ECONOMIC & POLICY ANALYSIS OF DEVELOPMENT STANDARDS & OTHER MITIGATION ACTIVITIES

IMPLEMENTATION RECOMMENDATIONS

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Executive Summary

The Louisiana Watershed Initiative seeks to establish a watershed-based approach to flood risk reduction in Louisiana, using scientific tools and data to enable regional governance and transparent decision making. To maximize the beneficial functions of watersheds and floodplains in Louisiana, the state must make changes to land use and development. This report seeks to understand the various costs and benefits of development standards and associated mitigation activities to inform state, regional, and local policy strategy and implementation.

One common source of benefits across all development standards and mitigation activities is the Community Rating System (CRS), part of the National Flood Insurance Program (NFIP). Communities who participate in the CRS can receive credit for a variety of risk reduction activities, which the NFIP translates into flood insurance policy savings for policyholders in the community. Regardless of the scale of implementation of these various development standards, the state should continue to emphasize, encourage, and assist communities with CRS participation so these savings can be realized.

Three categories of development standards were examined in this report: freeboard, fill and foundations, and development restrictions.

Freeboard is the elevation of buildings above the 1% annual exceedance probability (AEP) flood or Base Flood Elevation (BFE). Including freeboard is increasingly a mandatory component of building code updates, insurance program requirements, and post-disaster grant programs. Freeboard standards are broadly cost-beneficial to all stakeholders in national literature examining counties similar to areas of Louisiana, including inland areas subject to riverine flooding. Implementation options include setting statewide standards of BFE+1 (BFE plus one additional foot of elevation), BFE+2, or using a stepped standard that varies based on flood insurance rate map (FIRM) zones. The state could also strengthen and expand a freeboard standard by, for example, replacing the Base Flood Elevation with a 0.2% AEP Design Flood Elevation (DFE) and extent.

***The recommended implementation pathway is to*:**

- *set a freeboard standard of at least BFE+2 in the Special Flood Hazard Area (SFHA),*
- *consider strengthening that standard by zone or by extending the geography by using a higher DFE, and*
- *provide support to parishes and communities to speed adoption, adherence, and enforcement of these new standards.*

Fill and Foundations refers to the use of fill material to stabilize a foundation or increase its elevation, as well as regulating foundation type by mandating the use of 'open' foundations that preserve space underneath the structure. Elevation requirements like freeboard standards that do not specify fill or foundation requirements may lead to increased use of fill to elevate structures. Fill displaces floodplain storage and can negatively impact neighboring properties particularly in locations like Louisiana with flat terrain. Cost data obtained through national studies and local interviews show that open foundations are often only a small price premium above a

slab on grade foundation, but that when soil conditions require the use of friction pilings, both slab and open foundations become more expensive. No Net Fill policies, which require any fill used on a site to be compensated with storage or detention on another portion of the site, are in use in some communities in Louisiana. Harris County, TX and the City of Houston have regulated fill and foundations in the aftermath of Hurricane Harvey; they currently require pier and beam foundations in the floodway as well as V, A, and AO zones, and they have instituted prohibitions on fill or No Net Fill policies in certain zones.

The recommended implementation pathway is to:

- *encourage widespread use of No Net Fill policies,*
- *prohibit fill in regulatory floodways,*
- *require pier and beam foundations in the SFHA, and*
- *provide support to parishes, communities, and small businesses transitioning to these standards.*

Development Restrictions are less commonly deployed, but can be effective in certain circumstances by retaining open space in the floodplain and reducing future damage to structures that would have otherwise been built. While communities can earn CRS credits for restricting development within the SFHA, this would be impossible for parishes whose entire land area is within the SFHA. Communities could restrict development within regulatory floodways, as is done in the City of Houston, or they could continue to allow floodway development with strong freeboard, fill, and foundation requirements, as is done in Harris County. Conservation servitudes (known as conservation easements in other states) are voluntary legal agreements that permanently limit development and certain uses on privately-owned property for the purposes of protecting its conservation value. Conservation servitudes are another tool that could be used at a regional scale to preserve floodplains.

The recommended implementation pathway is to:

- *consider floodway restrictions and*
- *incorporate conservation strategies into regional watershed planning.*

Two additional mitigation methods targeting existing buildings and communities were also examined in this report: buyouts and local green infrastructure policy tools.

Buyouts are the acquisition of floodprone homes, and are a key component of mitigation practice. The Federal Emergency Management Agency (FEMA) considers any buyout that costs less than $276,000 to be cost-effective, and loss avoidance studies after disasters have shown that prior hazard mitigation projects, including buyouts, were cost effective. Buyouts are in progress in Louisiana, but they often take too long, with complex tax revenue implications and long-term maintenance considerations for local governments.

The recommended implementation pathway is to:

- *establish a standing or permanent state buyout program that can support local or regional initiatives while standardizing and streamlining shared resources and technical assistance;*

- *establish a fund to leverage and support federal buyout resources, as well as provide supplemental buyout incentives and relocation assistance; and*
- *support pre-disaster buyout and relocation planning at the local and regional levels so that trust can be built over time.*

Green Infrastructure directs stormwater runoff into passive natural systems at the building, street, or neighborhood scale, and can be cost-beneficial compared to 'gray' or concrete infrastructure built to manage similar volumes of water, while also providing environmental and social benefits to communities. Alternatives for implementation include financial and tax incentives, regulatory requirements or ordinances, and inclusion of green infrastructure in design and engineering plans.

The recommended implementation pathway is to:

- *develop a model ordinance and design guidelines for parishes and municipalities that considers best practices already in use in Louisiana.*

Introduction

BACKGROUND & PURPOSE

This report has been prepared for the Louisiana Watershed Initiative by Allison DeJong, Colleen McHugh, and Beaux Jones from The Water Institute of the Gulf; Anne Watkins from AECOM; and Dr. Marla Nelson from the University of New Orleans.

The purpose of this report is to understand the various costs and benefits of development standards and associated mitigation activities, sometimes called "non-structural" risk mitigation programs, to inform both statewide policy strategy as well as different scales of implementation. The research will provide context and recommendations for these policy and programmatic activities to better inform the direction and effectiveness of the Louisiana Watershed Initiative (LWI).

METHODOLOGY

This report was prepared to answer the following research questions:

- What are the relative costs and benefits of different methods of flood risk mitigation?
- How do the costs, benefits, and effectiveness of a given method vary across Louisiana geographic, environmental, and land use contexts, if at all?
- Who bears the costs and reaps the benefits of a given method?
- How can LWI resources be allocated most effectively between shifting future development practices and retrofitting existing development?
- What are existing best practices in flood risk mitigation methods?

To answer these questions, several methods were used. In lieu of conducting an original benefit-cost analysis, the authors conducted a national literature review that included existing benefit-cost analyses on hazard mitigation, as well as multiple academic and government reports. Additional desk research was conducted on policies and best practices covered in this report to inform implementation recommendations, examining practices both in Louisiana and from other jurisdictions in the United States.

In addition to literature review and desk research, the authors also conducted informal interviews with numerous stakeholders between November 2020 and March 2021. These interviews were conversational and conducted by phone and email. Stakeholders consulted include:

- Current and former parish government staff, including land use and planning staff

- Architects, landscape architects, and general contractors familiar with Louisiana building conditions
- State agency employees working on residential projects using federal funds
- Engineering and construction management consultants working on multiple projects in Louisiana
- Academics and researchers conducting studies and outreach to Louisiana communities on watershed modeling, mapping, flood insurance, and other related topics

These stakeholders have experience working in multiple Louisiana parishes, including St. Tammany, Plaquemines, Pointe Coupee, East Baton Rouge, Ascension, Rapides, and more. Discussions with stakeholders were wide-ranging, and included standard building practices, recent cost estimates, market trends, customer preference, experience with land and development regulations, and the enforcement of local floodplain management ordinances. Where possible, cost data from these conversations were compiled to form ranges that informed the regulations in this report. While desk research supplemented some of these conversations, not all information was available in standard literature. Where not otherwise cited, findings in this report are derived from these stakeholder interviews and conversations.

Finally, the authors conducted specific research to develop a case study of the efforts of Harris County (Texas) and the City of Houston to update their development standards. Sources for this case study included interviews and working relationships with staff at the City of Houston and Harris County Flood Control District, as well as a review of relevant legislation, news articles, and other pertinent desk research.

BENEFITS OF FLOOD RISK MITIGATION

The non-structural risk mitigation activities discussed in this report include elevation of existing or new structures, revision of building codes, implementation of land use restrictions designed to curtail future growth in the floodplain, creation of incentives for relocation to lower risk areas, and local policies to encourage the implementation of green infrastructure. Overall, research indicates that these types of non-structural strategies provide cost-effective risk reduction, especially in high-risk areas that experience flooding from a 1% annual exceedance probability (AEP) (otherwise known as the 100-year storm) and more frequent events.

For the mitigation methods in this report, stakeholders can be separated into five main groups:

- **Developers:** Corporations that invest in and build new buildings, usually selling them once completed
- **Title holders:** People or corporations who own existing buildings
- **Lenders:** Banks that hold mortgages
- **Tenants:** Building occupants, regardless of ownership
- **Community:** Anyone associated with the buildings or their occupants, including neighbors and local governments

Each of these stakeholders incurs different costs and accrues different benefits; however, in general, literature shows that the mitigation techniques to prevent future losses discussed in this report can be cost-effective (i.e., produce positive net benefits) for each of these stakeholder groups. Broadly speaking, the benefits of flood risk reduction include:

- Preventing loss of life and injury
- Reducing property damage to homes and businesses
- Reducing business interruption and revenue loss
- Lowering of emergency response and disaster recovery costs
- Attracting new businesses and residents
- Protecting cultural and historical assets
- Reducing environmental damage

A safe, resilient community results in residents and business owners feeling more confident and secure about their assets and investments, and can lead to a stronger sense of place and, ultimately, peace of mind.

One of the clearest and most immediate benefits of hazard mitigation can be reduced flood insurance costs. Local governments can reduce flood insurance premiums community-wide by participating in the Federal Emergency Magement Agency's (FEMA's) Community Rating System (CRS). CRS is a voluntary incentive program that recognizes and encourages community floodplain management activities that exceed the minimum National Flood Insurance Program (NFIP) requirements. Currently, 44 Louisiana communities (16 parishes and 28 cities) participate in CRS, covering approximately 400,000 flood insurance policies. These communities receive credit for a variety of different risk reduction activities which the NFIP translates into flood insurance policy savings for their policyholders (FEMA, 2020d). As of 2013, CRS participation was saving Louisiana homeowners over $35 million in annual NFIP flood insurance premiums, representing a discount of approximately 10% on premiums for policies in CRS communities (CRS State Profile, 2014). These discounts provide cash savings to the state's taxpayers as a result of coordinated hazard mitigation actions, over and above the discounts that an individual property owner would receive for taking these actions independently.

CRS savings apply to almost all of the mitigation methods described in this report. Most of the mitigation methods described herein fall under CRS category 430: Higher Regulatory Standards, which allows for up to 2,000 CRS points. In general, policyholders receive a discount of 5% for every 500 CRS points their community earns. The average credit for Louisiana participating CRS communities for category 430 is 167 points, which is below the national average of 291 points. West Baton Rouge Parish receives the most points for this category, at 403 (CRS State Profile, 2014). Paille, et al. (2016) found that higher CRS scores are associated most closely with higher median home values and a higher number of municipalities within the participating parish, whereas the number of floods in the prior five years, mean elevation, and the revenue base of the parish did not appear to influence CRS scores. Paille, et al. theorize that the existing participation of local jurisdictions in the CRS program may provide the technical expertise and government capacity required to implement measures for collective flood hazard mitigation over broader regions. Technical assistance to lower income jurisdictions may encourage

more collective action to reduce flood exposure risks. In addition, any regulation implemented at the State level would count towards CRS discounts for all participating communities within the State.

REPORT STRUCTURE

This report separates mitigation methods into two categories: development standards for new development and programs and policies that can address the existing building stock. In general, development standards for new development are most effective in growing areas, where new development will make up a greater portion of the building stock. Development standards can still provide benefits in slow-growing regions, but will have less of an impact on the overall watershed. To maximize benefits, a comprehensive effort to reduce flood damage should address both new and existing development.

Flood risk mitigation methods evaluated in this report include:

- Development Standards
    1. Freeboard
    2. Fill and Foundations
    3. Development Restrictions
- Programs and Policies for Existing Buildings and Communities
    4. Buyouts
    5. Local Green Infrastructure Policy Tools

For each mitigation method, the following are presented:

- Broad cost and benefit research,
- Alternatives for implementation,
- Tradeoffs for consideration, and
- Recommended implementation pathways.

Mitigation Methods: Development Standards

Predicting where and how flooding will occur in the future is a difficult task. Despite numerous advances in modeling, mapping, and forecasting, there are still uncertainties as to how current weather and future climate patterns impact flood risk in Louisiana. However, we do know that floods impact every parish in the state, and that flood risk is increasing. The prudent course of action is to ensure that every newly built structure in the state is responsive to both what is known about today's risk and what is not known about how that risk will change over the years and decades to come.

Hazard mitigation reduces long-term risk to people and property from future disasters. Mitigation planning breaks the cycle of disaster damage, reconstruction and repeated damage. According to FEMA's *Building Codes Save* study, just one inch of water in an average home can cause $25,000 in damage (FEMA & Compass PTS JV., 2020). Since over 80% of all structures nationwide are residential, residential development standards can have a large impact on overall structural flood damage reduction. Surveys have shown that Americans support far more aggressive government regulation to fight the effects of climate change than elected officials have been willing to pursue, and some of the highest support among people of all political backgrounds is in the area of new building codes (Flavelle, 2020).

Following Hurricane Ike in 2008, FEMA found that structural damage to newer buildings in communities with more stringent design and construction codes than NFIP-required minimums was generally less than in those communities that had not adopted higher standards. Damage to elevated homes which were properly designed and constructed was generally minor until water reached above the elevated floor system, at which point the damage increased dramatically with increasing water level and wave height. Performance of residential building foundations to coastal and near-coastal hazards depended primarily on the residence having adequate elevation, proper construction, and proper foundation selection. If any of these criteria were not satisfied, performance suffered (FEMA, 2009).

This section will present a case study and then explore three mitigation methods focused on new development:

1. Freeboard
2. Fill and foundations, and
3. Development restrictions.

CASE STUDY: LEARNING FROM HARRIS COUNTY

In the aftermath of Hurricane Harvey and other storms that caused widespread flooding in Southeast Texas, Harris County and the City of Houston updated their development standards in the face of increasing risk by increasing freeboard requirements, regulating fill and foundation type based on flood zones, and strengthening floodway prohibitions. Harris County, which includes the city of Houston, has a slightly larger population than all of Louisiana. In late 2017, a number of updated development standards were proposed by the county executive at the time, Harris County Judge Ed Emmett. Commissioners were supportive, as were developers. Ed Taravella, the chair of the developers council at the Greater Houston Builders Association, said that the organization supported the stricter regulations, and that any increased costs to elevate would be built into the price of the home and passed on to the buyer (Zavrei, 2017). The new regulations targeted both the elevation of the homes, setting different requirements based on zones, as well as setting the regulatory standard to a locally-defined Design Flood Elevation (DFE) based on the 0.2% AEP storm. In essence, they substituted the 500-year floodplain and elevation for the 100-year floodplain and elevation in the regulations, enforcing a higher standard though not through a direct application of BFE plus freeboard.

This case study highlighted four lessons learned and what they mean for Louisiana.

