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Code Compatibility Report

Federal Insurance Administration
Federal Emergency Management Agency

10/92
Volume 1 of 3

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The National Institute of Building Sciences (NIBS) is a non-governmental, non-profit organization, authorized by Congress to encourage a more rational building regulatory environment and to accelerate the introduction of existing and new technology into the building process.

This report was prepared under contract No. EMW-91-C-3610 between the Federal Emergency Management Agency and the National Institute of Building Sciences.

Code Compatibility Report

Sponsored by

The Federal Emergency Management Agency

October, 1992

National Institute of
BUILDING SCIENCES
1201 L Street, N.W., Suite 400
Washington, D.C. 20005

PREFACE

In August of 1991 Hurricane Bob inflicted extensive flood damage along the coastlines of Rhode Island and southern Massachusetts, contributing to the destruction of or substantial damage to 75 to 90 percent of the homes on barrier beaches. Later in October of the same year a nor'easter battered the Atlantic coastline with unexpectedly destructive flooding. Widespread flooding occurred in Texas when rivers overflowed their banks from heavy rains brought on by the "El Nino" warming in Pacific waters, *a phenomenon* which recurs every three to five years.

These three events in a single year underscore that construction of buildings to reduce hazards in flood-prone regions of the United States is an essential part of the national strategy to minimize the impact of natural disasters. Commercial, industrial and residential structures that have been constructed to adequately resist flood hazards according to technical guidelines and standards of the National Flood Insurance Program (NFIP) have fared best in floods.

The Federal Emergency Management Agency (FEMA), which prepares and distributes the NFIP technical guidelines and standards for reduction of flood hazards, has recognized that flood hazard reduction standards can be more widely implemented in flood-prone communities by their incorporation into the model building codes and standards which are adopted by the states and enforced on a regular basis by local building *departments.*

This study represents a major step toward eliminating the incompatibilities between the NFIP technical guidelines and standards and the model codes and standards. The report's recommendations provide a basis for coordinating NFIP documents with model codes and standards. In addition the report represents a starting point for the preparation of standard design guidelines, and eventually, a consensus standard for flood-resistant construction which can be referenced in the model building codes.

The National Institute of Building Sciences appreciates the opportunity to assist the Federal Emergency Management Agency in improving the levels of compatability between the NFIP guidelines and technical standards and the model building codes and standards. The Institute wishes to thank the members of the Flood Standards Project Committee for their insights and efforts in developing this document, especially G. Day Ding, the project committee chairman and Earl Flanagan, the vice-chairman. The Institute also wishes to commend the efforts of the subcontractors, the Building Officials and Code Administrators, International (BOCA), the Southern Building Code Congress International (SBCCI), the International Conference of Building Officials (ICBO), the National Fire Protection Association (NFPA), and the National Conference of States on Building Codes and Standards (NCSBCS), which contributed to report drafts for the project committee's review. The project committee members and subcontractors are listed in the appendix of the report.

The Institute accepts the recommendations of the Flood Standards Project Committee and approves their dissemination to the Federal Emergency Management Agency for implementation and to the public.

Robert C. Gibson, P.E.
Chairman of the Board

David A. Harris, AIA
President

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ABSTRACT

This study evaluates the compatibility of flood loss reduction standards of the National Flood Insurance Program (NFIP) with the construction standards for seismic, fire, and wind hazards that now appear in nationally recognized model building codes and standards and identifies those that are in conflict. Changes to the NFIP standards and technical guidelines and code change language for model codes and standards are recommended to resolve identified incompatibilities.

Keywords: codes, floods, guidelines, regulations, standards

INTRODUCTION

The purpose of this study is to evaluate the compatibility of flood loss reduction standards of the National Flood Insurance Program (NFIP) with the construction standards for earthquake, fire, and wind hazards that now appear in the nation's model building codes and standards, and identify any that are in potential conflict and recommend possible solutions.

This study was performed by a project committee of volunteers from the public and private sectors of the building community, operating in accordance with NIBS' consensus procedures. The final report was prepared according to NIBS guidelines for preparing reports. During the course of the project the committee oversaw the preparation of comparisons between the NFIP flood resistant design standards in 44 CFR 59 and 60, and sixteen related technical guidance documents and twenty-three model code and standard documents. Based on these comparisons incompatibilities were identified and recommendations written to address those incompatibilities. The project committee was supported in its work by five model codes and standards organizations: the Building Officials and Code Administrators, International (BOCA), the Southern Building Code Congress International (SBCCI), the International Conference of Building Officials (ICBO), the National Fire Protection Association (NFPA), and the National Conference of States on Building Codes and Standards (NCSBCS). A list of project participants is provided in Appendix 1 of the report.

Chapter 1 of this report provides background on the NFIP flood program, and the FEMA documents and the model codes and standards utilized in the study. A description of previous and future FEMA efforts for promoting compatibility between the FEMA documents and the model codes and standards is also provided.

Chapter 2 lists 23 model code/standards and 22 FEMA/NFIP publications reviewed for this study. Although this chapter lists 22 NFIP documents, one of the technical guidance documents (FEMA-15) and two of the technical bulletins (86-1 and 90-1) were not used in the comparisons for reasons cited in Appendix 1. Interpretative correspondence was reviewed only to clarify aspects of NFIP documents in the project. The model codes and standards are organized under six major code group headings: the BOCA National Codes, the Standard Codes, the Uniform Codes, the NFPA Standards, the Manufactured Housing Codes and Standards, and the CABO 1 & 2 Family Dwelling Code.

In Chapter 3 of the report is an overview summary of the major issues underlying incompatibilities identified in the evaluation of FEMA documents and the model codes and standards. This evaluation consists of comparisons of Federal Emergency Management Agency (FEMA) documents with the BOCA National codes, the Standard codes, the Uniform codes, the NFPA standards, the manufactured housing codes and standards, and the CABO 1 & 2 Family Dwelling Code. These comparisons are found in Appendices A through F of this report. Issues in the chapter are categorized by the code groups described above. For each comparison issues concerning the model codes and standards are listed first followed by issues for the FEMA documents.

Chapter 4 contains the recommendations for changes to NFIP standards and technical guidelines. The chapter is organized into six sections, 4A through 4F, by the same major groups of model codes and standards found in Chapters 2 and 3. Recommendations in each section are organized by the model codes and standards as listed in Chapter 2 under each major code heading. The name of the particular code or standard on which each recommendation is based (even if the issue in the recommendation is not directly

addressed in the document), is found on the right-hand side of the page above the text describing the recommendation. The corresponding NFIP documents which were compared with the model code or standard in the development of the recommendation are listed on the left-hand side of the page. Below each recommendation is a reference to the page and paragraph in the comparisons found in Appendices A through F.

Chapter 5 contains code change language for resolving incompatibilities between the NFIP standards and technical guidelines and the model codes and standards. Like Chapter 4, this chapter is also organized into six sections, 5A through 5F, by the same groups of major model codes and standards found in Chapters 2 and 3. Recommendations in each section, however, are organized by the NFIP documents as listed in Chapter 2. The name of the particular NFIP document on which each code language change is based, is found on the left-hand column on the page above the text describing the code change. Passages in the model code or standard which are affected by the code change are listed in the center column. The analysis supporting the code change is in the right-hand column. Each code change entry, including the referenced documents, the analysis and code change text has been taken verbatim from the comparisons in Appendices A through F.

Appendix 1 lists the project committee members and consultants who participated in the study. Appendix 2 is a glossary of acronyms found throughout the report.

Appendix 3 is a general description of each FEMA and NFIP publication as they relate to the overall codes and standards development process. The considerable data in the publications concerning the NFIP program, site considerations, classification of flood zones and other areas have not been included in the summaries. Instead, only the material utilized in the comparisons is briefly cited in the NFIP document summaries.

Appendix 4 is a general description of the content of each model code/standard publication.

Appendix A contains the comparison between the family of BOCA Codes and the NFIP standards and technical guidelines.

Appendix B contains the comparison between the family of Standard Codes and the NFIP standards and technical guidelines.

Appendix C contains the comparison between the family of Uniform Codes and the NFIP standards and technical guidelines.

