A Guide for Higher Standards in Floodplain Management

Prepared by:

Texas Floodplain Management Association

Higher Standards Committee

Adapted from

ASFPM Floodplain Regulations Committee's

A Guide for Higher Standards in Floodplain Management (2013)

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Acknowledgement

Texas Floodplain Management Association (TFMA) adapted this document from the March 2013 version of *A Guide for Higher Standards in Floodplain Management* published by the Association of State Floodplain Managers' (ASFPM) Regulations Committee.

The Texas 77th Legislature (2001) passed SB 936:

- Amends the Texas Water Code
- Authorizes political subdivisions (cities, counties, LID's, MUD's and WCID's) to adopt more comprehensive floodplain management rules (i.e. higher standards)
- Authorizes taking steps, using regional, watershed, and multi-objective approaches, to improve the long-range management and use of flood-prone areas
- Authorizes adopting more comprehensive floodplain management rules that the political subdivision determines are necessary for planning and appropriate to protect public health and safety
- Authorizes participation in floodplain management and mitigation initiatives such as FEMA's Community Rating System (CRS) Program
- Allows collection of reasonable fees to cover the cost of administering a local floodplain management program
- Authorizes the community (city or county) to enforce a criminal penalty against a person that commits an offense by violating this subchapter (ordinance or court order). An offense under this section is a Class C misdemeanor and each violation of this subchapter and each day of a continuing violation is a separate offense.

The annual TFMA Higher Standards Surveys from 2004 to 2018 document the higher floodplain management standards adopted by Texas cities and counties. Many of the higher standards referenced in this document are from actual flood damage prevention ordinances and programs developed by over 300 Texas communities that have submitted Higher Standards Surveys.

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Introduction

The purpose of the Guide for Higher Regulatory Standards in Floodplain Management is to provide options for communities that desire to implement floodplain regulations which reduce flood damage and the overall impacts of floods. These impacts include human risk, environmental damage, property damage, flood insurance claims, displacement of residents, and burden on community infrastructure and services.

The Guide is not a substitute for a set of community floodplain regulations, rather it is a guide to enhancing existing regulations with higher standards that will greatly reduce risk, and provide protections to functional floodplains.

Flower Mound, Texas 06-19-2015 Photo by Brandon Barth

The higher standards options in this guide are described in detail because they are recommended for safer development and use the natural protection provided by the natural functions and resources of the floodplain. Please note that the model language presented in this document was developed to promote effective floodplain management, and comply with FEMA flood damage

reduction standards described in 44CFR§60.3. Each community can tailor the model language to meet its own specific needs. Words and phrases that are underlined are defined in the Glossary/References (Chapter XXXIII)

A note about enforcement:

Higher regulatory standards are only as good as the enforcement process that supports them. Many of the higher regulatory standards suggested in this guide necessitate increased documentation requirements and enforcement efforts compared to the minimum NFIP standards

In 2001, TFMA was instrumental in passing legislation (Texas SB 936, 77th Legislature) allowing Texas communities to adopt higher floodplain management standards that exceeded the NFIP minimum regulatory standards and to allow participation in FEMA's Community Rating System (CRS).

TFMA strongly believes the minimum NFIP floodplain regulations do not provide adequate long-term flood risk reduction for communities and that the benefits of flood risk reduction achieved by higher regulatory standards far outweighs the burden of administering them.

TFMA RECOMMENDED HIGHER REGULATORY STANDARDS

I. FREEBOARD

RATIONALE:
Freeboard is the single most effective means for reducing flood risk to a structure in the floodplain. Freeboard is standard for placing the first floor of a structure above the elevation of the calculated 1% flood level in order to allow for nature's uncertainty and future changes in the watershed that will increase flood levels. Freeboard is relatively inexpensive to build into development, and typically pays for itself in reduced insurance premiums and prevented flood damage within the first 10 years of a structure's lifetime. Significant Community Rating System (CRS) credit is available for this activity, which leads to lower flood insurance premiums for all policy holders in the community.

During Tropical Storm Alison (2001) and again during Hurricane Harvey (2017) heavy rainfall in Harris County, Texas, over 5 days in 2001 and 4 days in 2017, resulted in over 73,000 residences in 2001 and 120,000 structures in 2018 being flooded with over 30,000 located outside the Special Flood Hazard Area (SFHA) in Zones B, C, X (shaded) and X (unshaded). With a goal to reduce the risk of loss of life and property damage from floods, TFMA recommends that communities adopt freeboard requirements in **all** flood risk zones.

Hurricane Harvey flooding in Houston, Texas. Photo by Brett Cooner, Houston Chronical Staff.

A. FREEBOARD IN ZONE A, A1-30, and AE

OBJECTIVE:
To protect structures against damage from floods in floodplain areas with 1% annual (base) flood elevations and in areas where no 1%-annual-chance flood elevations are available.

MODEL LANGUAGE:
Add the following sentence (bolded) to specific requirements for Residential Structures and Non-Residential structures:

Option 1:
New Construction and substantial improvement of any residential structure, including manufactured homes, shall have the lowest floor, including basement, elevated (1, 2, or 3) feet above the base flood elevation. For watersheds within communities that have an adopted Land Use or Zoning map, the base flood elevation shall be defined as the 1% chance (100-year) flow generated considering a fully-developed watershed condition. For watersheds where an adopted Land Use or Zoning map is not available, the base flood elevation is the level of the 1% annual chance flood. Where base flood elevation data is not available, a floodplain study must be performed by a Professional Engineer (PE) establishing the base flood elevation (BFE) and the floodplain and floodway boundaries prior to issuing a development permit.

Option 2:

New Construction and substantial improvement of any residential structure, including manufactured homes, shall have the lowest floor, including basement, elevated (1, 2, or 3) feet above the base flood elevation. For watersheds within communities that have an adopted Land Use or Zoning map, the base flood elevation shall be defined as the 1% chance (100-year) flow generated considering a fully-developed watershed condition. For watersheds where an adopted Land Use or Zoning map is not available, the base flood elevation is the level of the 1% annual chance flood. Where base flood elevation data is not available, the structure shall have the lowest floor, including basement, elevated at least two feet above the highest adjacent natural grade or above the crown of the nearest street, whichever is higher.

Option 3:
The following conditions must be met for new construction or substantial improvement of a structure:

The top of the subfloor of the lowest habitable floor must be elevated to twenty-four (24) or more inches above the 0.2 percent or 500-year flood elevation or twelve (12) inches above the level of the crown of the nearest public street, whichever is higher, except in a floodway where the bottom of the lowest supporting member of the structure shall be elevated thirty-six (36) or more inches above 0.2 percent or 500-year flood elevation. [Source Harris County Regulations effective 1/1/18]

The 2018 Harris County Floodplain Regulations are available using the following link:

http://www.eng.hctx.net/Portals/23/Publications/FPMRegs120517.pdf

B. FREEBOARD REQUIREMENTS IN ZONE X:

OBJECTIVE:

To protect structures against damage from floods in areas where flood elevations are calculated in addition to the 1% annual chance flood elevation. These include 0.2%-chance flood elevations; areas of (base) flood with average depths of 1 foot or with drainage areas less than 1 square mile; and areas protected by levees from 1% annual chance flood and areas upstream of "limit of detail study" on the community FIRM.

DEFINITION:

Zone X (shaded)*:*
In areas mapped as Zone X (shaded) on the community Flood Insurance Rate Map (FIRM), defined as Areas of 0.2% annual chance flood; ***areas of 1% annual chance flood with average depths of less than 1 foot*** *or with drainage areas less than1 square mile; and areas protected by levees from 1% annual chance flood.*

Zone X (unshaded)
In areas mapped as Zone X (unshaded) on the community Flood Insurance Rate Map (FIRM), defined as areas determined to be outside the 0.2% annual chance floodplain.

TFMA recommendation: **require a minimum of +2' freeboard in both Zone X (shaded) and Zone X (unshaded).** Even though the community FIRM may show areas outside both the 1% chance flood (100-year flood) and 0.2% chance flood (500-year) boundaries, flood risks still exist. As mentioned above, over 30,000 Houston area homes flooded in Zones B, C and X during Tropical Storm Allison (2001). Repetitive Loss and Severe Repetitive Loss properties have been identified in both Zone X (shaded) and Zone X (unshaded).

Note: Some communities require freeboard in areas of concentrated flow where the drainage basin exceeds 100 acres. In urbanized areas of Texas, such as the North Central Texas, HGAC and CAPCO regions, flooding and repetitive loss properties occur well upstream of the 1 square mile point.

MODEL LANGUAGE:

Add the following sentence (bolded) to specific requirements for Residential Structures and Non-Residential structures:

Option 1:
In areas mapped as Zone X (shaded) on the community Flood Insurance Rate Map (FIRM), new construction and substantial improvement of any residential structure, including manufactured homes, shall have the lowest floor, including basement, elevated above the 0.2 percent or 500-year flood elevation; or at least two feet above the highest adjacent natural grade: or above the crown of the nearest street, whichever is higher.

Option 2:
In areas mapped as Zone X (shaded and unshaded) on the community Flood Insurance Rate Map (FIRM), new construction and substantial improvement of any residential structure, including manufactured homes, shall have the lowest floor, including basement, elevated at least two feet above the highest adjacent natural grade or above the crown of the nearest street, whichever is higher.

Option 3:
In areas mapped as Zone X (shaded and unshaded) on the community Flood Insurance Rate Map (FIRM) and/or areas of concentrated flow where the drainage basin exceeds 100 acres) or a similar threshold area): new construction and substantial improvement of any residential structure, including manufactured homes, shall have the lowest floor, including basement, elevated (1, 2, or 3) feet above the nearest base flood elevation. For watersheds within communities that have an adopted Land Use or Zoning Map, the base flood elevation shall be defined as the 1% chance (100-year) flood elevation based on flow generated from a fully developed watershed condition. Where base flood elevation data is not available, a floodplain study must be performed by a Professional Engineer (PE) establishing the base flood elevation (BFE) and the floodplain boundaries prior to issuing a development permit.

Option 4:

In the "Shaded X" Zone it must be determined that the lowest adjacent grade (LAG) is above the 1 percent or 100-year flood elevation before a Class "I" Permit may be issued. The Community Floodplain Manager (County Engineer) may rely on data in his possession to make such a determination or require the submittal of topographical information by the applicant. [Source – Harris County Regulations effective 1/1/18]

Option 5:

In cases where the structure is located geographically in the 0.2 percent or 500-year flood plain and the ground is lower than the 0.2 percent or 500-year level but higher than the 1 percent or 100-year level, the finished floor elevation shall be elevated at or above the 0.2 percent or 500-year level. [Source – Harris County Regulations effective 1/1/18]

C. FREEBOARD IN SHALLOW FLOODING AREAS (Zones AO and AH)

To protect structures against damage from floods in shallow flooding floodplain areas with 1% annual (base) flood elevations and/or flood depths are available.

MODEL LANGUAGE – Zone AH:
Option 1:
Add the following sentence (bolded) to specific requirements for Residential Structures and Non-Residential structures located in Zone AH:

New Construction and substantial improvement of any residential structure, including manufactured homes, shall have the lowest floor, including basement, elevated (1, 2, or 3) feet above the base flood elevation. The base flood elevation is the level of the 1% annual chance flood.

MODEL LANGUAGE – Zone AO (with depth number):

Option 1:
Add the following sentence (bolded) to specific requirements for Residential Structures and Non-Residential structures located in Zone AO:

New Construction and substantial improvement of any residential structure, including manufactured homes, shall have the lowest floor, including basement, elevated (1, 2, or 3) feet above the flood depth shown on the community flood insurance rate map.

Option 2:

If the land is located in an "AO" Zone, the top of the slab of the lowest habitable floor (including basement) shall be elevated to thirty-six (36) or more inches above the depth number in feet specified on the FIRM. There must be a determination by the Community Floodplain Manager (County Engineer) that the development will not adversely affect the floodplain, if the development in excess of a single family residence on a single lot within the "AO" zone. *[Source Harris County Regulations effective 1/1/18]*

MODEL LANGUAGE – Zone AO (with no depth number):

Option 1:
In Zone AO areas where the "flood depth' is not shown on the community flood insurance rate map, the lowest floor, including basement, shall be elevated (3') feet above natural grade or above the crown of the nearest street, whichever is higher.

Option 2:

If the land is located in an "AO" Zone and no depth number is specified, the top of the slab of the lowest habitable floor (including basement) shall be elevated to at least six (6) feet above highest adjacent grade (natural ground). *[Source Harris County Regulations effective 1/1/18]*

D. ALTERNATIVES TO FREEBOARD:

1. Wet Floodproofing

OBJECTIVE:
FEMA recognizes that wet-floodproofing may be appropriate for certain types of agricultural structures, as well as low-cost, small detached residential accessory structures. If a community wishes to allow non-elevated accessory structures, it must establish the definition of "low-cost" and "accessory". Unless a community adopts specifications for these types of structures within its floodplain management ordinance, a variance will be necessary.

MODEL LANGUAGE:
Add the following language to specific requirements for small, detached residential accessory structures:

Small detached residential structures (garages, storage sheds) may be exempt from the freeboard requirements if they are not used for human habitation; designed to have low flood damage potential; firmly anchored and placed on the building site in a way that presents minimum resistance to flood flows; constructed with electrical and other services mounted above or

floodproofed the flood hazard elevation; and fitted with openings that allow the automatic entry and exit of floodwater. *For details refer to FEMA Technical Bulletin 7-93.*

2. Dry floodproofing

OBJECTIVE:
FEMA recognizes that dry floodproofing may be appropriate for certain types of non-residential structures. This option is not available to residential buildings, or mixed-use buildings with a majority of floor area dedicated to residential uses. When evaluating a mixed-use building that is designed to be dry flood-proofed, the applicant should submit proposed building plans to an insurance agent for a "submit to rate" to determine whether higher flood insurance premiums will apply to residential units.

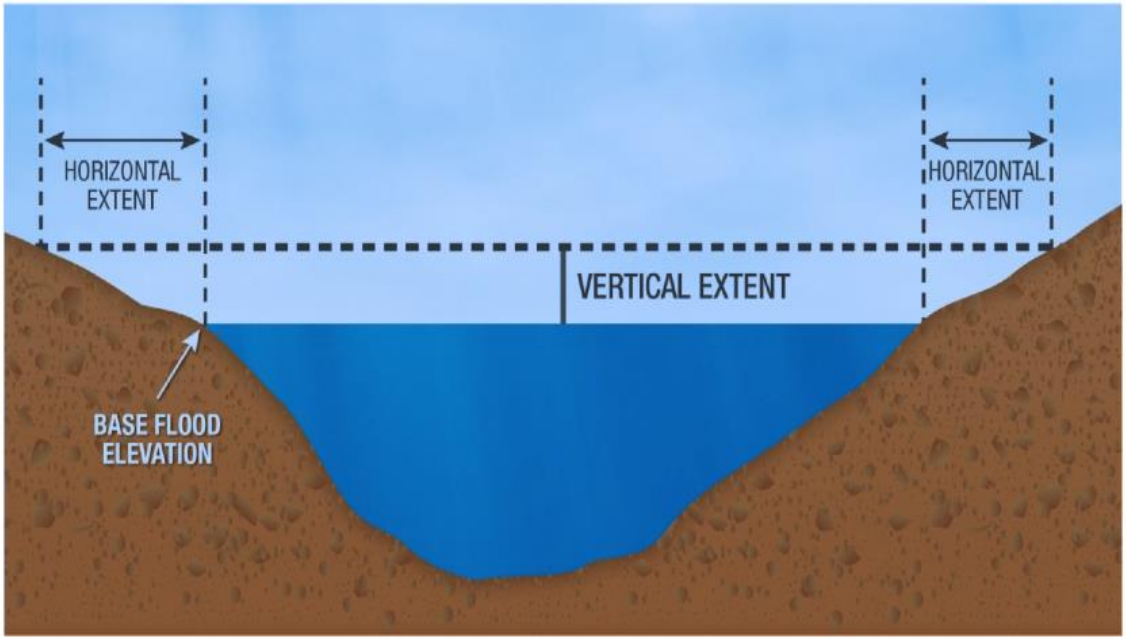
MODEL LANGUAGE:
Add the following language to specific requirements for non-residential buildings and mixed-use buildings where residential floor area is less than non-residential floor area:

> ***Non-residential structures may be exempt from the freeboard requirements if they are constructed with flood-resistant material that protect to one foot above the flood hazard elevation. Flood-resistant materials are building products that can withstand direct and prolonged contact with floodwaters for at least 72 hours, without resulting in damage other than what can be corrected cosmetically. This option is not available to residential buildings, or mixed-use buildings with a majority of floor area dedicated to residential uses.*** *For details refer to FEMA Technical Bulletin 2-93.*

E. VERTICAL AND HORIZONTAL EXTENTION CAUSED BY FREEBOARD

Freeboard results in higher elevations (vertical projection) and the higher elevation results in a wider floodplain. Therefore, freeboard has two important components being vertical and horizontal. A detailed hydrologic and hydraulic analysis is required to define the horizontal limits of the freeboard-impacted floodplain. However, if detailed topography (1' or 2') is available the horizontal limits of the freeboard-impacted floodplain can be estimated. In absence of detailed topography the community can establish a horizontal setback from the floodplain boundary such as 100'; 200'; 300' to 500'.