1. *Focus on updating understanding of risk.* Most households impacted by flooding from Hurricane Harvey were outside of the Special Flood Hazard Area (78% outside) and 500-year floodplain (60% outside). While Hurricane Harvey was in many ways unprecedented, it became increasingly clear that Harris County flood maps did not accurately reflect risk. The Harris County Flood Control Modeling, Awareness, and Assessment Project (MAAPnext) comprehensive data and modeling program is designed to develop the "next generation of flood mapping" and "provide [residents and decisionmakers] with the flood risk information [they] need to make important life decisions in Harris County." The MAAPnext program is closely coordinated with the Federal Emergency Management Agency (FEMA) and is aligned with the Flood Insurance Rate Map (FIRM) update process so that flood maps better reflect risk in the future.

2. *Regulatory standards should be designed and regularly updated to adequately reflect our understanding of current and future risk.* Texas updated their rainfall frequency values in 2018 through the National Oceanic and Atmospheric Administration's (NOAA) Atlas 14 study. This study found significantly increased rainfall frequency values in parts of Texas, especially Southeast and Central Texas. In Houston and Austin, for example, the rainfall totals that previously were used to classify a .2% AEP event were much closer to a 1% AEP event after NOAA's Atlas 14 update. Both Harris County and the City of Austin updated their regulations to reflect this updated understanding of risk – setting freeboard and other development requirements to a .2% AEP Design Flood Elevation (DFE) instead of the 1% Base Flood Elevation (BFE) based on the current effective FIRM.

3. *Continuous public communication of risk, as the data and science are being updated, is critical in order to empower residents to reduce their risk and to build public will for greater action and higher standards.* Harris

County and Houston built support for higher development standards in part by communicating risk clearly and consistently to the public and by including the professional building community in the process of updating the development standards. This transparency has generated public will for more action.

4. *No single approach to risk reduction can adequately address a region's needs now and in the future.* Development standards should be considered alongside a suite of other mitigation methods. Comprehensive regional planning and visioning is key to identifying the suite of policies, programs, projects, and coordinated implementation pathways that will holistically reduce risk and increase resilience. Several efforts (including *Resilient Houston* and recommendation reports produced by the Greater Houston Flood Mitigation Consortium) have served to identify comprehensive approaches in Houston and Harris County.

1. FREEBOARD

Freeboard generally refers to the elevation of buildings above the 1% AEP flood, also known as the Base Flood Elevation (BFE). These standards are often written in shorthand, such as BFE+1 (base flood elevation plus one foot of freeboard). Requiring buildings be elevated to higher freeboard standards is a critical policy tool to reduce flood risk to structures, and is increasingly becoming a mandatory component of building code updates, insurance program requirements, and other post-disaster programs benefitting property owners.

The term "freeboard" was historically used to describe the distance between the waterline and the main deck of a ship, but is now a standard engineering term used by FEMA and floodplain managers nationwide for building elevation requirements above the BFE. However, not all codes reference the term "freeboard." Indiana, for example, calls their two-foot requirement "Indiana Flood Protection Grade" (Indiana Department of Natural Resources Division of Water, 2018) A similar, more accessible approach could be taken here – for example, a requirement to build new homes to "Louisiana Flood Protection Grade" might be preferable to the public.

Higher freeboard standards have been recommended in previous statewide documents from the Coastal Protection and Restoration Authority and the Office of Community Development. The 2017 Coastal Master Plan's Flood Risk Resilience Program Policy Recommendations state that "it is recommended that [Louisiana State Unified Construction Code Council] and local parishes continue to adopt updated standards and, based on the potential for increasing risk, consider new higher ordinances or regulations above minimum requirements. The LSUCCC and local parishes must maintain minimum disaster related provisions of the adopted model code, including freeboard provisions, for the most current versions of the International Building Code and International Residential Code when updating the building code. Adopting higher regulatory standards such as increased freeboard, additional levels of protection for structures behind levees, or cumulative substantial damage tracking requirements must be strongly considered." (CPRA, 2017) Similarly, the Louisiana Watershed Initiative's Phase 1 Investigation, *Louisiana Statewide Comprehensive Watershed Based Floodplain Management Program Development,* stated that "Encouragement of the LSUCCC, on the part of state agencies, to pursue an amendment for higher minimum standards (e.g. freeboard) presents one potential opportunity to draw parish codes and regulations into deeper consistency with the 2017 Coastal Master Plan" (LWI, 2018) These themes were echoed by stakeholders during the LWI 2018 Statewide Listening Tour, where program documents outlining policy themes concluded that "the state should consider standardized policy measures such as BFE+1, zero net fill, and zero impact that establish a sound foundation for future community growth and development while achieving consistency across watersheds" (LWI, 2019).

COST BENEFIT RESEARCH

Freeboard is widely considered to be the single most effective method to reduce flood risk to structures in the floodplain. The National Institute of Building Sciences (NIBS) *National Hazard Mitigation Saves: 2019 Report* is the most exhaustive source of benefit-cost analysis data for natural hazard mitigation (Porter et al., 2019). This report found positive benefit-cost ratios (BCR) for elevations up to five feet above BFE. Not only are these

elevations cost effective, but the BCRs are well above the 1.0 threshold – nationwide, building even to elevations of BFE+5 has a BCR of 4.7. This means that for every dollar spent in elevating new homes to BFE +5, society saves $4.70 in flood costs avoided.

The report also examined representative typologies of counties for a more detailed study. In each county studied, all BCRs for BFE+2, +3, +4, and +5 were greater than 3.5. Two of the counties examined in the detailed study, Monroe County and Fulton County, are both in Georgia, and are analogous to the rural and urban parishes of Louisiana, respectively. Monroe County is a small rural county between Macon and Atlanta, with a population of approximately 27,500. Nearly four in five homes are owner-occupied. Fulton County is home to urban and suburban Atlanta and has a population of approximately one million. Half of Fulton homes are owner-occupied. The benefit-cost analysis for these counties examined a selection of homes with a mix of foundation types in the 0.2% (500-year) floodplain.

Monroe County had the highest benefit-cost ratios among the counties sampled. To explain why, the study team analyzed foundation type in a regression analysis, and found that Monroe County's open foundations (such as a pier and beam foundation) were statistically significant and could explain the high BCRs. Fulton County also had high BCRs in the analysis, with a BCR of 4.21 for BFE+2. The full benefit cost information is presented in Figure 1. The costs reference the specific costs to elevate the homes in the sample above BFE+1, the minimum standard in the 2015 International Building Code. **In summary, this examination of rural and urban county typologies showed that elevations and open foundations provide significant benefits over the costs of construction.**

Monroe County, Georgia

Height	Cost	Benefit	BCR
BFE +2	$ 185,855	$ 1,619,143	8.71
BFE +3	$ 270,575	$ 2,868,257	10.60
BFE +4	$ 359,165	$ 3,450,872	9.61
BFE +5	$ 452,175	$ 3,826,023	8.46

Fulton County, Georgia

Height	Cost	Benefit	BCR
BFE +2	$ 3.5 M	$ 14.8 M	4.21
BFE +3	$ 5.2 M	$ 28.5 M	5.40
BFE +4	$ 7 M	$ 39.7 M	5.65
BFE +5	$ 8.9 M	$ 48.7 M	5.44

Figure 1: Freeboard (BFE+), Construction Cost, Benefits (direct damages avoided) and BCR information for Monroe and Fulton Counties as detailed in Porter et.al., 2019.

An analysis looking at how freeboard performed in hurricane surge conditions found similar results (Porter et al., 2019). In Louisiana's coastal V-zone specifically, benefits increase more than costs for every foot of freeboard added up to 10 feet above BFE. This is the point where the last incremental improvement in the design cost-effectively captures the last incremental benefit, called the incrementally efficient maximum, or IEMax. This means that even elevations up to BFE+10 are cost-effective in coastal V-zones. Open foundations are a statistically significant contributing factor to high BCRs in this coastal analysis as well.

The costs of elevating a structure during construction typically adds approximately 1% of the cost per foot of freeboard, varying from 0.25% to 3% per foot depending on the type of foundation (Jones et al., 2006). This is significantly less than the cost to elevate an already-existing structure. Even if future building and contents

damage avoided are not considered, annual flood insurance premium savings are generally sufficient to pay for the costs of adding freeboard. The Association of State Floodplain Managers (ASFPM) states that the insurance savings from building to BFE+2 will cover the increased construction costs after only three years (Association of State Floodplain Managers, 2017). If the community participates in the CRS, flood insurance savings could be even higher.

The *National Hazard Mitigation Saves* study also examined how costs and benefits were distributed among stakeholder groups, including developers, title holders, lenders, tenants, and the broader community (Porter et al., 2019). For all mitigation methods examined in the study, they found that net benefits to all stakeholder groups were positive. While some groups reaped higher benefits than others, no group incurred costs without corresponding benefits.

These cost-benefit analyses pertain to new construction, not to retrofit projects or repairs of a damaged home. The NFIP requires that participating communities track cumulative damage and improvements to homes, and that freeboard requirements be enforced if existing homes are substantially damaged or substantially improved. The specific costs and benefits of elevating a damaged home post-disaster may vary from the analyses presented here, and the costs of elevation, in particular, may be burdensome to homeowners who have experienced flood damage. This affordability tradeoff is discussed at the end of this section. Additionally, the analyses from this national literature may not apply to a given structure based on its location, characteristics, or underlying risk.

LSU and the UNO Center for Hazards Assessment Response and Technology (UNO-CHART) are currently collaborating on a study, funded by Louisiana Sea Grant, that will conclude in February 2022. The study will look at incentives and barriers to increased freeboard in south Louisiana, focusing on three parishes: Terrebonne, Jefferson, and St. Tammany. The study will include the development of a web-based platform to showcase freeboard's new construction cost and flood hazard life-cycle cost at the parcel level. They will also identify potential solutions to non-economic freeboard barriers.

Early research in the study has shown overwhelming cost-effectiveness of freeboard standards from flood insurance premium savings alone, even without the additional avoided losses from flood hazards. As these benefits are realized through increased participation in the CRS program, additional outreach, engagement, and support will likely be needed to extend the economic benefits to those purchasing safer homes with increased freeboard.

As the web portal is rolled out, LWI should examine the results when developing a legislative or regulatory strategy for statewide freeboard requirements.

ALTERNATIVES FOR IMPLEMENTATION

Options for Height Requirements

There are several options for setting a freeboard height requirement. This section will look at three alternatives: BFE+1, BFE+2, and setting different heights based on zones.

BFE+1

FEMA is working to make BFE+1 a minimum standard for communities to adopt. It has been part of the International Codes (I-Codes) since 2015, and as of January 2021, it is the minimum requirement for all CRS communities Class 8 and above.

Currently, Louisiana does not have a statewide freeboard requirement, and only a portion of the Special Flood Hazard Areas (SFHAs) in the state require at least a foot of freeboard. As of 2016, only 33 jurisdictions out of 350 had adopted such a requirement, though that number has increased since then (Chapman-Henderson, 2016).

Freeboard requirements are most commonly set in a statewide building code. The Louisiana State Uniform Construction Code Council (LSUCCC), adopts building codes for the state (State Uniform Construction Code, 2005). They typically adopt the I-Codes one cycle behind their release by International Code Council. In 2018, the LSUCCC adopted the 2015 I-Codes, but amended Section R322.2.1 and R322.3.2 of the IRC, which relate to SFHAs, specifically to remove the BFE+1 requirement (International Residental Code, 2021). It is unclear whether this removal was necessary to avoid superceding local jurisdictions' freeboard requirements that were higher than one foot. The removal did prevent a new freeboard requirement from being implemented where none previously existed.

BFE+1 would provide a significant benefit to residential structures, even in a storm with as much rain as the 2016 floods. FEMA's data from those storms (Figure 2) showed that in the SFHA, nearly 12,000 structures flooded by less than one foot of water (FEMA, 2017a). Even outside the SFHA, another 18,795 structures flooded by less than a foot. If all of those structures had been built with an additional foot of freeboard, 30,690 structures would have incurred minimal or possibly no direct flood damage. The flood events that year exceeded the depthsof a 0.2% annual exceedance probability storm, so the benefits (reduced damage) would be even greater in the more frequent storms seen in Louisiana.

SFHA	Depth	March	August	Total
In	Less than 1 foot	2,232	9,663	11,895
	1 foot to less than 3 feet	2,237	15,635	17,872
	3 feet or greater	1,045	16,437	17,482
	Subtotal in SFHA	**5,514**	**41,735**	**47,249**
Out	Less than 1 foot	4,485	14,310	18,795
	1 foot to less than 3 feet	1,033	10,278	11,311
	3 feet or greater	280	2,323	2,603
	Subtotal Outside SFHA	**5,798**	**26,911**	**32,709**
Totals		**11,312**	**68,646**	**79,958**

Figure 2: Number and flood depth of affected residential structures for March and August 2016 floods in Louisiana (FEMA, 2017a)

BFE+2

The state could set the freeboard requirement higher, at BFE+2. The pathway for implementing this requirement would be essentially the same as BFE+1. However, the requirement would be more effective at averting flood damage.

As mentioned earlier, BFE+1 is the new minimum standard for communities participating in the NFIP. A statewide freeboard requirement of two feet is not common; a handful of states have set this requirement, including Indiana, New York, and Wisconsin (*Floodplain Construction Requirements in NYS - NYS Dept. of Environmental Conservation*, n.d.; Wisconsin Department of Natural Resources Waterways Bureau, 2019). However, based on what is known about Louisiana's current and future flood risk, increasing the elevation requirement to BFE+2 may be more prudent than BFE+1.

In the *Natural Hazard Mitigation Saves* study, the high BCRs resulting from the analysis excluded life safety benefits, as evacuation is encouraged during events where flooding is anticipated in a SFHA. They also excluded these benefits because, in the researchers' words, "the requirement for one foot of freeboard does not represent a sufficient increase in the factor of safety for consideration of life safety," specifically when analyzing costs and benefits of riverine floods (Porter et al., 2019). Simply, BFE+1 is not enough elevation to impact life safety, especially when evacuations are ordered. However, in Louisiana, flooding events can occur suddenly, without time to evacuate. In these events, additional elevation is even more important for factors of life safety.

An additional reason to increase the elevation requirement to two feet is that the higher elevation requirement would, in part, mitigate the uncertainty about the state's current and future risk as well as account for how future land use decisions may increase the risk to homes built today. A home built to BFE+2 is more resilient to flooding that could occur from increased exposure to natural hazards, such as more intense storms, as well as flooding that may be exacerbated by surrounding development, changing upstream conditions, or other land use decisions.

The *Natural Hazard Mitigation Saves* report states that "freeboard also addresses inherent uncertainty in the flood data where flood elevations meet or exceed the one percent elevation more frequently than one percent annually." While the 2016 floods were more extreme than a 1% AEP event, over 29,000 homes were flooded by more than one foot but less than three feet of water, as seen in Figure 2. Some portion of these may have still flooded if they were elevated to BFE+2, but thousands would have been spared flood damage. Louisiana is investing in both updated Atlas 14 rainfall data and improved hydraulic and hydrologic modeling that should be able to highlight areas where flood elevations are exceeding the current one percent elevation more frequently, but it may be several years before these model results can be used to set updated development standards. In the interim period, it would be reasonable and cost-beneficial for Louisiana to set a statewide BFE+2 requirement, though a more robust approach would also expand the regulatory geography of the standard beyond the currently delineated BFE (see section "Expanding the Regulatory Geography").

STEPPED STANDARD (SETTING DIFFERENT FREEBOARD HEIGHTS BY ZONE)

The state may also consider implementing a non-uniform freeboard standard given the variations in risk across the state. The most common way to differentiate risks is by the zones demarcated on a Flood Insurance Rate Map (FIRM).

Louisiana already differentiates construction requirements by zone. For the special flood hazard (Coastal A) the standard r322.2.1 language is amended as follows: "In areas of shallow flooding (AO Zones), buildings and structures shall have the lowest floor (including basement) elevated to a height of not less than the highest adjacent grade as the depth number specified in feet (mm) on the FIRM or not less than 2 feet if a depth number is not specified" (17 La. Admin Code Pt 1, 107). The LSUCCC could adopt differentiated freeboard standards by zone.