Appendix D contains the comparison between the NFPA standards and the NFIP standards and technical guidelines.

Appendix E contains the comparison between the manufactured housing codes and standards and the NFIP standards and technical guidelines.

Appendix F contains the comparison between the CABO 1 & 2 Family Dwelling Code and the NFIP standards and technical guidelines.

CHAPTER 1

BACKGROUND

NFIP Standards and Technical Guidelines

The National Flood Insurance Program (NFIP) was created by Congress in 1968 to provide federally backed flood insurance coverage since it was generally unavailable from private insurance companies. The NFIP was also intended to reduce future flood losses by ensuring that new development is adequately protected from flood damages. The NFIP is based on a mutual agreement with communities that have been identified as flood-prone. The Federal Emergency Management Agency (FEMA), which is the agency charged with administering the program, makes flood insurance available throughout a community provided that the community adopts and enforces adequate floodplain management regulations that meet the minimum requirements of the NFIP. This is accomplished through a local floodplain management ordinance which must either meet or exceed the minimum NFIP criteria. These minimum criteria are located in 44 CFR 60.3 and 60.6, and they establish design performance standards for buildings located in Special Flood Hazard Areas that specify how a structure should be constructed in order to reduce or eliminate the potential for flood damage.

To assist in the application of these requirements by the building community, which includes building code officials, local building officials, engineers, architects, builders, developers, and the general public, FEMA has developed technical guidance manuals and informational materials for public distribution. These materials contain guidelines that specify the use of certain techniques and materials for design and construction which will meet the intent of the NFIP general performance criteria for flood damage resistant construction. These publications report what is considered to be standard practice for flood resistant design and construction techniques.

The NFIP technical guidance documents have been written within the previous fifteen years either inhouse or under FEMA contract with various architects, engineers, and private organizations. As a result, the NFIP documents vary in approach and level of technical detail. For example, it appears that the Coastal Construction Manual which emphasizes wood superstructure was written from an architect's point of view. Floodproofing Non-Residential Structures which emphasizes foundation systems appears to have been written from the vantage point of an engineer. In terms of technical detail different levels of information are related for the same construction types. For example, some publications give rules of thumb while others offer structural tables. Finally, referencing between documents tends to be broad in scope and duplicates information. Chapter 2 lists 22 NFIP documents reviewed in the study, however, three were not used in the comparisons for reasons cited in Chapter 3.

Model Codes and Standards

The model codes and standards have been developed by consensus over a period of years under the auspices of the organizations (i.e. CABO, BOCA, SBCCI, ICBO, NFPA and ANSI) which promulgate the written documents.

The three national model codes are: BOCA National Building Code, which is a product of the Building Officials and Code Administrators (BOCA), and is generally adopted by eastern and mid-western States; Standard Building Code, which is a product of the Southern Building Code Congress International (SBCCI), and is generally adopted by southern States, and; Uniform Building Code, which is a product of the International Council of Building Officials (ICBO), and is generally adopted by western States.

In addition, there is a fourth model building code known as the CABO (Council of American Building Officials) One and Two Family Dwelling Code. This model code is used in various parts of the country for residential structures.

The National Fire Protection Association (NFPA) Life Safety Code is adopted in many areas of the country. The NFPA National Electrical Code is a national standard referenced by each of the three model codes.

These documents follow standardized formats for content and references, and within the families of codes (i.e. National, Standard and Uniform) the documents reference one another without duplicating information. For example, information on mechanical systems is found in exclusively the Standard Mechanical Code. The Standard Building Code only addresses construction which comes in contact with mechanical systems.

The manufactured housing codes and standards have their origins in a Federal program. The HUD Handbook 4930.3 and the Manufactured Housing Construction Safety Standards (MHCSS), are promulgated by the Department of Housing and Urban Development. The third, the Manufactured Housing Installation Manual (MHIM), written by the Manufactured Housing Institute (MHI), is designed to reference 4930.3 and the MHCSS. These documents contrast in origin with model building codes and NFPA documents which are promulgated by consensus based organizations. Such organizations are part of the Board for the Coordination of the Model Codes (BCMC) process which has coordinated each of these codes in many areas in the last ten years.

The other documents in the manufactured housing code comparison, ANSI A225.1, Appendix C of the CABO 1 & 2 Family Dwelling Code, and NFPA 501A, are either part of the families of the model codes or in the ANSI standard's case is referenced by the model codes. A list of the model codes and standards referenced in this study is found in Chapter 2.

NFIP Standards and the Model Codes

FEMA has undertaken a multi-year effort to incorporate the NFIP flood damage resistant design standards into the nation's model building codes, which are then adopted by either States or local communities.

This effort involved the extraction of specific building criteria from the NFIP floodplain management requirements (44 CFR Parts 59 and 60) and revising the language into a code format. This language was then submitted to the model building code groups as a proposed code change. The code change process consists of a recommendation for approval or disapproval by a code change panel at an annual code change hearing, followed by a vote by eligible model code members at an annual conference. FEMA's approach to this process has involved either working directly with the code organization or closely coordinating with State and local officials to submit the code change proposals.

As of this date, two model building code groups have accepted and published extensive sections of the NFIP floodplain management regulations that pertain to building standards. A third has recently accepted flood related language.

The BOCA National Building Code has already adopted the majority of the NFIP building regulations into the main body of its Building Code, as well as in the BOCA Mechanical, Plumbing and Fire Prevention Codes. The Building Code language is presently located under Section 2101.6. The title of Article 21 is Exterior Walls with Section 2101 entitled Performance Requirements, Exterior Walls. There are several administrative and land use sections of the NFIP regulations that are not covered by the BOCA Code. Because this language is located in the main body of the Building Code, it is unlikely that they can all be included.

The Standard Building Code (SBCCI) is the only model building code that has adopted all of the NFIP regulations. This is the result of a series of code changes submitted in 1986 and 1988. This language is located in a separate standard, the Standard For Floodplain Management (1989 Edition), and is referenced in the Standard Building Code under Section 1209. The Standard for Floodplain Management has been reviewed by FEMA Regions IV and VI and they have accepted it as a satisfactory alternative to their model ordinances. This is possible because this language is located in a separate Standard, although as a separate, it must be purchased and adopted independently.

The Uniform Building Code (ICBO) recently added flood resistant design standards in an appendix chapter. The language is similar to that of the BOCA Code in that it only covers the construction related requirements of the NFIP. The code language was submitted by the ICBO's High Wind/Hurricane Committee, and was based on a 1988 code proposal that was submitted by the State of California, Department of Water Resources and FEMA.

The purpose for FEMA involvement with the model building codes is that with the NFIP design requirements in the building codes, they have become more accessible, more credible, and easier to use and enforce by the building community. The same kind of involvement has not yet occurred with the organizations promulgating the NFPA standards and the manufactured housing codes and standards.

Future Directions

The nation's floodplains continue to be the site of significant amounts of new construction as well as the rehabilitation of existing buildings. In order for the NFIP to accomplish its goal of reducing the nation's flood losses, FEMA must encourage building practices that minimize flood damage to buildings located in flood-prone areas. At the same time, FEMA must ensure that there will not be any negative impact from these flood resistant design standards on the model building codes and the standards that they use to protect structures from other types of natural and man-made hazards.

Future efforts by FEMA to work with the model code groups is evolving. FEMA will continue to work with individual model code groups to place as much of the NFIP floodplain management standards as possible into the model building codes. A possible future initiative is the development of a consensus standard through a nationally recognized standards organization. The advantages to this action are that a national consensus standard is more credible and the same code language would then exist nationwide. FEMA has proposed that the American Society of Civil Engineers form a Flood Damage Resistant Design Standards Committee. One of the purposes of the committee will be the development of design standard guidelines for flood resistant construction through a consensus process. This will be an initial step leading to the development of consensus standards. FEMA also intends to interact with the Department of Housing and Urban Development to coordinate HUD documents with flood resistant standards and technical guidelines.

