multiplier for entire risk score based on buildings location within the 100-year depth-velocity zone) or probability-based scoring based on depth-velocity zones created for each storm event.

[Figure 13]
Example of buildings located in high/medium danger depth-velocity zones



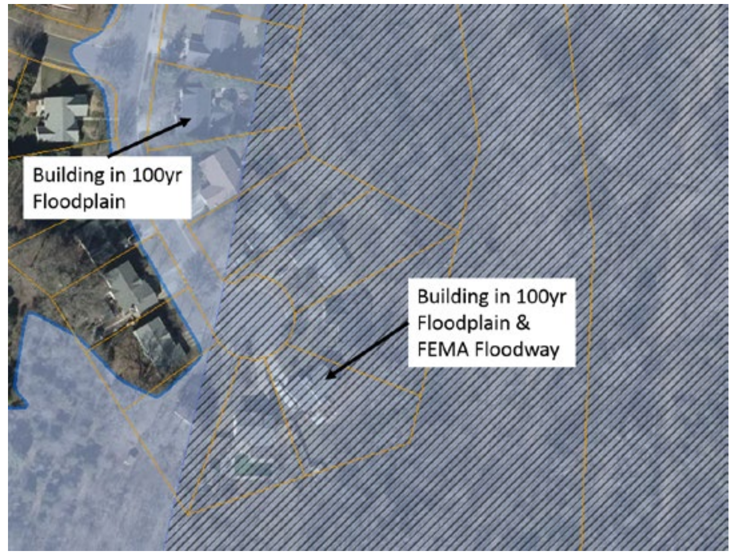
An approach that can be used to delineate the high and medium danger depth-velocity zones is found in a report issued in April 2010 for the Australian Rainfall and Runoff (ARR) guidelines project ("Project 10: Appropriate Safety Criteria for People, Stage 1 Report"). Using the relationship between the depth/velocity product and hazards posed to pedestrians, pedestrians were subdivided into three height/mass product categories that correspond to infants/small children, children, and adults. In order to establish two velocity hazard zones for location-based multipliers, the zone indicating significant hazard to children can be used for the medium danger depth-velocity zone and the zone indicating significant hazard to adults can be used for the high danger depth-velocity zone.

If it is desired to use the probability-based method to determine a risk score for depth-velocity zones, depth-velocity boundaries can be created for each storm event using the same methodology to create the 100-year depth-velocity zones. This risk factor can then be evaluated by determining the lowest storm event depth-velocity boundary that intersects the building. Similar to the previously mentioned factors, the probability of the trigger storm event times the base score for this risk factor gives the risk score for depth-velocity zones at each specific building.

Datasets that can be used for this evaluation include buildings (polygon features) and the 100-year HEC-RAS depth-velocity rasters or multi-return HEC-RAS depth-velocity rasters (classified as medium/high as defined by ARR, or using other values defined by the community).

Building Located in Floodway (or Non-Encroachment Area)

Structures located in the Floodway, or non-encroachment area (e.g., FEMA "limited detail" non-encroachment area, community buffer, etc.), are also subject to additional risk due to the proximity of the structure to the stream. Therefore, structures located in these areas are more likely to have higher flood risk. For these reasons, structures located in the floodways can be given a higher Flood Risk Property Score using a multiplier that is applied to the total risk score. Datasets that can be used for this evaluation include buildings (polygon features), and the Floodway/ Community Encroachment Area (depending on availability within the community).

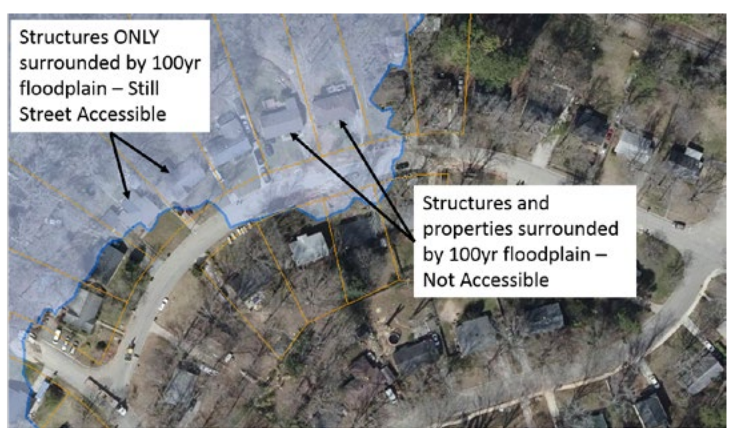


[Figure 14]
Example of structures located in floodways

Duration of Flooding (Building)

Flood water that does not drain quickly can present significant damage in and around structures, such as mold and mildew, warped flooring, downed power lines, and shorted electrical outlets. Structures located along larger streams may be at higher risk of long-term flooding. For these reasons, structures that are at higher risk for long-term flooding can be given a higher Flood Risk Property Score using a multiplier that is applied to the total risk score. Datasets that can be used for this evaluation include buildings (polygon features), drainage area (if known), and historic data.

[Figure 15]
Example of properties completely surrounded by flood water



ACCESS ISSUES

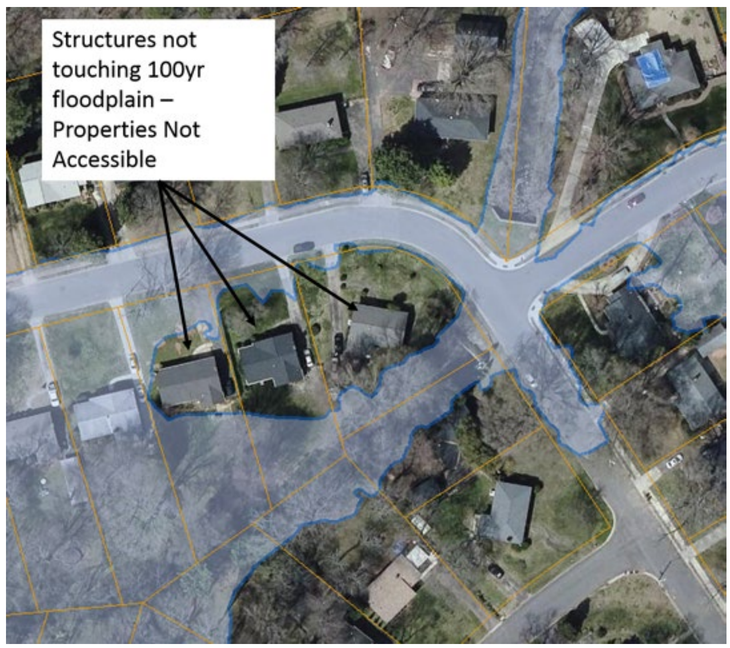
Property is Completely Surrounded by Flood Water

Flood water surrounding a property, even if it does not touch the structure, can lead to serious issues related to access. Multi-return floodplain boundaries, computed using the adopted HEC-RAS model, can indicate that the entire parcel, driveway, and street are inundated by flood waters during a storm event. To account for this, use the probability of the trigger flood event (where the floodplain boundary completely surrounds a parcel) times the base score for this risk factor to calculate the risk score for a parcel at risk of being surrounded by flooding. Datasets that can be used for this evaluation include parcels (polygon feature) and multi-return flood boundaries.

Structure is Completely Surrounded by Flood Water

Flood water surrounding a structure, even if it does not touch or enter the structure, can lead to serious issues related to access. Issues may also arise due to hydrostatic or hydrodynamic pressures exerting themselves on the structure, even if in a more indirect manner. Multi-return floodplain boundaries, computed using the adopted HEC-RAS model, can indicate if the structure is completely surrounded by flood water. To account for this, use the probability of the trigger flood event (where the floodplain boundary completely surrounds a building) times the base score for this risk factor to calculate the risk score for buildings at risk of being surrounded by flooding. Datasets that can be used for this evaluation include buildings (polygon feature) and multi-return flood boundaries.

[Figure 16]
Example of structures completely surrounded by flood water



Structure is Completely Surrounded by Flood Water and is a Critical Facility

Flood water surrounding a critical facility poses the additional concerns of emergency vehicles not being able to access the facility; the facility may not be able to perform its designated function; employees and staff may not be able to access the facility, etc. For these reasons, critical care facility structures that are completely surrounded by flood water can be given a higher Flood Risk Property Score using a multiplier that is applied to the total risk score. Datasets that can be used for this evaluation include buildings (polygon feature), critical facility points, and multi-return flood boundaries.

Structure is Completely Surrounded by Flood Water and is Multi-Family Residential

Flood waters surrounding a multi-family residential structure expose a more concentrated number of people and property to the flood risk. For these reasons, multi-family structures that are completely surrounded by flood water can be given a higher Flood Risk Property Score using a multiplier that is applied to the total risk score. Datasets that can be used for this evaluation include buildings (polygon feature attributed with occupancy type and number of units) and multi-return flood boundaries.

Duration of Flooding (Yard)

Flood water that does not drain quickly can present significant property damage around structures and may pose a safety hazard to children and pets as well as hinder access to the structure. For these reasons, properties that are at higher risk for long-term flooding can be given a higher Flood Risk Score using a multiplier that is applied to the total risk score. Datasets that can be used for this evaluation include parcels (polygon features), drainage area (if known), and historic data.

SECONDARY ISSUES

Flooding of Exterior Property Improvements (Moderate or Significant)

[Figure 17]
Example of flooding of exterior property improvements

Exterior property improvements can represent substantial investments by property owners and is therefore an additional option that can be helpful to take into account when assessing the potential impacts of a flood. This would only apply to single-family residential properties and is based on exterior property improvements that are deemed functional necessities for reasonable use of single-family properties. Since the amount of flood damage can vary based on the type of property improvement, it may be helpful to separate property improvements into different levels, such as "Moderate" and "Significant." Qualifications for these categories may be as follows:

1. Moderate –
    - a. Small/standard shed (≤ 250 sf), OR
    - b. At least two of the following exterior property improvements:
        - i. Permanent Outdoor Play Equipment
        - ii. Gazebo
        - iii. Detached Carport
        - iv. Yard Fencing (non-brick)
        - v. Doghouse.
2. Significant – Property contains one of the following items:
    - a. Swimming Pool
    - b. Detached Garage
    - c. Large Shed or Workshop (> 250 sf)
    - d. Large Outdoor Patio/Kitchen/Fireplace Area
    - e. Yard Fencing (brick)

It is recommended that these groups be mutually exclusive in that a building will only receive points for the highest level met. For example, if a property meets both the "Moderate" and "Significant" levels, it will only receive points for the "Significant" level (which carries the highest points). To account for this, use the probability of the trigger flood event (where the floodplain boundary touches property improvement points) times the base score for this risk factor to calculate an additional risk score for buildings with property improvements at risk of flooding. Datasets that can be used for this evaluation include parcels (polygon feature), multi-return flood boundaries, and property improvement points (developed manually).

Flooding around Vehicles Parking Areas

Flood waters impacting parking areas, especially those associated with a residential property, can lead to costly damages to vehicles. Depending on community values, vehicles parked around non-residential buildings may not be included since the occupants are typically nearby and are awake while the building is in use. To account for flooding around vehicle parking areas, use the probability of the trigger flood event where flood waters affect typical residential parking areas times the base score for this risk factor to calculate an additional risk score for buildings with vehicles at risk of flooding. Datasets that can be used for this evaluation include vehicle parking locations and multi-return flood boundaries.

[Figure 18]
Example of flooding around parking areas

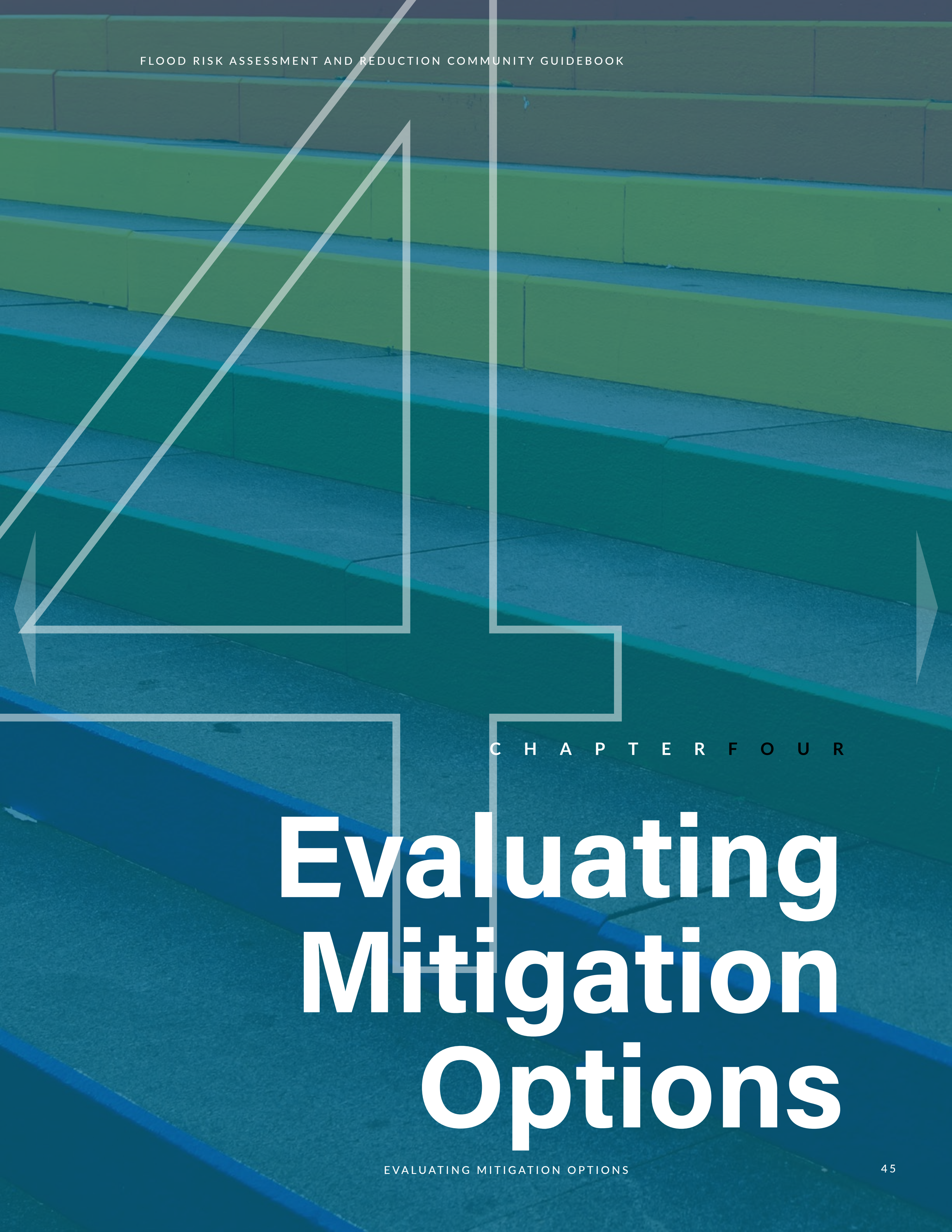
[Figure 19]
Example of yard flooding

Yard Flooding

Flood water on the property could pose a safety hazard to children and pets as well as hinder access to the structure and cause damage to landscaping and other investments, etc. To account for this, use the probability of the trigger flood event (where the floodplain boundary touches the parcel boundary) times the base score for this risk factor to calculate an additional risk score for yards at risk of flooding. Datasets that can be used for this evaluation include parcels (polygon feature) and multi-return flood boundaries.