Harris County, TX set a 3-foot freeboard height above DFE in the floodway and V zones, a 2-foot height above DFE in A zones, a 0.2% AEP DFE in X Shaded Zones, and a 1-foot height above street level in X Unshaded Zones. These regulations only impacted unincorporated Harris County and not the City of Houston (Blount et al., 2019). However, the City of Houston later set even stronger development standards, requiring freeboard of DFE +2 everywhere in the 500 year floodplain (Floodplain Ordinance, 2018). Louisiana could consider a similar approach to higher freeboard requirements in areas of higher risk.

Expanding the Regulatory Geography

The benefits of a freeboard requirement would be maximized by also expanding the regulatory geography to which the standard applies. Many homes damaged in floods lie outside the areas subject to standards like freeboard: in Louisiana's 2016 floods, as noted in Figure 2, 18,795 structures outside the SFHA flooded by less than a foot. Harris County and the City of Houston expanded the regulatory geography of their development standards by applying their new regulations to a 0.2% AEP DFE standard rather than the 1% AEP BFE.

Freeboard requirements are typically enforced using the SFHA (area that will be inundated by a 1% AEP flood event) as delineated on a FIRM. This means that new construction outside the SFHA would not be subjected to

freeboard requirements. Increasingly, however, properties outside the SFHA are seeing flood damage in storms. Guidance on elevating homes produced by the LSU AgCenter in 2008 noted that 25% of flood insurance claims were paid on buildings that were near, but not in, A- or V- flood zones (Skinner, 2008). The 1% AEP storm, or base flood, does not account for less frequent, more severe events. Hence, defining geographic extents for regulations based on the BFE significantly underestimates the geographic extents of flood risk across many areas of the state. In East Baton Rouge Parish alone, over 23,000 properties that flooded in 2016 were in an X zone, or areas outside of the SFHA (City of Baton Rouge & Parish of East Baton Rouge, n.d.). Comparing that figure to the 25,000 properties that flooded in the SFHA, half of the flooding occurred outside the SFHA. Statewide, 40% of homes affected by floods in 2016 were outside the SFHA (Figure 2).

More significantly, many parishes in Louisiana have outdated FIRMs. The average age of a parish FIRM in Louisiana is over ten years. Some parishes have not been mapped in over 25 years (FEMA, 2021a). However, every parish in the state experienced at least one federal disaster declaration due to flooding since 2005 (KALB, 2018). A critical component that informs flood mapping is rainfall frequency data: how much precipitation can be expected based on historic trends? The Louisiana state climatologist, Barry Keim, has studied these trends and found that storms are getting shorter and more intense, resulting in larger volumes of precipitation in a shorter time period (Wendland, 2019). As Louisiana is already the wettest state in the continental United States, it is critical that these meteorological trends are used to update the maps that underpin development regulations. NOAA's Atlas 14 precipitation data were released in 2013; the historical datasets used to inform Atlas 14 ended in 2011 (Perica et al., 2013). Even those data are now ten years behind, and do not reflect the increase in high intensity storms seen over the last decade.

From 2004 until 2009, FIRMs in Louisiana were updated under the FEMA Map Modification program. This program emphasized digitizing paper maps, but not all maps were updated using new, updated, or validated engineering analysis (FEMA, 2006). Parishes whose FIRMs have effective dates within the last ten years may still be using the same underlying data and modeling that was used when the original paper maps were drawn.

LWI is making an unprecedented investment in updated hydraulic and hydrologic modeling for the state, but new statewide maps are still many years away from adoption. In the interim period, Louisiana can consider extending the geographic boundaries where freeboard requirements would apply to areas outside of the SFHA. Louisiana can and should develop a "Louisiana Flood Protection Grade" standard based on the new hydraulic and hydrologic models under development. The standard could be based on either model outputs for 1% AEP flood hazard depths and extents plus freeboard, 0.2% AEP flood hazard depths and extents, or a combination of the two (i.e., the higher of 1% + freeboard or 0.2%, using the 0.2% floodplain extents). This can be established when the model results are available and quality-checked by the state's technical experts without waiting on a FEMA flood risk mapping process.

Interim standards may be appropriate especially in parishes that experience pluvial and fluvial flooding or are in a compound flood "transition zone" (compound coastal and pluvial/fluvial flooding). FEMA's Base Level Engineering products, used as a preliminary step towards updated FIRMs with community input and refinement,

are available for some watersheds in Louisiana. A comparison of the 100- and 500-year flood depth grids with the existing FIRMs shows that the current FIRMs are understating the flood risk in X zones.

For example, the maps below show an area of Gonzales, in Ascension Parish, between Black Bayou, Narcisse Bayou, and Airline Highway (US-61). The FIRM has an effective date of 2007. Figure 3 shows the FIRM: the dark blue is the AE zone, or the SFHA. The light green is the X zone, noted on the FIRM as an Area with Reduced Flood Risk due to Levee. Figure 4 shows the 100 year depth grid from the Base Level Engineering model shows expected flooding throughout the X zone. Figure 5 shows that the 500-year flood depth grid is considerably deeper throughout the X zone.

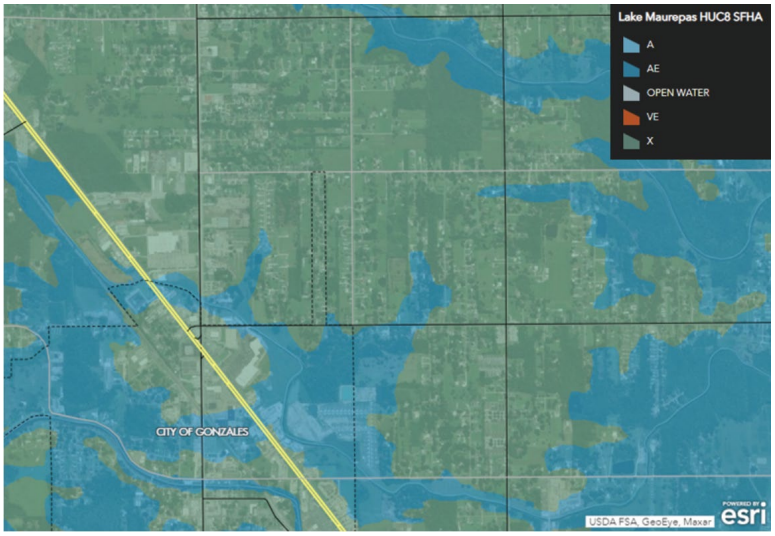

Figure 3: Map of current FIRM zones in Gonzales, LA.

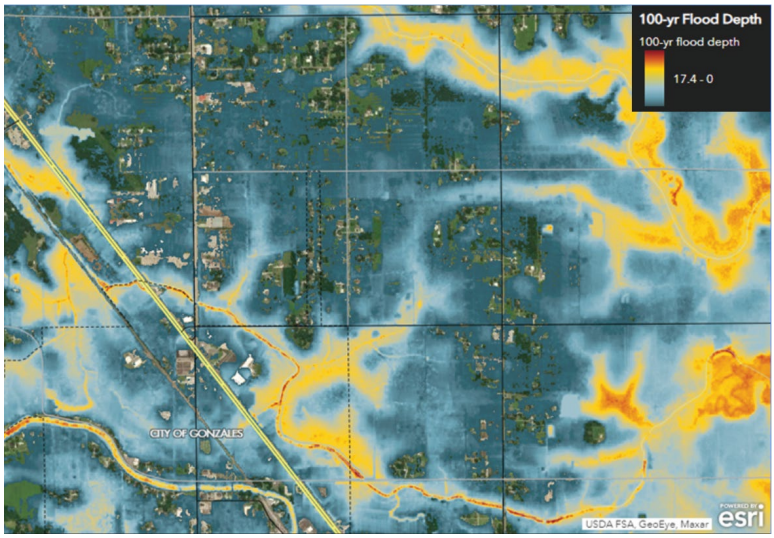

Figure 4: Map of 1% AEP depth grid from Base Level Engineering model in Gonzales, LA.

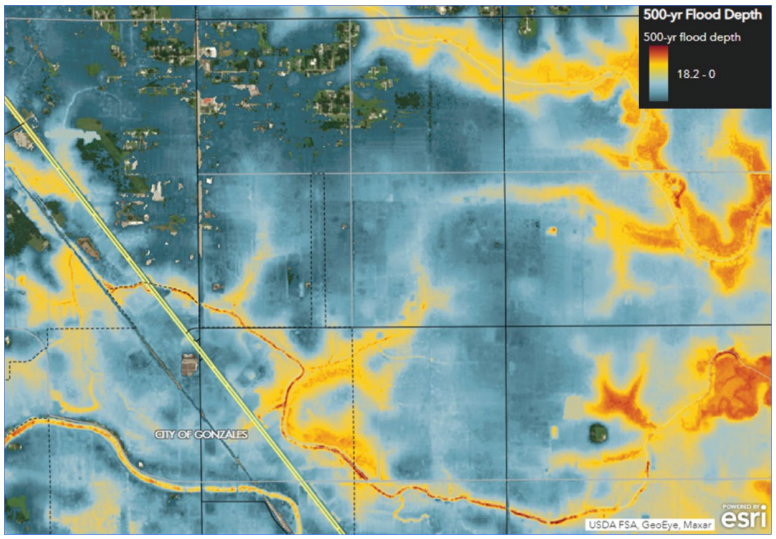

Figure 5: Map of 0.2% AEP depth grid from Base Level Engineering model in Gonzales, LA.

These flood depth grids show that the current maps, when compared to the Base Level Engineering model outputs, are not adequately delineating flood hazard depths and extents. Furthermore, even this BLE modeling may be understating true risk, because the rainfall frequency data used for BLE models do not include the historic rainfall data over the last ten years, including the flooding in 2016. These flood depth grids also do not account for the anticipated future risk from changing frequency or intensity of rainstorms over the next several decades.

In short, applying a development standard to the existing SFHA is insufficient. In south Louisiana and the coastal zone, the SFHA understates the number of properties at risk. Until the state's precipitation data are updated and a better understanding of flood hazards based on the best available science and data can be developed and communicated, it is necessary to expand the geography of any new development standards beyond the existing SFHA, especially in areas with outdated mapping.

This section explores two potential ways to expand the geography by which freeboard regulations would apply to areas beyond the SFHA.

USING A 0.2% AEP DESIGN FLOOD ELEVATION

Louisiana could model the Harris County approach of using the 0.2% AEP event as the new regulatory floodplain where supported by currently available data. Harris County made this decision based on their updated rainfall frequency data from NOAA's Atlas 14, where the rainfall intensity of the 0.2% AEP storm were almost the same as their 1% AEP storm. While Harris County is completing their own modeling and FIRM update process, the new interim standard of using the current effective 0.2% AEP elevation is reasonable based on their rainfall frequency data. The City of Austin took a similar approach to updating their development standards to the 500-year floodplain following the Atlas 14 updates (City of Austin, 2019).

A FIRM denotes the floodway and SFHA (using the 1% AEP floodplain). Depending on the age of the FIRM, X zones, including shaded X zones (the 0.2% AEP floodplain), are noted on the map. FIRMs also note the BFE; a land surveyor can determine the ground elevation for a particular property if no current elevation certificate exists. Figure 6 shows an example of the SFHA, 0.2% AEP floodplain, and regulatory floodway in Franklin Parish.

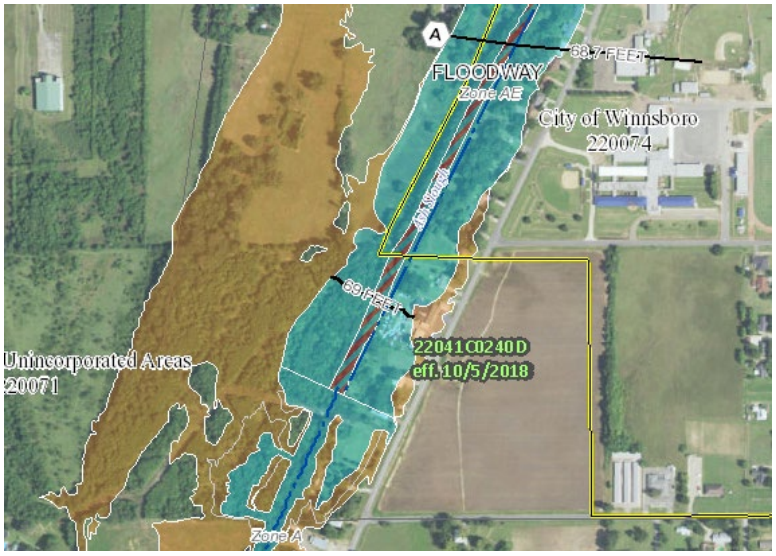

Figure 6: Example of FIRM from FEMA's National Flood Hazard Layer (FEMA, accessed 2021b). *This FIRM, in Franklin Parish, shows the SFHA in blue and the 0.2% AEP floodplain in brown. The regulatory floodway is the red and blue hashed section.*

Because of the wide range of quality of FIRMs, 0.2% AEP floodplains are not mapped everywhere in the state. In some parishes like Ascension and Jefferson, extensive areas are marked as "Zone X – Area with Reduced Flood Risk due to Levee." It is unclear whether these areas are within the 0.2% AEP floodplain, though similar maps in St. James (adjacent to Ascension) and Orleans (adjacent to Jefferson) mark these areas as the 0.2% AEP floodplain.

Setting regulatory standards to a design flood elevation based on the 0.2% AEP event could be accomplished through regulation or through statute. However, because the 0.2% AEP floodplains are inconsistently mapped throughout the state, this would be more difficult to implement and enforce in Louisiana than it was in Harris County, where all the 0.2% AEP floodplains are mapped (and available to the public at https://www.harriscountyfemt.org/). In some parishes, the entire developed area is within the 0.2% AEP floodplain.

EXTEND A ZONE GEOGRAPHY BASED ON BFE + FREEBOARD REQUIREMENT

In the parts of Louisiana with outdated or incomplete mapping, a different approach may be necessary to account for a wider risk geography. Following Hurricane Ike in 2008, the FEMA Mitigation Assessment Team recommended that, until new flood maps were available and adopted, new construction, substantial improvements, and repair of substantial damage should require the freeboard specified in ASCE24-05 *Flood Resistant Design and Construction* (since updated to ASCE24-14) **plus 3 feet**. The team also recommended enforcing Zone A design and construction standards (including freeboard) in the area between the SFHA

landward limit and a ground elevation equal to the adjacent Zone A Effective BFE plus freeboard (recommended in that report as 3 feet), shown in Figure 7 below (FEMA, 2009a). The LSU AgCenter also recommends that homeowners outside but near an A- or V-zone elevate to or above the nearby BFE (Heil and Skinner, 2007) Using a similar "bathtub" approach to extending the regulatory geography in which freeboard standards would apply may be a more feasible option.