The figure below demonstrates the horizontal extent of the floodplain resulting from freeboard (vertical extent)



Higher Elevation = Wider Floodplain

F. Freeboard higher standards throughout the combined 100- (1%) and 500- (.02%) year floodplains.

The City of Cedar Falls, Iowa is CRS 5 and they require new construction and substantial improved structures to be elevated to 500-yr (0.2%) flood elevation +1'. The following floodway fringe overlay district ordinance language is from the Cedar Falls floodplain ordinance:

> The floodway fringe overlay district shall include and incorporate both the 100-year (1%) and 500-year (0.2%) flood boundaries as illustrated on the official floodplain zoning maps. The elevation of the regulatory flood shall be considered to be the 500-year (0.2%) flood elevation. Flood insurance policies and insurance rates may continue to be evaluated and established based on federal and state laws and regulations. For all other city flood regulatory purposes, however, the regulatory elevation shall be the 500-year flood elevation.
>
> No new lots shall be established within the 500-year flood boundaries after January 1, 2010, unless the newly created lot has a floodplain buildable area outside of the 500-year flood boundary, provided further, that the 500-year floodplain does not encompass more than 25 percent of the newly created lot. All building lots which have been properly established under state law and this Code, filed with the county recorder and approved by the county auditor, all prior to January 1, 2010, shall be considered to be lots of record. A lot of record which is in existence on January 1, 2010, may be diminished in size via subdivision if the newly-created lot being separated from the existing lot has a floodplain buildable area outside of the 500-year flood boundary, provided further, that the diminished original lot of record will not be permitted a replacement or new structure

constructed thereon if that structure is located within the 500-year floodplain boundaries. An existing structure located on the original lot of record, if located within the 500-year floodplain, will be allowed to be maintained, upgraded, enlarged or replaced in conformance with this Code.

City of Cedar Falls Floodway Overlay District information:

https://www.municode.com/library/ia/cedar_falls/codes/code_of_ordinances?nodeId=COOR_CH29ZO_ARTIIIDIDIRE_DIV2SPDI_S29-156FLFROVDI

City of Cedar Falls Flood Damage Prevention Ordinance:

https://www.municode.com/library/ia/cedar_falls/codes/code_of_ordinances?nodeId=COOR_CH29ZO_ARTIIADEN_DIV1GE_S29-34FLDEPE

II. ACCESS (INGRESS-EGRESS)

RATIONALE:
Buildings in high risk floodplains can be elevated to reduce flood damage by elevating the lowest floor to an elevation +1', +2', +3' or more above the BFE (higher standard). However, residual risk remains on the property. Ensuring that building sites are relatively accessible during floods decreases the likelihood of stranded residents, reduces the need for water rescues which places emergency personnel at risk, and increases public safely.

OBJECTIVE:
To promote development design that will reduce flood damage and facilitate emergency vehicular access and/or pedestrian access and evacuation during flood events.

MODEL LANGUAGE:

(1) Add to specific requirements for Residential Structures:

> ***New development proposals will be designed, to the maximum extent practicable, so residential building sites, walkways, driveways, and roadways are located on land with a natural grade with elevation not less than the base flood elevation and with evacuation routes leading directly out of the floodplain area (dryland access).***

(2) Add to specific requirements for Nonresidential Structures:

> ***New development proposals will be designed, to the maximum extent practicable, so non-residential building sites, walkways, driveways, and roadways are located on land with a natural grade with elevation not less than the base flood elevation and with evacuation routes leading directly out of the floodplain area.***

III. COMPENSATORY STORAGE

RATIONALE:

Floodplains provide the critical and beneficial functions of flood storage, natural habitat, and water quality. The placement of fill impairs these functions and should be avoided. Where some placement of fill is unavoidable, requiring compensatory storage can mitigate some of the negative impacts of floodplain fill.

OBJECTIVE:

To compensate for the loss of floodplain storage caused by filling in the floodplain, which can result in raising flood elevations, especially with the impact of cumulative fills.

MODEL LANGUAGE:

There are a number of versions of compensatory storage language. The following sample language is provided as developed from a review of existing regulations:

(1) Add to language for the Assurance of Flood Carrying Capacity:

> ***Compensatory Storage Required for Fill***
>
> ***Fill within the special flood hazard area and/or watersheds established by a drainage area greater than (200 acres or value selected by community), shall result in no net loss of natural floodplain storage. The volume of the loss of floodwater storage due to filling in the watershed (or special flood hazard area) shall be offset by providing an equal volume of flood storage by excavation or other compensatory measures at or adjacent to the development site.***

(2) If your regulations explain the minimum application items necessary to seek a permit, add to the language for the Application Requirements section:

Volumetric calculations demonstrating compensatory storage.

The City of Dallas, Texas adopted detailed floodplain development regulations related to loss of valley storage as follows:

Section 51A-5.105 Filling in the Floodplain

Subsection (e)(4)(g)(4) Filling to remove a FP designation

The FP area may be altered only to the extent permitted by equal conveyance reduction on both sides of the natural channel. The following valley storage requirements apply to all FP areas except those governed by a city council-adopted management plan that contains valley storage regulations, in which event the valley storage regulations contained in the plan apply:

(A) Except as otherwise provided in Subparagraph (B):

(i) no loss of valley storage is permitted along a stream with a drainage area of three square miles or more;

(ii) valley storage losses along streams, with a drainage area between 130 acres and three square miles, may not exceed 15 percent, as calculated on a site by site basis; and

(iii) valley storage losses along streams with a drainage area of less than 130 acres is not limited.

(B) Hydrologic computations may be performed to evaluate basin-wide valley storage loss impacts on the design flood discharge. If the computations demonstrate that valley storage losses do not result in increases in the design flood discharge at any point downstream of the project, valley storage losses are permitted even though they exceed the limits provided in Subparagraph (A).

Harris County adopted the following regulations pertaining to reduction in floodplain storage or conveyance: [Harris County Floodplain Regulations effective 1/1/18]

Any reduction in flood plain storage or conveyance capacity within the 1 percent or 100-year flood plain must be offset with a hydraulically equivalent (one-to-one) volume of mitigation sufficient to offset the reduction. The reduction may result from development or the placement of fill within the 1% flood plain or 100-year flood plain. Such mitigation shall be within the same watershed and shall be provided on the same property or within the same hydrologic sub-watershed or at an alternate site meeting the approval of the Community Floodplain Manager (County Engineer). A full hydrological and hydraulic analysis must be submitted to support a request for

mitigation outside the boundaries of the property being developed. This requirement does not apply to Coastal Areas where flood plain fill mitigation is not an issue.

In areas of combined coastal and riverine flood hazard, this requirement only applies for the portion of fill placed below the riverine flood hazard elevation as provided in the FIS or an approved hydraulic model.

IV. CRITICAL DEVELOPMENT PROTECTION

RATIONALE:
Facilities which provide critical services, or services that are depended on during storms, should be protected to an even higher standard than other development. Failure to provide flood protection to these types of critical facilities creates severe and unacceptable public safety risk.

FEMA provides examples of critical facilities on www.fema.gov as:
"Facilities where even a slight chance of flooding is too great a threat"

- Hospitals
- Police stations
- Fire stations
- Storage of critical records
- Retirement centers
- Schools
- Correctional facilities
- Nursing homes
- Fuel storage facilities
- Hazardous storage facilities

- Water and wastewater treatment facilities
- Power plants
- Day care facilities
- Retirement facilities

OBJECTIVE:
To protect critical facilities and development against damage, and to minimize the potential loss of life from flooding.

MODEL LANGUAGE:
The standard used in Executive Order 11988 is the 500-year flood event, or the historically highest flood (if records are available), whichever is greater. Two alternatives are presented below, the first being more general, the second being more specific. Three (3) use regulations are suggested, ranging from the most permissive to the most restrictive.

(1) Add to Definitions:

Critical Development

Critical development is that which is critical to the community's public health and safety, are essential to the orderly functioning of a community, store or produce highly volatile, toxic or water-reactive materials, or house occupants that may be insufficiently mobile to avoid loss of life or injury. Examples of critical development include jails, hospitals, schools, daycare facilities, public electric utilities, fire stations, emergency operation centers, police facilities, nursing homes, wastewater treatment facilities, water plants, gas/oil/propane storage facilities, hazardous waste handling and storage facilities and other public equipment storage facilities.

[Option 2]
Critical Development

1. Class I Critical Facilities are those facilities that must remain accessible during the 0.2% flood event because they are the base of operations for emergency responders, are particularly difficult to evacuate during a flood event, or facilities that provide services essential to the life, health, and safety of the community. Class 1 critical facilities include police and fire stations, emergency medical centers, communication centers, hospitals, jails, nursing homes, and other residential uses for persons with limited mobility and/or dependency on life-sustaining medical equipment.

2. Critical Facilities are structures that store public records; museums and libraries; schools; and other buildings that store rare and/or valuable items and information that sustain the history and public records of a community. These structures are not expected to remain accessible or functioning during a flood event, though in many instances their functions must resume as soon as possible after a flood event. Critical Facilities also include public infrastructure such as water distribution and wastewater treatment facilities, which are expected to remain functioning during a flood event although they may be temporarily inaccessible or accessible only by watercraft during a flood event.

Option 3:

Critical Development (Critical Facilities)

3.1 Construction of critical facilities shall be, to the extent possible, located outside the limits of the 0.2% flood plain or 500-year flood plain (Shaded Zone X) and any "A" Zone. Construction of new critical facilities shall be permissible within the base flood plain if no feasible alternative site is available. [Harris County floodplain regulations effective 1/1/18]

1. ***Construction of critical facilities on land located in the 0.2% (500-year) flood plain or within the 1 percent or 100-year flood plain shall have the lowest floor elevated to three feet or more above the 0.2 percent or 500- year elevation, or twenty-four (24) inches above the crown of the adjacent road, which ever results in a higher elevation.***
2. ***Floodproofing and sealing measures must be taken to ensure that toxic substances will not be displaced by or released into floodwaters.***
3. ***Access routes elevated to or above the level of the base flood shall be provided to all critical facilities to the extent possible.***

Prohibited Uses (Add to Use Regulations):
[Option I]
Critical facilities and developments are prohibited in the 1% flood hazard areas. Where critical developments are located adjacent to 1%-chance flood areas, the flood protection elevation shall be two feet above the 0.2% flood elevation and that elevation shall be used as the basis for the ACCESS (INGRESS-EGRESS).

[Option II]
Class 1 Critical Facilities are prohibited in all flood hazard areas, including the 1% and 0.2% change flood areas.
Critical Facilities must be constructed to 1 foot above the 0.2% flood elevation.

[Option III]
Critical facilities and developments are prohibited in all special flood hazard areas, including the 1% and 0.2% annual (500-year) floodplains.

Caution: elevating structures on fill in 1% and 0.2% annual (500-year) floodplains may have negative impacts on valley storage and increase flood risk.

V. CUMULATIVE SUBSTANTIAL DAMAGE / SUBSTANTIAL IMPROVEMENT

RATIONALE:

The vast majority of flood damages to structures amount to less than 50% of the value of the structure. Without cumulative substantial damage/improvement provisions, the cycle of flood-repair-flood is typically never broken by mitigating risk. The NFIP Increased Cost of Compliance provisions (provides added funds to substantially damaged flood insurance claims for mitigating the structure) are most effective in communities with cumulative provisions.

OBJECTIVE:
To track cumulative improvements or damages to structures in special flood hazard areas to ensure that flood protection measures are incorporated.

DEFINITIONS:
The NFIP Regulations, 44 CFR 59.1, define "substantial damage and substantial improvement as:

Substantial damage means damage of any origin sustained by a structure whereby the cost of restoring the structure to its before damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred.

Substantial improvement means any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the "start of construction" of the improvement. This term includes structures which have incurred "substantial damage", regardless of the actual repair work performed.

MODEL LANGUAGE for HIGHER STANDARDS:

(1) Add the following sentence at the end of the "substantial damage" definition:

> ***Substantial Damage***
> ***Substantial damage also means flood related damage sustained by a structure on two (2) separate occasions during a 10-year period for which the cost of repairs at the time of each such flood event, on the average, equals or exceeds 25 percent of the market value of the structure before the damage occurred.***

(2) Add the following sentence (bolded) to the "substantial improvement" definition:

> ***Substantial Improvement***
> ***Any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the "start of construction" of the improvement. When the combined total of all improvements or repairs made after the adoption of this regulation equals or exceeds 50 percent of a structure's market value, that structure is considered to be substantially improved.***

VI. REPETITIVE LOSS PROPERTIES

OBJECTIVE:
Reduce the number of RL Properties that frequently strain the National Flood Insurance Fund. In fact, the RL properties are the biggest draw on the Fund. FEMA/NFIP has paid almost $3.5 billion in claims for RL properties. RL properties not only increase the NFIP's annual losses and the need for borrowing; but they drain funds needed to prepare for catastrophic events. Community leaders and residents are also concerned with the RL problem because residents' lives are disrupted and may be threatened by the continued flooding.

FEMA defines a Repetitive Loss Property as:
A Repetitive Loss (RL) property is any insurable building for which two or more claims of more than $1,000 were paid by the National Flood Insurance Program (NFIP) within any rolling ten-year period, since 1978.

Note: A RL property may or may not be currently insured by the NFIP.

Higher Standard Options eligible for CRS Credit:

Option 1:
A. Adopt the Following Repetitive Loss Definition:
"Repetitive loss" means flood-related damage sustained by a structure on two separate occasions during a 10-year period for which the cost of repairs at the time of each such flood event, on the average, equals or exceeds 25% of the market value of the structure before the damage occurred.

B. And modify the "substantial improvement" definition as follows:
"Substantial improvement" means any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50% of the market value of the structure before the "start of construction" of the improvement. This term includes structures that have incurred "repetitive loss" or "substantial damage," regardless of the actual repair work performed.

Option 2 Modify the "substantial damage" definition as follows:
"Substantial Damage" means damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damage condition would equal or exceed 50% of the market value of the structure before the damage occurred. Substantial damage also means flood- related damage sustained by a structure on two separate occasions during a 10-year period for which the cost of repairs at the time of each such flood event, on the average, equals or exceeds 25% of the market value of the structure before the damage occurred.

Data Source: CRS Credit for Higher Regulatory Standards 2006

City of Moorhead, MN Repetitive Loss Ordinance example:
Repetitive Loss: Flood related damages sustained by a structure on two separate occasions during a ten year period for which the cost of repairs at the time of each such flood event on the average equals or exceeds twenty-five percent (25%) of the market value of the structure before the damage occurred.

If any nonconforming use or structure is substantially damaged or experiences a repetitive loss, as defined in this ordinance, it shall not be reconstructed except in conformity with the provisions of this ordinance.

VII. FLOODPLAIN FILL STANDARDS

RATIONALE:
Nearly all floodplain filling activities create negative consequences to adjacent areas. Improperly designed and constructed fill can also jeopardize structures elevated on fill.

OBJECTIVE 1:
To provide guidelines for the placement of fill in special flood hazard areas.

MODEL LANGUAGE:
There are many variations and combinations of standards that can be used for fill. Your community may choose to prohibit any fill in a flood hazard area, other than soil brought in for landscaping projects. The model language below incorporates standards for quality, stability, and compaction.

Add to Use and Development Standards for Flood Hazard Reduction:

Fill
The following standards apply to all fill activities in special flood hazard areas:

- ***A. Fill sites, upon which structures will be constructed or placed, must be compacted to 95 percent of the maximum density obtainable with the Standard Proctor Test method or an acceptable equivalent method,***
- ***B. Fill slopes shall not be steeper than one foot vertical to three feet horizontal,***
- ***C. Adequate protection against erosion and scour is provided for fill slopes. When expected velocities during the occurrence of the base flood are greater than five feet (community can select a lower value) per second armoring with stone or rock protection shall be provided. When expected velocities during the base flood are five feet per second or less protection shall be provided by covering them with vegetative cover.***
- ***D. Fill shall be composed of clean granular or earthen material and will contain no trash, concrete debris or construction waste.***

OBJECTIVE 2:
To ensure structures built in areas removed from the floodplain via Letters of Map Revision Based on Fill (LOMR-F) are built "reasonably safe from flooding." Your community may choose to not recognize LOMR-F, as Cedar Falls, Iowa did when they adopted a new floodplain management ordinance.

MODEL LANGUAGE:
Add the following provisions to the residential and non-residential development requirements for new construction or substantial improvement:

In any area that has been removed from the floodplain via a Letter of Map Revision Based on Fill, any existing or new structure, addition, or substantial improvement must meet the required elevation freeboard requirements of the underlying flood hazard elevation.

Cedar Falls Municipal Code 29-156-e-9

No floodplain map revisions (Letter of Map Revision-fill or LOMR-f) involving placement of fill or involving land alterations in the floodway fringe overlay district, even if otherwise approved by FEMA, shall be allowed after January 1, 2010, provided, however, that owners of properties in the floodway fringe who have applied for a LOMR and which were in the process of being approved as of January 1, 2010, shall be exempt from this prohibition.

Dakota County, MN example*: Any fill placed in the Flood Fringe must be offset with compensatory flood storage capacity at a volume ratio of 2:1 storage to fill. Compensatory storage must occur on the same lot or parcel on which the fill is placed. The excavated material removed to create the compensatory storage area must not be deposited in the floodplain. Preparation and final grading of the area must be consistent with [any applicable erosion control standards].*

Minnehaha Creek Watershed District (MN) example*: Fill shall not cause a net decrease in storage capacity below the projected 100-year high water elevation of a water body… Creation of floodplain storage capacity to offset fill shall occur before any fill is placed in the floodplain, unless the applicant demonstrates that doing so is impractical and that placement of fill and creation of storage capacity can be achieved concurrently.*

Duluth, MN example*: Regulatory Flood Protection Elevation: An elevation corresponding with a point not less than two feet above the water surface profile associated with the regional flood plus any increases in flood stages attributable to encroachments.*

Ohio Model (Fill) Ordinance*:*
The following standards apply to all fill activities in special flood hazard areas:

A. Fill sites, upon which structures will be constructed or placed, must be compacted to 95 percent of the maximum density obtainable with the Standard Proctor Test method or an acceptable equivalent method,
B. Fill slopes shall not be steeper than one vertical on one-and-one-half horizontal,

C. Adequate protection against erosion and scour is provided for fill slopes. When expected velocities during the occurrence of the base flood of five feet per second or less by covering them with vegetative cover.