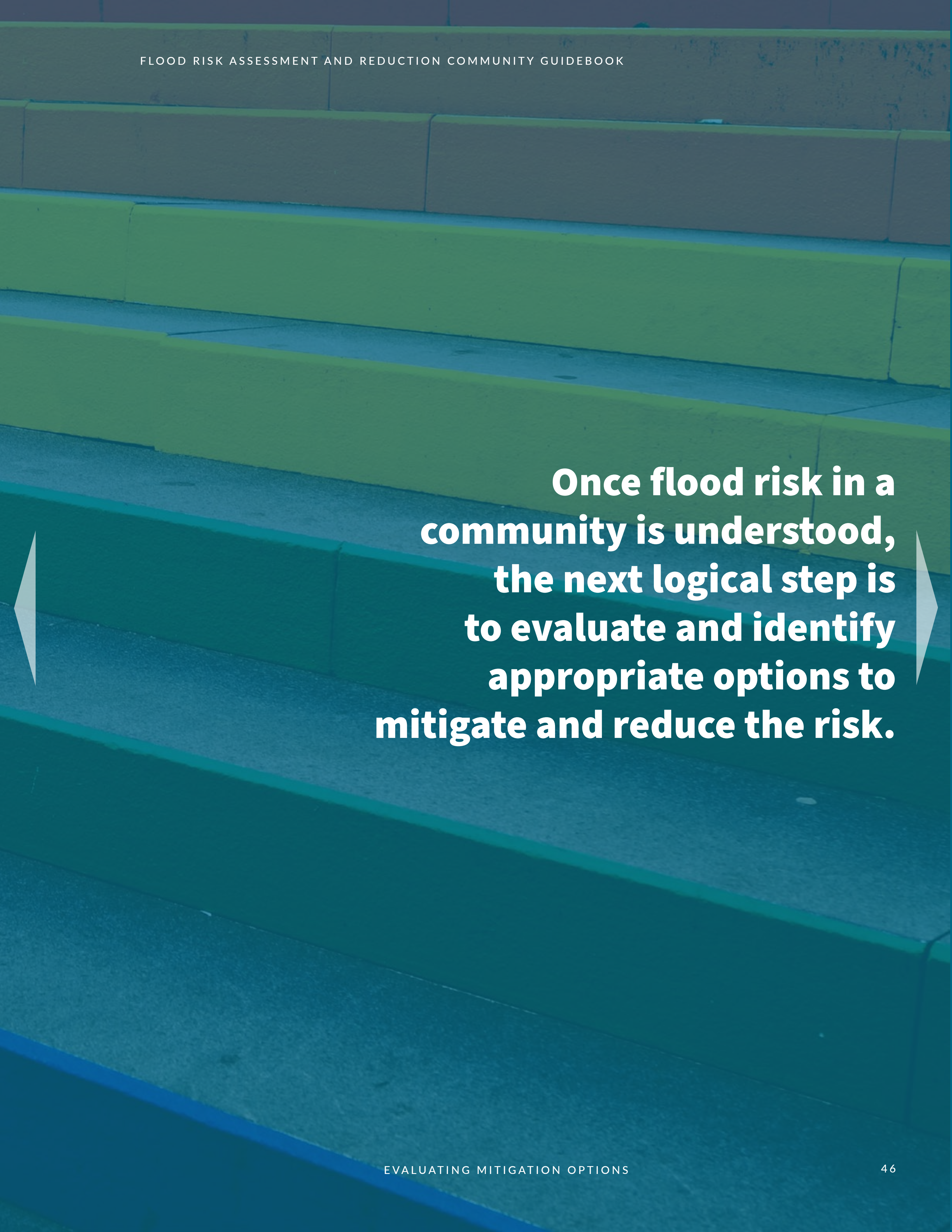
Social Vulnerability

Flooding of a structure has a direct financial impact to property owners and can be devastating. The Social Vulnerability Index (SVI) is an indication of a community's ability to prepare for, respond to, and recover from hazards. For these reasons, it may be appropriate to assign properties that have higher social vulnerability a higher Flood Risk Score. This could be done by assigning risk scores for various levels of vulnerabilities or through using a multiplier that is applied to the total risk score. Datasets that can be used for this evaluation include SVI or local community data that may provide a similar indicator.



CHAPTER FOUR

Evaluating Mitigation Options



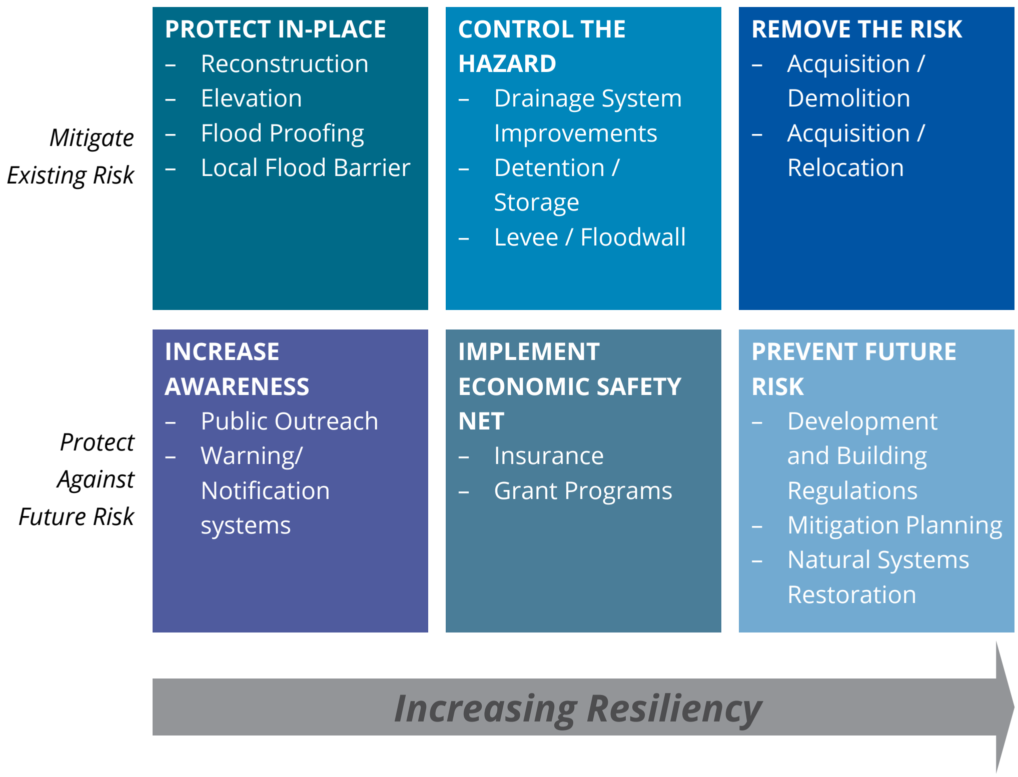
Once flood risk in a community is understood, the next logical step is to evaluate and identify appropriate options to mitigate and reduce the risk.

Evaluating Mitigation Options

Once flood risk in a community is understood, the next logical step is to evaluate and identify appropriate options to mitigate and reduce the risk. This can be accomplished by reducing the probability of flooding (typically through “structural,” man-made alterations) or by reducing the consequences/impacts that will result when a flood does occur.

There are a number of potential strategies that can be employed to mitigate flood risk, both for existing structures and to reduce the risk for future development. Strategies can include a variety of structural measures and/or physical actions that reduce the risk directly, as well as other indirect actions that may reduce the consequence of the hazard, but not necessarily change the risk itself. Some mitigation techniques, such as acquisition, essentially eliminate the flood risk by removing the potentially impacted structure altogether, whereas most techniques reduce the risk by “protecting” the structure and/or reducing/controlling the hazard. It is necessary to understand the nature (characteristics and magnitude) and cause of the hazard, as well as the site conditions to identify the risk.

Although the focus of this guidebook is communities, it should also be noted that mitigation activities can be identified, driven, and/or funded by other governmental entities, non-governmental organizations (NGOs), or directly by private property owners themselves. A listing of typical flood mitigation techniques is shown in Figure 19, followed by a brief description on each technique. Each general technique may have multiple sub-techniques associated with it.



[Figure 20]
Mitigation strategies

4.1 Mitigation Option Overview

There are several mitigation strategies that can be considered when evaluating flood risk. A general overview of various flood mitigation strategies can be found below.

PROTECT IN-PLACE

Protect-in-place mitigation strategies aim to decrease the flood risk to people and properties by converting, or rebuilding structures, in compliance with regulatory standards. These strategies are generally focused on an individual building level. Since these strategies involve the structure remaining in, or close to, flood-prone areas, they do not completely eliminate flood risk. Mitigation techniques that fall into this category include reconstruction, elevation, floodproofing, and local flood barriers.

CONTROL THE HAZARD

Strategies that control the hazard involve redirecting flood waters to protect structures (levees/floodwalls) or reducing upstream/downstream flooding at structures (upsizing of bridges/culverts, added storage, etc.). These strategies are generally focused on a group (or groups) of flood-prone structures as they can be more costly. While these strategies may reduce flood elevations, they do not completely eliminate flood risk and may give property owners a false sense of security. Some strategies (e.g., upsizing culverts) may even increase downstream flooding. Mitigation techniques that fall into this category include drainage system improvements, detention / storage areas, and levees / floodwalls.

REMOVE THE RISK

Strategies in this category aim to completely eliminate the flood risk at a structure by physically removing the at risk structure(s). These strategies can be focused at individual or groups of structures. The property where the structure was removed is then available for public use such as open space, greenways, parks, sanitary sewer projects, water quality projects, or similar, and can function again as a natural floodplain. Mitigation techniques that fall into this category include structure acquisition/demolition as well as structure acquisition/relocation.

INCREASE AWARENESS

Strategies that increase awareness aim to reduce risk and increase resilience through education and outreach. These strategies are typically targeted to property owners and residents in flood-prone areas in order to first increase awareness of the hazards they may be exposed to, but also provide steps that they can take to help prepare for and recover from flood events. These strategies also include alerting property owners of flooding in real-time so that the time owners have to vacate the property and/or protect personal property from flood damage is maximized. Mitigation techniques that fall into this category include public outreach and warning/notification systems.

IMPLEMENT ECONOMIC SAFETY NET

Economic "safety net" strategies encourage property owners to purchase flood insurance for flood-prone properties or seek grants to help fund mitigation activities. These strategies are good for limiting individual economic hardship due to flooding, encouraging property owners to bring structures into compliance without bearing the full economic cost, as well as reducing the long-term economic burden on the community itself. Mitigation techniques that fall into this category include flood insurance and grant programs.

PREVENT FUTURE RISK

These strategies aim to prevent flood risk before it occurs through planning, regulations, and community projects. In addition to FEMA regulations, communities may choose to implement higher standards or preserve areas to remain as natural floodplains. Communities can also choose to use funds to restore degraded streams in an effort to reduce flood elevations. Mitigation techniques that fall into this category include development and building regulations, mitigation planning, and natural systems restoration.

4.2 Mitigation Evaluation Considerations

There are several mitigation options that are effective in reducing or completely removing flood risk. Mitigation recommendations can be made for any flood-prone property, and many properties will have more than one flood hazard mitigation technique that can be employed to reduce or eliminate the flood risk. A general overview of various flood mitigation options, as well as advantages/disadvantages and associated criteria, can be found below.

PROPERTY ACQUISITION AND STRUCTURE DEMOLITION/RELOCATION/RESALE

Property acquisition involves the purchase of a flood-prone structure and underlying land, and the demolition or relocation of the structure.

Structure Demolition

With structure demolition, the flood-prone structure is demolished and the debris is removed from the site. The site is graded to accommodate local runoff and grass is planted to promote long-term stability of the soil. When FEMA funds are used to purchase the land for demolition, the flood-prone land must be maintained as open space, in perpetuity, to preserve the natural function of the floodplain.

[Figure 21]
Example of structure acquisition and demolition

Advantages of structure demolition include completely removing people and property from flood risk, improving water quality (through removal of structure and impervious surfaces), and making the property available for public use such as open space, greenways, parks, sanitary sewer projects, water quality projects, or similar. Disadvantages of this technique are that purchasing the land and building, as well as demolition, are all costly, and a large portion of demolition debris is taken to the landfill. The land is also removed from the community tax base, and if land is purchased using FEMA funds, it must remain as open space and cannot be resold.

Criteria that can be used to evaluate the effectiveness of implementing property acquisition/demolition include: severity/frequency of flooding, compliance with existing development standards, property value, social vulnerability, and location of the property in relation to future planned public projects (e.g., greenways).

Structure Relocation

With structure relocation, the structure is moved to a location outside the floodplain and remains the property of the private owner. The private owner bears the cost of acquiring a new parcel for the structure; however, the local government may bear the structure relocation costs. When FEMA funds are used to purchase the land for relocation, the flood-prone land must be maintained as open space, in perpetuity, to preserve the natural function of the floodplain.

Advantages of structure relocation include completely removing people and property from flood risk; making the property available for public use; reduction of demolition debris (since most of the building is being reused); and it is less costly than acquisition/demolition. Disadvantages of this technique are that the flood-prone land is removed from the community tax base, there can be difficulty in transporting the building from the existing lot to a new lot, and if land is purchased using FEMA funds, it must be used as open space and cannot be resold.

Criteria that can be used to evaluate the effectiveness of implementing property acquisition/relocation include many of the same criteria as for demolition mentioned above, but also physical characteristics of the structure (e.g., foundation type, wall type, the number of stories, age, structural integrity, etc.) that can help determine the ease or difficulty of relocating the structure.

Resale

When public funds are available, a local government may decide to acquire the land for resale later. This approach would eliminate the FEMA requirement that restricts the deed being passed from the private property owner to the government entity. Because of this the government entity can sell the portion of the property that is outside the floodplain while retaining the portion inside the floodplain.

[Figure 22]
Example of structure for acquisition and resale

Advantages of resale include: completely removing people and property from flood risk; retaining a portion of the property for use as open space, greenways, parks, sanitary sewer projects, water quality projects, or similar, if the community is involved; the portion of the property sold to a private owner remains in the community tax base; and the community recovers some of the expense of the purchase and demolition or relocation through the sale of a portion of the property. Disadvantages of this technique include initial high costs to purchase the property and demolish or relocate the building; demolition debris going to the landfill; relocation requires a willing buyer for the structure; FEMA grants are not available for this type of project; and a portion of the property is still removed from the community tax base. Criteria that can be used to evaluate the effectiveness of implementing property acquisition/relocation include many of the same criteria as for demolition mentioned above.