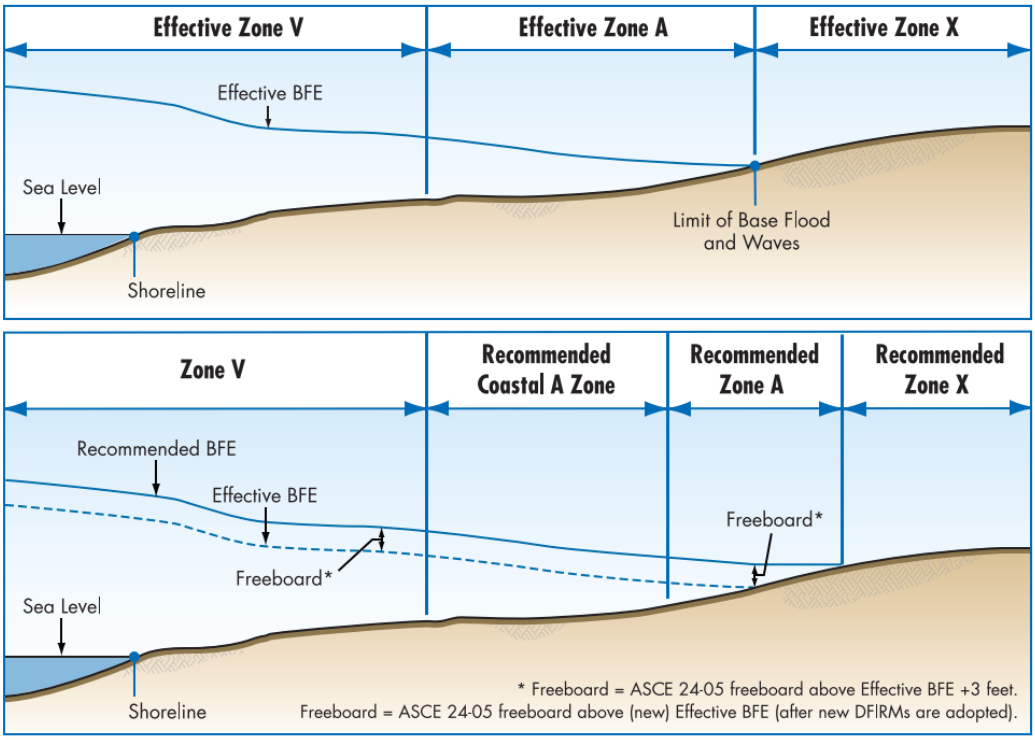

Figure 7: Diagram showing the effective expansion of the A zone using BFE + Freeboard. Source: FEMA 2009. P-757 Page 7-3

A hybrid approach could also be considered. The standard could be based on the higher of model outputs for 1% AEP flood hazard depths and extents plus freeboard or 0.2% AEP flood hazard depths plus freeboard.

TRADEOFFS AND CONSIDERATIONS

Authority – State, Regional, Local or Parish

Currently, several parishes and some municipalities have set freeboard standards higher than the BFE. The state building code council has specifically avoided adopting residential standards that require freeboard above BFE.[1] Should the regulatory or legislative will exist to make changes to the statewide freeboard standard or to floodplain triggers for the building standards, that could be accomplished either through regulatory changes made pursuant to La. R.S. 40:1730.21 *et seq., or* through a legislative act ordering amendment to the state

[1] *See* 17 LAC, Pt. I, Sec. 107.

building code like the process used to amend the state plumbing code by Act 836 of the 2014 Regular Legislative Session.

The Regional Watershed Management Guidebook, prepared for LWI in October 2020, examines which entities in the eight watershed regions of Louisiana have the authority to amend local building codes, enforce building codes, adopt new land use and zoning standards, and enforce land use and zoning standards (LWI, 2020). Nearly without exception, this authority remains with parishes or municipalities. Some regional structures under consideration, such as water conservation districts or watershed special districts, are authorized to develop or enforce some portion of building, development, and land use in a limited jurisdiction.

LSUCCC AND BUILDING CODE UPDATES

Improvements to the state's building code for flood protection could be accomplished via statutory and regulatory change. The LSUCCC has not been meeting during the COVID-19 pandemic and may need additional legal opinions or a directive from the legislature to add freeboard in the next code update.

The legislature could set high level parameters of what they would like the LSUCCC to consider; for example, using the 0.2% AEP floodplains and setting interim freeboard standards that can be reviewed periodically for state regulatory purposes. The legislature undertook a similar process in 2014 via Act 836 to add the state plumbing code to the purview of the LSUCCC (Louisiana Department of Health and Hospitals, 2015). The LSUCCC would then be responsible for determining the specifics of that implementation in the state's codes.

COMPLEMENTARY STATE EFFORTS TO UPDATE BUILDING CODE

Freeboard is not the only building code component that needs updating. Energy efficiency standards, removed from the state's last update to the building code, need to be addressed as well; making buildings more efficient will be an important strategy to reducing Louisiana's greenhouse gas emissions, a priority of Governor Edwards.[2]

These necessary changes to the state's building code will require coordination with the Governor's Office of Coastal Activities (GOCA), where staff are leading the planning of the Climate Initiatives Task Force. Given the multiple changes to the building code that need to be addressed in upcoming years, and the potential for legislative direction to the LSUCCC, LWI should coordinate with GOCA on climate-related code updates.

CRS Considerations

CRS communities can receive up to 500 points for implementing freeboard standards, depending on the level of freeboard required and whether or not fill is regulated (FEMA, 2017b). 500 points is equal to moving up one class in the CRS program. For every 500 points earned, owners of structures in the SFHA receive a 5% discount on their premium, up to 45%.

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[2] Executive Order JBE 20-18. Available at: https://gov.louisiana.gov/assets/ExecutiveOrders/2020/JBE-2020-18-Climate-Initiatives-Task-Force.pdf

Growing or Shrinking Region

Not everywhere in Louisiana is growing in population. Because freeboard requirements apply mostly to new construction, the rate of uptake will vary considerably depending on levels of population growth and associated construction of new homes or commercial buildings. In 2018, Louisiana issued a total of 15,835 building permits. Ten parishes contributed over two thirds of those permits: St. Tammany, East Baton Rouge, Calcasieu, Tangipahoa, Orleans, Lafayette, Ascension, Livingston, Bossier, and Jefferson. In contrast, that same year, three separate counties in Texas each issued more building permits than the entire state of Louisiana. Harris County alone tallied over 34,000 permits. East Baton Rouge Parish, the parish that issued the most building permits from 2010-2019, issued 12,720 permits over the whole 10-year timespan (United States Census Bureau, 2021). Figure 8 shows the ten parishes in the State that issue the most building permits; these ten parishes account for almost 70% of the total residential building permits issued.

Residential Building Permits	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	10-yr Total
East Baton Rouge Parish	1,129	1,219	1,070	1,220	1,464	1,475	1,340	1,179	1,336	1,288	12,720
Lafayette Parish	689	739	1,229	1,372	1,812	1,949	1,190	1,253	1,255	1,162	12,650
St. Tammany Parish	578	789	942	1,193	1,315	1,255	1,411	1,438	1,430	1,635	11,986
Calcasieu Parish	910	1,149	548	1,097	1,263	987	1,512	1,839	1,324	1,318	11,947
Orleans Parish	1,080	1,094	966	895	1,026	496	608	660	1,303	1,306	9,434
Bossier Parish	956	1,108	1,273	1,287	1,347	557	680	660	658	640	9,166
Ascension Parish	711	719	871	907	926	853	857	1,046	936	862	8,688
Livingston Parish	812	846	1,017	647	703	747	733	835	799	920	8,059
Tangipahoa Parish	526	575	587	689	592	627	698	983	1,322	988	7,587
Ouachita Parish	423	383	586	610	704	576	635	612	486	512	5,527
State Total	**11,365**	**12,262**	**13,077**	**14,092**	**15,321**	**13,829**	**14,503**	**15,224**	**15,835**	**15,740**	**141,248**

Figure 8: Residential Building Permits of Top-Growing Parishes, 2010-2019 (Source: US Census Bureau)

With total housing units of just under 2.1 million in Louisiana and a slow rate of new construction, standards that only apply to new construction will take many decades to have a significant risk-reduction impact. While these standards are still critical for all construction going forward, additional resources dedicated to retrofits and buyouts will be needed to ensure the safety of people living in higher risk areas. New development standards are necessary but not sufficient to address existing risk.

Affordability for LMI Homeowners with Substantial Damage

The least costly time to elevate a home is while it is under construction. After a disaster, when damage is widespread and the prices of both materials and labor are bid up because of increased demand, bringing damaged homes into compliance with updated building codes can be costly for a homeowner. Homes that are substantially damaged (where the cost to repair the structure exceeds 50% of the pre-disaster market value of the home) would be required to meet or exceed a freeboard standard. Depending on the age of the home, foundation type, and geography of the area, this post-disaster elevation requirement could be prohibitively expensive for a homeowner to undertake.

Additionally, as overall structure elevation increases, a number of other factors must also be considered. At higher elevations (above 3-4 feet), for example, a house may be further exposed to hurricane wind damage and

may need further reinforcement. In addition, new means of access must be constructed for high-elevation homes (stairs, ramp, or elevator), a particular concern for elderly and disabled populations.

Enforcement

Elevation requirements are typically enforced at the parish level through elevation certificates as a condition for a building permit. An elevation requirement is only useful, however, if it is enforced. Parishes in Louisiana, have very different levels of capacity or technical resources to administer, track, and enforce these requirements. That said, the parishes that are experiencing the highest rates of growth and development are also the parishes that may have the greatest capacity to administer these types of regulations, such as St. Tammany and East Baton Rouge.

To ensure compliance with the requirement, the state could encourage or purchase more effective tools for parishes to use in tracking and enforcing not just elevation certificates, but also tracking substantial damage and substantial improvement thresholds at each property. The software tool Forerunner was designed for these specific workflows (Forerunner, n.d.). Currently, there is not a universal portal for elevation certificates, and no statewide structure inventory with those data. The structure inventory being built for LWI modeling could be a starting point, but parishes would be responsible for updating that inventory with collected elevation certificate information when and where possible.

RECOMMENDATIONS

Set Freeboard Standards in the SFHA

Strong freeboard standards are needed to prevent high-risk development. Louisiana should set freeboard standards of at least BFE+2 throughout the SFHA, and it should consider increasing that requirement in flood zones with higher risk levels. This standard would be consistent with actions taken by other states and encouraged by FEMA within the CRS program and the broader NFIP.

Extend the Geography of a Freeboard Standard

Throughout much of the state, the currently delineated SFHAs are not an adequate representation of current flood risk. Louisiana should extend the freeboard requirement to the 500 year floodplains, where mapped. Where 500 year floodplains are not yet mapped, the method of extending the A zone requirements using the BFE+Freeboard method should be used. This would suffice as an interim or advisory standard until a more definitive “Louisiana Flood Protection Grade” could be created based on LWI model outputs. If these interim or advisory standards are created with best available data as soon as is feasible, the final “Louisiana Flood Protection Grade” should not be too different from what parishes have been using as their interim or advisory standard.

Provide Support to Parishes and Communities

Many of the tangible benefits to a freeboard standard are the cash savings on flood insurance premiums for an individual homeowner when they elevate their home, but additional savings can be had when their community participates in the CRS program. State support for communities to join the CRS program and improve their score will help more homeowners realize these savings. The state should prioritize and provide technical assistance to communities seeking to join or improve their CRS score.

Additionally, to support improved adherence to these standards, the state should roll out tools and policies that help speed adoption and enforcement of these regulations. Tools and policies can and should be developed with input from local communities and parishes to ensure they have the capacity needed to implement these standards.

Commit to Regular Updates

As the state continues the process of improving flood risk maps and other products, the height and extent of regulations like freeboard will have to be revisited to ensure they are effectively mitigating risk. For example, if in the future all SFHAs are inclusive of what is now the 0.2% AEP floodplain, the geography of a freeboard regulation can be adjusted. This process of aligning laws and regulations to the best understanding of risk must be continuous for the regulations to be effective.

2. FILL AND FOUNDATIONS

This section will examine the research and implementation alternatives for policies regulating the use of fill and policies specifying the types of foundations that can be used for constructing buildings. One of the goals of the LWI program is to maximize the beneficial functions of the floodplain. In addition to elevation requirements like freeboard, regulations that address fill and foundations help ensure the flow of water through the floodplain.

COST BENEFIT RESEARCH

Foundations in coastal areas must be able to perform several functions:

- Elevate the building above the flood level (including wave action)
- Remain intact and function despite scour and erosion effects
- Provide a continuous load path from the elevated building to the ground, and resist all vertical and lateral loads transferred from the building to the foundation
- Resist flood loads—including storm surge, wave, and floodborne debris—acting on the foundation and on any below-flood level obstructions that do not break away.

Structures can be elevated on several different foundation types. In some cases, the size of the lot or the required elevation above grade make an elevated foundation the only practical alternative. However, in many cases, the developer has the option of either an elevated foundation or slab-on-grade with fill to achieve the required elevation. In addition, elevated foundations can be either enclosed or open. Open foundations can be built on piers (masonry/concrete), posts (wood/steel), or piles (wood, steel, or concrete embedded deep into the ground). Piles are more stable and less susceptible to erosion and velocity effects, and are therefore used in areas outside of the levee system or where there is otherwise concern about water velocity and waves. FEMA provides closed foundation designs up to 8 ft. and open foundation styles up to 15 ft. above ground level (FEMA, 2009b). There are benefits and costs to each foundation type, but not all of these costs and benefits are currently able to be quantified on a community level.

National research found estimates for a slab foundation for an average home to cost approximately $5,200 to $13,000 including materials and labor, but not including the cost of fill to get to the required elevation. Fill costs approximately $30 per cubic yard; a 1,500 square foot slab would require approximately 55 cubic yards of fill for each foot of elevation, which would cost approximately $1,650 per foot, not counting the additional fill required for the slope around the structure. An average pier and beam foundation costs approximately $8,000 to $15,000, including materials and labor (O'Keefe, 2020). Overall, a raised foundation can increase costs by several thousand dollars compared to a slab-on-grade foundation, although the cost differential decreases as the elevation requirement increases, due to the additional fill required. A cost increase of $2,000-$3,000 represents an increase of 1%-2% if total construction costs are $180,000, which is the approximate cost of a "good standard" 1,500 square-foot house according to the 2020 National Building Cost Manual.

In Louisiana, foundation costs can vary from these national estimates, according to discussions with local builders. Under normal conditions, pier and beam foundations might be only slightly more expensive than a slab on grade foundation because of the differences in labor cost. However, pier and beam foundations use much more lumber than slab on grade, and according to the National Association of Home Builders, lumber prices have increased 250% since April 2020 (National Association of Home Builders, 2021). Currently, pier and beam foundations are more expensive relative to slab on grade foundations because of the increased material costs.

However, the main factor in foundation costs in Louisiana is the geology where the structure is built. Soil conditions vary throughout the state, and homes are often built in soils that require the use of pilings or excavation. Piling requirements impact both slab and pier foundations, and are driven by geotechnical conditions as well as municipal requirements. In other words, where pilings are required for a pier and beam foundation, they are also required to stabilize a slab on grade foundation. The addition of pilings can be a significant cost increase. Estimates obtained from Louisiana builders showed that timber pilings can increase the per square foot cost by $5-$10, for a total increase of $7,500 to $15,000 for a typical 1,500 square-foot house. These costs can only be avoided by building on land stable enough to support a slab foundation without pilings.

Even if the costs are slightly higher for a pier and beam foundation, the benefits are significant to both the homeowner and the watershed. A major benefit of open foundations is the relative lack of fill material needed to bring the home to the required elevation. Fill within the floodplain reduces the amount of flood storage and has the potential to increase flows BFEs along the bayou. Erosion to banks may result from increased flows, and more people downstream may flood. Fill restrictions prevent this increase in flooding by maintaining existing flows and flood storage. Policies commonly known as “No Net Fill” generally require that any fill used be compensated with detention and storage on the same site.

There are several cost components to fill ordinances. These include both the increased cost of construction as well as the cost of enforcement. If fill is completely prohibited, then builders will have to build raised construction, which costs more than slab-on-fill construction as described above. If fill is allowed, but an equivalent or greater amount must be removed from the lot (No Net Fill), builders have two options: either they can create and follow a fill plan, which removes the equivalent amount of fill from the project site, or they can build with a no-fill option in lieu of a fill plan (raised construction). In some cases, depending on the size of the site and the required elevation above ground, raised construction may be the only viable option. Both of these options involve increased costs. As discussed above, the increased costs of pier and beam foundations arise from the increased materials and skilled labor required. A fill plan requires detailed engineering and can cost between $500 and $1,000; the costs of implementing the fill plan will vary greatly between sites (S. Schenk, personal communication, November 6, 2020).