D. Fill shall be composed of clean granular or earthen material.

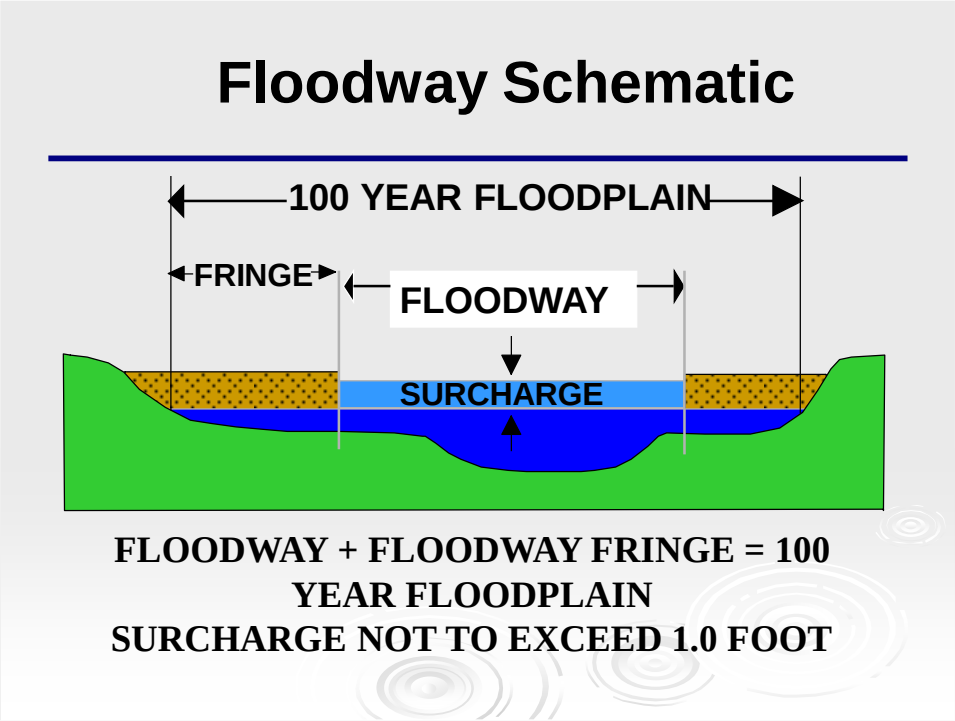
Minnehaha Creek Watershed District example*:*

No new impervious surface may be created within the lesser of the 10-year floodplain or 25 feet of the centerline of a watercourse, except impervious area may be created that is:

(1) no larger than 10% of the floodplain area of the parcel(s), or

(2) the surface is an integral component of a linear public roadway or trail.

VIII. FLOODWAY RISE



RATIONALE:

Communities with flood studies based on FEMA's standard floodway encroachment typically see more frequent and more severe flood events because those standards allow the carrying capacity to be reduced by pinching in the floodway until flood levels raise one foot, thus encroaching the allowable development area into the natural floodway. Base flood elevations and flood insurance premiums do not account for these increases, leaving communities unprotected during the base flood event, and property owners uninsured or under-insured.

In 1976, In a letter to "All Federal Agencies" (conducting flood insurance studies for the Federal Insurance Administration [FIA]) dated March 19, 1976, F. M. Crompton, Director, Engineering and Hydrology Division, Office of Flood Insurance, Federal Insurance Administration, included an updated list of nine (9) states with floodway delineation requirements that are more restrictive than those required by FIA regulation. FIA requested that the Federal agency delineate the floodways in these states in accordance with the state standards except as otherwise stated.

Colorado Michigan New Jersey

Illinois	Minnesota	Ohio
Indiana	Montana	Wisconsin

Many communities, as documented in ASFPM's *Floodplain Management State and Local Programs (2003 and 2010)*, have adopted floodway delineation requirements that are more restrictive than those required by NFIP regulation (44 CFR 60.3(d)).

OBJECTIVE:
To delineate a larger area within the 1%-annual-chance floodplain for flood flow conveyance and to restrict future encroachments that could increase flood levels.

MODEL LANGUAGE:

Option 1:
Add the following provisions to the floodway requirements:

The allowable floodway rise is that value stated in the community flood insurance study performed by FEMA. For new studies, floodway encroachment analyses shall be performed using a 0.1 foot or 0.5 foot (community select) surcharge to be determined by the community where practicable. (TFMA recommends an allowable floodway rise of no more than 0.5 foot and as little as 0.1 feet where vulnerable or critical development exists and strongly recommended in watershed's that are not fully developed.)

Option 2 (Development in the Floodway):

The following additional requirements must be met for development in the floodway [Harris County Floodplain Regulations 1/1/18]

1. The bottom of the lowest horizontal sill, beam or member supporting the structure in the floodway shall be at least thirty-six (36) inches above the 0.2 percent or 500-year flood elevation.
2. An engineering report sealed by a (Texas) registered professional engineer containing as a minimum the following information:
    1. A soils report which includes the results of a soil boring(s) to a depth of five (5) feet below the depth of any proposed piles and the geotechnical engineer's recommendations for the proposed structure signed and sealed by a (Texas) registered professional engineer; and
    2. A hydraulic analysis of pre- and proposed development conditions showing that no increase in the elevation of the base flood will occur as a result of the development signed and sealed by a (Texas) registered professional engineer.
3. Structures shall be elevated on posts or pilings so that the entire structure, exclusive of the posts or pilings, is thirty-six (36) inches above the 0.2 percent or 500-year flood elevation. Fill may not be used to elevate the structure. The drawings and specifications for said posts or pilings shall be prepared by a (Texas) registered professional engineer qualified in structural design and he or

she shall certify thereon that the posts or pilings have been designed to prevent undermining and structural damage resulting from erosive velocities of the base flood. Minimum pile depth shall be established using historical scour depth, stream velocity and soil conditions. As a minimum, piles shall be embedded ten (10) feet below the historical scour depth. Pile design must take into account hydraulic and debris loading imposed by the base flood. If no historical data is available a (Texas) registered professional engineer shall perform a scour analysis using the "Texas Secondary Evaluation and Analysis for Scour" (or similar) methodology. After the placement or installation of the posts or pilings, or during or prior to the final inspection or approval of the structure, the permittee shall furnish to the Community Floodplain Manager (County Engineer) a certificate from the said engineer that the posts or pilings have been constructed in the manner set forth in the drawings and specifications attached to the application for a permit. All other requirements must be met, but must not increase the base flood elevation.

4. The foundation design requirements presented herein assume that potential scour around a foundation system could extend to a depth as great as ten (10) feet below natural grade. The foundation system must extend to a depth below the maximum potential scour that is adequate to prevent excessive vertical and horizontal movement of the foundation system due to design axial and lateral loads imposed during base flood conditions.

These foundation design requirements present minimum foundation design requirements. Foundations must meet or exceed these minimum design requirements, regardless of the type of scour protection provided for the foundation.

1. Design Loads: The structural system of the building shall be designed, connected and anchored to the foundation system to prevent flotation, collapse and permanent lateral movement resulting from wind loads, impact loads, hydrodynamic loads and hydrostatic loads, including the effects of buoyancy from flooding equal to the base flood elevation.
2. Foundation Type: The foundation system shall consist of a driven pile or a drilled pier foundation system.

    a. Driven Piles: Driven piles may extend above natural grade and act as the columns supporting the elevated portion of the building above the base flood elevation, or the piles may be terminated near natural grade and a reinforced concrete cap shall be cast on top of the pile.
    b. Drilled Piers: Drilled piers shall be terminated below natural grade, and a reinforced concrete cap shall be cast on top of each pier. Columns for the building may consist of cast-in-place concrete connected by dowels to the pier cap.

    c. Type and Size of Driven Pile: Driven piles shall consist of either twelve (12) inch (minimum) square pre-stressed concrete piles or fourteen (14) inch (minimum) diameter steel pipe piles with a closed end.

1. Closure Plate: The tip of pipe piles shall be closed prior to driving by welding a circular steel plate over the tip of the pile. The closure plate shall be flush with the outside of the pile, i.e. the diameter of the closure plate shall not be greater than the outside dimensions of the pipe pile.

The minimum thickness of the closure plate shall be 3/8 inch. The weld shall be continuous, and the closure shall be waterproof.

2. Minimum Wall Thickness: The minimum wall thickness of the pipe pile shall be 1/4 inch.

d. Type and Size of Drilled Pier: Drilled piers shall be eighteen (18) inch diameter (minimum) and straight-sided (no belled or under reamed base) and shall be installed using the slurry displacement technique in accordance with the ACI Standard Specification for the Construction of Drilled Piers (ACI 336.1- 94).
e. Minimum Pile and Drilled Pier Embedment: The minimum embedment below natural grade for driven piles and drilled piers shall be twenty (20) feet if the computed allowable axial capacity of the driven pile or drilled pier (factor of safety of at least 2.0 with respect to ultimate axial capacity) is equal to or greater than the design axial load transmitted to the pile.
f. Lateral Restraint of Foundations at Groundline: The individual piles or piers shall be braced horizontally with reinforced concrete tie beams connecting the pier/pile caps each way (not diagonally). For piles that extend above natural grade and act as column supports for the structure, a reinforced concrete collar shall be cast around each pile at the groundline, and the collars shall be connected each way with reinforced concrete tie beams. The purpose of the horizontal bracing at the groundline is to enhance the lateral restraint of the individual piles or piers when scour around a pile or pier reduces the lateral stiffness of the pile or pier.
g. Anchorage of Timber Building Columns to Concrete Pile/Pier Cap: The timber column to concrete pile/pier cap connection should develop the full moment capacity of the timber column. The timber column shall be bolted into a steel sleeve with a welded steel base plate that is bolted to the concrete pile/pier cap using anchor bolts cast into the cap. The steel sleeve shall be oversized with the inside sleeve dimension at least 1 1/2 inch greater than the column dimension. The gap between the sleeve and column should be filled with a high strength non-shrink grout. The bolt(s) connecting the column to the sleeve should be designed for uplift forces and shall be 3/4 inch diameter minimum. The sleeve assembly and bolts shall be galvanized.
h. Driven Pile Installation Techniques: Driven piles shall be installed by driving alone. Jetting with water or air to create a pilot hole or to loosen the foundation soils before or during driving to aid driving will not be permitted. Piles may be driven with a vibratory hammer, a drop hammer, or a diesel or compressed air-operated pile driving hammer. To aid in stabbing and aligning piles, pilot holes may be drilled with a dry auger to a maximum depth of ten (10) feet. The pilot hole diameter shall not exceed the pile diameter or width.

i. Drilled Pier Reinforcement and Concrete: Reinforcement and concrete for drilled piers shall be in accordance with ACI Standard Specification for the Construction of Drilled Piers (ACI 336.1-94).

1. Minimum Reinforcement: The minimum steel area shall be one (1) percent which is equivalent to six (6) No. 6 reinforcing bars for an eighteen (18) inch diameter pier.

2. Concrete: The minimum twenty-eight (28) day compressive strength of the concrete shall be 3000 psi. The maximum nominal course aggregate size shall be 3/4 inch and the minimum concrete slump shall be seven (7) inch.

3. Inspection and Testing: The (Texas) registered professional engineer who designed the foundation shall observe the installation of each pier or pile foundation element and shall furnish the Permit Division of the Harris County Engineering Department a certificate that the piers or piles have been constructed per the design plans and specifications submitted with the permit application. Testing in connection with drilled pier installation shall be in accordance with ACI 336.1-94.

IX. NO ADVERSE IMPACT (NAI)

RATIONALE:

The Association of State Floodplain Managers (ASFPM) No Adverse Impact (NAI) Committee has posted the following rationale on www.floods.org:

Flood damages are on the rise. Current measures to reduce or eliminate flood damages, while a good start, aren't doing enough. A new approach is needed. Application of the No Adverse Impact (NAI) Floodplain Management philosophy can fill this need. NAI is a philosophy that looks at the impacts of land use decisions, identifies adverse impacts, and mitigates them through a variety of actions. NAI involves more than local floodplain managers -- planners, public works officials, zoning officials, development officials, regulatory (review) agencies, stormwater professionals, wetland managers, environmental engineers and environmentalists, emergency responders, disaster preparedness coordinators, hazard mitigation specialists, design professionals and design engineers, architects, landscape professionals, local officials, governing bodies, politicians and the public at large – the "whole community" all have a role. Through NAI, flood losses can be reduced, property can be protected and lives can be saved!

ASFPM's NAI Committee is seeking to develop applications of the philosophy for existing community activities. This includes an array of implementation tools that fall within seven Building Blocks from the NAI Toolkit:

1. Hazard Identification
2. Education and Outreach
3. Planning
4. Regulations and Standards
5. Mitigation Actions
6. Infrastructure
7. Emergency Services

A considerable amount of consideration is also given to legal issues - community liability and property rights - surrounding floodplain management, especially at the local level. While nothing can prevent all legal challenges, following the NAI approach can help to: 1) reduce the number of lawsuits filed against local governments, and 2) greatly increase the chances that local governments will win legal challenges to their floodplain management practices.

OBJECTIVE:
Minimize flood damages through sound floodplain management and development that mitigates adverse impacts throughout the watershed. Activities that could adversely impact flood damage to another property or community will be allowed only to the extent that the impacts are mitigated or have been accounted for within an adopted community-based plan.

MODEL LANGUAGE:

Add the following definition to the community flood damage prevention ordinance:

> City of Austin NAI Requirements:
>
> *ADVERSE FLOODING IMPACT - An increase in flood risk or hazards. This includes, but is not limited to, the following conditions: Any increase in the depth of flooding; any increase in the water surface elevation that causes stormwater to travel outside of defined public rights-of-way, defined drainage easements or FEMA floodplains or to exacerbate any of these situations if the water surface elevation already exceeds these boundaries; and increased velocity of stormwater flows that overtop roadways or other crossings.*

We consider the 100-year event as the measure. This means that a rise of 0.01 feet on another property is an adverse impact. In addition, any loss in floodplain volume on the property is also an adverse impact. This applies to private development and city work.

EXAMPLES of NAI:

Michigan's Natural River Act designates a river or portion of a river as a natural river area for

purpose of preserving and enhancing its values for water conservation, its free flowing condition, and its fish, wildlife, boating, scenic, aesthetic, floodplain, ecologic, historic and recreational values and uses. Local zoning ordinances and state zoning rules require structures to be setback at least 100-150 feet from the Ordinary High Water Mark (OHWM) on designated tributaries and 100-200 feet from the OHWM on designated mainstreams. Setback requirements are outlined in management plans developed for each designated river and are incorporated in zoning ordinances and rules. Vegetative buffers on state designated streams range from 25-100 feet on private land and up to 200 feet on public land. Federally designated rivers have restricted vegetative cutting zones on federal lands of up to 1/4 mile from the OHWM.

The State of Oregon requires local governments to adopt a 75 foot setback, unless they can justify a different number. Marion County, Oregon, requires all septic tanks and drain fields to be set back 100 feet from the high water line.

The Fairfax County, Virginia Comprehensive Plan establishes an Environmental Quality Corridor (EQC) system that includes 100-year floodplains, slopes greater than 15% adjacent to a floodplain, wetlands in stream valleys and a buffer zone along stream channels. The policy is to avoid development of the EQC by dedication to the Fairfax County Park Authority if it is in the public interest or as separate undeveloped lots with commitments for preservation. The policy allows a transfer of some of density from the EQC portion of the site to less sensitive areas on the site.
(The plan is available on the Fairfax County website. See the Plan subsection on the "Environment".)

In Michigan, the Shorelands Protection and Management directs the State Department of Environmental Quality (DEQ) to conduct studies along the coastal areas and determine the long-term average rate of shoreline movement. Areas that are found to be receding at a rate of one foot per year or greater are designated as high-risk erosion areas, and setback requirements are established which are based on the average rate of recession for the area. Therefore, setbacks along the shoreline of Michigan vary greatly. In addition, there are 30-year and 60-year setback requirements; structural characteristics of the structure and site dictate which setback applies to the project. A permit from the state is required for new construction, including additions and substantial improvements to existing structures, and the installation of septic systems. The geomorphic reference feature from where the setback is measured also depends on the conditions of the site. Without the benefit of a site inspection, an applicant is told that the farthest landward feature the setback would be measured from is the top of the lakeward facing slope. Depending on the site characteristics, the reference feature may actually be lakeward of that location.
A second Michigan DEQ program establishes a setback from the crest portion of the Great Lakes shoreline. Along with other restrictions, it prohibits development and contour changes lakeward of the crest in designated critical dune areas. While construction may occur close to the crest, there are standards in the statute which work to minimize the impact of that development, including limitations on vegetation removal and the requirement to re-plant areas with indigenous species. Permits from the state are required for all construction, terrain alteration and vegetation removal in critical dune areas.

X. FOUNDATION DESIGN

OBJECTIVE:
To ensure proper design and construction of building foundations to protect building structural integrity against the effects of buoyancy, uplift, debris impacts, and other flood forces.

RATIONALE:
ASCE-24 provides a standard of practice for flood resistant design and construction in flood-prone areas.