CHAPTER 2

LIST OF STUDY CODES AND STANDARDS

The FEMA and NFIP flood resistant design standards and technical guidelines listed in this report include:

1. National Flood Insurance Program Regulations for Floodplain Management and Flood Hazard Identification
   (44 CFR 59.1, 60.3 and 60.6)
2. Coastal Construction Manual (FEMA-55)
3. Elevated Residential Structures (FEMA-54)
4. Retrofitting Flood Prone Residential Structures
   (FEMA-114)
5. Floodproofing Non-Residential Structures (FEMA-102)
6. Manufactured Home Installation in Flood Hazard Areas (FEMA-85)
7. Alluvial Fans: Hazards and Management (FEMA-165)
8. Design Guidelines for Flood Damage Reduction (FEMA-15)
9. Manual for the Construction of Residential Basements in Non-Coastal Flood Environs
10. Technical Standards Bulletins:
    - Wet Floodproofing, No. 85-1
    - Foundation Wall Openings, No. 85-2
    - Breakaway Walls, No. 85-3
    - Hurricane Damage Patterns: A Focus on Pile Foundations, No. 86-1
    - Wind Design Standards and the NFIP, No. 88-1
    - Flood Resistant Materials, No. 88-2
    - Free of Obstruction Requirement in Coastal High Hazard Areas, No. 88-3
    - Protection of Elevator Equipment in Flood Hazard Areas, No. 88-4
    - NFIP Pile or Column Requirement in Coastal High Hazard Areas, No. 90-1
    - NFIP Requirements for Below Grade Parking Garages in Flood Hazard Areas, No. 90-2
    - Non-Residential Floodproofing Certification Requirements of the National Flood Insurance Program, No. 90-3
    - Installation of Manufactured Homes in Special Flood Hazard Areas, No. 90-4
11. Interpretative correspondence.

Model codes and standards which contain provisions for seismic, fire, and wind hazards include:

National Codes (BOCA):

1. 1990 BOCA National Building Code
2. 1990 BOCA National Fire Prevention Code
3. 1990 BOCA National Mechanical Code
4. 1990 BOCA National Plumbing Code
5. 1990 BOCA Property Maintenance Code

Standard Codes (SBCCI):

6. 1991 Standard Building Code
7. 1989 Standard for Flood Plain Management
8. 1991 Standard Mechanical Code
9. 1991 Standard Gas Code
10. 1991 Standard Plumbing Code

Uniform Codes (ICBO):

11. 1991 Uniform Building Code
12. 1991 Uniform Mechanical Code
13. 1991 Uniform Plumbing Code

NFPA Standards:

14. NFPA 101 - 1991 Life Safety Code
15. NFPA 70 - 1990 National Electrical Code
16. NFPA 54 - 1988 National Fuel Gas Code
17. NFPA 58 - 1989 Standard for the Storage and Handling of Liquified Petroleum Gases

Manufactured Housing Codes and Standards:

18. ANSI A225.1-87, Manufactured Home Installations
19. HUD Manufactured Home Construction and Safety Standards, Part 3280 with interpretative bulletins
20. Permanent Foundations Guide for Manufactured Housing, 4930.3
21. Model Manufactured Home Installation Manual
22. NFPA 501A - 1987 Standard for Firesafety Criteria for Manufacture Home Installations, Sites and Communities

CABO 1 & 2 Family Dwelling Code:

23. 1989 CABO One and Two Family Dwelling Code with 1990/1991 amendments

CHAPTER 3

SUMMARY OF ISSUES

An Overview of Issues

From a survey of the comparisons of NFIP standards and technical guidelines with the seismic, wind and fire safety provisions in the model codes and standards, it is apparent that issues leading to recommendations for changes to each of the model codes and standards vary with each code, while issues for the NFIP documents cluster into several recognizable themes.

In the comparison between the FEMA documents and the BOCA National Building Code, BOCA raised issues for its code that concern the means and methods of construction. Issues identified by SBCCI for the Standard Building Code reflect concerns with mechanical, electrical and plumbing systems. As with BOCA's comparison, issues identified for the Uniform Building Code center around construction means and methods. Both comparisons address corrosion of masonry, design of anchors, and design loads for breakaway walls. The NFPA comparison raised no issues in regard to amending its own codes. The comparison with manufactured housing codes and standards identified issues similar to the model code issues including the need to reference NFIP documents, utility protection, provisions for floodwalls and anchorage design criteria. The CABO 1 & 2 Family Dwelling comparison raised issues regarding the equalization of hydrostatic forces, and corrosion protection.

For FEMA documents the list of issues raised is considerably longer and displays ten themes which three or more code comparisons identified. Although each comparison presents these issues in different ways and suggests varying courses of action, the topic for each can be stated uniformly as follows:

1. Requiring a geotechnical report for any structural element bearing on soil including piers and piles

2. Coordinating wind loads and wind maps and referencing ASCE 7-88

3. Accounting for snow loads in design

4. Accounting for seismic loads in design

5. Supplying appropriate design values for various types of construction including wood construction, roof to wall connections, and floor beams to pile connections

6. Alternate means of construction, for example, types of shear walls, or wood post for pilings

7. Defining anchorage requirements

8. Application of wood preservatives, use of naturally durable wood and referencing ASTM standards

9. Load requirements for breakaway walls.

10. Occupancy in basements below the BFE

In addition to these ten, there are numerous other issues concerning the FEMA documents identified in at least two of the comparisons. This does not necessarily mean they are less important than the ten issues identified in three or more comparisons. For example:

- o Protection of electrical utilities was cited by both NFPA standards and the Standard Building Code comparisons.
- o Use of registered professionals for design was cited in the BOCA National Building Code and the Uniform Building Code comparisons.
- o Several common issues were defined by the Standard Building Code and CABO 1 & 2 Family Dwelling Code comparisons including:
  - Requirements for nailing and splicing
  - Stud length
  - Wind criteria for wall sheathing
  - Additional moment in piles produced by knee braces
  - Wind loads for windows and shutters

A third category includes the issues addressed by only one code group. For example, the comparison of manufactured housing codes and standards addresses FEMA's use of ground anchors. Other such issues are listed separately for each of the code comparisons below.

National Codes (BOCA)

As stated in the background chapter, the BOCA National Building Code has already adopted the majority of the NFIP building regulations into the main body of its Building Code as well as in the BOCA Mechanical, Plumbing and Fire Prevention Codes. Consequently, the comparison between the National Building Code and the NFIP standards and technical guidelines has resulted in a "check-off" list of final items to be reconciled.

For the BOCA National Building Code this list includes:

Design loads for breakaway walls
Use of fill
Corrosion protection for concrete and masonry
Scour around piles
Use of exterior plywood in subflooring
Flood water loads
Uplift and lateral forces for anchorage

Performance of interior wall finishes
Elevator equipment above the BFE

For the FEMA documents this list includes:

Requiring a geotechnical report for piers
Importance factor in wind forces
Corrosion protection for concrete and masonry
Use of registered professionals for tall structures
Application of wood preservatives
Wood posts
Roof design tables for sheathing and ponding
Design values for roof to wall connections
Footing design
Snow and wind loads
Reference standards for wood foundations
Including live loads in buoyancy considerations
Impact loads
Structural calculations for reinforced concrete slabs
Occupancy in basements below the BFE

In the above list of issues identified for FEMA documents, corrosion protection for concrete and masonry was the only issue unique to this comparison.

Standard Codes (SBCCI)

According to the background chapter, the Standard Building Code is the only model building code that has adopted all of the NFIP regulations. However, for its own code, SBCCI recognized outstanding issues related to mechanical, electrical and plumbing systems. For FEMA documents the comparison produced the longest list of suggested changes in relation to the other comparisons. Like the BOCA comparison, many of the suggested recommendations deal with construction means and methods.