Costs of fill can also be driven by tapering requirements. Projects funded by the U.S. Department of Housing and Urban Development (HUD) are subject to these requirements, and they have also been adopted by municipalities such as the City of Mandeville in St. Tammany Parish. HUD’s handbook for site grading and drainage guidelines requires a minimum fall of six inches away from the structure in ten feet. If a home was elevated three feet above grade using fill, under these requirements, that fill would have to extend more than

fifty feet out around the house (HUD, n.d.). Where these tapering requirements are in place, the cost of fill goes up, and the use of fill is limited by lot size. A developer building an entire subdivision could choose to fill and grade the entire area, but this would be both a significant up-front cost to the developer and may be prohibited by other ordinances or practices at the municipal or parish level.

The benefits of foundation requirements, freeboard, and fill restrictions are interrelated. Freeboard requirements without fill restrictions or foundation requirements will likely lead to additional fill within the floodplain, reducing flood storage capacities. A reduction in an area's overall flood storage will lead to increased flooding, over and above the current mapped levels both inside and outside of the SFHA. For these benefits to be quantified, modeling must be conducted to estimate flood levels in a particular floodplain or subbasin with- and without- the flood storage that would be lost to fill. Requiring open foundations and/or prohibiting slab foundations can also unify the look and feel of an area, leading to an improved sense of place and higher overall property values. Traditional architectural styles in most southern states often include pier and beam foundations left open, so this look can offer cultural appeal and community value. However, the drawbacks of freeboard requirements related to mobility and ADA compliance may be more pronounced with pier and beam foundations because the driveway or garage is less likely to be on the same level as the home, requiring increased costs of ramps for ingress and egress.

Another community-level cost of requiring pier and beam foundations (either directly or indirectly via fill restrictions) is the effect it could have on small homebuilders or developers. Not all homebuilders who currently build slab-on-grade structures may be capable of switching to pier and beam construction without assistance.

ALTERNATIVES FOR IMPLEMENTATION

No Fill (in certain areas)

Under the NFIP, any construction that encroaches on the regulatory floodway must not increase flood heights. This prevents cumulative development from impacting the flood height within the floodway. Similarly, fill prohibitions are more common within the floodway, as they can obstruct flood flows (FEMA, 2017b).

Louisiana's topography, particularly in the southern reaches of the state, is mostly flat, and thus even small changes in fill can impact surrounding developments upstream and downstream. This is particularly relevant in areas that are at risk of pluvial and fluvial flooding. Some parishes have limited the elevation of fill on individual properties, or implemented No Net Fill (NNF) ordinances that require compensatory excavation, but prohibitions on the use of fill within the floodway have not been proposed. However, a simplified policy of no fill in a floodway might curtail development in floodways altogether, or encourage the use of open foundations to satisfy freeboard requirements in the floodway. Either outcome would increase the safety of new structures.

Additional modeling could provide locations for fill prohibition beyond the floodway, including parts of the flood fringe susceptible to increasing flooding. One drawback to this approach is that parishes have varying amounts of regulatory floodways in their jurisdictions. Ascension Parish, one of the fastest growing parishes in the state,

has no floodways; Lafayette Parish, as seen in Figure 7 below, has many. A prohibition on fill that is limited only to floodways may not impact enough new development to make a meaningful difference. FEMA recommends evaluating all riverine floodplains as if they were floodways, conducting encroachment certifications to ensure development will not increase flooding on other properties. If a fill prohibition were treated similarly, parishes like Ascension might find that prohibiting fill within the entire SFHA would be appropriate based on their streams and bayous.

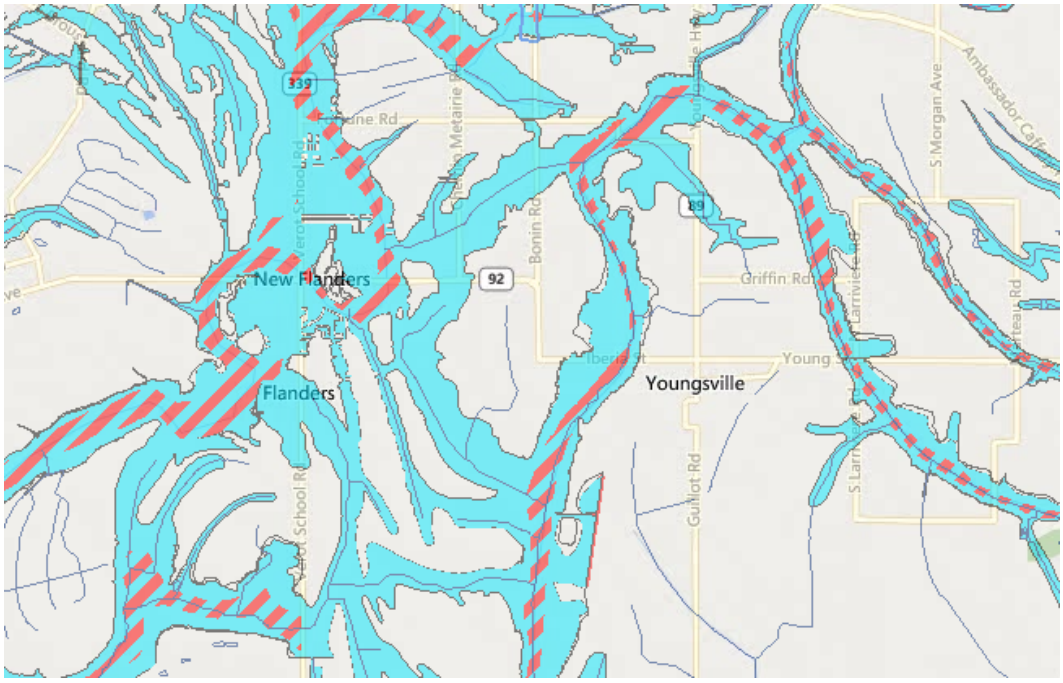

Figure 9: Portion of Lafayette Parish FIRM, Red hashes show the regulatory floodways; the blue areas are the SFHA (LSU AgCenter and LA DOTD, n.d.).

No Net Fill

No Net Fill is a policy regulating the placement of any fill material that results in any increase in the surface elevation of property from its natural or pre-development state by allowing fill to be placed on a portion of the lot if fill is removed from another portion of the lot.

Seven parishes in Louisiana currently have NNF ordinances: Ascension, Calcasieu, Lafayette, Livingston, East Baton Rouge, St. Tammany, and Terrebonne (CPRA, 2017). St. Tammany's NNF ordinance requires that detention be designed for the 100-year (1% AEP) flood, whereas the other six require that detention be designed for the 25-year (4% AEP) flood. These seven parishes represent just under 50% of the building permits issued in the State over the past 10 years.

The design of a NNF ordinance should consider both the size of the developments bound by the ordinance as well as the storm used to evaluate the volume of detention needed. It should also consider the development trajectory of surrounding areas, particularly along jurisdictional boundaries. Interview findings highlighted that if a NNF ordinance is in place in one jurisdiction but not in an adjacent one, landowners and developers may 'shop'

for the simplest set of rules or the lowest cost to develop. In particular, commercial developers that have to consider commercial fire codes as well as the requirements of the Americans with Disabilities Act may find elevation and net fill requirements onerous to follow within their preferred lot size. With consistent NNF policies across jurisdictions, the cost of doing business would also be relatively consistent.

Even in places with NNF policies, developers of new subdivisions can choose between building a larger detention for the entire development, or letting each individual lot owner or builder address their own drainage. This impacts both up-front costs and long-term maintenance. In cases where the developer has passed control of the drainage off to the homeowners association, there may not be enough funding to maintain the infrastructure over time, after which the homeowners may request that the parish or municipality step in to take ownership and maintenance of the drainage infrastructure. If the parish controls this infrastructure from the outset, they can set standards for its construction and plan for the cost of its maintenance over time. These disputes over detention design and maintenance have led to legal disputes in Louisiana (Mitchell, 2020). Stipulations on drainage ownership and maintenance should be considered as part of NNF policies.

Drainage infrastructure for individual subdivisions may also be inadequately sized to handle increasing future rainfall volumes, particularly if accounting for climate-related impacts. Additionally, in compound flood zones, the location of detention basins and other flood storage is important, as certain types of storm events may overwhelm storage that is downstream in the watershed. These regional and watershed-based considerations for detention and storage cannot be resolved at the subdivision level with a NNF policy.

Require Pier and Beam or Other Open Foundation

Limitations on fill have impacts on foundation types. If the use of fill is restricted and development continues in that area, open foundations will be used by necessity. However, open foundations can still be specified on their own, without merely inducing their use through a regulation of fill.

After Hurricane Harvey and a series of devastating extratropical storms, Harris County updated its stormwater management regulations to include foundation requirements. Since 2018, they have required pier and beam foundations in the floodway, V zones, A zones, and AO zones. Previously, in A and AO zones, any foundation types were allowed (Blount and Smith, 2019; Adoption and enforcement of emergency wind and flood mitigation requirements, 2006).

Analogous action in Louisiana would need to happen at the parish or municipal level due to home rule provisions. However, a statewide floodplain management ordinance or legislation could also mandate foundation type based on mapped flood zones, similar to Harris County. The legislature has pushed down flood and wind regulations before; for example, specifying that “the wind and flood requirements prescribed by the 2003 International Building Code… shall apply within the parishes of Calcasieu, Cameron, Vermilion, Iberia, St. Tammany, Orleans, Jefferson, St. Bernard, Plaquemines, Terrebonne, and Lafourche” (La. Stat. Ann. § 40:1730.27). State standards are adopted and amended from national standards, but passed to local parishes and municipalities for enforcement. However, the local enforcement must be consistent with the state standard.

Freeboard requirements without addressing fill or foundation may encourage tall mounded foundations or other unsafe development styles that negatively impact neighboring properties and impede the natural functions of the floodplain. Slope and tapering requirements, as discussed in the freeboard section, can lessen this dynamic if fill is still preferred for the site.

Incentivize Pier and Beam or Other Open Foundation

New regulations that would require open foundations may face pushback in parishes where slab-on-grade construction is common and expected. An incentive program could be designed at a parish level, structured either positively (tax incentive or writeoff) or negatively (fine or fee for a slab). The design and administration of such a program would be a complex undertaking, and would require additional study to determine if developers or homebuyers would be interested in such a program.

Prohibit Slab on Grade

Rather than requiring a specific foundation type, another alternative is to prohibit slab on grade construction. This would likely go hand in hand with an ordinance prohibiting or limiting the use of fill. Prohibiting this foundation type (and prohibiting new development completely) in a mapped floodway is seen in other jurisdictions.

TRADEOFFS AND CONSIDERATIONS

Authority – State, Regional, Local or Parish

Governing entities that issue permits for development—parishes and home rule charter municipalities—can implement new regulations around fill. LWI regional coalitions may be able to do this in the future, depending on the governing structure of those entities.

Additionally, the state could develop a model ordinance, or example ordinance, for stormwater, floodplain management, and other related topics and encourage or incentivize parishes to adopt it. Stronger regulations around fill could be part of such a model ordinance. A model ordinance would help alleviate multiple land use and development issues, especially for jurisdictions where development regulations are not digitized or contain ambiguous language that is difficult to interpret or enforce. A model ordinance could clarify this language and set a statewide standard. Additionally, some jurisdictions have learned from experience that certain drainage regulations need to be specified, such as specifying that in addition to not raising water elevations of adjacent lots, a new development should also be able to receive water from those lots.

In many places in Louisiana, drainage, stormwater management, fill planning, and other tasks may fall on only one person. A model ordinance would be of great help to these employees if it included best practices in regulations that could be tailored to local conditions.

Growing or Shrinking Region

Parishes experiencing higher rates of growth and development should prioritize limiting fill. Regions or parishes with limited growth in housing stock may not see impacts from such a policy commensurate with its increased administrative burden. However, if a consistent standard were applied, more parishes may find it feasible to administer.

Just as with freeboard, regulations around fill or foundation type are best implemented at the point of construction, not as renovations or retrofits. By the time a new subdivision is built out, it is too late to address the fill and foundations of individual lots and homes—but these cumulative decisions will impact the flow of water within the subdivision or to its neighbors. New subdivisions are not being built at the same rate throughout Louisiana. The places that are experiencing higher rates of growth should put these regulations in place so that their new development will not impede watershed function.

CRS Credits

Regulations prohibiting the use of fill can receive up to 280 points. A NNF regulation can receive up to half of that, because as per the CRS Coordinators' Manual, compensatory storage does not compensate for the adverse impact to the natural functions of the floodplain (FEMA, 2017b). Additional points are provided under the freeboard category if fill prohibitions are also included, as this necessarily leads to open foundations that allow the flow of water.

Modeling Analysis vs. Consistent Standard

NNF ordinances require professional engineering analyses to determine the volume of detention required. These analyses may increase the costs of development, though not by much: St. Tammany officials reported that the increased cost was only between $500 and $1,000 for a single-family home. Fill plans may also be the source of conflicting opinions about size, placement, and quantity of both fill and detention.

Cumulative impacts, generally, are more difficult to assess. An individual subdivision may not cause a one foot rise in water surface elevation in an engineering analysis, but over time, an individual subdivision may contribute to a cumulative impact that totals a one foot rise or greater.

Enforcement

NNF ordinances usually require a developer to submit a plan for the use of fill along with their other plans to receive building permits. Parish inspectors are needed to enforce these fill plans.

Additionally, working in the field and determining volume and placement of fill can be much different than calculating that volume on a computer, and changes are not always immediately visible. The real-world volume and impacts on detention and overflow could vary from the original plan.

Floodplain Approach Based on Zones

Based on observed building performance in Hurricane Ike in 2008, the FEMA Mitigation Assessment Team recommended that Coastal A Zone design and construction requirements be implemented in all areas mapped as Zone A on the Effective FIRM (FEMA, 2009b). The team also recommended enforcing Zone A design and construction standards in the area between the SFHA landward limit and a ground elevation equal to the adjacent Zone A Effective BFE plus freeboard (recommended in that Report as 3 feet).

Additional analysis of the locations where these design and construction standards could be applied would be required.

RECOMMENDATIONS

Enact No Net Fill Ordinances

Freeboard standards should not be enacted without also addressing fill and foundations. Any parish with a freeboard requirement should have a corresponding NNF ordinance that requires compensatory storage. Parishes may want to regulate fill further; NNF should be seen as the minimum standard.

Prohibit Fill in Regulatory Floodways

The use of fill should not be allowed within a regulatory floodway. Such a prohibition is consistent with FEMA guidance as well as other communities that have set these standards.

Require Pier and Beam Foundations in the SFHA

To preserve the flow of water through the floodplain, open foundations such as pier and beam should be required in the SFHA. This regulation would reduce the likelihood that new development would increase the risk to existing adjacent structures. If the regulatory geography were expanded for freeboard standards, as described earlier, the open foundation requirement could apply to an expanded geography as well.

Provide Support to Parishes and Communities

Many of the tangible benefits to a freeboard standard are the cash savings on flood insurance premiums that an individual homeowner can see in their pocket only when their community participates in the CRS program. State support for communities to join the CRS program and improve their score will help more homeowners realize these savings. The state should prioritize and provide technical assistance to communities seeking to join or improve their CRS score.

Additionally, to support improved adherence to these standards, the state should roll out tools and policies that help speed adoption and enforcement of these regulations. Tools and policies can and should be developed with input from local communities and parishes to ensure they have the capacity needed to implement these standards. A model ordinance should be developed to streamline regulations across jurisdictions.

Homebuilders with less experience with pier and beam foundation construction should receive support and training as needed to transition their business. The Louisiana Contractor Accreditation Institute, a partnership between Louisiana Economic Development and the Louisiana Community and Technical College System, should incorporate and emphasize open foundation construction as a preferred method for building homes in the state (Louisiana Economic Development, n.d.).