MODEL LANGUAGE:
Add the following sentence (bolded) to the Residential Construction section:

Option 1:
New construction and substantial improvement of any residential structure, including manufactured homes, shall have the lowest floor, including basement, elevated to or above the base flood elevation plus two feet of freeboard. Support structures and other foundation members shall be certified by a registered professional engineer or architect as designed in accordance with ASCE 24, Flood Resistant Design and Construction, or shall be constructed with designs meeting this standard.

Option 2: The following requirements are stated in Section VIII Development in the Floodway from the Harris County Floodplain Regulations 1/1/18:

The following additional requirements must be met for development in the floodway [Harris County Floodplain Regulations 1/1/18]

(1) The bottom of the lowest horizontal sill, beam or member supporting the structure in the floodway shall be at least thirty-six (36) inches above the 0.2 percent or 500-year flood elevation.
(2) An engineering report sealed by a (Texas) registered professional engineer containing as a minimum the following information:

a. A soils report which includes the results of a soil boring(s) to a depth of five (5) feet below the depth of any proposed piles and the geotechnical engineer's recommendations for the proposed structure signed and sealed by a (Texas) registered professional engineer; and
b. A hydraulic analysis of pre- and proposed development conditions showing that no increase in the elevation of the base flood will occur as a result of the development signed and sealed by a (Texas) registered professional engineer.

(3) Structures shall be elevated on posts or pilings so that the entire structure, exclusive of the posts or pilings, is thirty-six (36) inches above the 0.2 percent or 500-year flood elevation. Fill may not be used to elevate the structure. The drawings and specifications for said posts or pilings shall be prepared by a (Texas) registered professional engineer qualified in structural design and he or

she shall certify thereon that the posts or pilings have been designed to prevent undermining and structural damage resulting from erosive velocities of the base flood. Minimum pile depth shall be established using historical scour depth, stream velocity and soil conditions. As a minimum, piles shall be embedded ten (10) feet below the historical scour depth. Pile design must take into account hydraulic and debris loading imposed by the base flood. If no historical data is available a (Texas) registered professional engineer shall perform a scour analysis using the "Texas Secondary Evaluation and Analysis for Scour" (or similar) methodology. After the placement or installation of the posts or pilings, or during or prior to the final inspection or approval of the structure, the permittee shall furnish to the Community Floodplain Manager (County Engineer) a certificate from the said engineer that the posts or pilings have been constructed in the manner set forth in the drawings and specifications attached to the application for a permit. All other requirements must be met, but must not increase the base flood elevation.

(4) The foundation design requirements presented herein assume that potential scour around a foundation system could extend to a depth as great as ten (10) feet below natural grade. The foundation system must extend to a depth below the maximum potential scour that is adequate to prevent excessive vertical and horizontal movement of the foundation system due to design axial and lateral loads imposed during base flood conditions.

These foundation design requirements present minimum foundation design requirements. Foundations must meet or exceed these minimum design requirements, regardless of the type of scour protection provided for the foundation.

4.a Design Loads: The structural system of the building shall be designed, connected and anchored to the foundation system to prevent flotation, collapse and permanent lateral movement resulting from wind loads, impact loads, hydrodynamic loads and hydrostatic loads, including the effects of buoyancy from flooding equal to the base flood elevation.

4.b Foundation Type: The foundation system shall consist of a driven pile or a drilled pier foundation system.

4.b.1 Driven Piles: Driven piles may extend above natural grade and act as the columns supporting the elevated portion of the building above the base flood elevation, or the piles may be terminated near natural grade and a reinforced concrete cap shall be cast on top of the pile.

4.b.2Drilled Piers: Drilled piers shall be terminated below natural grade, and a reinforced concrete cap shall be cast on top of each pier. Columns for the building may consist of cast-in-place concrete connected by dowels to the pier cap.

4.c Type and Size of Driven Pile: Driven piles shall consist of either twelve (12) inch (minimum) square pre-stressed concrete piles or fourteen (14) inch (minimum) diameter steel pipe piles with a closed end.

4.c.1 Closure Plate: The tip of pipe piles shall be closed prior to driving by welding a circular steel plate over the tip of the pile. The closure plate shall be flush with the outside of the pile, i.e. the diameter of the closure plate shall not be greater than the outside dimensions of the pipe pile.

The minimum thickness of the closure plate shall be 3/8 inch. The weld shall be continuous, and the closure shall be waterproof.

4.c.2 Minimum Wall Thickness: The minimum wall thickness of the pipe pile shall be 1/4 inch.

4.d Type and Size of Drilled Pier: Drilled piers shall be eighteen (18) inch diameter (minimum) and straight-sided (no belled or under reamed base) and shall be installed using the slurry displacement technique in accordance with the ACI Standard Specification for the Construction of Drilled Piers (ACI 336.1- 94).

4.e Minimum Pile and Drilled Pier Embedment: The minimum embedment below natural grade for driven piles and drilled piers shall be twenty (20) feet if the computed allowable axial capacity of the driven pile or drilled pier (factor of safety of at least 2.0 with respect to ultimate axial capacity) is equal to or greater than the design axial load transmitted to the pile.

4.f Lateral Restraint of Foundations at Groundline: The individual piles or piers shall be braced horizontally with reinforced concrete tie beams connecting the pier/pile caps each way (not diagonally). For piles that extend above natural grade and act as column supports for the structure, a reinforced concrete collar shall be cast around each pile at the groundline, and the collars shall be connected each way with reinforced concrete tie beams. The purpose of the horizontal bracing at the groundline is to enhance the lateral restraint of the individual piles or piers when scour around a pile or pier reduces the lateral stiffness of the pile or pier.

4.g Anchorage of Timber Building Columns to Concrete Pile/Pier Cap: The timber column to concrete pile/pier cap connection should develop the full moment capacity of the timber column. The timber column shall be bolted into a steel sleeve with a welded steel base plate that is bolted to the concrete pile/pier cap using anchor bolts cast into the cap. The steel sleeve shall be oversized with the inside sleeve dimension at least 1 1/2 inch greater than the column dimension. The gap between the sleeve and column should be filled with a high strength non-shrink grout. The bolt(s) connecting the column to the sleeve should be designed for uplift forces and shall be 3/4 inch diameter minimum. The sleeve assembly and bolts shall be galvanized.

4.h Driven Pile Installation Techniques: Driven piles shall be installed by driving alone. Jetting with water or air to create a pilot hole or to loosen the foundation soils before or during driving to aid driving will not be permitted. Piles may be driven with a vibratory hammer, a drop hammer, or a diesel or compressed air-operated pile driving hammer. To aid in stabbing and aligning piles, pilot holes may be drilled with a dry auger to a maximum depth of ten (10) feet. The pilot hole diameter shall not exceed the pile diameter or width.

4.i Drilled Pier Reinforcement and Concrete: Reinforcement and concrete for drilled piers shall be in accordance with ACI Standard Specification for the Construction of Drilled Piers (ACI 336.1-94).

4.i.1 Minimum Reinforcement: The minimum steel area shall be one (1) percent which is equivalent to six (6) No. 6 reinforcing bars for an eighteen (18) inch diameter pier.

4.i.2 Concrete: The minimum twenty-eight (28) day compressive strength of the concrete shall be 3000 psi. The maximum nominal course aggregate size shall be 3/4 inch and the minimum concrete slump shall be seven (7) inch.

4.i.3 Inspection and Testing: The (Texas) registered professional engineer who designed the foundation shall observe the installation of each pier or pile foundation element and shall furnish the Permit Division of the Harris County Engineering Department a certificate that the piers or piles have been constructed per the design plans and specifications submitted with the permit application. Testing in connection with drilled pier installation shall be in accordance with ACI 336.1-94.

XI. FULLY DEVELOPED WATERSHED CONDITIONS HYDROLOGIC MAPPING

OBJECTIVE:
To protect property against impacts of increased flood heights due to anticipated fully urbanized development anywhere in the watershed, especially in rapidly developing areas.

RATIONALE:
In many cases, flood studies and floodplain mapping reflect past conditions since the studies often rely on old data (current conditions at best). As watersheds are developed, future flood heights will almost always increase. The flood risk criteria used to site and design a project should rely on conditions the location is likely to experience during the project's lifetime, not past or current conditions.

Community planners are urged to consider the effects of re-development or infill development of urban areas. Trends are towards higher density than the original development with few opportunities for resolving antiquated storm drain systems. Community planners and developers should analyze the existing flood hazard with existing hydrology and then explore how to mitigate increased impervious cover as well as providing additional detention /storage for undersized SD systems.

MODEL LANGUAGE:
Communities that are experiencing rapid urban and suburban growth and development should require that all new construction and substantial improvement have the lowest floor elevated to or above the fully urbanized (future) watershed conditions 1%-annual-chance (base) flood level, ideally with the freeboard and other higher standards recommended in this document. We recommend the following three regulations:

(1) Add the following definition:

Fully Urbanized or (Future) Watershed Conditions Flood Hazard Area – Also known as area of future (fully developed) watershed conditions flood hazard, the land area that would be inundated by the one-percent-annual-chance flood based on fully developed watershed conditions hydrology.

Note: Many communities perform studies based on fully developed conditions beginning in areas of concentrated flow where the drainage basin exceeds 100 acres**.**

(2) Add the following sentence to the "special flood hazard area" definition:

Any area outside the one-percent-annual-chance flood hazard area identified by FEMA and designated as Fully Urbanized (Fully Developed Watershed) Conditions Flood Hazard Area on FEMA's Flood Insurance Rate Map shall also be considered special flood hazard areas.

(3) ***Require that all map revisions and watershed studies include analyses based Fully Urbanized (Fully Developed Watershed) Conditions associated with anticipated watershed growth and land-use and land-cover changes. These Fully Urbanized (Fully Developed Watershed) Conditions analyses shall be included on community floodplain maps and will serve as the basis for this regulation.***

Note: Many communities perform studies based on fully developed conditions beginning in areas of concentrated flow where the drainage basin exceeds 100 acres

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XII. MATERIALS STORAGE

OBJECTIVE:

To protect the community against flood damage from materials that may block flood flows or which become buoyant, flammable, explosive, or cause other environmental health issues in floods.

RATIONALE:
Storage of materials is often difficult to regulate since many areas do not require building permits for storage. Stored materials can become waterborne debris during floods, endangering adjacent properties, and creating potential debris blockages where bridges or culverts exist.

Note: Gas and Liquid Storage Tanks are covered in another section of this Guide under that title.

MODEL LANGUAGE:
(1) Add the following to the Prohibited Uses section:

A. Storage or processing of materials that are hazardous, flammable, or explosive in the identified special flood hazard area.

B. Storage of material or equipment that, in time of flooding, could become buoyant and pose an obstruction to flow in identified floodway areas.

(2) Add the following to the Storage of Materials section:

Storage of material or equipment not otherwise prohibited shall be firmly anchored to prevent flotation.

XIII. SETBACKS

OBJECTIVE:
To provide a limited use/development set aside area along a stream for flood damage prevention, resource protection, floodwater storage, water quality, pollutant/sediment removal, and natural stream function.

RATIONALE:
Most floodplain regulations protect lands adjacent to streams with property protection and flooding conditions in mind. Floodplains provide a wide range of natural and beneficial functions, and many of these resource protection functions can only be achieved with setbacks that preserve a riparian corridor adjacent to streams. Significant CRS credit is available for this activity, if it results in floodplain open space.

MODEL LANGUAGE:
(1) Setbacks in riverine floodplains
Proposed development adjacent to riverine floodplains shall be setback (50', 100', 200'…) from the floodway boundary, top of channel bank, or from the centerline of the stream if the floodway has not been delineated.

(2) Setbacks in coastal floodplains

Proposed development adjacent to coastal floodplains, mapped as Coastal High Hazard Areas –Zones V, V1-30 and VE, shall be set back (100', 200', 300'….1000') from the mean low tide boundary or Zone V (V1-30 or VE) boundary as shown on the community FIRM.

(3) Proposed development in areas designated as coastal A Zones (areas between the 3' breaking wave and the 1.5' breaking wave), shall have the same development requirements as development in Coastal High Hazard Area, Zones V, V1-30 and VE. [Note: require 44 CFR 60.3(e) requirements in areas designated as LiMWA – Limited Moderate Wave Action on the community FIRM]

(4) Setbacks in erosion areas

Development in areas with annual erosion (advance) rates of (5, 10…) feet or more per year, based on a study by a Federal, State or local agency and adopted by the community, shall be set back (100', 200', …) from the mean low tide boundary in coastal areas and setback (100', 200'…) from the floodway boundary, top of channel bank or stream centerline if the floodway has not been defined.

[In areas with severe erosion rates the community may elect to require more stringent requirements]

(5) Floodway Setback and dedication as drainage easement:

a. Area within the floodway must be dedicated as a drainage easement
b. New and substantially improved structures must be setback a minimum of (10', 20', 30') from the floodway boundary

Specific model language has not been developed due to the technical and planning information needed to establish a setback for a given watercourse. The Center for Watershed Protection (www.cwp.org) has developed some excellent materials about setbacks and has sample ordinances that can be downloaded from the internet.

XIV. STORMWATER MANAGEMENT

OBJECTIVE:

To prevent increased flood flows and limit increased runoff from a proposed development to pre-development conditions, and to maintain floodplains and stream channels by reducing erosion and sedimentation from construction activities in flood hazard areas.

RATIONALE:

One of the most effective ways to prevent flooding problems from getting worse over time is to limit the changes in watershed hydrology that increase flood flows. Probably the single most effective way to accomplish this is through storm water regulations which limit increases in runoff that result from new development. Significant CRS credit is available for this activity.

MODEL LANGUAGE:
Communities should adopt comprehensive stormwater management regulations, which address water quality issues associated with development, and address increased runoff quantity by adopting regulations, which ensure, at a minimum:

All subdivision and other development proposals which involve disturbing more than (1 acre, 10000 square feet or community selected) of land shall include a stormwater management plan which is designed to limit peak runoff from the site to predevelopment levels for the 1, 10 (or 25), and 100 year rainfall event. These plans shall be designed to limit adverse impacts to upstream and downstream properties (and/or channels and floodplains) including considerations for maintaining water surface elevations and not increasing erosive velocities for the 1, 10 (or 25), and 100 year rainfall event. Plans shall also define reasonable party and requirements for operation and maintenance and frequency of inspection of drainage facilities. Single residential lots involving less than (1/4, ½, 1) acre of land disturbance are not subject to this regulation.

Several Texas communities have adopted regulations based on storms using a range of different frequencies, such as:

DESIGN STORMS

Size	Purpose	Frequency
Small Storm	Erosion analysis	1-yr or 2-yr
Medium storm	Conveyance	5-, 10- or 25-yr
Large Storm	Flood control FEMA mapping	100-year

For examples of comprehensive stormwater management regulations:

1) North Central Texas's integrated Stormwater Management (iSWM™) guidance documents and checklist:

http://iswm.nctcog.org/
http://iswm.nctcog.org/Documents/iSWM_Implementation_Tiered_Measurement.pdf

2) City of Austin Watershed Protection Ordinance No.20131017-046

http://www.ci.austin.tx.us/edims/document.cfm?id=199808

3) City of Houston Stormwater Regulations

a. Chapter 47 of the City of Houston Code of Ordinances

http://library7.municode.com/default-test/home.htm?infobase=10123&doc_action=whatsnew

b. PWE website for Stormwater Permit documents: http://documents.publicworks.houstontx.gov/document-center/storm-water-quality/index.htm
c. Clean Water/Clear Choice: http://www.cleanwaterways.org/

4) City of Arlington Stormwater Pollution Control: http://www.arlington-tx.gov/cityattorney/wp-content/uploads/sites/15/2014/05/STORMChapter.pdf

4.1 City of Arlington Flood Damage Prevention regulations: http://www.arlington-tx.gov/cityattorney/wp-content/uploads/sites/15/2014/05/FLOODChapter.pdf

5) The State of Delaware's regulations: http://regulations.delaware.gov/AdminCode/title7/5000/5101.shtml

6) The State of Minnesota regulations: www.dnr.state.mn.us/waters

Maintain or Restore Native Vegetation in the Floodplain
Native vegetation provides more effective infiltration than lawns or other surfaces, and slows down the rate of stormwater runoff, which can in turn reduce streambank erosion. In addition, protecting native vegetation also protects wildlife habitat and enhances the value of floodplains for many types of recreation. Minnesota's shoreland rules limit clearing of vegetation within shore and bluff impact zones and on steep slopes. However, where shoreland ordinances have not been adopted or where higher standards are desired, a buffer zone can be established, within which native vegetation must be protected or restored, and where fill and other disturbances are prohibited.

Replacement of roadway culverts and bridges:
A hydrologic and hydraulic study must be submitted to the community floodplain manager for approval prior to replacing roadway culverts and bridges that exceed 48" in diameter.

XV STORMWATER DETENTION

OBJECTIVE:
Stormwater detention basins are a place to store potentially damaging floodwaters temporarily until the channels can safely carry the water away. In areas with flat terrain, stormwater storage has to be excavated. Stormwater detention can be site specific or regional, and designed and constructed to reduce the risk of flooding to a specific site or regional to reduce the risk of flooding to a watershed or sub-

watershed. Large regional facilities, can be several hundred acres in size which is common in the Harris County Flood Control District. New developments often use stormwater detention to offset or mitigate the negative effect development may have on flooding (due to covering up soil with buildings and concrete and speeding up the rate water runs off an area). When full, detention basins often resemble lakes. When dry, detention basins are large excavated open space areas and have been used to enhance wetlands and wildlife habitat areas. Some systems are being designed to have a permanent water level, or small lake, in the bottom of the basin, and the flood storage is provided above the normal surface of the lake. Playa Lakes, for example, in the Texas Panhandle, in Lubbock and Amarillo, are both wet bottom and dry bottom lakes that have been incorporated into city-wide drainage systems.