STRUCTURE DEMOLITION AND REBUILD

Structure demolition and rebuild involves the demolition of a flood-prone structure and the construction of a floodplain regulatory compliant structure on the same property. The rebuilt structure is either located outside the floodplain on the same parcel or built above the FPE inside the floodplain and is compliant with the Community's Floodplain Ordinance.

Advantages of structure demolition and rebuild include decreasing the flood threat to people and property, it is less costly than demolition or relocation (for the community), and the property remains in the community tax base. Disadvantages of this technique are that it does not completely eliminate flood risk for people or property; the property is not available for public uses; it does not improve water quality by removing impervious surfaces; personal property, such as a car, may not be protected; and a storm event with a flood elevation greater than the FPE would still cause damage.

[Figure 23]
Example of structure for demolition and rebuild

Criteria that can be used to evaluate the effectiveness of implementing structure demolition and rebuild include: the area of the property outside of the floodway/community encroachment area, the property location in relation to a high velocity zone, the structure building grade, the property location in relation to the FEMA flood boundary, and the property and location of the property in relation to future planned public projects (e.g., greenways).

STRUCTURE ELEVATION

Structure elevation consists of physically raising the lowest finished floor of an existing structure to an elevation above the FPE. Elevation may be achieved by a variety of methods including piles, posts, and columns, or by elevating on fill. The elevated structure must be properly anchored to the foundation, and utilities must be elevated above the FPE as well.

Advantages of structure elevation include decreasing the flood threat to people and property; it is less costly than demolition or relocation because the community does not purchase the land or building; it is less disruptive to the property owners; it does not add as much debris to the landfill as complete demolition; and the property remains in the community tax base. Disadvantages of this technique are that it does not completely eliminate flood risk for people and property; the property is not available for public uses; it requires more communication time between the community and property owners; it does not improve water quality by removing impervious surfaces; personal property, such as a car, may not be protected; a storm event with a flood elevation greater than the FPE would still cause damage; and it does not decrease the need for emergency response or protective measures for building occupants during a flood event.

[Figure 24]
Example of structure elevation

Evaluation criteria that can be used to determine the effectiveness of implementing structure elevation include: structure location in relation to areas with high velocity flows, structure location in relation to the floodway/ community encroachment area, foundation type, FFE, the structure building grade, the property/structure location in relation to the FEMA base flood boundary, and property and location of the property in relation to future planned public projects (e.g., greenways).

ABANDON BASEMENT AND FILL

Abandoning the basement and filling involves raising the lowest finished floor of an existing structure to an elevation above the FPE by converting the finished basement to a crawlspace. This may be achieved by abandoning the basement and adding fill to create a crawlspace. Additional fill would be needed around the exterior perimeter of the foundation to raise the LAG above the FPE. The structure must be modified to allow fill in the basement and utilities must be elevated above the FPE.

Advantages of this technique include decreasing the flood threat to people and property; the method is less expensive than demolition or relocation because the community does not purchase the land or building; it is less disruptive to the property owners; it does not add debris to the landfill; the property remains in the community tax base; and it results in a fully compliant building. Disadvantages of this technique are that it does not completely eliminate flood risk for people and property; the property is not available for public use; it requires more communication time between the community and property owners; it does not improve water quality by removing impervious surfaces; and a storm event with a flood elevation greater than the FPE would still cause damage. Additionally, this technique requires adding fill to the SFHA, which may exacerbate flooding elsewhere or be in conflict with local ordinances.

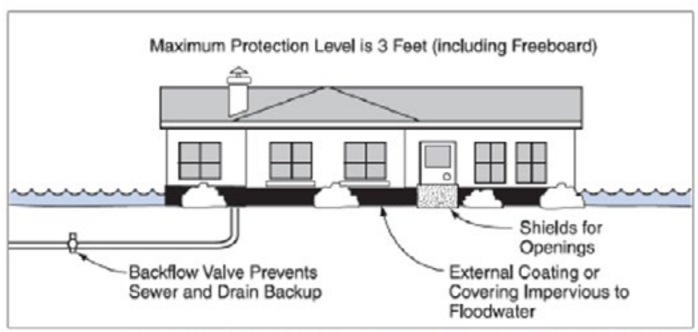
Evaluation criteria that can be used to determine the effectiveness of implementing the abandon basement and fill technique include: the structure location in relation to areas with high velocity flows, structure location in relation to the floodway/community encroachment area, foundation type (has basement), next higher floor elevation in relation to the flood protection elevation, the property/structure location in relation to the FEMA base flood boundary, and the property and location of the property in relation to future planned public projects (e.g., greenways).

FLOODPROOFING OF STRUCTURES

Dry Floodproofing

Dry floodproofing of a structure involves making any area below the FPE watertight to prevent floodwater from entering the structure. Water and sewer lines must be equipped with backflow preventer valves, and all mechanical and electrical equipment must be flood protected either by a floodproofing enclosure or by elevating above the FPE.

Advantages of dry floodproofing a structure include reducing risk to the property, businesses can re-open quickly after a flood event and provide employment, and the property and building remain in the community tax base. Disadvantages of this technique are that it does not reduce flood risk to people; it reduces but does not eliminate flood risk to the property; the property is not available for public uses; it may be cost prohibitive if foundation modifications are required; it may not protect personal property; and a storm event with a flood elevation greater than the FPE would still cause damage.



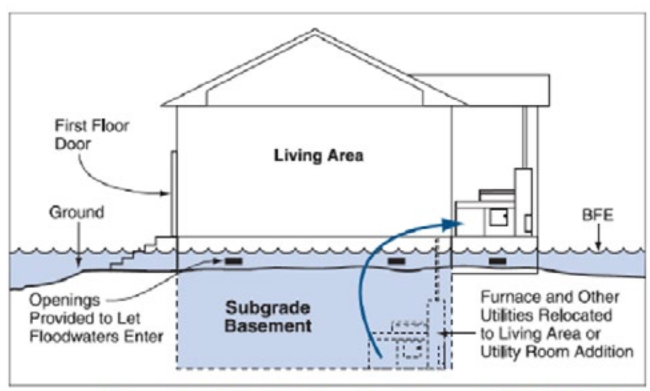
Example of Dry Floodproofing (Source: FEMA P-312)

[Figure 25]
Example of dry floodproofing (Source: FEMA P-312)

Criteria that can be used to evaluate the effectiveness of implementing dry floodproofing include: the structure age (pre-FIRM or post-FIRM), the low floor elevation, the lowest adjacent grade, foundation type (no basement), the structure wall type, the structure location in relation to high velocity flows, the location of the structure in relation to the floodway/community encroachment area, the structure location in relation to the FEMA base flood boundary, and property and location of the property in relation to future planned public projects (e.g., greenways).

Wet Floodproofing

Wet floodproofing of a structure is accomplished by modifying the areas of an existing structure to allow water to enter the space but not cause significant damage. Water is allowed to enter the impacted area, such as a crawl space, to equalize the hydrostatic pressure. The area that is inundated during the flood event must properly drain when the flood water recedes. All construction and finish materials in the inundated areas must be flood resistant materials. Mechanical and electrical equipment must be relocated above the FPE or a floodwall placed around the equipment for protection during flooding.



Example of Wet Floodproofing (Source: FEMA P-312)

[Figure 26]
Example of wet floodproofing (Source: FEMA P-312)

Advantages of this technique include reducing risk to the property, businesses can re-open quickly after a flood event and provide employment, and the property and building remain in the community tax base. Disadvantages of this technique are that it does not reduce flood risk to people; it reduces but does not eliminate flood risk to the property; the property is not available for public uses; it may be cost prohibitive if foundation modifications are required; it may not protect personal property; and a storm event with a flood elevation greater than the FPE would still cause damage.

Criteria that can be used to evaluate the effectiveness of implementing wet floodproofing include: the low floor/ finished floor elevation, the lowest adjacent grade, the base flood elevation, the foundation type (not slab-on-grade), the wall type, the structure location in relation to high velocity flows, the location of the structure in relation to the floodway/community encroachment area, the structure location in relation to the FEMA base flood boundary, and the property location in reference to water quality buffers, potential water quality capital improvement sites and/or a critical needs area of planned greenways, parks, sanitary sewer lines, or water lines.

Partial Floodproofing (Dry or Wet)

Partial dry/wet floodproofing of a structure involve floodproofing to protect it from smaller storm events. This technique only reduces risk from smaller, more frequent storm events. All mechanical and electrical equipment must be flood protected either by a floodproofing enclosure or by elevating above the FPE.

Advantages of partial dry/wet floodproofing of a structure include reducing the flood risk to a property, and the property and building remain in the community tax base. Disadvantages of these techniques are that they only protect from smaller storm events, they do not reduce the flood risk to people, and they reduce but do not eliminate the flood risk to the property.

Evaluation criteria that can be used to determine the effectiveness of implementing partial dry or wet floodproofing include: the foundation type, the wall type, the structure location in relation to high velocity flows, and the location of the structure in relation to the floodway/community encroachment area.

AUDIBLE FLOOD WARNING SYSTEM

An audible flood warning system for individual property owners includes the use of electronic flood warning systems to alert property owners of potential flooding, typically through the use of sensors and a monitor. The flood warning system would provide the property owner with an audible warning when flood waters reach a pre-specified level. This allows the property owner enough time to vacate the property and/or protect personal property from flood damage. The flood warning system can be attached to a structure or personal property, such as a car.

Advantages of an audible flood warning system for individual property owners include reducing the flood risk to people and property to a limited degree, the property and building remain in the community tax base, and it is typically a low-cost technique. Disadvantages of this technique are that it provides a very limited reduction in flood risk to the property (only property that can be removed or protected from flood waters would not be impacted); the property is not available for public uses; and it requires regular maintenance by the property owner.

Criteria that can be used to evaluate the effectiveness of implementing an audible flood warning system include: the property location in relation to any flood boundary, the lowest adjacent grade of the structure, multi-return water surface elevations, and the location of the structure in relation to velocity zones.

STORM WATER DETENTION FACILITIES

Storm water detention facilities include the installation of basins to detain storm water during large storm events. The intent of the detention basin is to reduce peak flood levels downstream of the basin. Storage of a large volume of water is necessary to have a significant impact on flood elevations during a large storm event. The detention facilities typically consist of offline storage areas directly adjacent to a stream. This technique is intended to reduce the potential flood damage to multiple structures and is not intended to benefit a single property.

Advantages of storm water detention facilities include limited disruption to people and property positively impacted by the detention facility, possibly having a positive impact on the flood elevations at bridges and culverts, and it provides a water quality benefit by reducing storm water pollutants like suspended solids. Along with possibly removing structures from flood-prone areas to construct the detention facility, this technique also has the potential to positively affect surrounding structures by lowering flood elevations. Disadvantages of this technique are that the detention will reduce but not eliminate flood risk downstream, it must improve flood elevations for a large number of properties to be economically feasible, construction of the detention basin is costly, it requires open space adjacent to the stream, and the detention basin must be maintained.

Criteria that can be used to evaluate the effectiveness of implementing storm water detention facilities include: the property area and the number of structures that will benefit from the detention.

STORM WATER SYSTEM CONTROL

This flood mitigation technique includes the replacement or modification of culverts or bridges to reduce the flooding potential caused by backwater. An undersized bridge or culvert will result in increased storm water depths upstream, so if the culvert or bridge is replaced or modified to allow more storm water to pass, this results in a reduction in the backwater upstream of the culvert or bridge.

Advantages of this flood mitigation technique include increasing the conveyance of bridges and culverts in a backwater situation which can have a significant impact on flood elevations upstream, and typically, the bridge or culvert is owned by a government entity, so the cost of the replacement/modification does not include land acquisition. Disadvantages of this technique are that the expansion of a culvert or bridge in a backwater situation may increase the flood elevations downstream, modifying or replacing bridges/culverts is costly, and modifying or replacing bridges/culverts typically requires permitting from the local, state, and federal government.

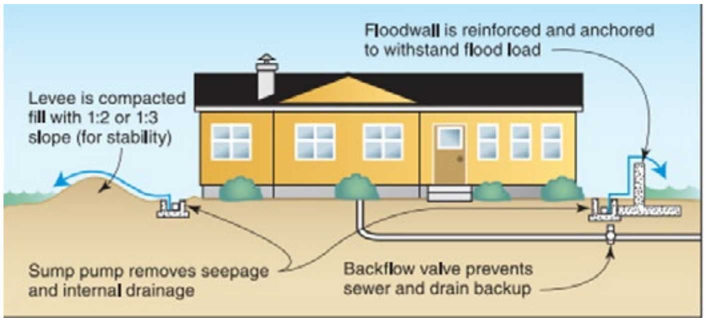
Evaluation criteria that can be used to determine the effectiveness of implementing storm water system control include: the number of structures impacted by the backwater upstream of a bridge/culvert, the roadway height, and the culvert opening height.

LEVEE/FLOODWALL PROTECTION (SINGLE OR MULTIPLE STRUCTURE(S))

This technique includes the installation or modification of a floodwall or levee system on an individual property, or multiple properties, which holds back floodwaters and eliminates or reduces the risk of flood damage to structures. Typically, this consists of an earthen berm and/or floodwall constructed of flood-proof materials. The levee or floodwall is constructed between the stream and the building(s) and is meant to protect with the intention of shielding the flood-prone building(s) from storm water.

Advantages of these techniques include allowing the property owner(s) to continue to occupy their building, the property(ies) protected by the levee or floodwall remain in the community tax base, and they reduce the likelihood

[Figure 27]
Example of levee and floodwall (Source: FEMA P-312)



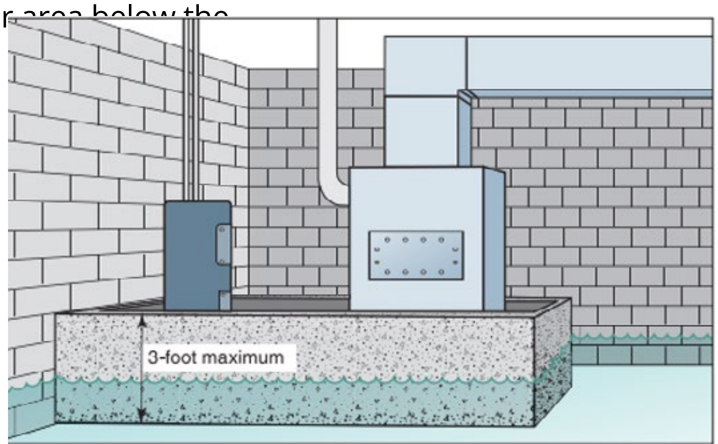
of flooding to the building(s). Disadvantages of these techniques are that they do not eliminate the threat of flooding and may give flood-prone property owners a false sense of security, they require maintenance for the life of the levee/floodwall/berm, they typically require local permits, they do not reduce the flood risk to people, and they reduce but do not eliminate flood risk to property. Additionally, construction of a levee or floodwall may increase flood levels downstream and may require the addition of fill in the SFHA, which may be in violation of local ordinances.