3. DEVELOPMENT RESTRICTIONS

While freeboard, fill, and foundation regulations impact new development, another method to consider is restricting development entirely. This land use approach is less commonly deployed, but depending on the risk of an area and other characteristics, may be necessary to improve the safety of adjacent communities or improve the functions of the floodplain.

COST BENEFIT RESEARCH

Retaining open space in the floodplain can reduce future flood damage in two ways. First, with less development in the floodplain, damage to buildings and other assets will be lower during a flood. Second, less impervious surface area in the floodplain reduces runoff, which can decrease peak discharge for rainfall events and lower flood heights. Wilkins et al. (2008) describe a list of possible low- or no-density use zones to consider for comprehensive planning purposes, for example, including Open, Conservation, Preservation, Hazard, Parks, Rural or Agricultural. The authors note that such zoning can provide multiple benefits: in addition to risk reduction, rezoning can provide parks or green space and/or provide conservation value.

Kousky et. al. (2013) found that restricting development can be costly based on assessed values. Easements, which retain private ownership but restrict allowable activities, cost between 40 and 60% of property values based on estimates from an appraisal company. An economically efficient approach to targeting parcels to reduce flood damage would, however, consider both the costs and the effectiveness of reducing flooding for each potential site, ranking parcels according to their benefit-to-cost ratio. Dividing the cost of preservation (property value) by an acre-foot measurement of flood damage to obtain an estimate of the cost per acre-foot of avoided flooding for each parcel; purchasing or restricting development on only those with lower costs per acre-foot would be the most cost-effective approach.

In addition to the direct costs of purchasing properties, there are other, indirect, costs of limiting local development. Properties that are removed from commerce reduce the tax base of a municipality if the owner relocates to a different municipality with lower flood risk. After a comprehensive literature review, Hudson and Botzen (2019) developed a detailed table seen in Figure 10 outlining the benefits and costs of land use modifications for reducing flood risk; these impacts were classified as financial, societal, and environmental.

	Benefits (positive impacts of the policy)	Costs (negative impacts of the policy)

Financial	• Reduced annual expected damage to physical property due to flooding
	  ∘ Due to lower exposure (less valuable assets located in the area)
	  ∘ Due to lower vulnerability (higher level of preparedness due to regulations)
	• Reduced annual expected flood losses due to business interruption caused by flooding
	  ∘ Due to lower exposure (fewer businesses located in the area)
	  ∘ Due to lower vulnerability (the businesses remaining are less likely to be heavily affected)
	• Reduced indirect economic impacts due to flooding
	• Fewer ripple effects into economic activity in other areas, that is, a factory must shut down because it cannot get input materials from a flooded factory
		• Suboptimal land-use
		  ∘ Lost income due to sub-optimal land-use
		  ∘ Cost of purchasing land that does not meet zoning requirements
		• Loss of employment
		  ∘ Average wage
		• Indirect economic impacts
		  ∘ Indirect business losses due to sub-optimal land-use
		• Administrative/enforcement costs
		  ∘ Cost of producing and maintain flood risk maps accounting for changing flood conditions
		  ∘ Costs of hiring staff and transaction costs of enforcing the zoning policy
		  ∘ Start-up and assessment costs
		  ∘ Deadweight welfare loss due to increases taxation to finance the zoning department
		• Cost of employing risk management methods and maintenance costs
		• Change in tax revenue due to changes in economic activity

Societal	• Prevented human welfare impacts by flooding
	  ∘ Dislocation of population
	  ∘ Community disruption
	  ∘ Fatalities and injuries suffered
	  ∘ Intangible emotional impacts
	• Improved level of risk perception/awareness
		• Increased risk awareness
		• Unequal distribution of impacts of land use change across stakeholders
		  ∘ Differences in benefit/cost ratios for the government versus landowners versus. residents

Environmental	• Newly developed eco-system services due to changing land-use patterns (different land-use patterns can promote different eco-system services)
	  ∘ New recreational uses
	  ∘ New landscapes
	  ∘ Increased bio-diversity
		• Negative changes in the environment (e.g., habitat loss)

Figure 10: Benefits and costs of land use modifications for reducing flood risk, from Hudson and Botzen (2019)

Unfortunately, Hudson and Botzen found a paucity of case studies that incorporated all of these benefits and costs; however, those case studies that exist do indicate that zoning regulations offer an overall benefit to society (BCR > 1) when focused on high-risk areas (defined as the 100-year floodplain).

In some parishes within Louisiana, over 80% of the parish is located within the SFHA, making a complete prohibition of development within the floodplain infeasible. A rezoning plan proposed by the Urban Land Institute in the months following Hurricane Katrina that would have taken flooded neighborhoods in New Orleans and converted them wholesale to green space produced significant public backlash ("Plan Shrinks City's Footprint", 2005; Donze, F., 2005). However, an approach that removed currently undeveloped or government-owned properties from commerce could be technically feasible and less controversial.

Following Hurricane Ike in 2008, FEMA's Mitigation Assessment Team stated that state and local governments should encourage siting away from eroding shorelines, acquire erosion-damaged properties, and prohibit reconstruction on those properties (FEMA 2009 Page 7-5).

Floodway Prohibitions

As noted previously in the section on fill and foundations, it is possible to prohibit construction in the regulatory floodway. However, this may not be the most feasible approach given the variations in both mapping and geography between parishes.

The City of Houston prohibits development in the regulatory floodway. Harris County continues to allow development in the regulatory floodway, but they require BFE +3, a pier and beam foundation, and no fill allowed. A similar approach of restricting development to very specific construction types, elevations, and siting may be a better approach for Louisiana.

Regional Land Use Planning and Open Space Conservation

Local and regional land use planning is an important component of a comprehensive approach to flood risk mitigation. Several tools and approaches exist at a local or potentially regional level to conserve open space to reduce future flood damage. Some of these include zoning, development impact fees, and transfer of development rights programs.

Alternative approaches to securing open space to reduce future flood damage include zoning, development impact fees, and transfer of development rights programs.

Conservation servitudes, in particular, may be an attractive tool to collectively limit development in certain areas. A conservation servitude (known in other states as a conservation easement) is a voluntary legal agreement that imposes permanent limitations to development on a privately-owned property for the purposes of preserving its ecological, recreational, scenic, agricultural, historical, and/or open space value. La. R.S. 9:1272 defines these agreements as follows:

> "Conservation servitude" means a nonpossessory interest of a holder in immovable property imposing limitations or affirmative obligations the purposes of which include retaining or protecting natural, scenic, or open-space values of immovable property, assuring its availability for agricultural, forest, recreational, or open-space use, protecting natural resources, maintaining or enhancing air or water quality, or preserving the historical, archaeological, or cultural aspects of unimproved immovable property.

In exchange for preserving land as open space, the property owner may receive tax benefits, incentives, or monetary compensation.

Conservation servitudes could be used to prohibit development in all or part of properties that are at high risk of sea level rise and flooding or that serve critical ecological and water management functions. Such conservation servitudes could be tailored to meet adaptation goals for specific shoreline zones. For example, conservation servitudes could require a development setback or prohibit building in "Wet Zones." In other areas, servitudes

could stipulate partial conservation of forest lands and limits to impervious surfaces. Several states such as Virginia and California are exploring rolling conservation easements, the provisions of which would "roll" upland as sea levels rise and the coast erodes, while allowing for certain activities in the near term (Wetlands Watch, n.d.). Such rolling easements could accommodate future risk as well as facilitate the migration of wetlands and other important ecological buffer zones. LWI compound flood models in the flood tranition zone, when used to assess various sea level rise increments, could be used to assess and implement this kind of buffer zone for ecological or flood risk purposes.

Conservation servitudes are typically less expensive than outright land acquisition and may be more politically palatable than regulatory tools. They also provide a high degree of flexibility, allowing the property owner and servitude holder to tailor the terms to meet each party's specific goals for the land and to address current and future risk. However, this flexibility also comes with the potential drawback of creating a patchwork of preserved lands in areas with many different landholders, and may reduce the land value of the property. Therefore, conservation servitudes may be a more appropriate tool where larger land parcels are owned by fewer individual owners.

Encouraging or incentivizing infill development outside the floodplain may also be a feasible strategy for certain parishes or regions. Mapping areas above sea level was a part of post-Katrina planning in Orleans Parish (Campanella, 2007). Using policy tools to encourage new development in low-risk areas is also a key recommendation of the Louisiana's Strategic Adaptations for Future Environments (LA-SAFE) adaptation plan (Louisiana Office of Community Development, 2019).

TRADEOFFS AND CONSIDERATIONS

Authority – State, Regional, Local or Parish

While floodway prohibitions would fall under the entity regulating land use and the floodplain, other tools could potentially be used on a regional basis, depending on their future authority and governance structure. LWI regional watershed coalitions may want to prioritize the ability to enact servitudes as a region.

CRS Credits

Prohibiting buildings in the regulatory floodplain is worth up to 1,000 points, enough to move a community up two classes (FEMA, 2017b).

RECOMMENDATIONS

Consider Floodway Restrictions

Because so many parishes have extensive SFHAs, restricting development entirely within the floodplain is not feasible. However, regulatory floodways can and should see either higher standards (as Harris County

implemented) or development prohibitions (as the City of Houston did). Rather than enact this statewide, it may be more effective to determine with LWI regions if floodway development restrictions would work in their particular watersheds.

Incorporate Conservation Strategies into Regional Watershed Planning

Regional watershed coalitions should consider the use of conservation servitudes as they develop their regional watershed plans and projects. As development restrictions may be more feasible on a regional basis than within a single parish, the watershed coalitions can examine risks, assets, and opportunities on a larger scale when planning for flood risk reduction. This may be of particular interest to the watershed coalitions representing Louisiana's coastal parishes, who will want to consider the sea level rise impacts on flood depths and extents to understand changes in flood hazards and risks before making decisions about long-range land use plans.

Mitigation Methods: Programs & Policies for Existing Buildings & Communities

While improving the standards for new development is important, it is only a piece of what needs to be done to mitigate the risks people face living in Louisiana. As referenced earlier, Louisiana is not constructing houses at a rapid pace, nor is the state's population seeing the growth in migration that other states have experienced. In short, it would take many decades of new development to see significant mitigation impacts from new development standards alone.

To meaningfully address risk and aid the people living in risky places, Louisiana must offer programmatic and financial support that addresses the places where people live today: the state's existing housing stock and communities. This includes developing better buyout programs that are able to move people out of harms' way and make them whole after a disaster. Additionally, local policies that encourage and standardize green infrastructure according to nationwide best practices can offer additional mitigation, especially for smaller (precipitation volume) storms.

While not considered in this report, retrofit elevation and floodproofing are commonly used methods for addressing existing buildings and communities. CPRA's Coastal Master Plan has outlined a strong need for these mitigation programs in the coastal zone, finding that they are cost-effective mitigation methods where buyouts may not be (CPRA, 2017). Under the right conditions, national literature shows that these can be highly cost-effective methods. Future research guided by LWI program needs should consider program design considerations for retrofit elevation and floodproofing programs across the state, where conditions can vary from the coastal zone analyzed through CPRA's master planning process.

This section will explore two mitigation methods focused on reducing risk for existing buildings and communities:

4. Buyouts
5. Local Green Infrastructure Policy Tools

4. BUYOUTS

The acquisition of floodprone homes or "buyouts" prevent the loss of life and private property from future disaster and reduce the burden on government hazard insurance programs to pay for repeated claims on the same properties. In addition to moving people and property out of harm's way, buyouts can restore the natural function of the floodplain, enhance community amenities through the addition of green space, and increase a community's CRS score, lowering NFIP premiums.

Since the 1990s, buyouts have been a key component of US mitigation practice for reducing residential flood risk. The number of buyouts has increased significantly in recent years following the devastating impacts of Hurricane Sandy (2012), Hurricane Matthew (2016), and Hurricane Harvey (2017) (BenDor et al., 2020). Demand for buyouts is expected to grow as climate-related hazards and damage from floods increases.

FEMA provides the majority of buyout funding through its Hazard Mitigation Assistance (HMA) program. The HMA includes: the Hazard Mitigation Grant Program (HMGP); the Flood Mitigation Assistance Program (FMAP); and the Pre-Disaster Mitigation Grant Program (PDM). As of 2020, FEMA's new Building Resilient Infrastructure and Communities (BRIC) program is replacing the PDM. Properties acquired through FEMA-funded buyouts are deed-restricted in perpetuity to open space or to conserve natural floodplain functions. Since 1993, over 55,000 residential properties have been acquired through FEMA-funded programs (FEMA, 2018).

HUD also supports buyouts through its Community Development Block Grant Disaster Recovery (CDBG-DR) and Mitigation (CDGB-MIT) programs. CDBG-DR and CDBG-MIT grantees can strategically buy out properties in a floodway, floodplain, or disaster risk reduction area and maintain them as green space in perpetuity to take high risk property out of productive use. Both programs, like FEMA HMGP, are tied to disaster declarations. CDBG-DR helps states and communities recover from presidentially declared disasters, while CDBG-MIT funding was provided to grantees impacted by qualifying disasters in 2015, 2016, and 2017 to mitigate disaster risks and reduce future losses. CDBG-DR and CDBG-MIT funding can be used as a non-federal cost share requirement under FEMA's HMA programs to reduce the financial burden of buyout participation for states and communities. A smaller number of buyouts also have been supported through the Department of Agriculture's Emergency Watershed Protection program and the Small Business Administration's disaster loan programs.

COST BENEFIT RESEARCH

Buyouts, though expensive and complicated to implement, are a one-time investment that result in a complete risk reduction. FEMA analyzed over 11,000 structures within the 100-year (1% AEP) floodplain acquired or elevated and found that the average benefits for each project type are $276,000 and $175,000 respectively. Therefore, FEMA considers any buyout that costs less than $276,000 cost-effective and provides a nationwide exemption from benefit-cost analyses for buyouts that do not exceed this amount (FEMA, 2020c).

FEMA has also conducted several Loss Avoidance Studies to determine the losses avoided in a particular disaster following prior hazard mitigation projects. FEMA's investment of $205 million in the coastal areas of Texas for acquisition and elevation of 1,618 properties avoided losses from Hurricane Harvey of more than $330 million (FEMA, 2020a). The investment of $1.6 million in Hancock, Harrison, and Jackson Counties, Mississippi, for the acquisition of 36 properties reduced losses from Hurricane Isaac by $1.5 million, and these properties will continue to accrue loss-avoided benefits from future flood events (FEMA, 2020b).

FEMA's Loss Avoidance Studies only calculated building, contents, and displacement losses avoided. They did not include costs such as emergency response costs, insurance payments, and debris removal, so the actual losses avoided are likely higher than estimated. The National Institute of Building Sciences (2019) conducted an analysis of buyouts over a longer time horizon considering a wider range of costs (Porter et al., 2019). They found that the acquisition of floodprone single family homes totaling $180 billion would generate $1.16 trillion in savings over a 100-year period. Most of the savings would be accrued by averting property damage typically paid for by federally subsidized flood insurance or other disaster programs.

ALTERNATIVES FOR IMPLEMENTATION

Buyout Program Structure

Federally funded buyout programs operate at different levels of government and take different approaches. Individual property owners do not apply directly to FEMA or HUD for buyout funding. They apply through eligible subapplicants such as state agencies, tribal agencies, federally recognized tribes and local governments. Subapplicants, in accordance with federal guidelines, determine the structure of and administer buyout projects (FEMA, 2015a). Program administrators have the discretion to decide which properties are eligible for buyouts and which areas should be prioritized for acquisition (Freudenberg et al., 2016).