Issues related to the Standard Building Code include:

Referencing FEMA documents for elevation of mechanical equipment and utilities
Referencing the Standard for Floodplain Management for mechanical and gas equipment, tank, utilities, and elevator equipment installations
Uplift of storage tanks
Sump and ejector pumps where gravity drainage is available
Air valves below the BFE
Referencing the Standard for Floodplain Management for plumbing, sewer and storm drain backflow valves and potable water protection

Issues related to the FEMA documents are:

Twelve foot spacing of concrete piers
Alternate means of construction for shear walls
Anchorage requirements

Nailing and splicing requirements
Use of naturally durable wood
Snow and seismic loads
Velocity pressures for tall structures
Referencing ASTM standards for wood preservation
Referencing ACI standards for masonry and concrete
Soils investigations for design of piles
Stud length
Wind criteria for wall sheathing
Additional moment in piles produced by knee braces
Wind loads for windows and shutters
Reference ASCE 7-88 for wind loads
Toe-nailing
Considerations for design of wood construction
Particle board for sheathing
Exposed ductwork
Referencing codes for exhaust installation clearances
Referencing codes for utility clearances
Acquiring building permits
Deletion of rule of thumb for floor beams
Clarifying design requirements for footings
Addressing wave impact on utilities
Providing parameters for substantial improvement of a structure
Occupancy in basements below the BFE

Issues related to both sets of documents are:

Manufactured housing in floodways and coastal high hazard areas
Consistency of criteria for residential and non- residential buildings

The issues related to both sets of documents are unique to this comparison. In the above list of issues identified for FEMA documents, toe-nailing and providing parameters for substantial improvement of a structure were the only issues unique to this comparison.

Uniform Codes (ICBO)

As stated in the background chapter, the Uniform Building Code recently added flood resistant design standards in an appendix chapter. The language is similar to that of the BOCA Code in that it only covers the construction related requirements of the NFIP. Despite the similarity of the UBC appendix to the flood provisions in BOCA, the UBC comparison raises a number of different issues. In addition, the UBC comparison identifies seven thematic issues which appear repeatedly in its recommendations for changes to FEMA documents. The first relates to issues identified by BOCA, the second and third relate to issues identified by BOCA, SBCCI and other comparisons. The next three issues are unique to this comparison. The last issue on referencing local codes was echoed by SBCCI, but for different building components.

ICBO's thematic issues are:

- o For the design of any type of structure, or structural member a registered architect or engineer should be utilized.
- o For any structural element bearing on soil, the design should be based on a geotechnical report prepared by a soils engineer.
- o Where the FEMA documents specify a certain type of construction, other means of construction should be allowed as long as technical criteria for flood hazard reduction is satisfied.
- o FEMA documents should emphasize that examples of design calculations are only examples.
- o Specific manufacturers products should not be specified in FEMA documents.
- o Standards referenced in the FEMA documents should represent the latest edition.
- o FEMA should reference local codes where applicable.

In addition the comparison raises singular issues for the both the UBC and the FEMA documents. For the UBC these issues are:

The flood zones where UBC allows elevated structures
Use of a national standard to define a manufactured home
Leakage through windows
Corrosion of masonry and metals
Protection of openings above the BFE
Wind design velocities for anchors
Design considerations for floodwalls
Water penetration criteria for sealants
Higher design loads for breakaway walls

For FEMA documents these issues are:

Protection of wood
Use of only piles in coastal high hazard zones
Use of wood shear walls
Consideration of lateral loads for all structures
Design tables based on materials, not connections
Loading criteria for fasteners of breakaway walls
Definition of grade should conform to UBC
Water penetration criteria for sealants
Occupancy in basements below the BFE

In regard to breakaway walls, the comparison identifies some significant conflicts between the UBC and the FEMA documents in regard to use of space below the BFE. According to ICBO, the FEMA documents should not allow parking without breakaway wall, and allow temporary storage. This and the following issues for FEMA documents are unique to the ICBO comparison:

Definition of grade should conform to UBC
Water penetration criteria for sealants

NFPA Standards

The NFPA comparison represents possibly the first evaluation of documents written for protection from flood hazards in relation to those written for protection from fire hazards. Because of the focused nature for the NFPA standards, the number of issues identified in the comparison are less broad in scope than the comparisons involving model building codes. Issues identified for FEMA documents center around protection of electrical systems, anchoring and maintenance of tanks, fire ratings for breakaway walls and water tight doors and maintenance of interior finishes for different occupancies as defined by the code. No issues were identified for the NFPA documents.

For electrical systems, issues are as follows:

Suitability for corrosive environments
Secure fastening of service mounting
Sealing of underground installations against flooding
Locating switches and circuit breakers for accessibility
Drainage for electrical systems installed below the BFE
Grounded and labeled power outlets for pumps and motors

Manufactured Housing Codes and Standards

Like the NFPA standards, manufactured housing codes and standards have probably not been compared with documents written for protection from flood hazards. Despite the origin of manufactured housing codes and standards described in the background chapter, many of the results of this comparison are similar to the comparisons for the National, Standard, CABO 1 & 2 Family Dwelling, Uniform and NFPA codes.

For 4930.3, the MHCSS and the MHIM, issues identified in the comparison regarding manufactured housing codes and standards are as follows:

Addition of complete flood design criteria
Addition of provisions for floodwalls
Utility protection
Addition of option for floating structure
Referencing FEMA documents where necessary

For FEMA documents issues are:

Clarifying limits of clay soil use
Language on removable chassis
Alternate forms of construction
Load requirements for breakaway walls
Anchoring requirements
Use of ground anchors

Referencing ANSI 58.1
Design stresses due to lateral movement

For both manufactured housing and FEMA documents, issues to reconcile are:

Coordination of wind criteria
Definition of forces for anchorage
Load requirements for open foundations

For ANSI A225.1, Appendix C of the CABO 1 & 2 Family Dwelling Code, and NFPA 501A the issues identified in the comparison for these codes are as follows.

Flood design criteria for extended wall foundations
Design requirements for anchorage
Referencing FEMA documents

For FEMA documents issues are:

Designing piers per manufacturer's recommendations
Provision for different concrete pier sizes
Designing anchors per manufacturer's recommendations

For both manufactured housing related model codes and standards and FEMA documents, issues to reconcile are:

Coordination of wind criteria
Correction of pier footings for scouring
Design loads
Anchoring requirements
Referencing ANSI 58.1

In the above list of issues identified for FEMA documents, the following issues were unique to this comparison:

Clarifying limits of clay soil use
Language on removable chassis

CABO 1 & 2 Family Dwelling Code

This comparison identified two issues related to the CABO 1 & 2 Family Dwelling Code. For FEMA documents, the list of issues is similar in length and content to the Standard Building Code comparison.

The issue related to the CABO 1 & 2 Family Dwelling Code is:

equalization of hydrostatic forces
corrosion protection

Issues related to the FEMA documents are:

Expansion of the definition of manufactured housing of include dimensional parameters
Snow and seismic loads
Reference ASCE 7-88 for wind loads
Alternate means of construction for shear walls
Anchorage requirements
Nailing and splicing requirements
Deletion of rule of thumb for cantilevers
Use of naturally durable wood
Velocity pressures for tall structures
Referencing ASTM standards for wood preservation
Referencing ACI standards for masonry and concrete
Soils investigations for design of piles
Stud length
Wind criteria for wall sheathing
Additional moment in piles produced by knee braces
Wind loads for windows and shutters
Lateral support for grade beams
Design considerations for truss bracing
Shear walls for pile foundations
Design considerations for floor beams and piles
Particle board for sheathing
Updating wind maps
Site preparation requirements
vapor barrier requirements

In the above list of issues identified for FEMA documents, the following issues were unique to this comparison:

Expansion of the definition of manufactured housing of include dimensional parameters
Lateral support for grade beams
Shear walls for pile foundations
Site preparation requirements
vapor barrier requirements

CHAPTER 4

RECOMMENDED CHANGES TO FEMA DOCUMENTS

Recommended Changes to FEMA Documents Based on the BOCA National Codes

1. NFIP 44 CFR 59.1 (Elevated buildings) — BOCA National Building Code
   NFIP 44 CFR 60.3 ((c)(2), (c)(3), (e)(4), (e)(5), (e)(6))

   FEMA should provide direction to the model codes concerning the need to include the subclassification of flood zones (A1-30, AH, etc.) and B, C, X and D zones versus the current zones (A and V) found in the model codes. Upon resolution, changes to NFIP regulations and code changes to BOCA could be considered.

   See Appendix, pages A-2: item 4; A-5: items 2, 3; A-6: items 1, 2 3.