Evaluation criteria that can be used to determine the effectiveness of implementing levee/floodwall protection include: property/structure location in reference to the floodway/community encroachment area; structure location in reference to the FEMA base flood boundary, water quality buffers, and/or areas with high velocity flows; and property and location of the property in relation to future planned public projects (e.g., greenways).

PROTECTION OF SERVICE EQUIPMENT

Protecting service equipment involves elevating, relocating, or protecting equipment in place. Service equipment installed outside the structure can be raised on pedestals or platforms to an elevation above the FPE. Service equipment located in a basement or other area below the flood level can be relocated to an upper floor, attic, or higher ground. Water and sewer lines can be protected with backflow preventer valves. If elevating and relocation are not possible, protecting service equipment in place may be done with low floodwalls and shields, and anchors and tie downs for aboveground and underground storage tanks.

[Figure 28]
Example of protecting service equipment in-place (Source: FEMA P-312)



Advantages of protecting service equipment include reducing the flood risk to property, and the property and building remain in the community tax base. Disadvantages of this technique are that it does not reduce the flood risk to people, and it reduces but does not eliminate flood risk to property.

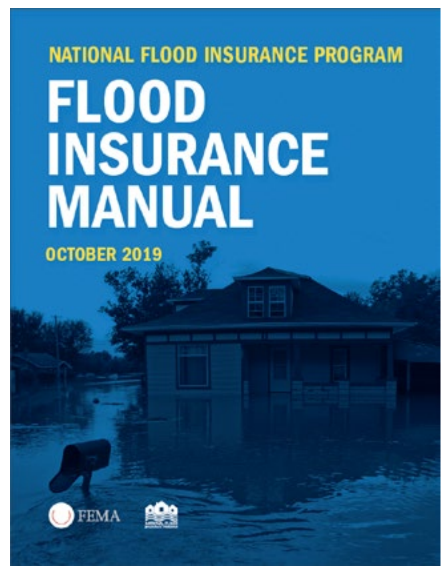
Criteria that can be used to evaluate the effectiveness of implementing this technique include: the elevation of the service equipment, the first-floor elevation, the FEMA base flood elevation, and the structure location in reference to the floodway/community encroachment area.

FLOOD INSURANCE

This technique involves encouraging property owners to purchase flood insurance through the National Flood Insurance Program for all flood-prone properties. This is one of the best methods for limiting the individual economic damage due to flooding. As a requirement of receiving flood mitigation grant funding, FEMA requires property owners to maintain flood insurance.

Advantages of encouraging property owners to purchase flood insurance include compensating individuals for economic losses due to flooding as well as removing this expense for the community. Disadvantages to this technique are that it does not reduce flood risk to people or property by structural, physical means, and it may provide a false sense of security.

Evaluation criteria that can be used to determine if a property might benefit from flood insurance include: the property touches any floodplain boundary, the first-floor elevation, and the FEMA base flood elevation.



[Figure 29]
Cover of NFIP Flood Insurance Manual

PUBLIC EDUCATION

This mitigation technique consists of a multi-media public education campaign to inform owners of flood-prone properties of the flood risks and methods for protecting their lives and property. The focus of this effort is to teach the public strategies to protect themselves before, during, and after a flood event. The education can be accomplished through broadcast media, a website, flyers, and/or public meetings.

Advantages of this mitigation technique include the ability to engage a large number of people in the flood mitigation process, empowering individual property owners to make good decisions about flood risk and flood mitigation, build the support necessary to further identify and fund more “active” methods of mitigation projects, and it is relatively inexpensive. Disadvantages of this technique are that it is not an active method of flood mitigation, and it cannot be assured that contact is made with every impacted property owner. Public education is considered effective for any property that touches any floodplain boundary.

4.3 Performing a Mitigation Evaluation

Once applicable mitigation techniques are identified within a community, it is necessary to evaluate their effectiveness as well as determine the viability of implementing those techniques for each flood-prone property. Each technique has various criteria that can be used in an effectiveness evaluation. The evaluation criteria may be different depending on a community’s method/priorities for determining what makes a technique effective in their respective community. Some communities may want to prioritize community values, and other communities may want to base effectiveness on physical parameters, while others may want to implement an effectiveness evaluation that takes both into consideration.

Community Values

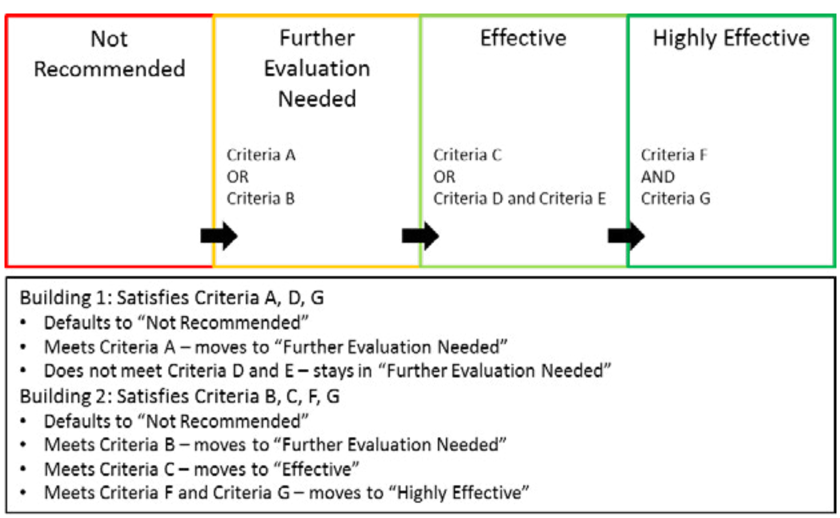
Community values, in relation to mitigation effectiveness, help a community further their vision for flood risk reduction through the promotion of techniques that are specific to their floodplain regulations. The use of community values may encourage mitigation techniques that would remove structures that are in or near water quality buffers, stormwater CIP projects, water CIP projects, or planned parks/greenways, while discouraging other mitigation techniques that would leave structures in areas where natural floodplains are targeted for restoration. Other criteria to be considered are proximity to the floodplain, floodway, and velocity zones. For example, most communities want to discourage building within the floodway and higher danger areas, so elevating a structure located in the floodway or high velocity zone would not be considered effective.

Physical Parameters

While community values put a larger emphasis on preferable location, physical parameters focus more on whether or not a mitigation technique can be implemented to reduce the flood risk of the structure. These criteria would include more physical building characteristics (such as first floor elevation, lowest adjacent grade, highest adjacent grade, etc.), as well as risk-based parameters such as the base flood elevation and proximity to the floodplain, floodway, and high velocity zone. These parameters can be used to promote the removal of structures that have significant flooding depth on the structure or are completely surrounded by water while similarly discouraging the elevation of structures located within the floodway, high velocity zones, or other high risk areas where removal of the structure is preferred.

MITIGATION TECHNIQUE EFFECTIVENESS EVALUATION

One way to evaluate the effectiveness of mitigation techniques for flood-prone properties is to use a “filtering” system with different categories of criteria specific to each mitigation technique. The concept is that the criteria act as filters and allow the properties meeting the criteria to move on to the next category (or bucket). This process would be repeated for each mitigation technique. For example, the minimum criteria might filter the properties into two buckets, “Not Recommended” or “Further Evaluation Needed.” The properties that do not meet the criteria remain in the “Not Recommended” bucket, and the properties that meet the criteria move on to the “Further Evaluation Needed” bucket. The properties that are in the “Further Evaluation Needed” bucket then must filter through the “Effective” bucket criteria in order to move on to the “Effective” bucket. This would continue with the “Highly Effective” bucket criteria. At the end of this process, each property evaluated would fall into one of the four buckets. Criterion that may be used



[Figure 30]
Example of filtering system to determine effectiveness

to evaluate and filter the effectiveness of each of the mitigation techniques are provided in the table below.

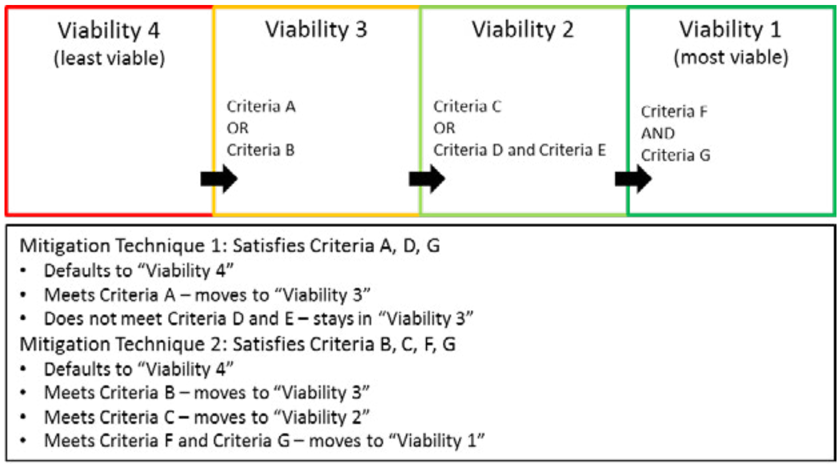
[Table 3]
Mitigation technique considerations, by technique

Considerations	*Techniques*															
	Structure Demolition	*Structure Relocation*	*Resale*	*Structure Demolition and Rebuild*	*Structure Elevation*	*Abandon Basement and Fill*	*Dry Floodproofing*	*Wet Floodproofing*	*Partial Floodproofing (Dry or Wet)*	*Audible Flood Warning System*	*Storm Water Detention Facilities*	*Storm Water System Control*	*Levee/Floodwall Protection (Single or Multiple Structures)*	*Protection of Service Equipment*	*Flood Insurance*	*Public Education*
Property Touches Any Floodplain	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆	◆
FFE	◆	◆	◆		◆			◆						◆	◆	
LFE							◆	◆								
Lowest Adjacent Grade	◆						◆	◆		◆						
Highest Adjacent Grade	◆															
Lowest Mechanical Elevation														◆		
Next Higher Floor Elevation	◆					◆										
Foundation Type		◆				◆	◆	◆	◆							
Wall Type		◆					◆	◆	◆							
Number of Stories		◆														
Structure Area		◆														
Property Area			◆	◆							◆					
Structure Building Grade				◆	◆											
FEMA Base Flood Elevation	◆							◆		◆				◆	◆	
Community Flood Protection Elevation	◆	◆	◆			◆										
Proximity to FEMA Flood Boundary	◆			◆	◆	◆	◆	◆					◆			
Proximity to Floodways	◆				◆	◆	◆	◆	◆				◆	◆		
Proximity to High Velocity Zones	◆			◆	◆	◆	◆	◆	◆	◆						
Proximity to Publicly Owned Lands	◆	◆	◆													
Proximity to Water Quality Buffers	◆	◆	◆			◆	◆	◆					◆			
Proximity to Water Quality Capital Improvement Sites	◆	◆	◆	◆	◆	◆	◆	◆					◆			

Considerations	Techniques															
	Structure Demolition	Structure Relocation	Resale	Structure Demolition and Rebuild	Structure Elevation	Abandon Basement and Fill	Dry Floodproofing	Wet Floodproofing	Partial Floodproofing (Dry or Wet)	Audible Flood Warning System	Storm Water Detention Facilities	Storm Water System Control	Levee/Floodwall Protection (Single or Multiple Structures)	Protection of Service Equipment	Flood Insurance	Public Education
Proximity to Critical Needs Area (Greenways, Parks, Sanitary Sewer, Water Lines)	◆	◆	◆	◆	◆	◆	◆	◆					◆			
Number of Structures that will Benefit											◆	◆				
Roadway Height												◆				
Culvert Opening Height												◆				

VIABILITY

While the effectiveness evaluation determines whether a certain technique can be implemented, a viability evaluation is necessary to determine how successful the implementation of any effective technique might be for each property. In order to be evaluated for viability, a technique would need to be considered effective (i.e., it can be implemented for a specific flood-prone property) in the previous effectiveness evaluation. Criteria that can be used to evaluate viability include the estimated cost of the project, the benefit-cost ratio (BCR), property location, the cost per risk point reduced, and social vulnerability. Similar to the effectiveness evaluation, viability can be evaluated using a “filtering” system for each effective mitigation technique (e.g., Viability 1 through Viability 4). Using the criteria as filters, any technique that meets a certain category’s criterion would then to move on to the next category. This process would be repeated for each mitigation technique. Further description of viability considerations is provided below.



[Figure 31]
Example of filtering system for viability

ESTIMATED PROJECT COST

The estimated project cost can be used by communities to set a limit on the amount they are willing to spend on a community funded project. Using the project cost to evaluate a project's viability allows the community to set limits on what would realistically be spent to mitigate a structure and allows for a lower cost project to show as being more viable. A community may decide to use different cost ranges for different techniques (e.g., higher cost allowed for acquisition since risk is completely mitigated).

BENEFIT-COST RATIO

The benefit-cost ratio (BCR) can be used to promote a mitigation technique that may have a higher upfront cost but will have significant long-term benefits that offset the initial cost. As with estimated project cost, a community can set BCR criterion for each viability category as it sees fit. Since the BCR normalizes the cost using benefits, it may be more appropriate to use the same BCR criterion/ranges for all techniques.

PROPERTY LOCATION

The property location can be used to determine which techniques and/or properties would provide synergy with other projects or a community's overall risk reduction goals. The easiest way to determine this may be to assign points based on favorable location (proximity to other mitigation projects, publicly owned land, planned greenway trails, environmental focus areas, water quality buffers, etc.) or reduction of risk (permanent removal of property, repetitive loss structure, etc.) to determine a mitigation technique score. A technique would then be assigned more points for meeting multiple location or risk removal criteria. The same location factors would not necessarily apply to all techniques, so different mitigation techniques may have different mitigation technique scores for the same property/structure. Mitigation technique scores could be used in a similar manner to cost or BCR with different score ranges used as viability category criteria.

COST PER RISK POINT REDUCTION

The cost per risk point reduction can be used to promote a mitigation technique that may have a higher upfront cost but will significantly reduce or completely remove the flood-prone structure from flood risk. As with estimated project cost, a community can set the cost per risk point reduction criterion for each viability category as it sees fit. Since this value normalizes the cost using risk points reduced, it may be more appropriate to use the same criterion/ranges for all techniques.