The New Jersey Department of Environmental Protection (NJDEP) launched the Blue Acres Buyout Program in 1995 to purchase homes that routinely flooded, establishing one of the country's few standing buyout programs. The program expanded after Hurricane Sandy with the goal of acquiring approximately 1,300 properties in Sandy-impacted areas. The Blue Acres program takes a state initiated approach to buyouts. The state selects areas for buyouts and conducts outreach to identify owners willing to sell in municipalities that agree to participate in the program (Freudenberg et al., 2016). In deciding where to target buyouts, the state considers flood damage from Hurricane Sandy or repeated flood damage from previous storms, clusters or whole neighborhoods of floodprone homes, willing sellers, and support from local government (New Jersey Department of Environmental Protection, 2015).

The State of New York established the NY Rising Buyout program to purchase the properties of interested homeowners whose homes were substantially damaged or destroyed during Hurricane Sandy, Hurricane Irene, or Tropical Storm Lee. NY Rising takes a different approach to buyouts than the Blue Acres program. The Governor's Office of Storm Recovery (GOSR), which administers the program, collaborates with county and local officials to identify contiguous parcels in the most floodprone locations (New Jersey Department of

Environmental Protection, 2015). GOSR provides incentives for group participation in these 'enhanced buyout areas' to prevent holdout households that could result in 'checkerboarding' of bought out properties.

Harris County, TX established a buyout program in 1985 administered by the Harris County Flood Control District (HCFCD) in coordination with the state. From the program's inception through 2017 HCFCD has spent $342 million in federal and local funds to acquire over 3,100 properties in floodplains, making it the single largest program in the country in terms of completed buyouts. Patterson (2018) speculates that the high number of acquisitions is due, in part, to the relatively low cost of land in the county. Homeowners initiate the process by volunteering to participate. After determining eligibility for a buyout, HCFCD submits an application to the State Office of Emergency Management, which is the FEMA grantee for HMGP and FMAP.

State and Locally Financing to Leverage and Supplement Federal Funding

While federal programs provide the bulk of funding for acquisitions, local and state governments are increasingly financing their own buyout programs to leverage and supplement federal resources. State and local buyout initiatives can cover federal cost-share requirements to help maximize access to federal buyout funds. They can also fund acquisitions directly, providing local jurisdictions additional resources and greater autonomy from federal regulations. State and local assistance is essential in communities where flooding is too localized to warrant a federal disaster declaration or properties prioritized for buyouts are ineligible for federal funding.

State and local financed buyout programs utilize a variety of funding mechanisms (Peterson, 2020). At least four states—Maryland, Minnesota, Washington and Wisconsin—have established grant programs to provide financial or technical assistance to local governments for buyouts. Grants are supported by general fund allocations and bond revenue and often require some form of local government cost share.

The State of New Jersey has used bond financing to support its Blue Acres Buyout Program. The program was authorized in through the Green Acres, Farmland and Historic Preservation and Blue Acres Bond Act of 1995. Since that time, the Blue Acres Program has received funding through two subsequent bond acts totaling $68 million for the acquisition of floodprone properties (Freudenberg et al., 2016). Following Hurricane Sandy in 2012, the Blue Acres program was authorized to acquire up to 1,300 private properties with funds derived from FEMA-HMGP and CDBG-DR as well as the Blue Acres Acquisition Fund (Patterson, 2018).

Local government entities including Harris County, TX, Portland, OR, and Tulsa, OK have used municipal or green bonds to fund floodplain buyouts as part of a larger flood mitigation strategy. In Harris County, voters approved a $2.5 billion bond measure in August 2018 to finance stormwater and flood protection efforts. The bond includes $184 million, coupled with $522 million of outside funding, to acquire 3,600 buildings in the floodplain (Despart, 2018).

Several communities, including Charlotte-Mecklenburg County, NC, have directed or are intending to direct portions of their stormwater fee revenues to cover federal matches and directly fund buyouts in floodprone areas. The Charlotte-Mecklenburg Storm Water Services (SWS), a joint county/municipal stormwater utility, developed a voluntary buyout program to reduce flood losses in 1999. For the first 12 years of the program, SWS

buyouts were funded through FEMA programs. In response to circumstances that rendered many floodprone properties ineligible for FEMA funding, SWS created its own Quick Buy program in 2003 supported by a "rainy day" fund to purchase flood damaged homes before residents begin to rebuild. Currently, buyouts are funded almost entirely by local stormwater fees (City of Chartlotte, n.d.).

Other communities have adopted local option sales taxes (LOSTs) to support buyouts and other mitigation activities. Proceeds from the taxes and LOST secured bonds are used to cover cost share requirements and directly fund buyouts. Communities that have adopted LOSTs include Augusta, GA; Austin, MN; Cedar Rapids, IA; Neosha, MO; and Tulsa, OK.

The self-financing of buyouts by municipalities, while promising, could increase disparities in access to federal funds among communities. Smaller and lower-income communities might find it more difficult to impose a new sales tax or issue a bond, remaining heavily reliant on federal resources, but with limited local matching funds (Patterson, 2018). State support is needed to address capacity and resource disparities in the development and implementation of local buyout programs. State support could include matching funds, technical assistance in applying for federal funds and designing buyout programs, supplemental buyout and relocation assistance, and resources to cover the costs of acquiring and maintaining properties.

Supplemental Buyout Incentive & Relocation Assistance

Federally funded buyout compensation is often insufficient for participating homeowners to secure comparable replacement housing in a low risk part of the community or region. Most federally funded buyout awards are based on the post-flood market value of a property. Local administering agencies often have the option to offer pre-storm values instead, but this requires substantially more buyout funding. Even with buyout compensation based on pre-storm market values, many homeowners are unable to move to areas of substantially lower risk given depressed property values in hazard prone areas. Supplemental housing assistance is needed to ensure buyout participants receive appropriate aid and increase participation in buyout programs. This is particularly important for low- and moderate income households and the elderly who are unable or unwilling to take out a mortgage to purchase a replacement home (Nelson et al., 2020).

Federal buyout programs offer a replacement housing allowance in accordance with the Uniform Relocation Act to cover the gap between pre- or post-storm housing values and the cost of comparable replacement housing in an area not prone to flooding. FEMA allocates an initial housing incentive up to $31,000 per property for owners (FEMA, 2015b). CDBG-DR or CDBG-MIT assistance can be coupled with FEMA hazard mitigation assistance to cover housing or relocation costs not allowed under FEMA programs. Coupling CDBG with FEMA funding requires both FEMA and HUD requirements be met for the buyout program.

State and local funds can be used to supplement housing and relocation assistance, and increase buyout participation. The State of North Carolina established the State Acquisition and Relocation Fund (SARF) in the aftermath of Hurricane Floyd (1999) to enhance FEMA buyout compensation that was insufficient for many residents to purchase a suitable replacement home outside the floodplain (Smith, 2012). SARF is used to pay the difference between the pre-disaster fair market value (FMV) of a home being purchased through a buyout and

the cost of a comparable replacement home outside the floodplain in the same general geographic area. Renters involuntarily displaced in an HMGP or state buyout can receive rental relocation assistance for up to 42 months (Easley, 2005).

After Hurricane Matthew, homeowners received up to $50,000 in supplemental assistance through SARF as a five-year deferred loan, forgiven 20% per year (NCDEM, 2019). To increase the likelihood of property acquisition, SARF has also been used to make satisfactory offers to homeowners whose property values exceeded the maximum allowed under FEMA guidelines (UNC Environmental Law Institute, n.d.). Local governments can receive SARF assistance to cover the management costs of property acquisition, including title work, appraisals and legal fees.

TRADEOFFS AND CONSIDERATIONS

Buyouts Take Too Long

The buyout process is time-consuming and complicated. Long wait times make buyouts less accessible and less effective, particularly for those individuals and communities most in need of resources. Weber and Moore (2019), in an analysis of FEMA buyout data, found that the median time from the date of a flood disaster until a buyout project was completed was 5.2 years (Weber and Moore, 2019). In Louisiana, the buyout process took even longer, with a median time of 10 years. Many residents rebuild after filing a flood insurance damage claim while waiting for a buyout, resulting in fewer buyout participants and higher purchase costs. Other homeowners, unable to wait for possible buyout funding, sell to real estate speculators at a loss.

To expedite buyouts, funding and basic requirements can be standardized at the federal level while allowing local flexibility. Local funds can also speed up the buyout process. The Charlotte-Mecklenburg SWS can complete buyouts much faster, typically within 6 months of a flood, through its Quick Buy program (Weber, 2019). Because the buyouts are funded almost entirely by local stormwater fees, they are unfettered from federal procedures and regulations (City of Charlotte, Charlotte-Mecklenberg Storm Water Services, n.d.). In Harris County, TX, county officials have recognized the need for rapid buyouts and have released county funds, as well as funds granted by the City of Houston, to begin the process as soon as possible (Patterson, 2018).

Participatory pre-disaster planning can increase program participation and expedite federally funded buyouts. Planners and local officials need to anticipate the possibility of buyouts and work with community members to develop buyout goals and alternatives *prior* to a disaster (Freudenberg, 2016). Establishing community liaisons can also help build resident trust with local officials and buyout managers and accelerate the buyout process (DeVries and Fraser, 2012).

In Kinston, NC the community developed a predisaster acquisition application after Hurricane Fran in 1996 in the event that there was another storm. When Hurricane Floyd hit in 1999, the community promptly submitted

their application and had buyout funds approved by the State of North Carolina and FEMA within a week (NOAA, n.d.). Three years earlier, after Hurricane Fran, it had taken the community over a year to put together the acquisition application.

The State of New Jersey has been able to relatively quickly acquire over $300 million in floodplain properties through its Blue Acres Buyout program. This success is attributed, in part, to the coordination of multiple state and local entities, the colocation of experts from across levels of government in impacted communities, and the assignment of case managers to each homeowner to help them navigate the buyout and relocation process from application to closing (Patterson, 2018).

Potential Loss of Tax Revenue for Local Governments

Local government support for buyouts is essential to program success. Yet the possibility of lost property tax revenue can limit local government participation in buyout programs. Although buyout programs may have the greatest negative impact on local tax revenues in states that rely heavily on property taxes, the potential of lost property taxes in states that rely heavily on sales taxes like Louisiana can be a significant disincentive to buyout participation (Wiley, 2018).

Properties acquired through buyouts are converted to open space, removing them from the tax rolls. Unless buyouts are offset by new development or increasing property values elsewhere in the community, the tax base will decline. To address concerns about tax losses, local jurisdictions can build new housing in lower risk areas of the community to accommodate buyout participants and encourage them to resettle in those areas through relocation incentives or land swaps.

In New Orleans, LA after Hurricane Katrina, Project Home Again, a non-profit housing organization worked closely with the New Orleans Redevelopment Authority (NORA) to develop and implement a homebuilding and land swap program. Mistrust of local government efforts to guide resettlement and the lack of incentives to promote safer and more concentrated development left homeowners with little choice but to build, or attempt to build, back in place. Within this context, PHA's initiative clustered redevelopment in targeted areas of the city and offered houses to 100 low- and moderate-income households displaced by Hurricane Katrina in exchange for their damaged properties (Nelson, 2014). Landswaps and clustered development strategies are most viable in communities with tracts of developable land or substantial amounts of vacant property under public control.

Finding replacement housing for buyout participants within jurisdictions is difficult in communities with limited options for development outside of the floodplain. Coordination and cooperation between government agencies and across municipality or parish boundaries is needed to plan for and develop viable receiver communities throughout the region.

Need to Minimize Maintenance Costs and Enhance Community Amenities

The long-term management and maintenance of properties acquired through a buyout can be an additional fiscal burden for communities. Maintenance costs vary based on the location and use of the property, but there

are creative strategies that can be used to try to minimize these costs. For example, Harris County, TX reduces maintenance costs by prioritizing land adjacent to existing parks or greenways, as they are easier to incorporate into the existing maintenance schedule and budget.

In contrast, checkerboarding, when vacant lots of open space are interspersed among homes, reduces a communities' ability to develop alternative uses that minimize maintenance costs and create community-wide amenities , such as hike and bike trails, wetlands, and playgrounds. This results in underutilized post-buyout landscapes that require significant municipal funds to mow and maintain. Some methods to reduce maintenance costs include redevelopment of wetlands, community gardens, or low-cost leasing to the adjacent landowner. In New Orleans, NORA, which is responsible for the vacant lots purchased by the Road Home Program following Hurricane Katrina, partnered with landscape architects from LSU to develop strategies for enhancing vacant properties by planting wildflowers, trees, and meadows and installing amenities such as fences and birdhouses. These strategies are aimed at reducing NORA's long-term maintenance costs, as well as beautifying and stabilizing neighborhoods still recovering from Hurricanes Katrina and Rita and improving ecosystem services on NORA properties.

Local governments need to consider the long term fiscal impacts of buyouts and balance the competing goals of mitigation and development when creating buyout programs. Fiscal impact analyses can help local jurisdictions estimate the financial consequences of buyouts and design buyout strategies to minimize local tax revenue losses and enhance community benefits. Recent studies by BenDor et al. (2020) and Freudenberg et al. (2016) offer guidance to municipalities on estimating potential the fiscal impacts of buyouts on their communities.

RECOMMENDATIONS

Establish a Standing/Permanent State Buyout Program

The State of Louisiana should establish a standing buyout program to support locally and regionally led buyout initiatives. Through the program, LWI would work with local officials and residents to identify priority buyout areas and develop buyout projects that reflect community needs while meeting federal and state guidelines. LWI could act as a grantee for federal buyout resources and support parishes and other political subdivisions in applying for federal funds. LWI would also coordinate a statewide support structure to provide shared resources, technical assistance, and supplemental buyout funding. As demonstrated through New Jersey's Blue Acres Buyout Program, the statewide coordination of staff and experts across government agencies can build buyout capacity and accelerate the buyout process.

Establish a State Fund to Support Buyouts

The State of Louisiana should create a sustainably financed fund to leverage and supplement federal buyout resources and support acquisitions ineligible for federal funding. State support is needed to address capacity and resource disparities among communities in the development and implementation of local buyout programs, expedite the buyout process, and ensure homeowners have adequate resources to move to a comparable home

in a lower flood risk area. A state buyout fund could cover cost matches, support pre-disaster buyout and relocation planning, provide resources for local governments to cover the expenses of acquiring and maintaining buyout properties, and support supplemental buyout and relocation assistance for buyout participants and displaced tenants.

Provide Supplemental Buyout Incentives & Relocation Assistance

The minimum buyout and relocation program standards outlined in LWI's guidelines for Round 1 project funding are designed to provide sufficient funding to ensure homeowners interested in participating in a buyout are able to move to areas of substantially lower flood risk than their prior residences. Assistance includes buyouts at current FMV, a housing incentive to cover gap between FMV and cost of comparable housing in a low risk location (up to $250,000 for buyout and incentive), interim housing assistance and moving cost assistance for buyout participants (including owner occupants on non-owned land) and relocation assistance for tenants displaced through a buyout. Exceptions to the individual award cap of $250,000 may be provided at the sole discretion of OCD.

While the support included in the guidelines is essential, supplemental buyout and relocation assistance may be needed to increase buyout participation and effectively and equitably enable buyout participants to relocate to safer areas. Buyout and relocation case management should be included in minimum buyout and relocation program standards. Case management is vital to understand the specific needs and concerns of buyout participants and displaced tenants and to help them navigate the buyout and relocation process.

Support Pre-disaster Buyout and Relocation Planning at the Parish and Regional Levels

The State of Louisiana should support ongoing buyout and relocation planning at the parish level prior to a disaster or major flood event. Meaningful and ongoing participation can build credibility and trust among local officials and residents, increase buyout participation, and expedite buyout processes. Through pre-disaster planning, local officials can convey current and future flood risk, discuss the possibility of buyouts, and familiarize residents with federal and state buyout guidelines and processes. Together, local officials and residents can define buyout and relocation goals, identify potential buyouts areas and relocation sites, and outline recreation and open space priorities to inform the reuse of properties acquired through future buyouts to create and enhance community amenities.