2. NFIP 44 CFR 59.1 (Breakaway wall) — BOCA National Building Code
   NFIP 44 CFR 60.3 ((e)(5))
   FEMA-55 (4.3.5.1, 4.3.5.2)

   FEMA should conduct the necessary research to support the 10-20 psf design loading for breakaway walls. A system designed in this load range may breakaway under a design wind condition. Upon resolution of this issue, it would then be appropriate to prepare a code change which reflects the results of the research as design criteria to be included in NFIP regulations and BOCA.

   See Appendix, pages A-1: item 4; A-6: item 2, A-26: item 2; A-27: item 1.

3. NFIP 44 CFR 60.3 ((e)(5)) — BOCA National Building Code
   FEMA-55 (4.3.5.1)

   FEMA may wish to clarify that break-away walls are allowed in A-zones provided the opening criteria is met. This would also be a viable option under the alternative approval provisions of BOCA.

   See Appendix, pages A-6: item 2; A-26: item 2.

4. NFIP 44 CFR 59.1 (Substantial improvement) — BOCA National Building Code

   The term "substantial improvement" used in FEMA is based on 50% of market value while BOCA's reconstruction or restoration provisions are a function of 50% of replacement cost. FEMA to evaluate whether the criteria to determine compliance should be based on "market value" or "replacement cost".

   See Appendix, page A-4: item 6.

5. FEMA-54 (Piers) — BOCA National Building Code
   FEMA-55 (4.3.1.1, Appendix D)

   FEMA should require soil testing and a geotechnical report prior to the placement of foundations to ensure sufficient load bearing capacity of the soil.

   See Appendix, pages A-10: item 1; A-18: item 2; A-34: item 2.

6. FEMA-54 (Pier foundation connections) — BOCA National Building Code
   FEMA-114 (3.13)

   Anchor bolt embedment differ slightly between BOCA and FEMA. If viewed as a conflict, FEMA would need to conduct an evaluation of the relevant standards to determine if a "correct" embedment can be ascertained.

   See Appendix, pages A-10: item 3; A-48: item 3.

7. FEMA-55 (4.1.1) — BOCA National Building Code

It is recommended that FEMA revise its importance factor for wind from 1.11 to 1.05 for all buildings other than essential facilities and assembly buildings with less than 300 occupants. This will bring the importance factors into correlation with ANSI A58.1/ASCE 7-82 which is referenced by BOCA.

See Appendix, page A-14: item 2.

8. FEMA-54 (Building materials)
FEMA-55 (4.1.2, 4.2.2, 4.2.3.1, 4.2.3.2, 4.2.3.3, 4.3.2.4) — BOCA National Building Code, BOCA National Fire Prevention Code

It is recommended that FEMA include a general provision to address moisture protection. Suggested language is: Construction materials, including connections, shall be resistant to water damage such that conditions of corrosion, deterioration, or decay will not occur.

See Appendix, pages A-11: item 2; A-12: item 1; A-14: item 3; A-17: items 2, 3, 4, 5; A-20: item 4: A-80: item 1.

9. FEMA-55 (4.1.4) — BOCA National Building Code

Registration laws for engineers and architects vary from state to state and FEMA should acknowledge these laws.

See Appendix, page A-15: item 3.

10. FEMA-55 (4.1.4) — BOCA National Building Code

The requirements for professional registration (V-zones) require correlation with the NFIP regulations.

See Appendix, page A-15: item 3.

11. FEMA-55 (4.2.1.3) — BOCA National Building Code

Main supporting members are critical to the structural integrity of a building but so are joists and other structural elements. It is not clear why FEMA only requires certain structural elements to be preservative treated.. FEMA should revise its' criteria to include a requirement for pressure preservative treatment for all structural members subject to flooding.

See Appendix, page A-16: item 4.

12. FEMA-54 (Building materials)
FEMA-55 (4.2.1.4, 5.2)
FEMA-102 (Chapter III Part C) — BOCA National Building Code

FEMA should reference the appropriate standards for the pressure preservative treatment of wood. These include AWPA C1-88, C2-89 and C9-85 for above grade construction and AWPA C3-89, C4-89, AWPB MP1-88, MP2-88, and MP4-88 for timber piles. Preservatives should conform to AWPA P1-89, P2-89, P5-89, P8-89, and P9-87. Wood used in foundations should conform to AWPB-FDN-88.

See Appendix, pages A-11: item 2; A-12: item 1; A-17: item 1; A-31: item 3; A-43: item 1.

13. FEMA-55 (4.3.1.3)
MCRB (III.A.1) — BOCA National Building Code

It seems overly restrictive to preclude the use of a building material. If adequately designed, wood posts (FEMA-55) or unreinforced masonry (MCRB) should be considered acceptable. It is recommended that FEMA relax their recommendation of material types in favor of a designed system of material of the designer's choice when such materials can be shown to be suitable for their intended use.

See Appendix, pages A-19: item 2; A-54: item 1.

14. FEMA-55 (4.3.2.8) — BOCA National Building Code

FEMA should include design tables for the maximum span of roof sheathing as well as ponding provisions for the design of flat and low-slope roofs. Alternatively, FEMA could reference the model codes for roof sheathing design tables.

See Appendix, page A-22: item 1.

15. FEMA-55 (4.3.3.4) — BOCA National Building Code

FEMA should revise their provisions to include a prohibition of shear or other walls which are part of the structural frame below the BFE in V-zones.

See Appendix, page A-24: item 2.

16. FEMA-55 (4.3.4.1)
FEMA-85 (Chapter IV Part A) — BOCA National Building Code

It is recommended that FEMA reference the wind and snow design values of ANSI A58.1/ASCE 7-82.

See Appendix, pages A-24: item 4; A-39: item 2.

17. FEMA-55 (4.3.4.4) — BOCA National Building Code

FEMA should reference the design standard for wood, namely, NFoPA NDS-1986 with 1987 revisions and 1988 Supplement - Design Values for Wood Construction.

See Appendix, page A-25: item 3.

18. FEMA-55 (4.3.7.2) — BOCA National Building Code

FEMA should determine the appropriate performance criteria for storm shutters and stipulate when and what type are required. This could then be considered by BOCA.

See Appendix, page A-29: item 1.

19. FEMA-55 (4.3.7.4) — BOCA National Building Code

FEMA should stipulate the locations which require flashing.

See Appendix, page A-29: item 3.

20. FEMA-54 (Building Materials and Wood, Steel, Concrete and Masonry)
FEMA-55 (5.2, 5.3)
MCRB (III.A.3, III.A.4, III.B.7.b) — BOCA National Building Code

FEMA should reference the applicable standards for plain and reinforced concrete design, ACI 318-89 and ACI 318.1-89, respectively. Concrete materials and admixtures should conform to ASTM C260-86, ASTM C618-88, and ASTM C989-89. Ready-mix concrete should conform to ASTM C94-89b or ASTM C685-89b.

See Appendix, pages A-11: item 2; A-12: item 1, A-31: items 3, 4: A-54: items 3, 4; A-57: item 4.

21. FEMA-85 (Chapter III-Fill)
FEMA-102 (Chapter III Part B) — BOCA National Building Code

FEMA-85 and -102 require coordination with the NFIP regulations relative to the use of structural fill in V-zones. NFIP regulations do not permit fill in V-zones.

See Appendix, pages A-37: item 1; A-42: item 3.

22. FEMA-85 (Chapter III-Elevated foundations) — BOCA National Building Code

Pier height restrictions differ slightly between BOCA and FEMA. If viewed as a conflict, FEMA would need to conduct an evaluation of the relevant standards to determine if a "correct" pier height can be ascertained.

See Appendix, page A-37: item 2.

23. FEMA-85 (Chapter IV D) — BOCA National Building Code

It is not clear how the recommendations found in FEMA would be implemented relative to providing a means of evacuation and/or rescue during a flood event. In all likelihood, compliance with these recommendations would preclude a structure from being built in an area prone to flooding. FEMA to evaluate.

See Appendix, page A-41: item 1.

24. FEMA-102 (Maintenance) — BOCA National Building Code

FEMA should evaluate how the provisions in FEMA-102 correlate with the NFIP requirements relative to "substantial improvements".