SOCIAL VULNERABILITY

The Social Vulnerability Index (SVI) can be used as an indication of a community's ability to prepare for, respond to, and recover from hazards. It is thought that owners of properties located in higher social vulnerability areas may have a tougher time finding housing at a similar cost if a mitigation technique such as acquisition is implemented. For that reason, it may be appropriate to use social vulnerability when evaluating the viability of any mitigation technique that requires acquisition and relocation. Unlike the cost, BCR, location, and cost per point reduction criteria that filers through viability criteria, it may be more appropriate to implement social vulnerability criteria as an adjustment after an initial mitigation technique viability is determined. For example, the "adjusted" viability may show a lower viability for those properties with a higher social vulnerability that may not be able to find a similar housing situation as easily.

CHAPTER FIVE

Developing a Community Mitigation Strategy

Every community is different and there is no "one size fits all" strategy. The most effective approach should involve community leaders, technical resources, and those potentially impacted by flooding.

Developing a Community Mitigation Strategy

Once a community has completed an evaluation of the building specific risk and mitigation evaluations, it can begin to think of an overall strategy to manage and mitigate flood risk. The evaluations can be used by private property owners and local government officials in making informed decisions about flood mitigation strategies. Moreover, the data can be used to assist in identifying, prioritizing, and planning future flood mitigation projects. This information can also be used to identify synergies with other municipal projects and goals such as sewer projects, environmental stewardship, and open space needs.

A Community Mitigation Strategy can range from simple approaches, such as removing all flood-prone structures, to complex, interdependent community-wide initiatives where multiple techniques are used in conjunction with input from diverse stakeholders. Every community is different and there is no 'one size fits all' strategy. The most effective approach should involve community leaders, technical resources, and those potentially impacted by flooding.

5.1 Mitigation Strategy Considerations

Reducing flood risk can be accomplished by reducing the probability of flooding (typically through "structural," man-made alterations) or by reducing the consequences/ impacts that will result when a flood does occur. It is rare to find one mitigation technique that is appropriate for all flood-prone structures within a community. Some techniques, such as acquisition/demolition (buyout), can eliminate large numbers of high-risk properties. However, as local programs evolve, it becomes necessary to evaluate a broader range of techniques in order to arrive at a strategy that targets the full range of flood-prone properties throughout the planning or project area. Additionally, the consideration of site-specific characteristics, such as special environmental assets, planned sewer or park projects, development pressure, and other community goals may influence site specific strategies. Moreover, the goals of individual property owners will ultimately define the implementation of any mitigation strategy.

In general, a community must define the mitigation actions and techniques that are appropriate for it. In determining the applicability of specific flood mitigation strategies, a community may examine the appropriateness of individual techniques along with the following considerations discussed below.

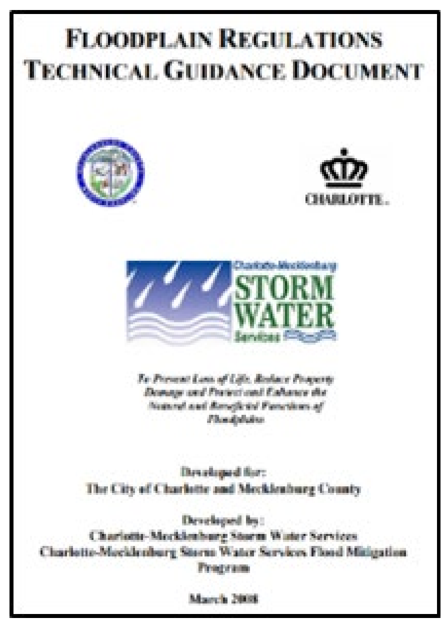
FUNDING

Availability of funding is a critical factor to consider when developing a mitigation strategy. Funding sources may require the end-product of a strategy to be in ‘full compliance’ with local, state, or federal requirements, whereas community or property owner goals may be met with cheaper strategies that do not achieve full compliance.

REGULATORY

The regulatory capabilities of a community could influence mitigation strategies. For example, home elevation projects need to be periodically inspected for the retrofitting of non-compliant elements. If non-compliant elements are found, the community must have the regulatory infrastructure in place to enforce ordinance requirements and ensure the removal of these elements. In contrast, acquisition is a one-time event that requires no regulatory follow-up; however, acquired parcels may still need routine maintenance, such as mowing and trash/debris removal.

[Figure 32]
Cover of CMSWS floodplain regulations document



FLOODPLAIN REGULATIONS
TECHNICAL GUIDANCE DOCUMENT

CHARLOTTE.

Charlotte-Mecklenburg
STORM WATER
Services

Developed for:
The City of Charlotte and Mecklenburg County

Developed by:
Charlotte-Mecklenburg Storm Water Services
Charlotte-Mecklenburg Storm Water Services Flood Mitigation Program

March 2008

POLITICAL ENVIRONMENT

Communities where a significant portion of the jurisdiction lies within the Special Flood Hazard Area (SFHA) may not desire the implementation of widespread acquisition/demolition because of negative impacts to the tax base, population, or social fabric. In these instances, targeted acquisition of the highest risk properties could be used in conjunction with other techniques, such as elevation or wet flood-proofing, to preserve the community fabric.

COMMUNITY VALUES

Community values (i.e., what is important to a community) are often reflected in local policies, practices, and regulations. For example, a community which places a high value on open space will often reflect this through more specific and/or restrictive policies in community master plans, development standards, and funding allocations.Whereas, a community that puts a greater emphasis on encouraging development and growth, may have less stringent development standards and encourage development through economic incentives. The risk tolerance of a community will significantly influence a mitigation strategy. A community that has not experienced a flood in several years may be more risk tolerant than one that has experienced recent or devasting flooding.

SOCIOECONOMIC

A community's socio-economic standing could influence the mitigation strategy in several ways. A wealthier community with flood-prone structures may opt to acquire and remove them from the SFHA, whereas a less wealthy community, where finding an equivalent living situation may be more difficult for most property owners, may implement alternative mitigation techniques that allow the homes to remain in-place and mitigate risk to a community defined level.

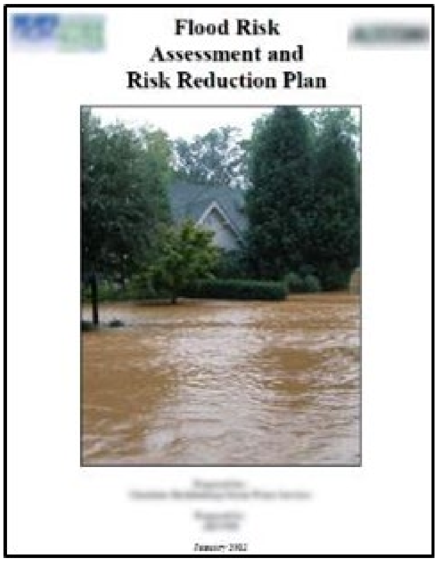
NEW DEVELOPMENT

Communities experiencing a lot of new or re-development interest may choose to adopt a wait-and-see approach to mitigation in highly desirable areas. Often times, developers will target non-compliant, flood prone structures for tear-down and rebuild with the end result being a new, compliant structure.

OTHER COMMUNITY NEEDS

Communities undertaking infrastructure projects in the SFHA may want to consider integrating mitigation efforts at the same time. For example, if a community is planning to undertake a sewer project in a flood prone area, it may be beneficial to acquire flood prone-structures instead of purchasing easements. Similarly, a community that intends to locate greenways within the riparian area of the SFHA may benefit from acquisitions rather than elevation or other measures.

[Figure 33]
Example Risk Assessment and Mitigation Action Plan



5.2 Developing a Mitigation Strategy

Development of a mitigation strategy is an important step toward achieving community goals related to flood risk. Various approaches may be used, including implementing mitigation for individual properties or implementing mitigation for larger project areas that include multiple at-risk properties in the same area. While mitigating individual properties targets the highest risk properties first, project areas can be used to prioritize larger areas based upon overall flood risk. This type of strategy allows for focused neighborhood level outreach and education where targeted mitigation measures can be implemented. Project areas typically include flood-prone structures along with other properties that may experience yard flooding, road over-topping, or very low risk of structure flooding. A unified outreach effort can then be implemented, typically through neighborhood groups, and the neighborhood is asked to provide input before mitigation is implemented. While mitigation is implemented on a property by property basis, neighborhood input is an important consideration during the process. Preferably, all mitigation in the neighborhood would be completed before moving on to the next project area, whereas mitigating scattered properties individually could make outreach efforts more intensive, requiring multiple neighborhood visits over several years before mitigating all at-risk properties in an area.

The process for developing a mitigation strategy involves layers of review, assessment, and recommendations from a variety of sources. A multi-disciplinary approach is intended to broaden the perspective for the development of flood hazard mitigation strategies in the community. This approach may include contributions by people with extensive flood mitigation experience as well as people with limited flood mitigation experience, but who possess extensive experience in other areas such as water quality and engineering. Community staff involvement might include community employees (specifically related to stormwater) at various levels: project managers, supervisors, and division managers. Other information may be sourced from people in other areas that are impacted by floodplains such as park and recreation, utilities, and schools. Overall, the process to develop a mitigation plan should include: developing a framework for the approach, refining the approach, finalizing the approach, and applying the approach.

DEVELOP FRAMEWORK

The first phase is to develop the framework for the approach and methodologies to be applied. Tasks will include assessing the flooding circumstances that drive flood risk and warrant increased mitigation effort, determining the flood mitigation techniques and strategies (whether public or private) that are most effective in a given community at reducing flood risk, and developing criteria for applying the mitigation actions at the building level. At this point, an initial risk and mitigation scoring system should be established for the community. Then, methodologies for evaluating the effectiveness of potential mitigation strategies should be decided by selecting criteria for determining the flood mitigation techniques that provide the best results for a particular flood-prone property.

REFINING, FINALIZING, AND APPLYING THE APPROACH

The next phase should consist of refining the approach that was developed in phase one. To perform this step, a community should consider hiring a consultant familiar with flooding and mitigation to run a pilot study to evaluate the methodologies developed in the previous phase and suggest any changes to the scoring systems. To conduct a pilot study, the community will need to acquire the best data available related to their approach, which may include the following: mapped flood hazard boundaries, parcel boundaries, building footprints, and building elevation data. Using this information, the consultant should test the proposed scoring methodologies created during the development phase and apply them, through manual processing, for each property. Manual processing will consist of assessing each property independently in GIS using available data layers, including aerial imagery, flood model data, building footprint data, Elevation Certificate (EC) information, and

[Figure 34]
Citizen advisory group meeting

other local data layers, where available.

In addition to a pilot study, it would be useful to establish a citizen advisory group to assist in the review, improvement, and finalization of the plan as well as to help get public buy-in. In establishing a citizen advisory group, it would be beneficial to include owners of flood-prone properties from various neighborhoods and watersheds within the community. The overall purpose of a citizen-based committee/advisory group is to review the developed approach to assessing community flood risk and mitigation and provide input and feedback on the plan. Holding regular meetings with this group can help ensure that affected residents are part of the solution, which will ultimately result in a better product. This committee can also fulfill a vital role as a “sounding board” for the discussion of ideas and provide cross-checks to make sure that proposed thoughts, details, and approaches make sense. Specific topic areas where the committee can provide the most useful feedback would likely include discussions involving risk scoring and mitigation recommendation criteria.

Once risk and mitigation approaches are finalized, it is up to the community to apply the approaches to evaluate the risk facing flood-prone properties as well as applicable mitigation techniques for those properties. This will establish a baseline for risk and mitigation opportunities within the community that can then be communicated to all community stakeholders, including elected officials and the general public. Overtime, these approaches can also be used to monitor and track risk and mitigation activities within the community.

Appendix B includes a case study from Mecklenburg County, NC. It includes discussion on the driving factors, challenges, public involvement, and other factors that they considered in developing their mitigation strategy.

CHAPTER SIX

Funding and Implementing the Strategy

Funding is a driving force in the implementation of mitigation strategies.

Timing, strategy, and funding source are key factors to consider.

Funding and Implemening the Strategy

The next key step after a community develops a mitigation strategy is implementing that strategy. Funding is a driving force in the implementation of mitigation strategies. There are a few key factors to consider when implementing a mitigation strategy, as discussed in the section below. Different communities may put more or less emphasis on these factors, depending on community goals and initiatives. Each factor should be considered as a strategy is newly implemented, but it is also advisable to reevaluate these considerations over time to ensure community goals are still being met.

6.1 Implementation Considerations

Flood mitigation funding, like many other investments, can be grouped into the following “buckets”:

Bucket	*Description*
Timing	When is the best time for the community to invest?
Strategy	How should the community make the investment?
Source/Driver	Where is the funding coming from?

TIMING

A community may be best served by looking at investing in flood mitigation similar to how a person ideally invests for retirement - consistently and continuously with long term objectives. Achieving a long-range vision of a more resilient community may be best accomplished before a disaster occurs. It is risky, and probably not as effective, to prepare for the next disaster like someone who would “prepare” for retirement by playing the lottery or assuming they will be included in the family will. It is not sustainable to time the investment of public funds to disasters, as this can lead to a roller coaster ride that exclusively, or at least, heavily relies on federal or state funding, which can prove more difficult for a community or individuals to obtain when it is most needed.

In addition to investing consistently and continuously, some people may have a "nest egg" set aside for investing in their retirement when a certain opportunity presents itself. This "opportunistic approach" can also be replicated by a community – a progressive flood mitigation program could put itself in an opportunistic position to greatly reduce flood risk and increase resilience after a crisis. The "opportunistic approach" is not just an opportunity for the community to reduce future flood losses that will occur when the community experiences flooding again, but it provides flood victims an opportunity to completely avoid, or significantly reduce, the cost of the next flood before it occurs.

STRATEGY

Proactive and *reactive* strategies are two of the simplest categories to group flood mitigation investments.

Proactive investments are those that minimize losses before the structures (homes, apartments, businesses, places of worship, schools, etc.) are built in harm's way. It is much more cost effective to grow as a community when structures are built with flood loss reduction as a priority. Investments in floodplain mapping, ordinance enforcement, and higher standards (free board, future conditions, etc.) are much less costly than paying for flood losses by elevating or acquiring a structure after it has flooded. If there are existing structures in flood-prone areas, they can also be proactively mitigated before incurring damage from a storm event.

Although this is not as ideal as preventing them from being built in flood-prone areas in the first place, proactive mitigation can be used to avoid significant direct damage, as well as avoid many of the associated negative impacts (e.g. displacement, emergency response resources, distress, etc.) that occur after a flood event.

Reactive investments are those that would take place immediately after a flood. For those structures that have been placed in harm's way, the most opportune time to mitigate is during the recovery phase of a flood. Although more costly than proactive investments in flood loss reduction, the investment should pay for itself over time by eliminating or reducing the cost of flood damage from future flood events. Reactive investments are typically acquisition, elevation (entire structure, mechanical/ electrical components, etc.), and floodproofing.

A flood mitigation program that strategically focuses on not only reducing flood losses, but also on what the community values, has a greater chance of being successful. Flood mitigation solutions that not only reduce the chances for loss of life or property, but also support other community values (environment, housing, commerce, open space, greenways, etc.), are not only better for the community overall, but they may yield partnerships with agencies that assist in funding projects.