RATIONALE:

When a stormwater detention basin is used to mitigate development projects, it may not necessarily be adjacent to a channel. Under this condition, the detention basin will typically be filled by a storm sewer pipe or sheet flow draining into it from the surrounding development. The basic concept here is "big pipe in - little pipe out" to provide storage of the excess runoff produced by development. Also note, that if a single development is part of a larger planned development, the detention site may not be located on each property but is centralized into one larger facility in another nearby location.

Stormwater detention basins, particularly in Harris County, are typically designed so that they drain by gravity, as opposed to having pump systems drain them. Because this is the case, the depth of the detention basin and location and depth of its outfall or drain is dictated by the depth of the receiving channel. The rate at which stormwater drains out of a detention basin is influenced by several factors, one of which is the stormwater level in the receiving channel. Typically, as stormwater levels recede in the receiving channel, stormwater will drain out of the detention basin accordingly.

The Cole Park Detention Cavern in Dallas, with 71 million gallon storage capacity, is completely underground, located below Cole Park, and must be pumped when the storm peak has passed.

TECHNICAL RESOURCES

1. HCFCD – Harris County Flood Control District

1.1 Harris County Flood Control District Technical Library
https://www.hcfcd.org/technical-area/technical-document-library/

https://preview.hcfcd.org/learning-center/stormwater-detention-how-it-works/

1.2 Design Guidelines for HCFCD Wet Bottom Detention Basins with Water Quality Features

https://www.hcfcd.org/media/1757/designguidelineswetbottombasins_final.pdf

1.3 HCFCD Detention Basin Pump Operation and Maintenance Manual Submittal Requirements

https://www.hcfcd.org/media/1581/dbp_operationandmaintenancemanual.pdf

3.2 City of Houston

3.3 City of Houston Design Manual – Chapter 9 Stormwater Design Requirements

https://edocs.publicworks.houstontx.gov/documents/design_manuals/chapter_9_draft_revision_4_13.pdf

3.0 Fort Bend County

3.1 Fort Bend County Drainage Criteria Manual

http://co.fort-bend.tx.us/index.aspx?page=336

3.2 Fort Bend County Drainage Criteria Manual – 6.0 Storm Runoff Storage

http://co.fort-bend.tx.us/modules/showdocument.aspx?documentid=1255

XVI. SUBDIVISION STANDARDS

OBJECTIVE:
To ensure subdivisions, including infrastructure and lots are created and designed to minimize risk of damage to property and potential loss of life from flooding, and to minimize the disturbance of floodplain riparian zones.

RATIONALE:
Avoidance of floodplains is far preferable to setting standards and allowing building in the floodplain. The annual premium of typical flood insurance policy can range from $300 to $10,000 dollars, and this doesn't account for public expenses associated with building in the floodplain.

MODEL LANGUAGE:
The following higher standards language should be adopted into the community's subdivision ordinance and regulations (if applicable) and/or flood damage reduction regulations:

Option 1:
(1) Modify the section on subdivisions and large-scale development to incorporate the bolded text:

For watersheds within communities that have an adopted Land Use or Zoning map, the base flood elevation shall be defined as the 100-year flow generated considering a built-out condition. This base flood elevation mapping shall begin in areas of concentrated flow where the drainage basin exceeds 100 acres. If these base flood elevations are not available, the applicant shall provide a hydrologic and hydraulic engineering analysis that generates the fully developed base flood elevations and floodway boundaries for all subdivision proposals, and other proposed developments at least 5 acres or 5 lots in size (optional language: greater than 1, 2, 5 acres) . These studies may be submitted to FEMA as a request for map revision if appropriate*.*

(2) Add the following to the section for Subdivisions and Large Scale Development:

A. All preliminary plans for platted subdivisions shall identify the flood hazard area and the elevation of the base flood.

B. All final subdivision plats will provide the boundary of the special flood hazard area, the floodway boundary, and base flood elevations.

C. In platted subdivisions, all proposed lots or parcels that will be future building sites shall have a minimum buildable area outside the natural (non-filled) 1% chance annual floodplain (base flood elevation area). The buildable area shall be large enough to accommodate any primary structure and associated structures such as sheds, barns, swimming pools, detached garages, on-site sewage disposal systems, and water supply wells, if applicable.

D. Approval shall not be given for streets within a subdivision, which would be subject to flooding in the base flood. All street surfaces must be located at or above the base flood elevation.

E. Drainage and Floodplain Easements along with assignment of responsibility shall be required for all drainage systems that convey stormwater runoff across property boundaries. These easements must include sufficient area for operation and maintenance of the public drainage system, along with needed terrain for access.

F. Where on-site detention is utilized, a downstream timing analysis shall be prepared, confirming that the proposed detention does not exacerbate peak flows in downstream reaches. Consideration of a regional detention option may be a preferred solution where flow releases greater than pre-developed are allowed.

Option 2:

The following conditions must be met if the proposed development for which a Development Permit is sought is for a subdivision, including a manufactured home park or subdivision. [Harris County Floodplain Regulation effective 1/1/18]

1. **The subdivision must be planned to provide adequate drainage so as to reduce flood hazards.**
2. **If water and sanitary sewer systems are planned, the drawings must be reviewed to determine if they meet the requirements of these regulations.**
3. **The drawings for development of the subdivision must be adequate to assure that all public utilities and facilities (including gas, electrical systems, sewage systems and water supply systems) are located and elevated or constructed to avoid or minimize flood damage.**
4. **If a subdivision proposal includes 50 or more lots or is on an area larger than 5 acres the proposal (plat and/or plans) must include 1 percent or 100-year and 0.2 percent or 500-year flood elevations for each lot.**

Option 3: Mobile Home Parks and Subdivisions:

The following conditions must be met by a manufactured home park or manufactured home subdivision that seeks a Development Permit:

1. **The lowest floor of the manufactured homes will be at least twenty-four (24) inches above the 0.2 percent or 500-year flood elevation;**
2. **Adequate surface drainage and access for a hauler must be provided;**
3. **Lots must be large enough to permit steps. Piling foundations must be placed in stable soil no more than ten feet apart, and reinforcement must be provided for piers more than six feet above the ground level;**
4. **Each manufactured home within the park shall be placed on a permanent foundation and anchored to resist flotation, collapse or lateral movement by providing an anchoring system installed in accordance with the Texas Department of Housing and Community Affairs and the Housing and Urban Development (HUD) standards for manufactured housing. Any additions to the manufactured home must be similarly anchored. (This paragraph applies to manufactured homes to be placed or substantially improved in an expansion to an existing manufactured home park or subdivision. This paragraph does not apply to manufactured homes to be placed or substantially improved in an existing manufactured home park or subdivision except where the repair, reconstruction, or**

improvement of the streets, utilities and pads equals or exceeds fifty (50) percent of the value of the streets, utilities and pads before the repair, reconstruction or improvement has commenced).

5. **All utilities and common facilities including gas, electrical systems, sewage systems and water supply systems, must be located and elevated or constructed to avoid or minimize flood damage.**
6. **The fact that the manufactured home park or subdivision is located below the 0.2 percent or 500-year flood elevation must be disclosed on a form furnished by the Community Floodplain Manager (County Engineer) and completed by the owner of the manufactured home park or subdivision and provided to the manufactured home lot purchaser or lessee. The owner of the manufactured home park or subdivision shall forward a copy of each notice to the Community Floodplain Manager (County Engineer).**
7. **The manufactured home park or subdivision may not be in a floodway or a "V" Zone.**
8. **An evacuation plan must be developed for evacuation of all residents of all new, substantially improved or substantially damaged manufactured home parks or manufactured home subdivisions located within the area of special flood hazard. This plan shall be filed with and approved by the Community Floodplain Manager (County Engineer) and the Emergency Management Coordinator prior to permit issuance.**

Option 4: Mobile Home Parks and Subdivisions -entrance/access/evacuation route:

All new mobile home parks and residential subdivisions located in the SFHA and Zone X (shaded) must have one primary entrance/access/evacuation route that is elevated above the BFE and cannot impede flow.

Option 5: Dedicated drainage ROW in new subdivisions:

Special Flood Hazard Areas within new subdivisions must be dedicated as drainage right of way (ROW).

XVII. HIGHER STANDARDS IN EXTRATERRITORIAL JURISDICTION AREAS (ETJ)

OBJECTIVE:
To regulate development in Extraterritorial Jurisdiction Areas (ETJ) based on the highest regulation standard adopted by incorporated cities and county unincorporated areas. Texas

incorporated communities have building code authority where only Texas counties have building code authority when granted by special state legislature action. Therefore, incorporated communities, for the most part, adopt and enforce more stringent land development regulations. The ideal higher standard objective is to adopt higher standards countywide but where this is not possible, the objective is to enforce higher standard regulations in the ETJ, regardless if the higher standard is the county of an incorporated community.

RATIONALE: Texas land use law requires that incorporated areas regulate areas within the corporate boundaries and counties regulate areas in unincorporated areas including the ETJ.

HB 1445 (77th Legislature September 1, 2001)

House Bill 1445 amends the Local Government Code to require that certain municipalities and counties enter into written agreements that identify which of the two entities is responsible for the regulation of subdivision plats and approval of related permits in the extraterritorial jurisdiction of a municipality and to set out deadlines for the finalization of such agreements. An agreement may grant the authority to regulate subdivision plats and approve permits to either the municipality or the county exclusively, allow the two entities to apportion the area and the respective regulatory authority between the two entities, or allow the two entities to enter into an interlocal agreement to create a single office under which various municipal and county regulatory functions regarding platting are consolidated. The bill retains current provisions relating to the regulation of subdivision plats to govern the interactions between a municipality and county in this regard until the two entities have reached their required agreement, with the added provision that in a conflict between municipal and county regulations the more stringent regulation prevails.

The **City of Austin** is located in both Travis and Hays counties and has requirements both within the Austin city boundary and the ETJ:

Inside the City Limits (full purpose annexation) – Zoning, Subdivision, Site plan, Building, Trade and Concrete permits are required.

Extra-territorial Jurisdiction (not limited purpose annexation) – The extra-territorial jurisdiction (ETJ) is that area extending five miles outside the City of Austin corporate limits. All development in the ETJ is required to obtain site plan (development permit) approvals or site plan exemptions from the City. In addition, plumbing and/or electrical permits may be required if the project is served by City utilities (ETJ fees will be assessed in addition to the permit fees). Development, building permits and driveway permits are required by Travis County and Hays County.

Other commonly required approvals both inside the city limits and/or ETJ:

- Austin/Travis County Health Department permits, if the project needs a septic system or if it is a sanitary land fill or salvage yard. LCRA has jurisdiction for permits for septic tanks adjacent to Lake Travis.
- US Fish and Wildlife Service permits for endangered species habitats.
- Texas Water Commission permit for projects over the Edwards Aquifer.
- Texas Parks and Wildlife Department, Corps of Engineers approval for drainage

modifications.

Projects involving single-family boat docks, earthwork, site clearing, utilities, and street and drainage improvements require a site plan (development permit) or site plan exemption. Boat docks also require building and electrical (if lighted) permits along Lake Austin.

XVIII. FLOODPLAIN USE RESTRICTIONS

OBJECTIVE:
To restrict or prohibit uses of the floodplain which are dangerous to health, safety or property in times of flood, or which cause excessive increases in flood stages or velocities.

RATIONALE:
Avoidance of floodplains is far preferable to setting standards and allowing building in the floodplain. For many types of critical facilities, the tolerance for even minimal flood risk is extremely low, and complete avoidance of the floodplain should be the standard.

DEFINITION:

Conex box - an intermodal container for shipping and storage. Conex is a trade name for meta-aramid fiber.

MODEL LANGUAGE:
Add the following to the Prohibited Uses section:

A. New construction of any residential or nonresidential structures in floodway areas and within or below the base flood elevation.

B. Storage or processing of hazardous, flammable, or explosive materials in special flood hazard areas. [Caution: while this policy defines the floodplain, floodway and BFE's future conflicts may occur when the watershed is remapped or modified by a LOMC]

C. Critical development in special flood hazard areas. (Note: Must also adopt the critical development definition – see critical development higher standard).

D. The use of nonconforming structures shall not be changed from a non-residential structure to a residential structure or a mixed-use structure, or increase the residential use area of a mixed-use structure.

E. The use of any structure shall not be changed to a critical facility, where such a change in use will render the new critical facility in violation of Section IV - Critical Development Protection.

F. Metal storage containers (Conex boxes) are prohibited as permanent structures within the special flood hazard area. Temporary use permits are allowed, not to exceed 180 days, if containers are anchored to resist 10 psi uplift forces.

XIX. REGULATING AREAS NOT MAPPED ON FIRM

OBJECTIVE:
To provide a means for a community to regulate development in areas at risk to flooding that have not been mapped on FEMA's FIRMs.

RATIONALE:
At best, most FEMA flood insurance studies do not map floodplains in watersheds with drainage areas, of less than one square mile, floodplain widths less than 200', and in areas with poor drainage not associated with flooding sources. In many undeveloped areas, some larger watersheds may not have been mapped. Estimates are that nationally, over 1/3 of flood damage occurs outside of mapped floodplains.

MODEL LANGUAGE:
(1) Add the following sentence to the "special flood hazard area" definition:

Any area outside the FEMA studied areas lying along streams as shown on the United States Department of the Interior Geological Survey (hereafter referred to as "USGS") 7.5 minute quadrangle map of which [community name] is contained and/or areas with flood prone soils which are contiguous to blue line streams as shown on the USDA Natural Resources Conservation Service (NRCS) published Soil Survey for Texas counties.

[Note – in determining the extent of land "contiguous" to streams, (blue line streams on some USGS maps) communities may elect to establish a buffer defined by width, land elevation, historical flooding, or other data. USGS Quadrangle Maps (Quads) are available through the National Geospatial Program of the USGS – www.nationalmap.gov. USDA NRCS published Soil Surveys are available on line at www.nrcs.usda.gov].

(2) In areas upstream of the Limit of Detail Study, as delineated on the community FIRM, where ***base flood elevation data is not available, where areas of concentrated flow are formed from a drainage basin exceeding 100 acres, a floodplain study must be performed by a Professional Engineer (PE) establishing both existing conditions and the fully developed base flood elevation (BFE) and the floodplain and floodway boundaries prior to issuing a development permit.***

(3) Add the following references to the flood hazard data adopted in Basis for Establishing the Areas of Special Flood Hazard:

A. USGS 7.5 minute quadrangle maps for (community or area name) showing the watershed the community is located in.
B. USDA Natural Resources Conservation Service (NRCS) published Soil Survey for the Texas county that the community is located in.

XX. HIGHER STANDARDS IN ZONE D

OBJECTIVE:

To provide a means for a community to regulate development in areas mapped on FEMA's FIRMs as Zone D. The Zone D designation is used for areas where there are possible but undetermined flood hazards, as no analysis of flood hazards has been conducted.

RATIONALE:

MODEL LANGUAGE:

TFMA recommends that communities require new development in Zone D to meet the same requirements for new development in Zone X. By requiring new structures to be elevated a minimum of +2' above natural grade provides a level of protection and allows owners to benefit when Zone D areas are remapped and placed in a higher risk zone.

Add the following sentence (bolded) to specific requirements for Residential Structures and Non-Residential structures:

In areas mapped as Zone D on the community Flood Insurance Rate Map (FIRM), the structure shall have the lowest floor, including basement, elevated at least two feet above the highest adjacent natural grade or above the crown of the nearest street, whichever is higher.

XXI. ELEVATION REQUIREMENTS FOR STRUCTURE ADDITIONS

OBJECTIVE:
To protect new horizontal additions (increase in building footprint) from flood damage.

RATIONALE:
Building an addition below flood level is essentially expanding a non-conforming use – a practice that has been prohibited in many contexts.

MODEL LANGUAGE:
Add the following provisions to the residential and non-residential development requirements:

> ***All new horizontal additions to structures must have the lowest floor and all HVAC and supporting mechanical and electrical equipment elevated to the regulatory base flood elevation.***

XXII. COASTAL SITING and COASTAL HIGH HAZARD AREAS

OBJECTIVE:
To provide greater protection to coastal resources and structures that would be at risk of experiencing damage in coastal high hazard areas from wave action (V Zones).

RATIONALE:
Coastal flood risk increases dramatically with proximity to oceans and bays. While the NFIP has no siting requirements for V-Zones, locating new construction landward of frontal sand dunes and erosion prone lands provides tremendous protection. Note: several states have higher regulatory standards requiring new development to be landward of mean high or mean low tide, minimal setbacks for new construction and protection of sand dunes and mangroves.

MODEL LANGUAGE:
Add the following provisions to the general requirements for development in V Zones:

> ***All new structures shall be located on the lot so as to minimize exposure to coastal hazards and shoreline erosion. Structures should be located outside of the V-Zone, to the greatest extent possible. Building setback requirements should consider predicted future erosion rates, or historical erosion rates.***

XXIII. COASTAL HIGH HAZARD AREA HIGHER STANDARD in REMAPPED AREAS

Option 1 – Remapped Zone V and VE area
If a community is not in agreement with FEMA's action to remap a Coastal High Hazard Area (Zone VE) as any other hazard zone (A, AE, AO, AH, X or other zone designation) and FEMA has provided flood damage data (paid flood insurance claims information from previous events that did not exceed the 1% annual chance flood), the community may consider amending their flood damage prevention ordinance and establish higher standards in the reclassified (remapped) area. The revised flood damage prevention ordinance may require new construction and substantially improved structures, located in the previously mapped Zone VE area (reclassified area), to comply with Zone VE requirements as defined in 44 CFR 60.3(e) regardless of the new flood hazard zone shown on the FIRM.