See Appendix, page A-44: item 1.

25. FEMA-102 (Appendix D Part B)
MCRB (III.C.4.g, V.B.1, I.B.4) — BOCA National Building Code

FEMA should provide data for determining floodwater depth and velocity for use in hydrostatic and hydrodynamic load calculations. This would include the conditions of flood water velocity, erosion, sediment, depth and watershed hydrology. If no such data exists, a research effort should be undertaken to establish such data as the basis to develop specific hydrodynamic design loads for incorporation into ASCE 7.

See Appendix, pages A-46: item 3; A-60: item 3; A-62: item 4; A-66: item 5.

26. FEMA-114 (3.5) — BOCA National Building Code

FEMA-114 requires a revision to clarify when openings to equalize floodwaters are required (A-zones) versus breakaway walls (V-zones)

See Appendix, page A-48: item 1.

27. FEMA-114 (6.5)
FEMA-54 (Building materials)
MCRB (III.A.1, III.A.2) — BOCA National Building Code

FEMA should reference the current masonry standard for unreinforced and reinforced masonry, ACI 530/ASCE 5-88. Masonry mortar should conform to ASTM C270-88a.

See Appendix, pages A-11: item 2; A-12: item 1, A-49: item 3; A-54: items 1, 2.

28. MCRB (III.A.6) — BOCA National Building Code

FEMA should review the referenced standard for wood foundations (NFoPA TR7-87) to determine applicability to flooded conditions.

See Appendix, page A-55: item 1.

29. MCRB (III.B.4) BOCA National Building Code

The FEMA MCRB Manual discusses the design and construction of residential basement walls subjected to hydrostatic and hydrodynamic loads (i.e., below the BFE). Under BOCA, residential basements usable for human occupancy are required to be above the BFE. The BOCA codes does not permit the water-resistant design option for residential structures with floors usable for human occupancy below the BFE-this option is acceptable for all uses except residential. FEMA NFIP 44 CFR 60.3 (c)(2) also requires "residential structures...(including basements) elevated to or above the base flood level" - unless a variance is granted in accordance with NFIP 44 CFR 60.6. Therefore, FEMA should clarify the use of the MCRB with respect to residential basements.

See Appendix, page A-56: item 3.

30. MCRB (III.C.3) BOCA National Building Code

FEMA should review the calculations relative to the inclusion of live load in buoyancy considerations.

See Appendix, page A-59: item 4.

31. MCRB (III.C.5) BOCA National Building Code

The basis for FEMA's assertion that loads other than impact and debris will not "appreciably alter the designs recommended" requires substantiation. Additionally, the FEMA MCRB Manual takes the position that debris is not considered but other documents such as FEMA-54 (pages 69-70) and FEMA-55 (Section 4.1.3) require this type of loading to be evaluated. FEMA needs to clarify the effect this has on the use of the manual.

See Appendix, page A-60: item 4.

32. MCRB (V.A.2.h) BOCA National Building Code

FEMA presents an oversimplified view that a 6 inch thick reinforced slab is adequate (rebar size and placement not described). FEMA should either provide a series of prescriptive design solutions for a broad range of conditions or simply require structural calculations in accordance with the current edition of ACI 318-89.

See Appendix, page A-62: item 2.

33. FEMA Technical Bulletin 85-3 (Design Considerations) BOCA National Building Code

The 8th sentence under "Masonry walls" in 85-3 is probably incorrect for most conditions. This sentence states "Once the pins fail, the wall will cantilever with the reinforcing bars at the bottom of the wall, providing additional resistance to failure until the wall's capacity is reached." What is more likely, is that a load sufficient to cause the failure, in shear, at connecting pins at the top of the wall, can be expected to result in an immediate failure, in bending, at the bottom. We therefore recommend this statement be deleted or modified.

See Appendix, page A-72: item 3.

34. FEMA Technical Bulletin 88-2 (Flood Resistant Materials) BOCA National Building Code
FEMA-55 (4.3.2.4)

FEMA should conduct the necessary research to indicate in 88-2 which of the materials referenced by Section 2101.6.6 of the BOCA National Building Code will withstand direct and prolonged contact with flood waters without sustaining significant damage. The criteria by which significant damage is accessed is especially important to establish. Such information can then provide a technical basis for proposed changes to the model codes which will establish a regulatory basis for approving flood damage resistant material.

See Appendix, pages A-20: item 4; A-74: item 1.

Recommended Changes to FEMA Documents Based on the SBCCI Standard Codes

1. FEMA 54 (Posts, Post Embedment, Post Anchorage) — STANDARD BUILDING CODE
   FEMA 55 (4.3.1.3 Posts Wood)
   FEMA 102 (III. C. 2 Posts)

   FEMA 54, FEMA 102, and FEMA 55 should combine post foundations and pile foundations into one section with more prescriptive requirements.

   See Appendix, page B-4, items 1-3
   See Appendix, page B-12, item 3
   See Appendix, page B-29, item 3

2. FEMA 54 (Shear Walls and Floor Diaphragms) — STANDARD BUILDING CODE

   FEMA 54 should address the use of shear walls and floor diaphragms as a method of bracing but should permit the building designer to choose the method.

   See Appendix, page B-5, item 4

3. FEMA 54 (Pier Foundation Connection) — STANDARD BUILDING CODE

   FEMA 54 should provide wind load values or forces for which the anchorage is adequate.

   See Appendix, page B-5, item 5

4. FEMA 54 (Floor Beams) — STANDARD BUILDING CODE
   FEMA 55 (4.2.1.2 Main Supporting Members)

   FEMA 54 and FEMA 55 should provide better nailing and splice location requirements.

   See Appendix, page B-6, item 1
   See Appendix, page B-10, item 4

5. FEMA 54 (Cantilevers) — STANDARD BUILDING CODE

   FEMA 54 should delete the "rule of thumb" or add better guidance for the design of the cantilever.

   See Appendix, page B-6, item 2

6. FEMA 54 (Wood) — STANDARD BUILDING CODE

   FEMA 54 should include "naturally durable wood."

   See Appendix, page B-7, item 3

7. FEMA 54 (Performance Criteria)
FEMA 55 (5.1 General Design Considerations)
FEMA 55 (G-7. Foundation Standards)
FEMA 55 (G-8. Anchoring Standards)
FEMA 114 (3.14 Technical Design Criteria Open Foundations)
FEMA 114 (Appendix C - Forces)
No. 85-2 (Flood Forces)
No. 85-3 (II Wind and Water Forces)
No. 88-1

STANDARD BUILDING CODE

FEMA 54, FEMA 55, FEMA 114, No. 85-2, No. 85-3, and No. 88-1 should address snow and seismic loads. The use of the phrases "unacceptable risks", "unacceptable health hazards", and "unacceptable magnitude" are too subjective. FEMA 114, No. 85-3, and No. 88-1 should update the wind speed maps to the latest editions and address snow and seismic loads. SBC should address hydrostatic, hydrodynamic, and buoyancy forces in floodplain areas.

See Appendix, page B-8, item 2
See Appendix, page B-17, item 4
See Appendix, page B-21, item 5
See Appendix, page B-22, item 3
See Appendix, page B-33, item 4
See Appendix, page B-35, item 4
See Appendix, page B-48, item 1
See Appendix, page B-49, item 1
See Appendix, page B-50, item 1

8. FEMA 55 (4.1.1 Wind)
FEMA 55 (G-6. Determination of Loading Forces)
FEMA 55 (G-14. Reference Documents)
FEMA 85 (Design of Elevated Foundations)
FEMA 114 (Appendix C - Forces)
No. 85-3 (II Wind and Water Forces)
No. 88-1

STANDARD BUILDING CODE

FEMA 55, No. 85-3, and No. 88-1 should update reference to ASCE 7-1988. FEMA 85 and HUD 's MHCSS should update the wind and snow loads to ASCE 7-88. FEMA 85, No. 85-3, and No. 88-1 should address seismic loads. FEMA 114 should update the wind speed maps to the latest editions and address snow and seismic loads. SBC should address hydrostatic, hydrodynamic, and buoyancy forces in floodplain areas.