SOURCE/DRIVER

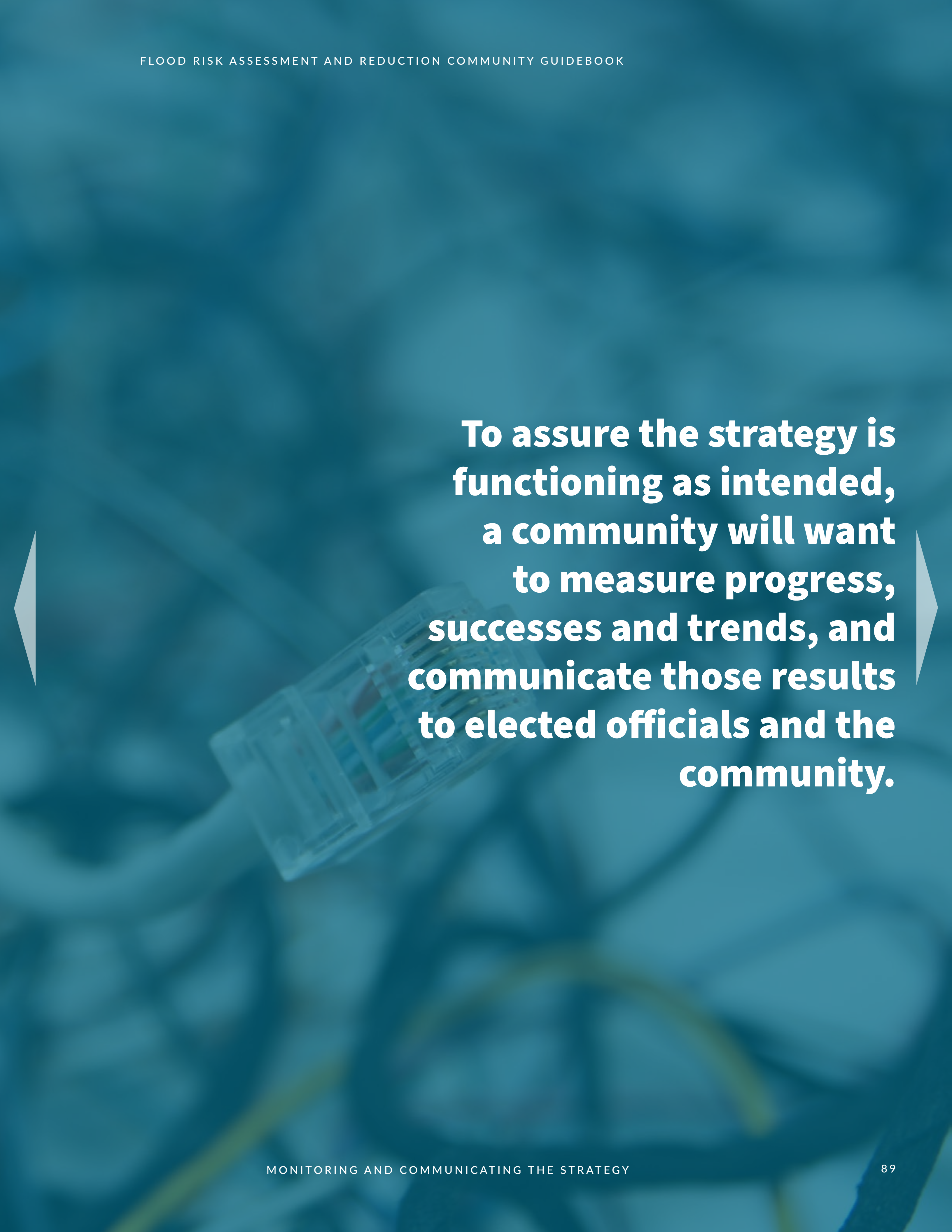
Medium and large counties and municipalities are developing stormwater programs to address the decrease in water quality and the increase in flooding due to urbanization. Property values (ad valorem tax revenue) have been the traditional method of funding stormwater programs that have been part of public works departments. Some communities allocate/dedicate a portion of property taxes to the local stormwater program. However, for the last several years, there has been an increased interest in looking at alternative funding sources.

For several reasons, there has been a heightened interest in establishing stormwater fees to fund local stormwater programs, including: soaring stormwater management costs; increased competition for limited tax funds; regulatory consequences of underfunding stormwater services; increasing data availability that allows for a stormwater fee; technology for implementing and maintaining a fee is readily available and affordable; legal precedent for fees as the concept of a stormwater fee is more mainstream; and increased public willingness to support fee-based funding if it can be shown to be equitable. A popular driver to base the fee on is the impervious area which has the greatest impact on, or contribution to, poor water quality and flooding. Flood mitigation can become a significant expense to the stormwater program, but it can also produce substantial public benefit.

In summary, more states/counties/municipalities are recognizing the public benefits associated with a well-balanced stormwater program that invests in flood mitigation. Communities that approach investing in flood loss reduction in a timely and strategic manner, based on a dedicated funding source, will be committed to a culture of flood loss reduction for years to come. The public benefits do not end with a community becoming more resilient as other community values, such as greenways, open space, tree canopy, water quality, etc., can also be realized.

CHAPTER SEVEN

Monitoring and Communicating the Strategy



To assure the strategy is functioning as intended, a community will want to measure progress, successes and trends, and communicate those results to elected officials and the community.

Monitoring and Communicating the Strategy

Once a strategy is developed and implemented, it will need to be tracked and monitored to assure the strategy is functioning as intended. A community will want to measure progress, successes, and trends, as well as communicate those results to elected officials and the community. Results can be communicated to community constituents and elected officials in multiple ways, including public meetings, mailing, and utilizing dedicated online applications, such as risk-focused websites and dashboards that provide comprehensive information.

7.1 Monitoring Considerations

To fully evaluate the effectiveness of the implemented mitigation strategy, it is necessary to keep good records of past, present and future mitigation actions. This involves retaining data such as past elevation surveys, building footprints and characteristics, and tax assessments for both privately and publicly mitigated properties. Other things to monitor include the cost of past mitigation projects as well as the projected cost for future projects which can help identify funding sources such as federal, state, local, or private. It is also useful to track a community's risk pool over time and to note the cause of change in risk for any given structure (due to mitigation activities, changes in maps, tax revaluations, etc.).

RISK POOL

The risk pool is a representation of a community's overall flood risk at a given point in time. The risk pool can be represented in several ways:

Number of Buildings in the SFHA

The risk pool could be represented by a simple count of the buildings touching the SFHA. This number could be refined to show the number of compliant and non-compliant buildings to give a better representation of risk compared to a community's overall building stock.

Value of Building Stock in the SFHA

Depending upon community values, risk could be defined by the overall value of the building stock touching the SFHA. Structure tax value may be a useful metric that is generally available in most communities. As with building counts, the value could be broken down into compliant and non-compliant categories. Furthermore, the non-compliant building category could be represented by the value of buildings affected by individual flood return intervals or physical characteristics. For example, the non-compliant building value could be further categorized by those with finished floors 1 foot, 3 feet, and more than 5 feet below predicted flood elevations to give a broad indication of the likelihood of inundation.

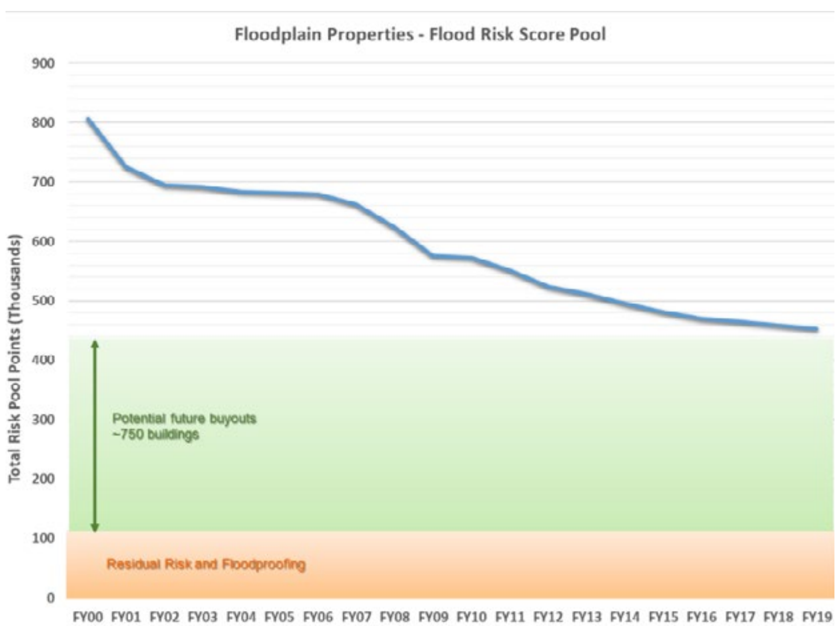
Total Risk Points

If a community develops a numeric scoring metric for flood risk, summing the risk is a straightforward means of communicating the overall risk.

Residual Risk

Residual risk is an important communication tool, especially for communities that allow new development within the SFHA. Residual risk can be thought of as a community's end goal – the level of risk a community can live with. A highly risk adverse community may decide that the level of risk they can live with is no structures within the SFHA. In this case, residual risk would be very low and likely include yard and outbuilding flooding, impacts to open space, and parking areas. Another community that is more tolerant of flood risk may define residual risk in terms of all building stock within the SFHA being compliant with local regulations. In this community, risk would be higher and possibly include flooding under structures and inaccessibility of structures during flood events. In this case, emergency responders would still need to deploy to inundated structures during flood events, and clean-up costs could be significant.

The risk pool may be calculated annually and presented to citizens and other stakeholders within the community. Possible items to showcase would be historical risk pool values along with the number of remaining structures to mitigate and residual risk levels. An example graphic of how the risk pool metric might be used is shown in Figure 35.



[Figure 35]
Example risk pool chart over time

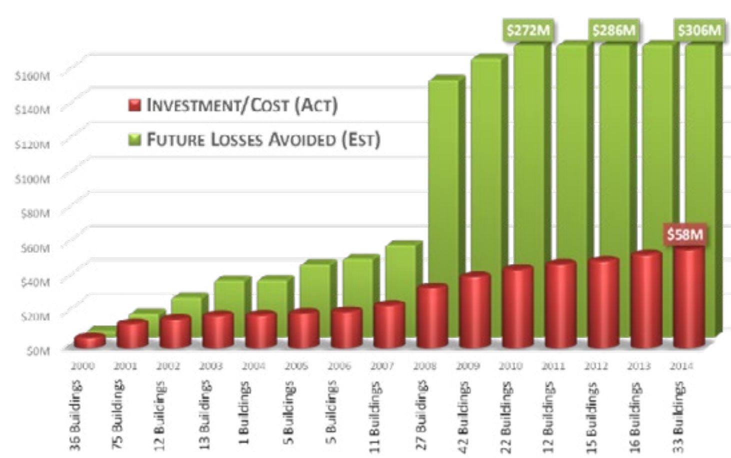
LOSSES AVOIDED

An important concept when managing community flood risk is losses avoided. Essentially, losses avoided is an estimate of the cost savings generated over time by the implementation of mitigation measures in a community. For example, if a community acquires a flood prone structure and removes it from the SFHA, that action removes the flood risk from the community. If the area where the building was located subsequently floods, the value of the damages prevented are the losses avoided by the buyout. The overall losses avoided include various prevented impacts:

- Structural damage to the building – removing a structure from the SFHA will prevent any damage to that structure, so the value of the damage can be included in the losses avoided calculation.
- Content losses – value of the loss of contents of the structure can also be included in the losses avoided calculation.
- Vehicle loss – the value of vehicles parked in garages, or designated parking areas, can be included in the calculation.
- Displacement costs – if a home or business is impacted, the residents will need to relocate, at least temporarily.
- Emergency response costs – costs associated with police and fire crew being dispatched to a flooded structure would be included as avoided losses.

Similar to the Risk Pool, losses avoided can be tracked and presented to citizens and other community stakeholders on an annual basis. Figure 36 shows an example of how the history of a mitigation program can track losses avoided by the program.

[Figure 36]
Example losses avoided chart



7.2 Metrics to Monitor

The comprehensive communication of flood risk needs to address both a community's overall risk as well as risk to individual properties. Establishing a set of metrics that can be measured on a routine basis can allow a community to track progress toward goals, assess program cost effectiveness, and inform individual property owners and real estate professionals on the status of individual properties. Tracking risk over time is a powerful communication tool, and maintaining data on previously mitigated properties, along with existing building stock, will allow communication of return on investment to the community and elected officials.

LOSSES AVOIDED

In order to effectively calculate losses avoided, a community must maintain information on mitigated properties, along with information about flooding, that would have impacted the mitigated property. At a minimum, the data presented in the following sections is needed to calculate losses avoided.

Mitigated Property Data

To track losses avoided over time, a community will need to maintain data on individual mitigated properties. This includes elevation certificates, building characteristics, location and elevation of parking areas, location of property improvements, and property tax valuations. Data on acquisitions, elevations, and floodproofing could be included in this dataset.

High Water Mark Data

In order to calculate water depths, a community must have a means to measure or closely estimate the water depth or elevation on a previously mitigated property. This can be accomplished through existing USGS gage data, measurement of rack lines, or establishment of high-water-mark monuments at mitigation sites.

Displacement Costs

These costs are associated with the expenses to temporarily relocate residents, or a business, should a structure suffer major flood damage. Displacement costs can be estimated from past events associated with similar structures.

Emergency Responder Costs

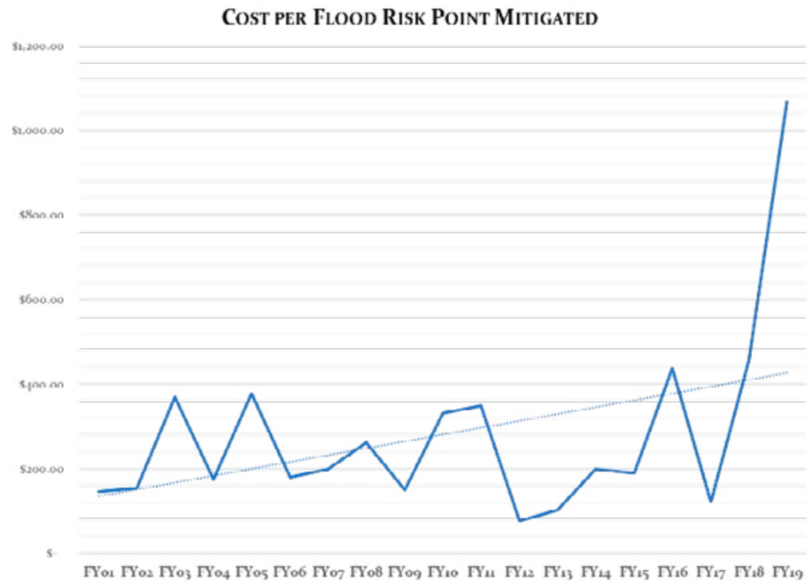
These costs are established by the community and reflect the actual cost for police and fire to respond to a scene and conduct appropriate evacuation and response activities.