The recommended flood damage prevention ordinance language is as follows:
"New construction and substantially improved structures located in areas shown as Zone V and VE on previously published Flood Insurance Rate Maps must comply with 44 CFR 60.3(e) (Zone VE - Coastal High Hazard Area) requirements regardless of zone shown on the current community FIRM".

It is recommended that the community maintain flood insurance claims information to support the ordinance revision and to document previous damage from flood events in the reclassified area. It is important to document that the previous hazard event did not exceed the 1% annual chance event (100-year flood).

Option 2 – Establish Zone VE requirements for all waterfront properties

Santa Barbara County, California established the "Coastal High Hazard Zone" that basically made any property with the ocean as a property boundary, subject to V zone building techniques. The County established the waterfront BFE at 13' (1929 datum) or 16' (NAVD 88 datum).

Should you elect to follow the Santa Barbara County example the recommended language for your flood damage prevention ordinance could be:

New Construction or substantial improvement on properties with the ocean (or Gulf of Mexico) as a property boundary must be constructed to Zone VE (44 CFR 60.3(e)) building requirements. The BFE that must be complied with is __ ___' NAVD 1988 or applicable datum.

Option 3 – Establish Zone VE requirements for all properties within a setback distance of mean high tide

This option is similar to Option 2 but applies to all properties within an established setback landward of the reach of Mean High Tide line. The recommended language for your flood damage prevention ordinance could be:

New Construction or substantial improvement on properties within _____ (1000', 1500', 2000' or ____') landward of the reach of mean high tide must be constructed to Zone VE (44 CFR 60.3(e)) building requirements. The BFE that must be complied with is _____' NAVD 1988 or applicable datum.

Option 4 – Establish "Flood of Record" Higher Standards

Should the community decide that a flood of record, that exceeded the 1% annual chance event (100 year flood) and exceeds the BFE and/or hazard zone shown on the FIRM, should become the standard for new and substantial improvement then this becomes the community higher standard. In this example the recommended flood damage prevention ordinance language could be:

"New construction and substantially improved structures located in areas damaged by the "flood of record" established by the community "flood of record report dated _____", on file in the community building permit office, must comply with 44 CFR 60.3(e) (Coastal High Hazard Area) requirements regardless of zone shown on the current community FIRM".

The requirements for new and substantial improvement shall comply with 44 CFR 60.3(e) and include:

- Bottom of the lowest horizontal support member must be elevated at or above the BFE
- New construction and substantial improvement must be elevated on piling or columns
- Fill cannot be utilized for structural support
- Construction below lowest floor must be free of obstruction, breakaway walls or open latticework or insect screening
- Elevated portion and supporting foundation shall not be subject to collapse, displacement, or other structural damage due to wind and water loads

- A registered professional engineer or architect shall develop or review the structural design, specifications and plans for the construction , and shall certify that the design and methods of construction meet the requirements of 44 CFR 60.3(e)

XXIV. DUNE PROTECTION

OBJECTIVE:
To provide greater protection to sand dunes and mangroves and their flood mitigation qualities.

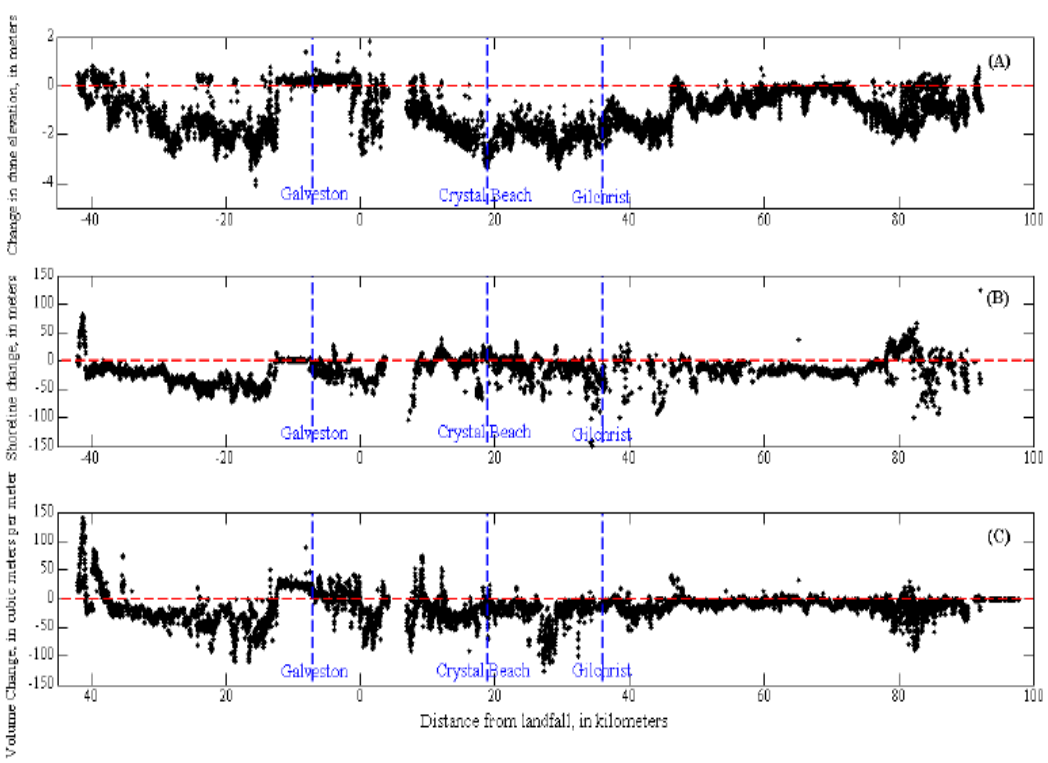


Figure 25. Hurricane Ike (*A*) dune-elevation change (*B*) shoreline change (*C*) and beach-volume change. Blue lines indicate the center of the towns of Galveston, Crystal Beach, and Gilchrist, Texas.

Reference: Hurricane Ike: Observations and Analysis of Coastal Change, USGS Open-File Report 2009-1061

Bolivar Peninsula in 2008 before and after Hurricane Ike.
Photo Credit: Weatherflow.com

Palisades Palms Condominiums, Galveston Island.
Before and after Hurricane Ike.
Photo credit: coastal.er.usgs.gov

RATIONALE:
Sand dunes and mangroves act as flood protection barriers along shorelines, and absorb wave energy before it causes damage to buildings. Land altering activities can destabilize sand dunes, and reduce the ability of the dune to absorb wave energy. Note several states have higher regulatory standards protection sand dunes and mangroves.

Note: The Texas General Land Office (GLO) regulates coastal construction and dune protection in Texas. www.glo.tx.us

MODEL LANGUAGE:
Add the following provisions to the general requirements for development in V Zones:

Retaining walls, landscaping, dune crossovers and other non-essential accessory structures shall be designed and located to minimize impacts to sand dunes and mangroves. Primary frontal dunes shall not be altered unless a qualified engineer demonstrates and certifies that flood risk will not be increased to the subject, or other, properties. Activities which reduce the volume of sand on the dunes or beach can generally be presumed to increase flood risk to landward locations. Adding sand volume to the dune or beach can generally be presumed to not increase flood risk.

XXV. COASTAL CONSTRUCTION

OBJECTIVE:
To provide a greater factor of protection to structures built in V Zones.

RATIONALE:
Because of the extreme potential for damage from wave energy and high velocity flows and debris associated with coastal flooding, higher construction standards are essential. Breakaway enclosures are a compromise strategy, which allow coastal property owners ground level improvements, but maintain structural integrity. Breakaway walls typically create debris problems and should be kept to a minimum. Enclosures, below BFE, should be limited to less than 300 square feet to permit the parking of two vehicles, limited storage and building access.

MODEL LANGUAGE:
Add the following provisions to the residential and non-residential development requirements for V Zone construction:

A. New and substantially improved structures shall have the bottom of the lowest horizontal structural member elevated (1', 2', 3') above the base flood elevation.

B. Enclosures below the lowest floor of elevated buildings shall be usable solely for parking, access, and limited storage. These enclosures shall be less than 300 square feet in area, and shall be designed and constructed with breakaway walls which minimize the amount and impact of debris and adverse effects on adjacent properties.

C. Option to B – Enclosures below the lowest floor of elevated buildings is prohibited in V Zones.

D. Breakaway walls for enclosures below the lowest floor shall be designed to meet building code wind requirements. Such enclosures may be used only for limited storage, parking and access and shall be designed to minimize adverse debris impacts to adjacent properties. Where enclosures are used as access ways to elevated buildings, a secure door located at the elevated floor level must separate the enclosed area from the elevated building.

E. Detached accessory structures such as sheds or garages shall be prohibited in V-Zones.

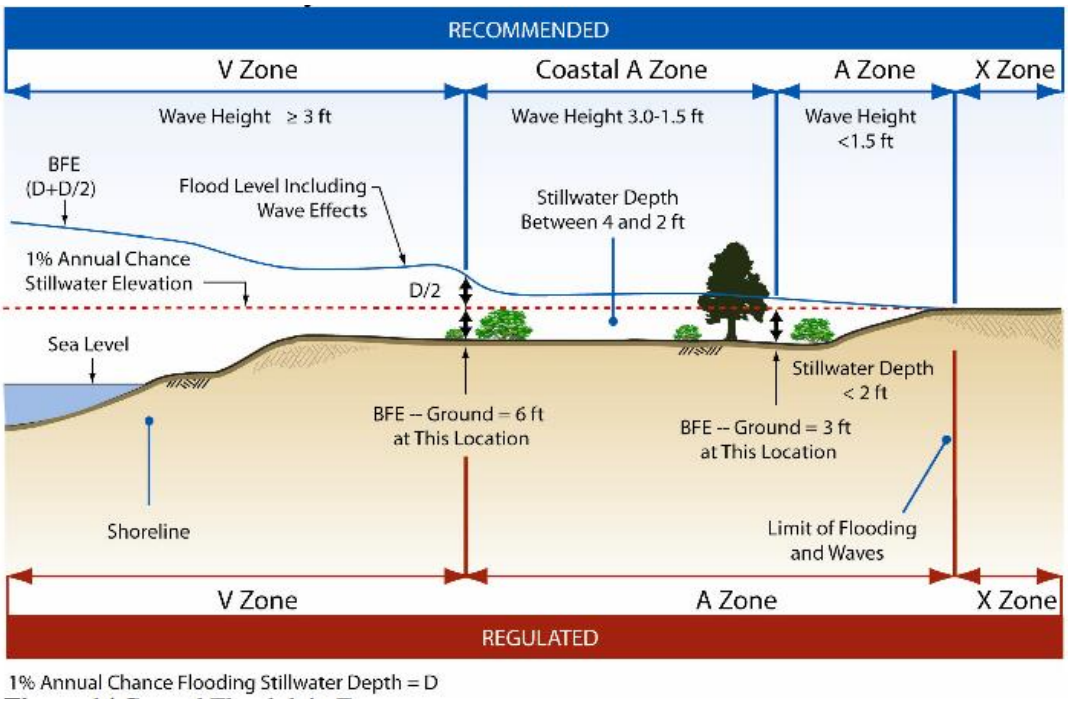
XXVI. COASTAL A-ZONE – LiMWA, LIMIT of MODERATE WAVE ACTION

OBJECTIVE:
To better protect structures in coastal areas subject to storm-induced velocity wave actions.

RATIONALE:
Flooding with wave heights of as little as 1.5 feet can transmit significant energy loads to buildings or other obstructions. A reasonable amount of protection can be provided to development in these A-Zone areas with the potential for 1.5 feet or greater by adopting V-Zone standards in these areas.

FEMA Flood Insurance Study and mapping criteria has been modified to include mapping of LiMWA's, Limit of Moderate Wave Action.

Coastal areas delineated as Zone V and VE are areas where wave action exceeds 3' and new construction must be elevated on piling or piers.
Coastal A Zones are areas adjacent to Zone V and VE where wave height is less than 3' and greater than 1.5', also known as LiMWA - Limit of Moderate Wave Action.
The recommended "higher standard" is to require new construction in Coastal A Zones and LiMWA areas to meet VE Zone requirements.



1% Annual Chance Flooding Stillwater Depth = D

MODEL LANGUAGE:
Add the following provisions to the residential and non-residential development requirements for Coastal A Zone construction:

> ***In areas which have been identified as LiMWA, Limit of Moderate Wave Action or areas subject to limited wave action (between 1.5 and 3 feet) and designated as a Coastal A-Zone, new and substantially improved structures shall comply with all of the V-Zone provisions of this ordinance. Elevation requirements should refer to the bottom of the lowest horizontal structural member of the lowest floor.***

XXVII. SINK HOLE STANDARDS

[The following standards and ordinance language is patterned after the Lexington, Kentucky Sinkhole Ordinance and can be modifies as needed]

Background:
Sinkhole flooding can be divided into 3 categories:
1) Sinkhole flooding that is predominantly from surface runoff;
2) Flooding predominantly from surcharging of the caves below, and
3) Flooding that can be a mixture of the two.

The first category is the easiest to analyze though you may get one sinkhole overflowing into another, and that one into another, and so on, and so on. Bowling Green, Kentucky, for example, has a series of seven (7) sinkholes that share water during big flood events.

Category 3 is the hardest to analyze because often the caves below cannot be entered. They operate basically as storm sewers that cannot be inspected or maintained. Massive changes in underground drainage caused by debris/sediment plugging have been documented. Analysis of sinkhole systems (three categories) requires that you can identify the correct category for any given sinkhole. This can only be done by careful field investigation and/or eye witness accounts. Once you have the sinkhole classified as to flooding in category 3, then you must delineate the groundwater basin and somehow model the cave hydraulics.

Sinkhole-- Any closed depression formed by removal (typical underground) of water, surficial soil, rock, or other material. The existence of a sinkhole shall be indicated by the closed depression contour lines on the Unified Mapping Program topographic maps or other documents as approved by the Community Floodplain Manager. Its actual limits may, however, be determined by field measurements with concurrence of the Community Engineer. Sinkholes may be either circular in plan or irregular, depending upon structural control.

Plan Requirements - A sinkhole, the immediate sinkhole drainage area, a sinkhole cluster area, or portions of such items shall be shown on any development or preliminary subdivision plan for land where they exist. Sinkhole-related non-buildable areas and restricted fill areas shall be shown on final subdivision plans and development plans.

Sinkhole-Related Non-buildable Areas - Based upon the topography, geology, soils, and known history of the sinkhole (such as past filling) and the developer's engineer's stormwater analysis and the community Planning Commission shall establish sinkhole-related, non-buildable areas. No buildings, parking areas, or other structures shall be permitted within the sinkhole related, non-buildable area.

This non-building area shall follow the limits of the sinkhole in most cases. However, the non-building area may be expanded or contracted by action of the Community Planning Commission where warranted due to the nature of the specific sinkhole, the underlying geology, soils, drainage, and any related information such as depth to bedrock. In sinkhole cluster areas, the Community Engineer may require the developer to provide recommendations from a consulting engineer and a consulting hydrologist based upon substantial and state-of the-art field studies and evaluation of the specific sinkhole system. Such studies shall be submitted to the Community Floodplain Manager, which shall review said studies and make recommendations to the Community Planning Commission.

Development in Sinkhole Drainage Areas - Development may occur in the immediate sinkhole drainage area if the developer provides alternative surface drainage away from the sinkhole, while keeping the water in the same surface drainage basin, and provided further that the water shall not go into another sinkhole drainage area off the petitioner's property, nor into another stream of known flooding problems. The immediate sinkhole drainage system area (or portion thereof) which cannot be provided with an alternative drainage system can be deleted from the development area and can be used to meet the normal open space requirements. The developer may request that the Community Planning Commission increase the density on the remainder of

the developable area, with the total resulting density no greater than if the entire area were developed to the permitted density.

For portions of the immediate sinkhole drainage area where alternative surface drainage methods cannot be provided, as determined by the Community Engineer, the developer may choose one of the options described below.

Sinkhole Surface Drainage Analysis - The sinkhole can be used for surface runoff drainage of a proposed development of the conditions of either of the following alternatives are met:

A. Alternative 1: A sinkhole can be used for surface runoff of a proposed development with or without retention or detention facilities as recommended by a consulting Engineer and a consulting hydro geologist, provided that any increase in the quantity of surface runoff due to development of the entire sinkhole drainage area in question will nit aggravate flooding on the proposed development, adjacent existing development, or connected/adjacent sinkhole sub-surface systems. Such engineering and geologist reports must be substantive and based on state-of the -art field studies and evaluation of the specific sinkhole system. The Community Planning Commission shall not approve developments of this subsection unless the Community Engineer concurs with those findings and recommendations.