Parish level buyout and relocation goals and priorities should be incorporated into LWI's regional watershed plans to facilitate coordination among local, regional and state agencies and stakeholders. Regional watershed plans should account for future flood risk and identify areas for suitable for future development to facilitate the development of inter-jurisdictional programs to incentivize movement out of the floodplain. Through regional watershed planning stakeholders can also align hazard mitigation, restoration, and recreation priorities to identify buyouts areas that could be integrated into large-scale efforts to restore the natural function of the floodplain while serving recreational and conservation goals.

5. LOCAL GREEN INFRASTRUCTURE POLICY TOOLS

Excess stormwater runoff can be a serious problem for paved areas, causing flooding, water pollution, groundwater recharge deficits, and ecological damage. Many historical solutions have involved large, expensive, centralized infrastructure. However, widespread implementation of smaller-scale green infrastructure measures can also reduce the stormwater runoff and associated flooding and other negative impacts. Green infrastructure measures for stormwater management can include maintaining open space, installing porous pavement, green roofs, rainwater harvesting, retention ponds and infiltration basins, reduced hardscapes, and grassy swales and wetlands. These "passive" stormwater runoff and retention measures restore, protect, and mimic natural hydrologic functions within the built environment while also adding aesthetic and recreational value to local residents.

COST BENEFIT RESEARCH

Green infrastructure is a large category that includes multiple scales of interventions across ecosystem types, with varying degrees of successful implementation over time. As such, costs and benefits are also scaled to the level of the intervention. For example, green roofs, sometimes known as ecoroofs, are an increasingly common best management practice that includes structural and vegetative plantings on a building roof. A 2008 Cost Benefit Evaluation of EcoRoofs found that, over the 40-year life of the ecoroof, the net benefit to the private property owner was over $400,000 and that public benefits in Year 40 were almost $200,000 (in 2008 dollars) (City of Portland, 2008). Private benefits included reduction in stormwater management fees and facility costs, reduced HVAC costs, and avoided roof replacement costs, while public benefits included reduced stormwater management system costs, carbon reduction, improved air quality, and habitat creation.

McPherson, et. al. (2005) reviewed public trees in five U.S. cities and found that for every dollar invested in public tree management, annual benefits ranged from $1.37 to $3.09. Benefits include controlling stormwater, mitigating urban heat-island effect, and carbon dioxide reduction. An EPA case study review found that overall low impact development and green infrastructure approaches can cost less than gray infrastructure alone and result in multiple social, environmental, and financial benefits, such as increased recreational opportunities, air quality improvements, water quality and ecosystem enhancement, creation of green infrastructure-based jobs, increased property values, and reduced urban heat stress; when these benefits are monetized, they exceed costs of implementation (EPA, 2013).

Green infrastructure measures are usually small in scale and have very localized impacts. This makes the benefits of a specific measure or individual project hard to generalize over an entire watershed. Additionally, these measures are most effective for more frequent, low volume "nuisance" flooding. However, they can still be an important part of comprehensive stormwater management strategies. Many green infrastructure solutions can be implemented by private landowners on their own properties; multiple non-profit organizations in New Orleans, for example, already assist residents by removing unnecessary pavement, installing rain barrels, and planting native trees. As of January 1, 2020, these non-profits had planted 125 trees, installed 16 rain

barrels, and replaced over 1,300 square feet of pavement in the Hoffman Triangle neighborhood, thereby preventing 30,000 gallons of water per hour from entering the city's drainage system (Uporsky, 2020).

ALTERNATIVES FOR IMPLEMENTATION

Wider implementation of green infrastructure best management practices will help to slow and store stormwater where it falls. Green infrastructure is an important component of an integrated water management strategy that can reduce risk in Louisiana communities.

Achieving this level of stormwater management and green infrastructure adoption will require multiple policy levers and tools and take a comprehensive and strategic approach to planning. For an accessible and comprehensive guide to green infrastructure implementation, see Georgetown Climate Center's Green Infrastructure Toolkit (Georgetown Climate Center, n.d.). A brief description of policy tools to consider are outlined here.

Incentives

Development incentives such as density bonuses or expedited permits can be a useful tool to encourage green infrastructure installation in areas planned for significant growth and larger scale new developments. Height and density bonuses can be applied in urban contexts for decreasing stormwater runoff and impervious surfaces as well as installing vegetated green roofs. Model program guidelines can shape a more comprehensive green infrastructure incentives program that incorporates more holistic guidelines for green development.

The City of Houston's newly released Incentives for Green Development study may serve as a useful case study (Bloom et al., 2019). This study found that existing development rules and design criteria act as a barrier to green infrastructure implementation and recommends "enacting an integrated set of green stormwater infrastructure development rules that harmonize parking, landscaping, open space, drainage design, detention design, and stormwater quality design requirements." This study compared detailed cost estimates for conventional development designs under existing rules to cost estimates under a proposed suite of integrated green infrastructure design rules and found that the latter may actually reduce overall costs for developers.

Financial incentives, such as grants, subsidies, rebates, and tax abatements, may provide other useful tools to encourage stormwater management and installation of green infrastructure for new and existing development. Houston's incentives study includes recommendations for exploring tax abatements. Financial incentives may also be combined with stormwater fees. The Philadelphia Water Department, for example, charges its customers a stormwater fee that is based on the area of impervious surface on their property. They provide various subsidies, grants, and rebates for residential and non-residential properties that install green infrastructure features and reduce stormwater runoff – including a reduction in the customer's stormwater fee. (City of Philadelphia, n.d.)

Regulations

Some parishes or municipalities could consider going beyond incentives and include certain requirements for stormwater management in the zoning code, building code, or through a stormwater ordinance. Norfolk, VA's Zoning Ordinance, for example, includes a Resilient Quotient System that requires developments to earn a certain number of points by including different resilient design measures, including stormwater management features (City of Norfolk, 2018). Article 23 of New Orleans' Comprehensive Zoning Ordinance includes a requirement that all new developments or significant reconstructions manage the first 1.25 inches of stormwater on site (Landscape and Screening, 2018). Such regulatory tools may ensure more widespread implementation of green infrastructure and stormwater management practices than a purely incentives-based approach. However, they may prove more politically difficult and may require more legislative changes to enact. The state could create a model ordinance that would be responsive to Louisiana's local contexts and encourage or incentivize parishes to adopt and implement it.

Planning & Government Operations

Implementation of green infrastructure should be strategic. Louisiana should take a comprehensive planning approach to green infrastructure as part of an integrated water management strategy, and should seek to incorporate green infrastructure into other state plans. This work is underway with the emphasis on nature-based solutions through LWI.

Louisiana's state agencies, in partnership with local parishes and municipalities, should also work to incorporate green infrastructure and improved drainage features into street design standards and the construction and maintenance of state facilities. Standard details for infrastructure projects can be developed at the state level and implemented at multiple scales. New Orleans' Department of Public Works has valuable experience from implementing and maintaining these types of projects over the last fifteen years that can provide important lessons on design treatments that have been successful in this specific context. New Orleans Redevelopment Authority (NORA) published a report in December 2016 titled Building Resilience with Green Infrastructure that outlines practices that could be replicated across the state.

TRADEOFFS AND CONSIDERATIONS

Authority – State, Regional, Local or Parish

Green infrastructure can be implemented at multiple scales; it can be a component, requirement, or suggestion at every scale, from state agency to parish to municipality. State agencies can include green infrastructure in state construction projects, adjust the design standards of state roadways, and guide strategic implementation at a watershed level. Existing regional structures, like Metropolitan Planning Organizations, can guide the development and implementation of green infrastructure. New regional structures, like the LWI watershed coalitions, may be able to do this depending on their governing structure and the projects they pursue. Parishes

and municipalities can also set policies regarding the design and use of green infrastructure on public and private projects.

Growing or Shrinking Region

While green infrastructure can be applied anywhere, including areas that are not seeing new development, financing projects may be more difficult in areas that are not growing or declining. Communities where more development is occurring have financing options, such as a parcel fee or an impact fee, that could be dedicated to implementing more green infrastructure projects.

CRS Credits

Green infrastructure and low-impact development can improve a community's CRS score, leading to reductions in flood insurance premiums. Multiple activities can earn points, including adding green infrastructure requirements to the building code, open space preservation, and dedicating funding for green infrastructure in a capital improvement plan.

Enforcement

Enforcement of green infrastructure regulations can be a learning curve for engineers and inspectors not trained in its design and maintenance. Just as design, engineering, and construction professionals will need additional training on green infrastructure best practices, a jurisdiction's permitting and public works staff will also need support and resources to be able to effectively enforce a green infrastructure regulation or implement an effective program.

RECOMMENDATIONS

Develop a Model Ordinance and Design Guidelines for Parishes and Municipalities

While implementation of green infrastructure should be responsive to local conditions, standardizing best practices, designs, and policies can be done across a region or state. The state should develop a model ordinance for parishes or municipalities to implement that takes into account both national best practices as well as the lessons learned from implementation in New Orleans and other Louisiana communities. This model ordinance could also include floodplain management policies, if those have not been addressed through statewide action. The state could incentivize the adoption of such a model ordinance through LWI or some other mechanism.

Design guidelines, based on national and local best practices for green infrastructure, would be a helpful aid for communities seeking to implement these kinds of projects for the first time. Guidelines would also be useful information for the state's engineering and design professionals to adequately meet LWI standards for green infrastructure and other nature-based solutions.

Future Research

LWI MODELING PROGRAM DATA

STRUCTURE INVENTORY

The structure inventory that will be generated jointly by the LWI program and CPRA Coastal Master Plan, and used in the LWI consequence models, will provide notable analytical value going forward. When compared to flood hazard data and other information, like demographic information, it will be possible to calculate the number of properties and better understand the demographics and characteristics of households impacted by redrawing the SFHA, for example. First floor elevations, property values, and foundation types could provide fine-grained details on the magnitude and nature of direct damages modeled under specific conditions.

Parishes and municipalities may be responsible for providing and maintaining this information over time, though as with maintenance of numerical models, the maintenance of a statewide structure inventory should be planned for as the inventory would provide benefits to the state over time. For instance, the LWI Operational Guidance for State Agencies recommends the creation of a common statewide database for nonstructural projects, such as home elevations; the analysis of nonstructrual projects could be vastly improved with a high quality structure inventory. A single statewide structure inventory could also provide useful information for future research on regional areas of risk, investment, and needs.

A single structure inventory could also assist parishes and municipalities in the tracking and enforcing of elevation certificates, substantial damage, and substantial improvement thresholds at each property. Currently, there is not a universal portal for elevation certificates, and no statewide structure inventory with those data. The structure inventory being built for LWI modeling could be a starting point, but parishes would be responsible for updating that inventory with collected elevation certificate information when and where possible.

CONSEQUENCE ANALYSES

Consequence models provide direct damage estimates that can be used to analyze how flood hazards could impact the existing built environment. These consequence models would use the structure inventory described above, similar to CPRA's application of flood damage modeling in Coastal Master Plan development (Fischbach et.al., 2017; Johnson et.al., 2013). This analysis could provide additional casemaking evidence for development standards, provide additional geographic detail on locations for buyout and retrofit programs needed to improve safety, and inform benefit-cost comparisons for specific investments or project proposals. The need for damage estimation and consequence analysis should inform the development of consequence models through the LWI data and modeling program.

The LWI models can also be useful for conducting further analyses of development standards outlined in this report, such as No Net Fill ordinances, which require detailed modeling that shows flood levels with- and without- the flood storage lost to fill. Hydrology and hydraulic models, once completed, can be used to estimate flood depths and extents with- and without- specific fill ordinances. Outputs of these models, combined with the structure inventory noted above, can be used to assess changes in flood exposures based on various policies. Additionally, combined with consequence models and the structure inventory, model outputs can be used to assess changes in flood damages associated with various policy implentations and support the development of Louisiana specific BCRs for polices like those discussed within.

RAINFALL FREQUENCY DATA

Louisiana's rainfall frequency data was updated in 2013 in volume 9 of NOAA's Atlas 14. The historical datasets used to create the rainfall frequency estimates ended in 2010-2011. Even the current data from Atlas 14 is over a decade old. Texas, who used their updated data to strengthen their development standards, was included in volume 11 of Atlas 14, released in 2018.

To understand how the state's risk is changing, particularly in areas that experience pluvial and fluvial flooding, another update of the Atlas 14 rainfall frequency data is needed. This update is currently being planned by LWI, NOAA, and other partners. As soon as the data are available, they should be incorporated into the LWI model inputs and outputs. The data should also be assessed to see if they can inform safer interim flood protection standards, as was done in Harris County and other locations in Texas.

CLIMATE CHANGE PLANNING

While Atlas 14 contains historic rainfall frequencies, it does not provide any projections about how rainfall frequency might change over time into the future. Louisiana needs better data for the present as well as projected scenarios for rainfall frequency and other flood hazard contributing factors that may be exacerbated by climate change. These future climate impacts should be considered when making long-range land use decisions and setting standards for buildings that will last many decades (Chester, 2020).

Long-range planning, such as transitional planning for buyout programs, should also be informed by the LWI models as is feasible, especially if those models are able to incorporate climate-related impacts into analyses of current and future risk.

Summary of Recommendations

SHORT TERM: SET INTERIM STANDARDS

In the short term, interim standards are needed to prevent unsafe development. Louisiana should set freeboard standards of at least BFE+1 throughout the SFHA, and consider requiring BFE+2 in certain zones.

Because the SFHA understates the geography of risk so significantly, Louisiana should also address the geography and extent of these freeboard requirements. In the short term, they should be extended beyond the SFHA to the 500 year floodplains or shaded X zones, where mapped. Where 500 year floodplains are not mapped, the method of extending the A zone using the BFE+Freeboard requirement should be used.

However, freeboard should not be enacted without addressing fill and foundations. Anywhere freeboard regulations will be applied should also at minimum enact a No Net Fill ordinance and require pier and beam foundations within the SFHA. The legislature could direct parishes to adopt these requirements. These standards are necessary to preserve the natural functions of the watershed.

Finally, where regulatory floodways exist, higher standards should be applied. Similar to Harris County, the use of fill should not be allowed at all within a floodway. Pier and beam foundations should be required, and at least three feet of freeboard should be required of any new structure within a floodway.

MEDIUM TERM: UPDATE PROGRAM AND POLICY GUIDELINES AND PROVIDE SUPPORT FOR IMPLEMENTATION

Over the medium term, after interim standards are implemented, Louisiana should prioritize providing support to parishes and municipalities to join or improve their score in the CRS. CRS scores are critical to realizing the cost savings on flood insurance premiums.

Louisiana should also roll out additional tools, standards, and policies that help speed adoption and enforcement of new regulations. A model stormwater ordinance for parishes and municipalities should be prepared, addressing green infrastructure and floodplain management.

To effectively manage buyout programs, Louisiana should establish a standing or permanent state buyout program infrastructure that can support local and regional programs. Louisiana should also establish a state fund to support these buyouts, to fund essential components like cost match, pre-disaster planning, acquisition and maintenance, and supplemental incentives and relocation assistance.

Finally, LWI should support parish and regional pre-disaster buyout and relocation planning by incorporating these elements into the upcoming regional watershed planning process.

ONGOING: ALIGN LAWS AND REGULATIONS WITH REAL RISK

Most critically, Louisiana's laws and regulations must be aligned with the state's real risk. The current status of flood insurance mapping in Louisiana is inconsistent and out of date. Without updated tools and maps, communication to the public will be equally inconsistent, and regulations will not keep up with the state's changing risk.

The state should ensure that all data sets, models, and model outputs funded through LWI are maintained and updated to be as effective as possible.

Louisiana should commit to a regular update interval for FIRMs, modeling, risk geography, and development standards. The state should set standards using updated modeling and model outputs using the best possible understanding of risk, and ensure that all standards are tied to outputs that are updated consistently over time.

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