Using the mitigated property information along with site-specific high-water mark data, a community can calculate the value of the damages that would have occurred and estimate the damages to the contents and vehicles using the FEMA depth/damage estimates. Adding in the displacement costs and emergency responder costs give an overall picture of the true losses avoided by a community through implementing a mitigation action.

To track the losses avoided over time, a community will need to track individual event losses avoided and sum over time. These losses can then be compared to the investment made by the community to provide a true community benefit to cost comparison.

RISK MITIGATED

As described in the Risk Pool section, a community can provide an up-to-date assessment of the overall risk pool in relation to residual risk along with presenting the estimated costs to mitigate. Tracking the risk mitigated over time will require retaining pre-mitigation risk along with cost to mitigate as well as the post-mitigation risk, if appropriate (e.g. elevation or floodproofing). This data can be further extended to provide information on program efficiency, such as with a cost per point mitigated metric, overall expenditure, or number of buildings mitigated. Figure 37 shows an example of annual cost per point mitigated.



[Figure 37]
Example historical cost-per-point mitigated

7.3 Communicating the Strategy

Communicating the strategy involves target audiences as well as how information is presented to those audiences. The sections below describe the various audiences a community may have as well as different means of communication that information.

TARGET AUDIENCE GROUPS

Elected Officials

A crucial group to target with information regarding community flood risk is elected officials. Elected officials should be informed prior to initiating a flood risk assessment process to gain their buy-in and support of the approach and strategy. Furthermore, implementation of any recommendations resulting from the assessment will likely need to be approved by an elected body. Therefore, it is critical that they be informed of the process, approach, and potential outcomes. Typically, communication to this group is very condensed and focused upon strategy with emphasis on costs and benefits to the community. Often, staff performing the risk assessment process will request elected officials to suggest citizen representatives to form advisory groups and committees.

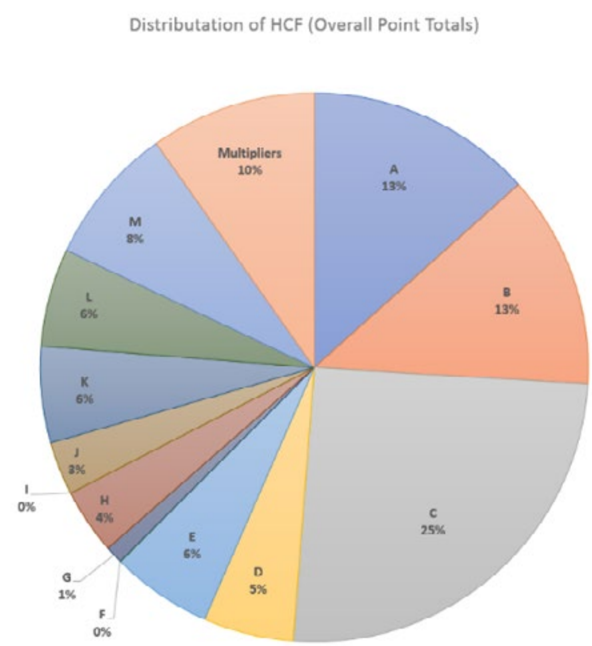
Advisory Groups

Advisory groups and citizen committees will generally be comprised of individuals familiar with real estate, development, and engineering. Communication to these groups will be more in-depth and educational in nature. Staff performing the risk assessment process will update these groups frequently during the process and turn to them for guidance on policy and strategy.

Property Owners and General Public

Communication to property owners is generally property and neighborhood specific. Each community will need to decide the level of detail to provide for each property. It may be useful to determine the risk factor(s) that contribute most to each property's risk score, also referred to as the Highest Contributing Factors (HCFs). This can be communicated to property owners so they have a better understanding of their risk and also which mitigation options might be best for their property. An example of the risk factor breakdown can be seen in Figure 38.

[Figure 38]
Example highest contributing factor distribution pie chart



FORMS OF COMMUNICATION

Presentations

These may be formal or informal meetings in which results and findings as well as strategies are communicated to elected officials, community stakeholders, and citizens. With elected officials, presentations may involve a broad overview of the strategy and progress whereas for advisory groups, it may be more educational in nature. When communicating to the general public, it will likely include a broad overview of community risk as well as mitigation strategies and results of past mitigation implementation.

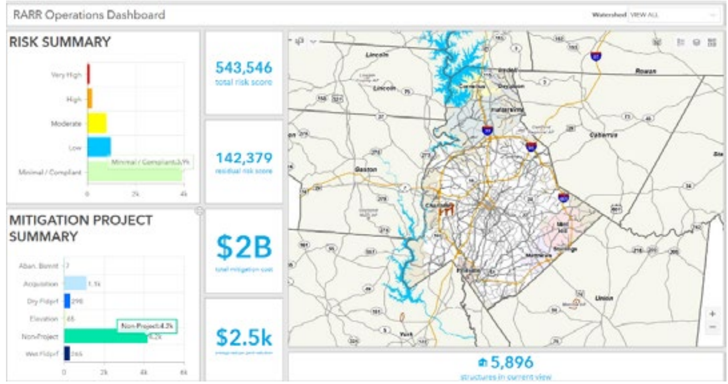
Written

In general, written communication is a more formal type of communication. For elected officials, this may be in the form of an executive summary while for property owners and the general public, and would likely include a property specific summary of risk and mitigation options.

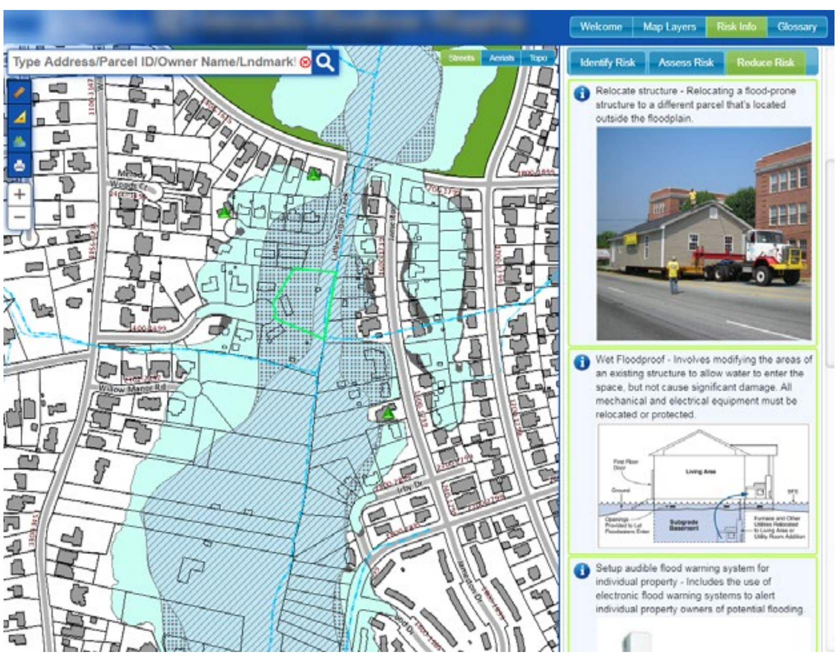
Web

A dedicated web page would be a way for all community stakeholders (elected officials, advisory groups, and the general public) to access risk assessment and risk reduction activities online. Information to display might include: a community's collective risk; progress towards residual risk goals, including progress to date and estimated timeline to completion; and risk previously mitigated, including number of structures mitigated, total dollars spent, and dollars per risk point reduced. Additionally, building specific information from the risk assessments along with actions that could be taken to reduce the flood risk may be presented. Available building specific elevation data (both elevation certificates and elevation data) may also be provided to the user. For elected officials, a community may want to present more specific data, such as actual risk values, budgets, forecasted residual risk, etc., in which case a more detailed dashboard may be appropriate. An example of this can be seen in Figure 39.

For property owners, it may be better to display general risk information (e.g., high, medium, low) in an online web portal (with risk assessment and general mitigation options), instead of specific risk/mitigation data, as seen in the example in Figure 40. If a property owner wishes to obtain more detailed information, they could then contact the community and discuss their individual property and risk and mitigation options.



[Figure 39]
Example dashboard



[Figure 40]
Example of web portal for general public

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Appendices

Appendix A

DATA LINKS

Source	*Link*	*Available Data*
USGS The National Map (TNM)	https://viewer.nationalmap.gov/datasets/	DEM; LiDAR; Boundaries (State, County, Municipal, etc.); Hydrography (NHD, NHDPlus, WBD); Imagery; Structures; Transportation
FEMA National Flood Hazard Layer (NFHL)	https://www.fema.gov/national-flood-hazard-layer-nfhl	Flood hazard zones; stream centerlines; cross sections/coastal transects; LOMR boundaries; FIRM boundaries; community boundaries; levees; etc.
FEMA Map Service Center (MSC)	https://msc.fema.gov/portal/home	FIS Reports, FIRM panels, and LOMC data for Effective, Preliminary, Pending and Historic Products; NFHL state and county data for Effective Products
USGS National Hydrography Products	https://www.usgs.gov/core-science-systems/ngp/national-hydrography	NHDPlus, NHD, and WBD datasets including flow networks, waterbodies, points (gages, dams, etc.), and watershed boundaries
FEMA Hazus	https://www.fema.gov/hazus	Flood hazard information, risk assessments., and estimated impacts available at State level
U.S. Interagency Elevation Inventory	https://coast.noaa.gov/inventory/	LiDAR
U.S. Army Corps of Engineers (USACE)	https://www.hec.usace.army.mil/software/	Hydrologic Engineering Center (HEC) Software (including HEC-HMS and HEC-RAS)
Microsoft Building Footprints	ArcGIS Link to Microsoft Building Footprints	125 million U.S. building footprints
American Community Survey (ACS)	https://www.census.gov/acs	Demographic data (age, race/ethnicity, mobility, disability, employment, income, housing, etc.)
Census TIGER Data Products	https://www.census.gov/programs-surveys/geography	Boundaries; roads; address information; water features; demographic information; etc.
CDC	https://data.cdc.gov/	Social Vulnerability Index (SVI)

Source	*Link*	*Available Data*
Hazards and Vulnerability Research Institute	http://artsandsciences.sc.edu/geog/hvri	Social Vulnerability Index (SoVI)
Mecklenburg County	https://managefloodrisk.org/	Example Flood Risk Calculator
	https://charlottenc.gov/StormWater/Flooding/Documents/Flood_RARR_Plan-Final.pdf	Flood Risk Assessment and Risk Reduction Plan

ADDITIONAL RESOURCES

FEMA's HAZUS Tool

FEMA's Hazus software uses a suite of data to help users in assessing risks and mitigation planning. Hazus is packaged with datasets that include building inventories and infrastructure for the entire United States. Because Hazus is currently built on GIS technology, the inventory and infrastructure datasets can be mapped and intersected with the hazard information. The outputs and estimates can be used in hazard mitigation planning, emergency response, and planning for recovery and reconstruction.

Hazus estimates the potential economic and social impact that a natural hazard can have on buildings, people, services, and infrastructure. Higher-quality data produces better and more reliable results in the risk assessment. Accurate and reliable risk assessment results help communities develop sound mitigation options to reduce their vulnerabilities. A community enhancement to Hazus may be providing more refined data for individual structures and loss estimation values, when available.

For more information, please visit https://www.fema.gov/hazus.

FEMA's Benefit-Cost Analysis Tool

Benefit-Cost Analysis (BCA) is the method by which the future benefits of a hazard mitigation project are determined and compared to its costs. Therefore, it is used to determine the cost effectiveness of proposed mitigation projects for several FEMA mitigation grant programs. The end result is a Benefit-Cost Ratio (BCR), which is calculated by a project's total benefits divided by its total costs. The BCR is a numerical expression of the "cost-effectiveness" of a project. A project is considered to be cost effective when the BCR is 1.0 or greater, indicating the benefits of a prospective hazard mitigation project are sufficient to justify the costs.

For more information, please visit https://www.fema.gov/benefit-cost-analysis.

Appendix B
Case History: Mecklenburg County

Mecklenburg County is the most populated county in North Carolina and one of the fastest growing metropolitan areas in the country. There are over 370 miles of Federal Emergency Management Agency (FEMA) mapped streams, and an estimated 2,800 houses and buildings in the mapped floodplain areas.

Charlotte-Mecklenburg Storm Water Services (CMSWS) manages and maintains the regulated floodplains for the unincorporated areas of Mecklenburg County, NC, as well as the incorporated municipalities, including the City of Charlotte and the Towns of Cornelius, Davidson, Huntersville, Matthews, Mint Hill, and Pineville. CMSWS aims to reduce potential loss of life and property from flooding by monitoring, studying and reducing flood risk, while enhancing the natural and beneficial functions of the floodplain along FEMA-mapped streams. To reduce future flood related losses, CMSWS implements floodplain regulations and manages flood hazard mitigation.

CMSWS maintains a nationally-recognized flood mitigation program that has a history of developing and implementing innovative and effective flood mitigation strategies. CMSWS' success stems from progressive vision and leadership to identify and develop strategies, combined with the community buy-in and support from private, local, state, and federal partners to enable implementation of those strategies. Examples of notable aspects and achievements of CMSWS' program are listed below:

- Investing in data capture/development and technology to aide in the identification, risk assessment, and mitigation of flood hazards. Examples of county-wide collection efforts include aerial imagery, LiDAR, elevation certificates, and digital building footprints.

- Voluntary acquisition of over 400 flood-prone properties that were funded through a combination of local funds and federal grants. Many acquisition projects were combined with community greenway and other public amenity projects to enhance public quality of life.
- Maintaining the Flood Information & Notification System (FINS) consisting of over 70 rain gages and of over 50 stream gages that is accessible to the public via a website.
- Proactively updating and maintaining accurate regulatory floodplain mapping as a Cooperating Technical Partner (CTP).
- Mapping to future land use conditions and regulating to higher standards.
- Proactively updating and maintaining flood mitigation plans to identify short- and long-term strategies to reduce risk.
- Planning and constructing capital projects to implement projects to reduce risk and restore beneficial natural functions of floodplains.
- Administering a local flood mitigation grant program (retroFIT) that encourages owners of flood-prone property to mitigate against flood risk.
- Proactive public outreach and education about flood safety, flood risks, and mitigation techniques through a combination interactive websites and targeted outreach efforts.

As part of its overall flood mitigation strategy, CMSWS developed a Risk Assessment and Risk Reduction (RARR) plan to help assess flood risks within the County as well as prioritize and guide implementation of mitigation strategies. The RARR plan, initially implemented in 2012, includes a data-driven framework and associated tools that allow the County to dynamically assess, evaluate, and prioritize mitigation strategies for flood prone buildings/ properties. RARR is designed to assist the County's Flood Mitigation Program in building and expanding upon previous efforts to minimize the consequences to people and property when a flood occurs. CMSWS is currently updating to enhancing RARR to provide additional support to its flood mitigation program initiatives.