B. Alternative 2: A sinkhole can be used for surface drainage of a proposed development if all of the following conditions and provisions are met:

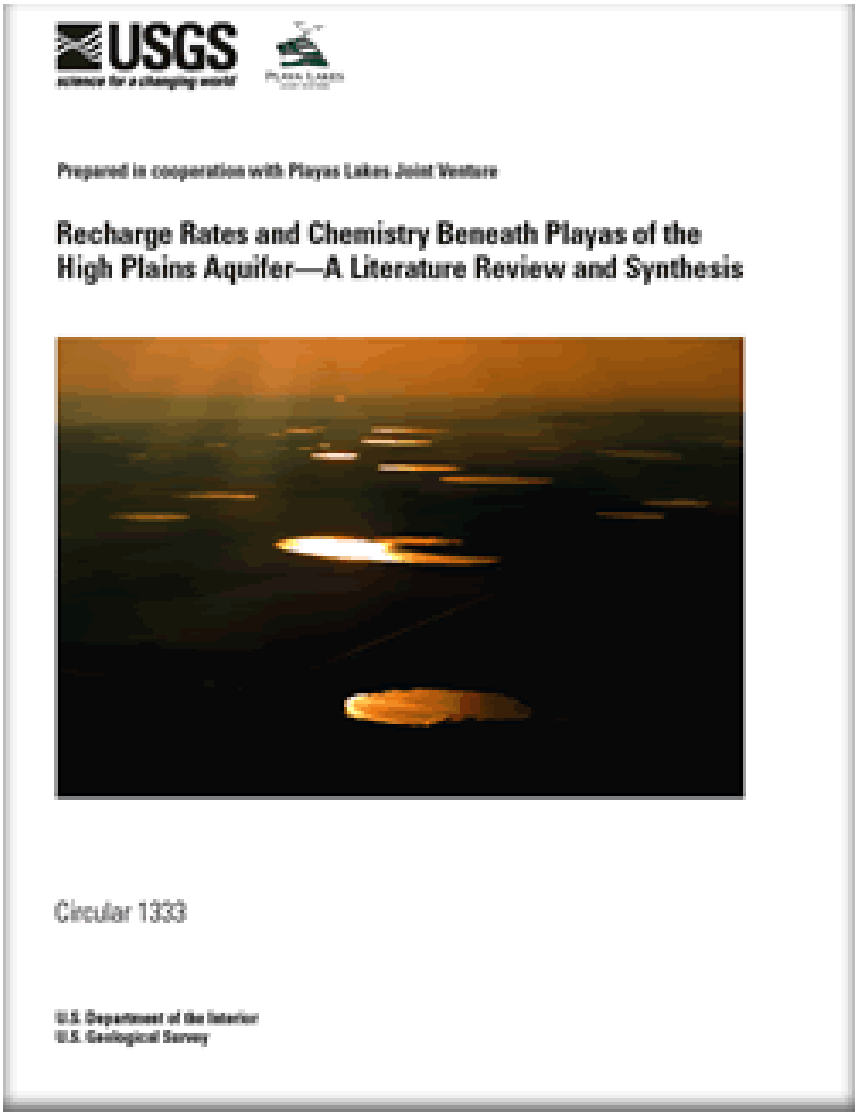
1. That the runoff from the development area is either completely retain in a retention basin or detained in a detention basin. The flow rate out of the above basin shall be regulated so that it is no greater than the flow rate into the sinkhole of the development area prior to development of each of the following storms: 10 year/1-hour, 25year/24-hour storm or a 100 year/1-hour storm. The outflow rate shall not aggravate flooding on downstream properties for any of these storms.

2. As previously noted, the developer may elect to divert enough of the sinkhole drainage area so that the development of the remaining area does not increase the total quality of the runoff into the sinkhole where additional runoff is anticipated, a consulting engineer and hydro geologist shall evaluate and show the effect of any additional quantity of runoff to the sinkhole and sinkhole system. For approval, the study must show the development will not aggravate flooding on the proposed development, adjacent lands, or connected/adjacent sinkhole systems. The Community Engineer shall review the study findings and make recommendations to the Community Planning Commission for alternative 2 to be accepted.

3. Where the sinkhole outlet is offsite, either the runoff leaving the subject property must be shown to be no greater in flow or in quantity than that which existed before development or written approvals must be submitted from owners of property where any increase in flow or quantity of water must go to reach the sinkhole outlet. Easement areas shall be approved by the Community Engineer based upon the calculations of the engineer of the developer on the proposed ponding elevation.

Filling in Sinkholes and Drainage Areas - Development may involve some filling of the sinkhole drainage area or sinkhole upon approval by the Community Engineer. However, no principal or accessory building s with soil- bearing foundations shall be permitted to be constructed on fill within the limits of any sinkhole.

XXVIII. PLAYA LAKE STANDARDS


USGS
science for a changing world

Prepared in cooperation with Playas Lakes Joint Venture

Recharge Rates and Chemistry Beneath Playas of the High Plains Aquifer—A Literature Review and Synthesis

Circular 1333

U.S. Department of the Interior
U.S. Geological Survey

Background:

The Spanish word *playa* (pronounced [ˈplaˌʝa]) literally means "beach". Dry lakes are known by this name in some parts of Mexico and the western United States. This term is also used on the Llano Estacado and other parts of the Southern High Plains.

In South America, the usual term for a dry lake is **salar**, Spanish for "salt pan".

The surface of a dry lake is typically dry, hard and rough during the dry season, but wet and very soft in the rainy season. Dry lakes are generally small, round depressions in the surface of the landscape.

A playa lake is formed when rain fills a round depression in the landscape, creating a small lake. The water is generally freshwater, when all of the water evaporates, a playa is formed. The playa appears as a flat bed of clay, generally encrusted with precipitated salts. These evaporate minerals are a concentration of weathering products that have been left behind. Some examples of evaporite minerals are sodium carbonate, borax, and other salts. Playas are often found in bajadas, a depositional landform of desert environments.

Dry lakes can also form when the water table intersects the surface and water seeps into them.

Dry lakes are typically formed in semi-arid to arid regions of the world. The largest concentration of dry lakes in the world (nearly 22,000) is in the southern High Plains of Texas and eastern New Mexico.

Most dry lakes are small, however Salar de Uyuni in Bolivis, near Potosi, the largest salt flat in the world is of 4,085 square miles (10,582 square km).

Many dry lakes contain shallow water during the rainy season, especially during wet years. If the layer of water is thin and is moved around the dry lake by wind, an exceedingly hard and smooth surface may develop. Thicker layers of water may result in a "cracked-mud" surface and "teepee" structure desiccation features. Very little water can result in dune formation.

While the dry lake itself will be devoid of vegetation, they are commonly ringed by shadscale, saltbrush and other salt-tolerant plants that provide critical winter fodder for livestock and other herbivores.

Threats to dry lakes include pollution from concentrated animal feeding operations such as cattle feedlots and dairies, erosion, fertilizer, pesticide and sediment runoff from farms, and overgrazing.

The extremely flat, smooth and hard surfaces of dry lakes make them ideal for motor vehicles and bicycles. Furthermore, large-sized dry lakes are excellent spots for pursuing land speed records, as the smoothness of the surface allows low-clearance vehicles to travel very fast without any risk of disruption by surface irregularities, and the path traveled has no obstacles to avoid. The dry lakes at Bonneville Salt Flats in Utah and Black Rock Desert in Nevada have both been used for setting land speed records. Dry lake beds that do not fill with water at any time are

sometimes used as locations for air bases, for similar reasons. Examples include Area 51 in Nevada, and Edwards Air Force Base (originally known as Muroc Dry Lake) in California.

Brines from the subsurface of dry lakes are often exploited for valuable minerals in solution.

Under United States law, a "playa lake" may be considered isolated wetlands, and may be eligible to enroll in the new wetlands component of the Conservation Reserve Program, enacted in the 2002 farm bill (P.L. 107-171, Sec. 2101).

Note: The Texas Panhandle and areas near Lubbock and Amarillo have Playa Lakes.

Development Requirements:

The following requirements were established by the City of Lubbock, Texas regarding development in Playa Lake areas:

In Playa Lake areas, there are 5 criteria that would be used to determine what a new structure's lowest floor should be, based upon Local Floodplain Administrator's requirements:
(1) - The floor shall be a minimum of 12" above the highest adjacent top of curb (or street crown).
(2) – If the structure is located within a playa lake, the lowest finish floor (LFE) shall be a minimum of 1' above the FEMA BFE **OR** a minimum of 2' above the lake overflow, ***whichever is higher***. If the playa is a 'true non-overflow lake' (where it doesn't overflow even in the 500-year event) the LFE shall be a minimum of 1' above the 500-year event.
(3) - If a Drainage Analysis has been prepared for a **new** development, the LFE is to be a minimum of 6" above the established BFE.
(4) - If a new structure is to be built in the SFHA shown on the FIRM, then the LFE shall be built a minimum of 1' above FEMA's BFE.
(5) - The lowest floor elevation may have to be raised to allow the site to drain properly, consistent with COL requirements.

Whichever of these 5 requirements yields the highest elevation will govern and shall be used to set the floor level for the proposed structure.

XXIX. ALLUVIAL FAN STANDARDS

Alluvial Fans are usually mapped on Flood Insurance Rate Maps (FIRMs) as Zone AO (shallow overland flooding) by FEMA. Development in Alluvial Fan areas creates unique floodplain management issues for local communities, developers and homeowners. The ASFPM Arid Regions Committee prepared an excellent companion White Paper entitled *Riverine Erosion Hazards & Floodplain Management.* The Arid Regions Committee has been requested to provide guidance and higher standards recommendations to CBOR regarding development in Alluvial Fan areas to help guide communities in their quest to mitigate flood risks.

The following information regarding Alluvial Fans is from FEMA's website (www.fema.gov) ; FEMA 480, *Floodplain Management Requirements – A Study Guide and Desk Reference for Local Officials* and FEMA IS-9, *Managing Floodplain Development through the NFIP*:

- Alluvial Fan in Southern Iran. Image from NASA's Terra satellite

Background:

An **alluvial fan** is a fan-shaped deposit formed where a fast flowing stream flattens, slows, and spreads typically at the exit of a canyon onto a flatter plain. A convergence of neighboring alluvial fans into a single apron of deposits against a slope is called a **bajada**, or compound alluvial fan.

Owing to the flow as stream gradient decreases, coarse-grained solid material carried by the water is dropped. As this reduces the capacity of the channel, the channel will change direction over time, gradually building up a slightly mounded or shallow conical fan shape. The deposits are usually poorly-sorted. This fan shape can also be explained with a thermodynamic justification: the system of sediment introduced at the apex of the fan will tend to a state which minimizes the sum of the transport energy involved in moving the sediment and the gravitational potential of material in the cone. There will be iso-transport energy lines forming concentric arcs about the discharge point at the apex of the fan. Thus the material will tend to be deposited equally about these lines, forming the characteristic cone shape.

Alluvial fans are often found in desert areas subject to periodic flash floods from nearby thunderstorms in local hills. They are common around the margins of the sedimentary basins of the Basin and Range province of southwestern North America. The typical watercourse in an arid climate has a large, funnel-shaped basin at the top, leading to a narrow defile, which opens out into an alluvial fan at the bottom. Multiple braided streams are usually present and active during water flows.

Phreatophytes are plants that are often concentrated at the base of alluvial fans, which have long tap roots 30 to 50 feet (9.1 to 15 m) to reach water. The water at this level is derived from water that has seeped through the fan and hit an impermeable layer that funneled the water to the base of the fan where it is concentrated and sometimes forms springs and seeps if the water is close enough to the surface. These stands of shrubs cling onto the soil at their bases and over time wind action often blows away sand around the bushes which form islands of habitat for many animals.

Note: Areas in West Texas near El Paso have alluvial fans.

44 CFR 59.1 Definitions:

Alluvial fan flooding means flooding occurring on the surface of an alluvial fan or similar landform which originates at the apex and is characterized by high-velocity flows; active processes of erosion, sediment transport, and deposition; and, unpredictable flow paths.

Apex means a point on an alluvial fan or similar landform below which the flow path of the major stream that formed the fan becomes unpredictable and alluvial fan flooding can occur.

NFIP Requirements (from www.fema.gov):

Flooding occurring on the surface of an alluvial fan or similar landform which originates at the apex and is characterized by high-velocity flows; active processes of erosion, sediment transport, and deposition; and unpredictable flowpaths. Alluvial fan flooding is depicted on a Flood Insurance Rate Map (FIRM) as Zone AO, with a flood depth and velocity.

FEMA IS-9, *Managing Floodplain Development through the NFIP*, provides the following guidance related to "Uncertain flow paths":

Section 1-14 - The previous section in IS-9 on riverine erosion explained that stream channels change their locations gradually or only after very large and rare floods. However, in some areas of the country, every flood may change channels. For example, in mountainous areas, high-velocity floodwater picks up sediment and rock. At the base of the valley where the slope flattens out, the floodwater decreases in speed and spreads out, as in a sheet flow, dropping sediment and rock over a fan-shaped area called an alluvial fan.

Figure 1-8. This alluvial fan flood caused over $7 million in damage and one death

Figure 1-8 shows how an alluvial fan can have numerous channels. During the next flood, the channels may be in different locations.
Alluvial fan flooding is more common in the mountainous western states, where there is less ground cover and more opportunity for erosion.
Alluvial fan floods are not as predictable as riverine floods—one never knows where the floodwaters will spread out across the fan. Thus, they pose three hazards:

- Velocity of floodwaters and the debris they carry.
- Sediment and debris deposited by the floodwaters.
- The potential for the channel to move across the fan during the flood.

FEMA IS-9 Section 1-15, Floods and Floodplain Management
Figure 1-8. This alluvial fan flood caused over $7 million in damage and one
Death. The arid west is subject to another type of flooding that features uncertain flow paths, known as movable bed streams. When a high-velocity flood runs through an area with sand or loose soil, the erosion and sedimentation can occur so fast that the stream channel can be

lowered, filled in or relocated through processes known as degradation, aggradation and migration. In some cases, these processes may occur simultaneously, or one process may occur in one flood and another process in a later event.

FEMA IS-9 Section 6-28 UNCERTAIN FLOW PATHS
This hazard includes alluvial fans and moveable bed streams. They occur in hilly or mountainous areas rich in sediments and where precipitation is not sufficient to carry the sediments downstream as rapidly as they accumulate. In the United States, these conditions exist primarily in the arid and semi-arid regions west of the Great Plains, although there are alluvial fans in Alaska and Appalachia.
Both types of uncertain flow path floodwaters carry large amounts of sediment which can fill in a channel or move it to a new location. Regulatory standards must address the three components of the hazard: velocity of the water, sediment and debris; the volume and movement of sediment and debris during floods; and the potential for channel migration during a flood.

Regulatory standards
A good study may be able to identify the limits of channel migration and require new buildings to be set back from that area. A permit applicant can be required to prepare such a study. Otherwise, because the characteristics of the hazard is site-specific, many ordinances simply require the builder to have an engineer certify that the project will be protected. In alluvial fans, a subdivider can be required to install debris basins, channels and walls to keep debris and velocity flows away from houses.

Reference: *CRS Credit for Management of Areas with Uncertain Flow Paths and Reducing Losses in High Risk Flood Hazard Areas: A Guidebook for Local Officials*.

XXX LEGAL RIGHT OF ENTRY TO ENFORCE FLOODPLAIN ORDINANCE

OBJECTIVE:
The community floodplain administrator must have legal authority to enter private property to enforce the community floodplain ordinance and the minimum requirements of the NFIP. While this may not be considered a higher standard this authority is paramount for a community to have a sound floodplain management program.

RATIONALE:
44 CFR

- Part 60.2 (h) - The community shall adopt and enforce floodplain management regulations…
- Part 60.3 (a) (1) - Require permits for all proposed construction and other developments in the community…
- Part 73 - a property that has been declared to be in violation of State or local laws, regulations or ordinances using Section 1316 of the National Flood Insurance Act of 1968

The *Texas Guide to Local Floodplain Management*, RG-12 (Rev. 8/06), Chapter 4 (page 33) - Duties of a Floodplain Administrator include:

- enforcing ordinances, which includes follow-up inspections on all permits granted;
- addressing violations by working with the community's attorney and informing citizens of the penalties of noncompliance with NFIP requirements;

Texas Guide to Local Floodplain Management, Chapter 4 (page 42), Importance of Enforcing Permit System:

- Your community is violating its agreement with the NFIP by failing to maintain a permit system, by granting variances regularly, and by being lax about enforcement responsibilities

FEMA 480, *A Study Guide and Desk Reference for Local Officials, Unit 7* Section D, page 7-39:
Later Inspections:

- "Your office should periodically check to ensure that the property continues to remain in compliance over time. Later inspections are particularly important when a structure contains an enclosure below the lowest floor. Such areas can be easily modified and made into habitable spaces in violation of regulations".

- Note: "In some states, communities do not have the statutory authority to go onto private property to look for violations."

FEMA 480, Unit 7 Section E, page 7-40:
Enforcement

- "In order to ensure that development is meeting these requirements, you must monitor the floodplain, and where necessary, conduct an inspection of a property. Some permit officials have statutory limits on where they can go to inspect a potential violation. Be sure to review your authority to access onto private property with your attorney."

Texas Water Code 13.315 [example of a State Code]
"... All political subdivisions are hereby authorized to take all necessary and reasonable actions to comply with the requirements and criteria of the National Flood Insurance Program, including but not limited to:..." those political subdivisions are acting as functionaries of state, and federal government in the enforcement of those actions necessary to comply with the "Flood Control Insurance Act". The authority to inspect on private property is passed on from the federal, and state government, to county government by the Texas Constitution's description of the rights and duties of county government as it acts as an extension of the State therefore the authority does not have to be specifically created in additional statute.