See Appendix, page B-9, item 1
See Appendix, page 21, item 4
See Appendix, page 25, item 3
See Appendix, page 27, item 1
See Appendix, page 35, item 4
See Appendix, page 49, item 1
See Appendix, page 50, item 1

9. FEMA 55 (4.1.4 Effects of Forces on Higher and Larger Structures)

STANDARD BUILDING CODE

FEMA 55 should provide velocity pressures (psf) for varied wind speeds and building height.

See Appendix, page B-10, item 1

10. FEMA 55 (4.2.1.1 Pilings Wood) STANDARD BUILDING CODE

FEMA 55 should provide additional information such as ASTM standard preservative treatment and allowable stresses of timber piles.

See Appendix, page B-10, item 3

11. FEMA 55 (4.2.1.4 Wood Preservatives) STANDARD BUILDING CODE

FEMA 55 should list some of the AWPA standards.

See Appendix, page B-11, item 1

12. FEMA 55 (4.2.2 Masonry Materials and Concrete) STANDARD BUILDING CODE

FEMA 55 should add references to ACI 318 and ACI/ASCE 530.

See Appendix, page B-11, item 2

13. FEMA 55 (4.3.1.2 Piles) STANDARD BUILDING CODE

FEMA 55 should emphasize that type of pile, pile depth, and method of installation should be based on the soils investigation.

See Appendix, page B-12, item 2

14. FEMA 55 (4.3.1.4 Piers) STANDARD BUILDING CODE

FEMA 55 should clarify that the reinforcing, footing size, and grade beam size should be based on the design forces.

See Appendix, page B-12, item 4

15. FEMA 55 (4.3.2.2 Beams) STANDARD BUILDING CODE

FEMA 55 should provide nailing requirements for built-up members.

See Appendix, page B-13, item 1

16. FEMA 55 (4.3.2.3 Joists and Rafters) STANDARD BUILDING CODE

FEMA 55 should delete the reference to rafters or add information on rafters.

See Appendix, page B-13, item 2

17. FEMA 55 (4.3.2.4 Subflooring) STANDARD BUILDING CODE

The provisions are compatible. FEMA 55 should provide some recommended nail spacing and spans.

See Appendix, page B-13, item 3

18. FEMA 55 (4.3.2.5 Studs) STANDARD BUILDING CODE

FEMA 55 should address sizing of studs including number of stories which the stud supports or limits for the use of 2x4 studs.

See Appendix, page B-13, item 4

19. FEMA 55 (4.3.2.6 Wall Sheathing) STANDARD BUILDING CODE

FEMA 55 should provide additional information addressing the wind speed in addition to height above grade.

See Appendix, page B-14, item 1

20. FEMA 55 (4.3.2.7 Wall Bracing) STANDARD BUILDING CODE

FEMA 55 should combine 4.3.2.6 Wall Sheathing and 4.3.2.7 Wall Bracing into one section and address the design requirements for the wall bracing method chosen.

See Appendix, page B-14, item 2

21. FEMA 55 (4.3.3.1 Knee Braces) STANDARD BUILDING CODE

FEMA 55 should emphasize that the wood foundation piles should be designed for the additional moment introduced into the pile from the knee brace.

See Appendix, page B-14, item 5

22. FEMA 55 (4.3.3.2 Grade Beams) STANDARD BUILDING CODE

FEMA 55 should emphasize the need to design the grade beams to assure that they are actually providing lateral support of piles.

See Appendix, page B-15, item 1

23. FEMA 55 (4.3.3.3 Truss Bracing) STANDARD BUILDING CODE

FEMA 55 should emphasize the need to design the bracing members.

See Appendix, page B-15, item 2

24. FEMA 55 (4.3.3.4 Shear Walls) STANDARD BUILDING CODE

FEMA 55 should address wood shear walls for wood pile foundations.

See Appendix, page B-15, item 3

25. FEMA 55 (4.3.4.4 Floor Beam to Pile, Post, or Pier) STANDARD BUILDING CODE

FEMA 55 should provide some design values or wind speeds for which the connections are appropriate.

See Appendix, page B-15, item 5

26. FEMA 55 (4.3.7.1 Window Selection
FEMA 55 (4.3.7.2 Operable Shutters) STANDARD BUILDING CODE

FEMA 55 should address the design of the windows and shutters for the wind load pressures

See Appendix, page B-16, item 4
See Appendix, page B-16, item 5

27. FEMA 55 (4.3.7.4 Roofing Materials) STANDARD BUILDING CODE

FEMA 55 should emphasize the need to have a roof covering designed to withstand the uplift from the wind. SBC should emphasize that the roof covering should be designed to 1205.

See Appendix, page B-17, item 2

28. FEMA 55 (5.3 Slabs an Grade) STANDARD BUILDING CODE

The minimum slab thickness in FEMA 55 should be changed to 3 1/2 inches and delete the requirement for welded wire fabric.

See Appendix, page B-18, item 2

29. FEMA 55 (G-3. Scope) STANDARD BUILDING CODE

Since market value is a variable based on location, economy, etc., FEMA should require compliance for all improvements since noncompliance of any part of the structure makes the entire structure out of compliance.

See Appendix, page B-21, item 1

30. FEMA 55 (G-7.1 Pile Foundation Design) STANDARD BUILDING CODE

FEMA 55 should emphasize that pile spacing and embedment should be based on the foundation investigation. FEMA 55 should reduce the minimum compressive strength of the concrete for reinforced concrete piles to 4000 psi, since 4000 psi has been a building code requirements since 1980.

See Appendix, page B-22, item 1

31. FEMA 55 (G-8.1 Connector and Fasteners) STANDARD BUILDING CODE

FEMA 55 should not prohibit toe nailing if the connection is adequate for the calculated loads. SBC should address corrosion protection of metal connectors.

See Appendix, page B-22, item 4

32. FEMA 55 (G-8.2 Beam to Pile Connections)
FEMA 55 (G-8.5 Ceiling Joist Rafter) STANDARD BUILDING CODE

FEMA 55 should permit the designer to design the connection.

See Appendix, page B-23, item 1
See Appendix, page B-23, item 4

33. FEMA 55 (G-8.3 Floor to Deck Connections)
FEMA 55 (G-8.4 Exterior Wall Connections) STANDARD BUILDING CODE

FEMA 55 should permit the designer the leeway to meet performance requirements.

See Appendix, page B-23, item 2
See Appendix, page B-23, item 3

34. FEMA 55 (G-9. Roof Sheathing) STANDARD BUILDING CODE

FEMA 55 should permit particleboard roof sheathing provided it is of the appropriate strength.

See Appendix, page B-24, item 1

35. FEMA 55 (G-13. Certification Requirements) STANDARD BUILDING CODE

FEMA 55 should provide parameters for which sections 7 and 8 are appropriate (wind load, height above grade, etc.).

See Appendix, page B-25, item 2

36. FEMA 85 (Anchoring) STANDARD BUILDING CODE

FEMA 85 should address minimum number of ties and anchors.

See Appendix, page B-26, item 4

37. FEMA 102 (III.C.3 Piles) STANDARD BUILDING CODE

FEMA 102 should emphasize that the length and maximum design load is based on the foundation investigation and report.

See Appendix, page B-29, item 4

38. FEMA 102 (Table III-1 Minimum Requirements for Reinforced Piers) STANDARD BUILDING CODE

FEMA 102 should clarify the soil bearing capacity was used for the minimum footing size and the design loads used for the minimum pier size.

See Appendix, page B-30, item 2

39. MCRB (III.A.2 Reinforced and Grouted Block) STANDARD BUILDING CODE

MCRB should reference ANSI A41.2 and ACI/ASCE 530.

See Appendix, page B-37, item 2

40. MCRB (III.A.4 Reinforced Concrete) STANDARD BUILDING CODE

MCRB should reference ACI 318.

See Appendix, Page B-37, item 4

41. MCRB (III.B.9 Anchorage) — STANDARD BUILDING CODE

MCRB should be changed to comply with current model codes.