An overview of the approaches, methods, and products described in the County's Risk Assessment / Risk Reduction (RARR) plan, which are necessary to further integrate the County's risk identification, assessment, and planning efforts, are described below. For more detailed information, please refer to the Flood Risk Assessment and Risk Reduction Plan (link provided in Appendix A).

DATA CONSIDERATIONS

RARR leverages a combination of community-specific and FEMA hazard datasets in order to perform property-specific risk assessments, identify planning-level mitigation projects, and set project priorities. It allows CMSWS to engage in risk-based mitigation planning and decision making, resulting in strategic, sustainable actions that reduce or eliminate risks to life and property from flooding. Table B-1 below lists the datasets used by RARR.

Table B-1. Mecklenburg County Local Datasets

Type	*RARR Dataset*	*Source*
Hazard	Multi-Return Flood Event Polygons	Flood Insurance Study (FIS) products
	Floodway Polygons	
	Cross Sections	
	Water Surface Elevation Rasters	Developed from FIS hydraulic model results and cross sections

Type	*RARR Dataset*	*Source*
Vulnerability / Risk	Elevation Certificates	Community-maintained dataset
	Parcel	
	Building Footprints	
	Critical Care Facilities	
	Parking Locations	
	Significant Property Improvements	
	Moderate Property Improvements	
	Mitigation Projects	
	Project Areas	
	Buildings Impacted by Overflows	
	Neighborhoods	
	High Danger Depth-Velocity Areas	Derivative products develop from Flood Insurance Study Models
	Moderate Danger Depth-Velocity Areas	
	Repetitive Losses	NFIP
	NFIP Policies	
Supplemental	Water Quality Buffer	Community-maintained dataset
	Local and National Historic Sites	
	5-year Water CIP	
	5-year Sewer CIP	
	5-year Greenway	
	Parks	
	Water Quality CIP Sites	
	Public Lands	
	Environmental Focus Areas	

ASSESSING RISK

RARR uses a scoring system to assign relative flood risk to individual buildings and properties. A "Flood Risk Score" is assigned by identifying the potential flood impacts to the property, quantifying the likelihood that the flood impact will occur, and accounting for additional risks to the structure due to location. Flood Risk Scores provide information about the relative flood risk for the property. CMSWS uses these scores to aid in identifying and prioritizing the individual flood-prone properties, understanding an overall flood risk profile for the community, and setting targets and program needs to reduce risk to acceptable levels. The Flood Risk score used by RARR intentionally neglected the monetary value of what was impacted/damaged in order to normalize properties.

The calculation of the Flood Risk Score begins with an assessment of flood risk for a given property. RARR considers eleven (11) "impact" criteria and four (4) "location" criteria to calculate an overall Flood Risk Score for each property. Table B-2 (on the following page) is a list of the impact and location criteria used by RARR. Each impact criteria is assigned a number of base points, which indicates the relative importance of a given criteria relative to the other criteria. During the scoring process, each impact is assessed to determine not only if it is triggered (e.g., finished floor is flooded), but also at which storm event it is triggered (e.g. flooded in the 2% and larger events). RARR assesses impacts for eight storm events ranging from the 50% (2-year) event through the 0.2% (500-year) event.

An individual component score is calculated by multiplying the base points by the probability of the smallest event where the impact is triggered. If a given impact criteria is not met, then zero points are assigned for that component. The process is evaluated for all individual impact criteria and the individual impact components scores are totaled to obtain a total impact score.

In addition to impact criteria, there are four location-based factors that affect a property's flood risk. These are accounted for through a location-based multiplier applied to the total impact score. Similar to the impact assessments, each location factor criteria is evaluated for a given property. If a given location criteria is met, a multiplier is assigned. If no location criteria is met, a default multiplier of "1" is used.

The final Flood Risk Score is calculated by multiplying the total impact score by the maximum location multiplier. For more information on impact-based and location-based risk categories/multipliers, please reference the Flood Risk Assessment and Risk Reduction Plan (Section 2) using the link provided in Appendix A.

Table B-2. Impact-Based and Location-Based Categories

Impact-Based Category	*Base Points*
Flooding above the lowest finished floor of a building	2800
Flooding of electrical and/or mechanical equipment	1200
Flood water is touching a portion of the building (likely crawlspace or unfinished basement being impacted)	1000
Property is completely surrounded by flood water (ingress/egress off of flooded property)	1100
Structure is completely surrounded by flood water (ingress/egress from building)	500
Structure is completely surrounded by flood water AND is a Critical Facility	2700
Structure is completely surrounded by flood water AND is multi-family residential (additional people, vehicles)	1400
Flood water is touching a portion of the building AND has structural damage (subsidence, shifting, cracking) as a result of cumulative flooding	2000
Flooding of SIGNIFICANT/MODERATE exterior property improvements which are deemed functional necessities to reasonable use of single family residential property (see separate guidelines)	600 / 300
Flooding around area where single-family residential vehicles are typically parked (see separate guidelines)	600
Flooding of any yard (any portion of parcel)	30

Location-Based Category	*Multiplier*
Building located in high danger depth-velocity zone	1.5

Location-Based Category	*Multiplier*
Building located in medium danger depth-velocity zone	1.3
Building located near area impacted by frequent storm drainage overflows	1.3
Building located in Community Encroachment Area	1.1

EVALUATING AND PRIORITIZING MITIGATION TECHNIQUES

Once risk is assessed and a total Flood Risk Scores is assigned, as described above, RARR evaluates and prioritizes a range of structural and non-structural techniques to mitigate the flood risk. RARR considers up to nineteen (19) mitigation techniques for each property, listed in Table B-3 on the following page. As noted in the table, some techniques such as acquisition/demolition remove the risk all together since the flood-prone building is removed altogether. However, most techniques mitigate the structure "in-place" (i.e., the building remains), thus there will usually be some level of residual risk.

Similar to evaluating impact criteria, each technique is evaluated against a set of criteria to assess its effectiveness given the flood hazard conditions (e.g., depth of flooding), physical structure characteristics (e.g., foundation type), and other factor specific to a given building. Based on the evaluation each technique is placed into one of the following four categories for each property:

- **Highly Effective** —the mitigation technique is determined to be highly effective at reducing flood risk and in providing an additional community benefit
- **Effective**—the mitigation technique is determined to be feasible and effective for reducing flood risk
- **Further Evaluation Needed**—the minimum criteria for the mitigation technique are met but further evaluation or additional data is needed to determine if the

technique is a viable option

- **Not Recommended**—the minimum criteria for the mitigation technique are not met - therefore the technique is likely not feasible, effective, or may be cost prohibitive

Table B-3. Summary of Mitigation Techniques

Mitigation Technique	*Solution Type*
Property Acquisition and Structure Demolition	Risk Removed
Structure Demolition and Rebuild	Risk Reduced
Property Acquisition and Structure Relocation	Risk Removed
Property Acquisition, Demolition or Relocation, and Re-sale	Risk Removed
Structure Elevation	Risk Reduced
Abandon Basement and Fill	Risk Reduced
Dry Floodproofing of Structures	Risk Reduced
Wet Floodproofing of Structures	Risk Reduced
Audible Flood Warning System for Individual Property	Risk Reduced
Storm Water Detention Facilities	Risk Reduced
Storm Water System Control	Risk Reduced
Automated Flood Notifications	Risk Reduced
Public Education	Risk Reduced
Flood Insurance	Risk Reduced
Levee/Floodwall Protection for Multiple Structures	Risk Reduced
Protecting Service Equipment (HVAC, electrical, utilities, fuel)	Risk Reduced
Partial Dry Floodproofing	Risk Reduced
Partial Wet Floodproofing	Risk Reduced
Levee/Wall/Berm for a Single Structure	Risk Reduced

Once the techniques are evaluated for effectiveness at each property, each technique that was deemed 'Effective' or 'Highly Effective' is evaluated against another set of criteria (i.e. prioritization criteria). The prioritization criteria consider factors such as cost-effectiveness, benefits safety, synergies with planned community projects, and other community benefits. The prioritization criteria are used to rank the applicable techniques and identify an overall "recommended" for each property.

Once a recommended mitigation technique is identified for each property, the prioritization criteria is used to weight/adjust the Flood Risk Score in order to create an overall 'Mitigation Property Score.' The Mitigation Property Score, which is a single value that integrates both flood risk and mitigation potential, can be used to prioritize mitigation actions among floodprone properties in the County.

For more information on mitigation techniques evaluated by RARR, please reference the Flood Risk Assessment and Risk Reduction Plan (Section 3 and Section 4) using the link provided in Appendix A.

PATH TO DEVELOPING AND IMPLEMENTING THE STRATEGY

The process for developing Mecklenburg's Flood Mitigation Strategy (RARR plan) began in 2009. It involved layers of review, assessment, and recommendations from a variety of sources. This multi-disciplinary approach was intended to broaden the perspective for the development of flood hazard mitigation strategies in Mecklenburg County. This approach included contributions by people with extensive flood mitigation experience and people with limited flood mitigation experience but extensive experience in other areas such as water quality and engineering. Staff involvement included CMSWS employees at various levels: project managers, supervisors, and a division manager. The final source of information included people from other areas that impact the floodplains such as park and recreation, utilities, and schools. The process followed to develop the plan consisted of two phases. Phase I focused on developing a framework for the approach and Phase II focused on refining, finalizing, and applying the approach. For more information on the planning process, please reference the Flood Risk Assessment and Risk Reduction Plan (Section 5) using the link provided in Appendix A.

Phase I: Develop Framework

The first phase of this effort was to develop the framework for the approach and methodologies to be applied. Phase I tasks included assessing the flood risk by identifying the flooding circumstances that warrant increased mitigation effort, determining the flood mitigation techniques and strategies (both public and private mitigation actions) that are most effective in Mecklenburg County at reducing the flood risk, and developing criteria for applying the mitigation actions on a parcel or building level. Using a handyman analogy, Phase I of the update loaded the toolbox with the tools to complete the work and provided the instruction books for which tools to use under which circumstances. The effectiveness of potential mitigation strategies were evaluated for use in Mecklenburg County. Selection criteria were developed to determine the flood mitigation techniques that provide the best results for a particular flood-prone property.

Phase II: Refine, Finalize and Apply Methods

The second phase consisted of refining, finalizing, and applying the methods in Phase I. CMSWS worked with an experienced consultant to run a pilot study to refine and finalize the methodologies developed in Phase I. The first step in the pilot study was to acquire the best data available, including mapped flood hazard boundaries, parcel boundaries, building footprints, and elevation data. The second step was to identify and highlight high hazard zones based on potential flood depths and velocity. The proposed scoring methodologies from Phase

I were then applied through manual processing for each property. The manual processing consisted of assessing each property independently in GIS using aerial imagery, flood model data, building footprint data, Elevation Certificate (EC) information, and other County data layers. In addition, Benefit-Cost Ratios (BCRs) were determined for each property using FEMA BCA methodologies. (Note: an MS Excel based calculator for Mecklenburg County's scoring methodology is provided with this guidebook and can serve as an example scoring methodology for another community's pilot study).

In addition to the pilot study, a Citizen Review Committee (CRC) was established to assist in the review and improvement of the plan. The CRC was a citizen-based committee established to assist CMSWS in reviewing and improving the Flood RA/RR Plan. The overall purpose of the CRC was to review the new approach based on flood risk and provide input and feedback on the plan. The CRC was provided with updates on the Flood RA/RR Plan's progress. The committee was comprised of 12 residents, all of which are owners of flood-prone residential properties. These 12 committee members represented seven different neighborhoods within three distinct watersheds. Having the CRC in place and holding regular meetings ensured that the affected residents were part of the solution, which ultimately resulted in a better product. The CRC also fulfilled a vital role as a "sounding board" for the discussion of ideas and cross-checks to make sure that proposed thoughts, details, and approaches made good sense. The CRC provided input and feedback throughout the process. Specific topic areas where the CRC provided feedback included risk scoring and mitigation recommendation criteria.

The CRC met a total of nine times. Table 4 below presents the topics covered during each meeting.

Table B-4. CRC Meeting Topics

Meeting #	*Main Topics Covered*
1	Introduction of CRC members; purpose of the CRC; flood mitigation plan background
2	Introduction to flood risk; Flood Risk Property Score; pilot study areas and purpose
3	Flood risk factor comments; location factors; “money exercise”; vehicles
4	Flood Risk Property Scores; pilot study results; mitigation techniques concept overview; mitigation techniques
5	Mitigation techniques follow-up and discussion; Flood Mitigation Priority Score concept overview; Flood Mitigation Priority Score discussion
6	Mitigation techniques follow-up and discussion; Flood Mitigation Priority Score concept; Flood Mitigation Priority Score
7	Changes to mitigation techniques table; Flood Mitigation Priority Score walkthroughs; preliminary results of pilot study
8	Updated mitigation techniques table; Flood Mitigation Priority Score; project area criteria; conclusions from pilot study; group accomplishments; plan communication results
9	Communicating flood risk information; path forward; CRC member summary statement(s); wrap up and member recognition

IMPLEMENTING THE STRATEGY

In 1993, Charlotte-Mecklenburg Storm Water Services (CMSWS) was created. The City of Charlotte, Mecklenburg County and the six towns agreed to a collaborative approach to manage runoff, reduce flooding, restore floodplains, and protect water quality. They also agreed the stormwater fee would be based on the amount of impervious area on the property.

Mecklenburg County's Floodplain Management program has been in place for many more years than CMSWS has been in existence. However, the Floodplain Management program was funded by property tax, ad valorem tax revenue. In the early years of CMSWS, the operational and regulatory portions of the County Floodplain Management program were funded by the local Storm Water fee. Approximately $25 million dollars in voter-approved Flood Control bonds were funded by property tax revenue. In 1999, partially as a result of totally revamping the floodplain program as a result of the 1995 and 1997 floods, the floodplain mapping and buyout programs were funded by the Storm Water fee using a Pay Go approach (not bond funds) for funding capital expenditures.

CMSWS's bills over 280,000 residential, commercial, industrial, multi-family, faith-based, and government properties the Storm Water fee. The portion of the fee allocated to the Floodplain Management program (mapping, blockage removal, water quality, buyouts, etc.) is $1.20 per month for most residential accounts and $20.00 per impervious acre for non-residential accounts. The fee generates approximately $11.7M per year in revenue for the Floodplain Management program, of which, $3.15M in Pay Go is allocated to the Flood Mitigation efforts (floodplain mapping, buyouts, and retroFIT programs). Therefore, only 33 cents per month, for most homes goes to Flood Mitigation efforts. However, the application of the dedicated funding source to floodplain mapping and buyouts has paid great dividends in not only reducing flood losses, but also assisting in the expansion of the greenway system, creation of open space, re-establishing water quality buffers, etc.