MODEL LANGUAGE:
Add the following provisions to the Community flood damage prevention ordinance or court order:

> **the "community floodplain administrator, or his designee, has the right to enter any structure to perform any duties or responsibilities imposed by this Chapter (Ordinance or Court Order)".**

XXXI. Enforcement – Fines and Penalties

Legal Authority:
The Texas 77th Legislature (2001) passed SB 936:

- Amends the Texas Water Code
- Authorizes the governing body of each city and county to adopt ordinances or orders to participate in the National Flood Insurance Program.
- Authorizes enforcement of Civil Penalty (Texas Water Code Section 16.322)
    - A person who violates this subchapter or a rule adopted or order issued under this subchapter is subject to a civil penalty for each act of violation and for each day of violation.
- Authorizes enforcement of Criminal Penalty
    - (a) A person commits an offense if the person violates this subchapter.
    - (b) An offense under this section is a Class C misdemeanor.
    - (c) Each violation of this subchapter and each day of a continuing violation is a separate offense.

Several Flood Damage Prevention Ordinances, adopted by participating NFIP communities, contain the following language:

PENALTIES FOR NON COMPLIANCE

No structure or land shall hereafter be constructed, located, extended, converted, or altered without full compliance with the terms of this ordinance and other applicable regulations. Violation of the provisions of this ordinance by failure to comply with any of its requirements (including violations of conditions and safeguards established in connection with conditions)

shall constitute a misdemeanor. Any person who violates this ordinance or fails to comply with any of its requirements shall upon conviction thereof be fined not more than $1,000 or imprisoned for not more than 30 days, or both, for each violation, and in addition shall pay all costs and expenses involved in the case. Nothing herein contained shall prevent (name of community) from taking such other lawful action as is necessary to prevent or remedy any violation.

The following City of Houston Flood Damage Prevention Ordinance contains language where a person violating the ordinance can be guilty of a misdemeanor punishable by a fine of not less than $250.00 Nor more than $2,000.00. Each day that any violation continues shall constitute a separate violation. This is considered a "higher standard" action making violation of the flood damage prevention ordinance a serious offense.

City of Houston Section 19-91 Actions authorized to enforce chapter.

(a) The city, acting through the city attorney or any attorney representing the city, is hereby authorized to file an action in a court of competent jurisdiction to:
    (1) Enjoin any person from violating the terms, conditions and restrictions of any permit issued under this chapter:
    (2) Enjoin the violation of the provisions of this chapter:
    (3) Recover civil penalties for violations of the terms, conditions and restrictions of any permit issued under this article;
    (4) Recover civil penalties for violations for conditions of this article; or
    (5) Recover damages from the owner of a site in an amount adequate for the city to undertake any construction or other activity necessary to bring about compliance with this chapter.

This authority is in addition to all provisions of this code and the Construction Code relative to the definition of offenses and the provision of penalties for violations of such ordinances.

(b) The city, acting through the city attorney or any other attorney representing the city, is hereby authorized to enter into agreements in lieu of litigation to achieve compliance with the terms, conditions and restrictions of any permit issued under this article or the provisions of this article.
(c) The city engineer is authorized to:
    (1) Whenever any work authorized by a development permit is being performed contrary to the provisions of this chapter, or other pertinent laws or ordinances implement through the enforcement of this article, order the work (other than work to cure a violation) stopped by notice in writing served on any persons performing the work or causing the work to be performed. Any such persons shall forthwith stop the work until authorized by the city engineer to proceed with the work.

(2) At the time a stop order is issued, the person performing the work and the permit holder shall be given notice of a right to a hearing on the matter pursuant to Section 116.2 of the Building Code for permits authorized by that Code. Upon request, such a hearing shall be held within three business days unless the permit holder or person who was performing the work requests an extension of time. Any stop order that has been issued shall remain in effect pending any hearing that has been requested unless the stop order is withdrawn by the city engineer.

Section 19-92 Criminal sanctions

Any person violating any provision of this chapter within the corporate limits of the city shall be guilty of a misdemeanor punishable by a fine of not less than $250.00 nor more than $2,000.00. Each day that any violation continues shall constitute a separate offense.

[Reference City of Houston Ord. No. 85-1705, 1, 9/25/1985; Ord. No. 92-1449, 34, 11/4/1992; Ord. No. 02-399, 48, 5/15/2002; Ord. No. 03-1190, 16, 12/3/2003; Ord. No. 06-894, 30 &31, 8/30/2006]

MODEL LANGUAGE:

It is recommended that a community consider amending their flood damage prevention ordinance to include authority to enforce and criminal sanctions similar to the City of Houston ordinance above.

Enforcement – Section 1316 – "When all else fails"

Section 1316 of the National Flood Insurance Act of 1968, as amended, provides for the denial of flood insurance coverage for any property, which the Administrator finds, has been declared by a duly constituted State or local authority to be in violation of State or local floodplain management regulations.

Important: The community must initiate Section 1316 action.

Reference: www.fema.gov/section-1316

XXXII. Gas and Liquid Storage Tanks

OBJECTIVE:

To preserve the flood carrying capacity of the floodway and floodplain, to prevent hazardous spills and environmental incidences, and to better protect structures in and adjacent to the floodplain.

RATIONALE:

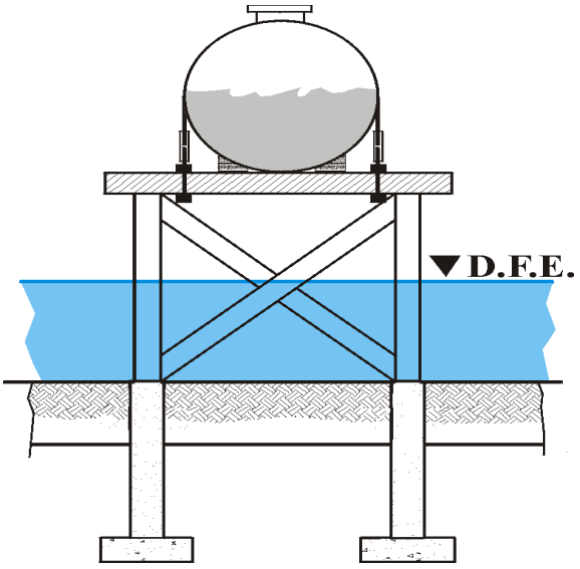
Texas has experienced a major increase in oil and gas production that has increased the number of production wells and placement of gas and liquid storage tanks in the Special Flood Hazard Area.

The NFIP Regulations, 44 CFR 60.3.c, require that all new construction and substantial improvements of nonresidential structures within Zones A1– 30, AE and AH zones on the community's firm (i) have the lowest floor (including basement) **elevated to or above the base flood level** or, together with attendant utility and sanitary facilities, be designed so that below the base flood level the structure is watertight with walls substantially impermeable to the passage of water and with structural components having the capability of resisting hydrostatic and hydrodynamic loads and effects of buoyancy;

The NFIP Regulations 44 CFR 59.1 defines a "structure", for floodplain management purposes, is a walled and roofed building, including a gas or liquid storage tank, that is principally above ground, as well as a manufactured home.

Therefore, a gas or liquid storage tank placed in the Special Flood Hazard Area must be elevated above the BFE or capable of resisting hydrostatic and hydrodynamic loads and effects of buoyancy if placed below the BFE.

FEMA's publication, *FEMA P-348, Edition 1 / November 1999, •Principles and Practices for the Design and Construction of Flood Resistant Building Utility Systems,* provides the following guidance for elevated gas and liquid storage tanks:



FEMA P-348 Figure 3.2.3A
A liquid storage tank elevated above the DFE on a platform in a velocity flow area

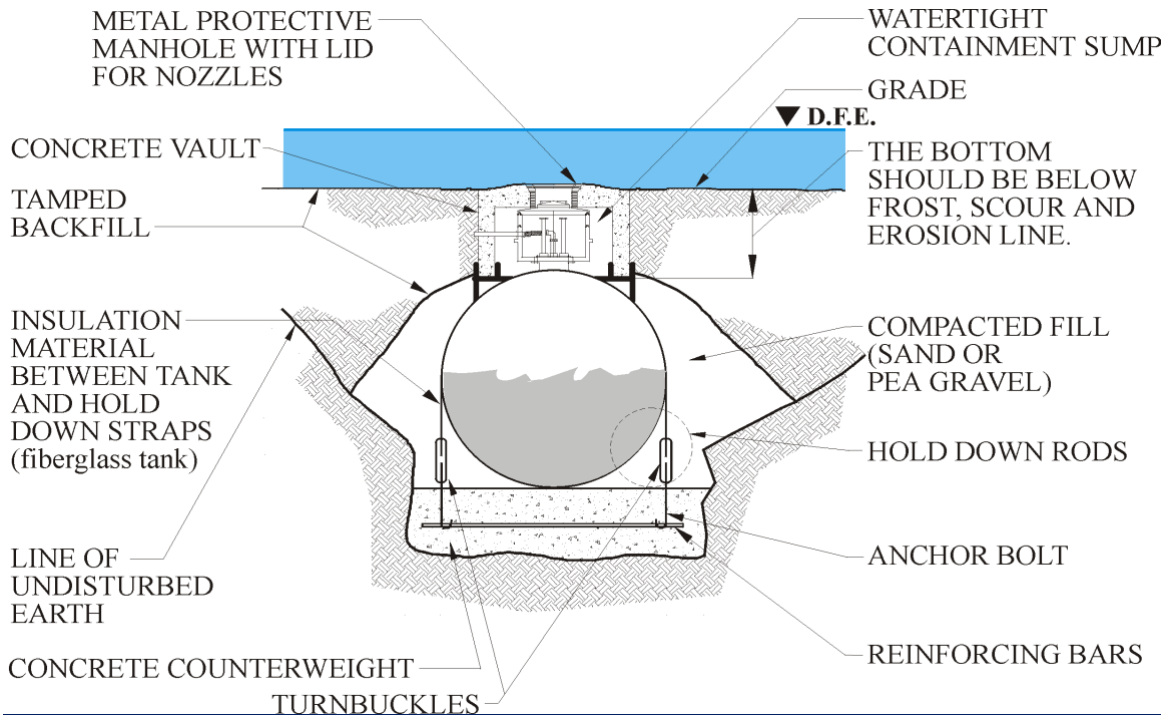
The most effective technique for providing flood protection for a liquid storage tank is elevation of the tank on a platform above the Design Flood or Base Flood Elevation.

The following outlines some additional considerations when protecting tank storage systems:
• 1. The tank should be anchored to the platform with straps, which would constrain the tank in wind, earthquake, and other applicable forces.
2. In coastal zones, the straps should be made of non-corrosive material to prevent rusting.
3. In velocity flow areas, the platform should be supported by posts or columns that are adequately designed for all loads including flood and wind loads.

Construction requirements for elevated tanks:

(1) The posts or columns should have deep concrete footings embedded below expected erosion and scour lines.
(2) The piles, posts, or columns should be cross-braced to withstand the forces of velocity flow, wave action, wind, and earthquakes; cross-bracing should be parallel to the direction of flow to allow for free flow of debris.

FEMA P-348 Section 3.2.3C provides the following guidance for below grade gas and liquid storage tanks. If a fuel tank must be located below the DFE in an SFHA, it must be protected against the forces of **buoyancy, velocity flow, and debris impact**. This can be achieved by the following methods:



FEMA P-348 Figure 3.2.3C
Liquid Storage Tank installed below grade and below the BFE

Anchoring Tanks Below Ground

A liquid storage tank located below ground in a flood-prone area can be anchored to a counterweight in order to counteract the buoyancy force that is exerted by saturated soil during a flood.
One effective method is to anchor the tank to a concrete slab with (non-corrosive) hold-down straps. The straps must also be engineered to bear the tensile stress applied by the buoyancy force. The maximum buoyancy force is equal to the weight of floodwaters which would be required to fill the tank minus the weight of the tank.

Texas communities have incorporated “higher standards” that apply to gas and liquid storage tanks located in the SFHA such as:

1. Gas and liquid storage tanks cannot be placed within the SFHA
2. Gas and liquid storage tanks must be elevated a minimum of +1’; +2’; +3’ above the BFE
3. Gas and liquid storage tanks cannot be placed within 100’;…500’ of the boundary of the 1% chance flood also known as the floodplain boundary.

MODEL LANGUAGE:
The City of Arlington Gas Drilling and Production Ordinance 11-068, 12/06/2011:
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No Gas Well Permit shall be issued for any well to be drilled within any floodway, as defined in the Flood Damage Prevention chapter of the City's Code of Ordinances, and as identified by FEMA on the most current FIRM. Tanks and equipment located in any floodplain must also meet the minimum requirements of the Flood Damage Prevention chapter.

A Gas Well Permit shall be required if proposed well is to be located within the City limits or extraterritorial jurisdiction on private or public property. The Gas Well Permit for the initial well(s) for a drill site must be approved by the City Council. After the initial well(s) are permitted, any future wells proposed for the same site may be approved by the CD&P Director, provided such future wells are to be drilled on and within the approved drilling zone and no deviations from any standards are requested by the Operator. Any wells proposed to be drilled outside the drilling zone will require an amendment to the approved zoning. In addition, the permits may not amend any site conditions established in the approving SUP.

In making its decision, the City Council shall have the power and authority to refuse any Gas Well Permit to drill any well at any particular location within the City, when by reason of such particular location and other characteristics, the drilling of such wells at such particular location would be injurious to the health, safety or welfare of the inhabitants in the immediate area of the City.

If the CD&P Director or designee denies a Gas Well Permit application for reasons other than lack of required distance as set out in this Ordinance for the requested Gas Well Permit, he shall notify the Operator in writing of such denial stating the reasons for the denial. Within thirty (30) days of the date of the written decision of the Inspector to deny the Gas Well Permit, the Operator may: 1) cure those conditions that caused the denial and resubmit the application to the Inspector for approval; or 2) file an appeal to the City Council under the provisions outlined in this Ordinance pursuant to Section 9.01, Appeals of this Ordinance.

If the CD&P Director or designee determines that all of the provisions of this Ordinance have been complied with by the Operator, but that the proposed drill site does not comply with the distance requirements of this Ordinance under the requested Gas Well Permit, the Inspector shall notify the Operator. The Operator may revise the permit to comply or the Inspector shall notify the official designated by the City Manager and the official shall place the request for a Gas Well Permit under this Ordinance on the City Council agenda for public hearing within the next forty-five (45) days.

The City of Arlington Gas Well Permit Application must include the following:

1. A site plan of the proposed drill site showing the location of all improvements and equipment, including the location of the drilling zone and the proposed well(s) and other facilities, including, but not limited to, fire hydrants proposed to supply water to the site, tanks, storage tanks, pipelines, fencing, lights, floodways, compressors, separators and storage sheds. Indicate proposed pipeline routes on the plan and the water storage proposal for facing.
2. Aerial exhibit showing the location and description of all buildings within 600 feet of the drilling zone. Include setback reduction support letters if a protected use is within 600 feet of the drilling zone.

3. A detailed site plan that includes specific details to the projected location of the major components of the drilling site, impacted vegetation, creeks and other topographic features, adjacent buildings and other structures and the measured distance from the drill site to these buildings and structures, temporary and permanent fencing and landscaping. Provide distance measurements and general ordinal direction, from drilling zone to the nearest residence, school and park.
4. An Emergency Action Response Plan establishing written procedures to minimize any hazard resulting from drilling, completion, or production of gas wells. Said plan shall use existing best practices regarding protection of the public and be consistent with laws and regulations of the Fire Code, NFPA, RRC, TCEQ, API, Department of Transportation, and/or the Environmental Protection Agency. The Emergency Action Response Plan shall be kept current with any additions, modifications, and/or amendments concerning all construction related activities, natural gas operations and natural gas production. Updated plans shall be submitted to the Inspector within five (5) business days after any additions, modifications, and/or amendments to said plan(s). A copy of the emergency response plan shall be kept on site. At a minimum, the emergency response plan shall provide for:
    1. Prompt and effective response by the Operator to emergencies regarding leaks or releases that can affect public health, safety and welfare; fire or explosions at or near a gas well; and natural disasters and severe weather.
    2. Effective means to notify and communicate required and pertinent information to local fire, police and public officials during an emergency.
5. A Hazardous Materials Management Plan, prepared in accordance with the Fire Code, shall be submitted and be on file with the Fire Department and the Inspector.
6. A copy of the pre-drilling ambient noise level report. The report shall reference the site, include dates the test was performed, identify the testing equipment used and where it was placed for testing, and include results.
7. A Site Restoration Plan shall be submitted with the initial gas well permit on an approved site. At a minimum, this plan shall document the following:
    1. The existing conditions of the property prior to drilling activity, including site photographs.
    2. A detailed description of site restoration methods that will ensure the site is restored to pre-development conditions, including site grading, vegetative restoration, and abandonment of any equipment or facilities.

Please review the entire City of Arlington Gas Drilling and Production Ordinance as an example ordinance for regulating oil and gas production and placement of storage tanks in the SFHA.

XXXIII. Glossary and References

The TFMA Higher Standards Guide is designed to function as a TFMA on-line document therefore references and acronyms are included in the following document links:

TFMA Higher Standards Survey (annually from 2004 to 2018)
www.tfma.org

FEMA P-524, FEMA Acronyms, Abbreviations and Terms, July 2009:
www.fema.gov/plan/prepare/faat.shtm

FEMA 480, Floodplain Management Requirements, A Study Guide for Local Officials:
http://www.floods.org/index.asp?menuid=388&firstlevelmenuid=180&siteid=1

ASFPM/CBOR Technical References Certified Floodplain Manager (CFM) Exam:
http://www.floods.org/ace-files/certification/CFM_Exam_TECH_REFERENCES_8.2017.pdf

This *Guide for Floodplain Management Higher Standards* was prepared by the TFMA Higher Standards Task Force utilizing the ASFPM Floodplain Regulations Committee 2013 higher standards guidance document. NFIP communities are encouraged to modify this document as needed to meet their floodplain management requirements necessary to minimize flood hazards.

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TFMA Higher Standards Task Force