See Appendix, Page B-40, item 5

42. MCRB (III.C.5 Debris, Wind, Impact, Snow, Ice, and Other Live Loads) — STANDARD BUILDING CODE

MCRB should include wind, snow, and seismic loads.

See Appendix, Page B-42, item 5

43. MCRB (Ch. V Basements for Floods) — STANDARD BUILDING CODE
MCRB (A.2 Designs, Methods, and Tables)
MCRB (A.2.a Building Model, Dimensions, and Loading)
MCRB (A.2.b Structural Analysis Model) (Wall)
MCRB (A.2.c Structural Plain Concrete)
MCRB (A.2.d Reinforced Concrete)
MCRB (A.2.e Plain Masonry Block)
MCRB (A.2.f Reinforced Masonry Block)
MCRB (A.2.g Flood Waters Above Grade)
MCRB (A.2.h Slab Thickness) (Based on Bending)
MCRB (A.2.i Structural Slab Design) (Ultimate Strength Design)

MCRB should not reference a single model code. MCRB should reference only national consensus documents.

See Appendix, Page B-42, item 13

44. FEMA 54 (Insulation) — STANDARD MECHANICAL CODE

Change FEMA 54 to address insulation of exposed ductwork.

See Appendix, page B-59, item 3

45. FEMA 102 (Ch. IV Other Floodproofing Measures) — STANDARD MECHANICAL CODE

(1) Revise SMC to reference the Standard for Floodplain Management (2)) Revise FEMA 102 to reference the locally adopted model code for installation clearances.

See Appendix, page B-62, item 2

46. FEMA 102 (Appendix D "Floodproofing Performance Criteria") — STANDARD MECHANICAL CODE

(1) Revise FEMA 102 to reference the local model codes for access and clearance. (2) Revise SMC to reference Standard for Floodplain Management.

See Appendix, page B-62, item 4

47. FEMA 114 (Ch. 9 Protection of Utilities, 9.4 Permanent Protection Measures) — STANDARD MECHANICAL CODE

(1) Change FEMA to reference locally adopted model codes for clearances to combustible materials and minimum access (2) change the SMC to reference the Standard for Floodplain Management.

See Appendix, page B-64, item 2

48. FEMA 114 (Ch. 9 Protection of Utilities, 9.5 Utility Relocation to Existing Space) — STANDARD MECHANICAL CODE

Section 9.5 of FEMA 114 should be revised to reference minimum clearances for heat producing appliances according to local model codes.

See Appendix, page B-64, item 3

49. FEMA 114 (Ch. 9 Protection of Utilities, 9.6 Utility Relocations to New Space) — STANDARD MECHANICAL CODE

Section 9.5 of FEMA 114 should be revised to encourage obtaining a building permit for new construction/alterations. It should also reference model codes for minimum clearance to combustibles and access to equipment.

See Appendix, page B-64, item 4

50. FEMA 54 (Mechanical Equipment) — STANDARD GAS CODE

(1) Revise FEMA to caution that fuel-fired equipment must be installed to local codes (2) Revise SGC to reference the Standard for Floodplain Management.

See Appendix, page B-79, item 3

51. FEMA 55 (Ch. 4 - Structure Design, Section 4.3.6 Utilities)
FEMA 55 (Appendix G "Sample Coastal Construction Code" 12 Utilities)
FEMA 102 (Ch. IV Other Floodproofing Measures)
FEMA 102 (Appendix D "Floodproofing Performance Criteria) — STANDARD GAS CODE

(1) For elevation - revise the SGC to reference the Standard for Floodplain Management. (2) For fuel supply - revise FEMA 55 AND 102 to reference model codes for installation.

See Appendix, page B-81, item 1
See Appendix, page B-81, item 3
See Appendix, page B-83, item 2
See Appendix, page B-83, item 4

52. FEMA 114 (Ch.9 Protection of Utilities, 9.6 Utility Relocation to Existing Space) — STANDARD GAS CODE

FEMA 114 should be revised to reference readers to local model codes for other safety considerations.

See Appendix, page B-85, item 4

53. No. 90-3 (Section D-2) STANDARD GAS CODE

Revise No. 90-3 to reference the local model code for venting and combustion air.

See Appendix, page B-97, item 1

54. NFIP (60.3(b)(8) Manufactured Home Installation) STANDARD FOR FLOODPLAIN MANAGEMENT

In order to avoid confusion, NFIP and SFM should list the zone designation (A, AO, AH, VO, M, etc.) along with the word description (floodway, coastal high hazard)

See Appendix, page B-120, item 3

55. FEMA 54 (Posts, Post Embedment, Post Anchorage)
FEMA 55 (4.3.1.3 Posts) STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 54 and FEMA 55 should combine post foundations and pile foundations into one section.

See Appendix, page B-123, item 1
See Appendix, page B-129, item 2

56. FEMA 54 (Floor Beams, Cantilevers) STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 54 should delete the "rule of thumb".

See Appendix, page B-123, item 4

57. FEMA 54 (Performance Criteria)
FEMA 55 (4.1.1 Wind)
FEMA 55 (5.1 General Design Considerations)
FEMA 55 (5.6 Exterior Wall Systems)
FEMA 114 (3.14 Technical Design Criteria Open Foundations)
FEMA 114 (Appendix C - Forces)
No. 85-3 (II Wind and Water Forces)
No. 88-1 STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 54, FEMA 55, FEMA 114, No. 85-3 and 88-1 should include performance criteria for snow and seismic loads. The use of the phrases "unacceptable risks", "unacceptable health hazards", and "unacceptable magnitude" are too subjective. FEMA 114 should update the wind speed maps to the latest edition. FEMA 55, No. 85-3 and No. 88-1 should update reference to ASCE 7-88. Section 801.1 of the Standard for Floodplain Management should reference Chapter 12 instead of only 1205 (Wind) to include 1204 (Snow) and 1206 (Seismic).

See Appendix, page B-125, item 1
See Appendix, page B-126, item 2
See Appendix, page B-132, item 2
See Appendix, page B-133, item 2
See Appendix, page B-143, item 4
See Appendix, page B-145, item 3
See Appendix, page B-156, item 1
See Appendix, page B-157, item 1

58. FEMA 55 (4.1.4 Effects of Forces on Higher and Larger Structures) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should provide velocity pressures (psf) for varied wind speeds and building height.

See Appendix, page B-127, item 1

59. FEMA 55 (4.2.1.2 Main Supporting Members, Beams, Wood) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should provide more specific parameters for which the stated nailing is appropriate.

See Appendix, page B-127, item 4

60. FEMA 55 (4.3.1.2 Piles) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should emphasize that the type of pile, pile depth, and method of installation should be based on the soils investigation.

See Appendix, page B-129, item 1

61. FEMA 55 (4.3.1.4 Piers) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should clarify that the reinforcing, footing size, and grade beam should be based on the design forces.

See Appendix, page B-129, item 3

62. FEMA 55 (4.3.2.3 Joists and Rafters) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should delete the reference to rafters.

See Appendix, page B-130, item 1

63. FEMA 55 (4.3.2.6 Wall Sheathing, 4.3.2.7 Wall Bracing) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should combine wall sheathing and wall bracing into one section and address the design requirements for the wall bracing method chosen.

See Appendix, page B-130, item 4

64. FEMA 55 (4.3.2.8 Roof Details, 4.3.3 Foundation Bracing, 4.3.4 Connections) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should provide some design values or wind speeds for which the connections and details are appropriate.

See Appendix, page B-130, item 5

65. FEMA 55 (4.3.6 Utilities) — STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should address the potential damage from high winds in coastal areas.

See Appendix, page B-131, item 2

66. FEMA 55 (G-6 Determination of Loading Forces)
FEMA 55 (G-14 Reference Documents)
FEMA 85 (Ch. IV Design of Elevated Foundations)
FEMA 114 (Appendix C - Forces)
No. 85-3 (II Wind and Water Forces)
No. 88-1

STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55, FEMA 85, HUD's MHCSS, No. 85-3 should update its reference to ASCE 7-88. FEMA 114 should update the wind speed maps to the latest edition and address snow and seismic loads. Section 801.1 of the Standard for Floodplain Management should reference Chapter 12 instead of only 1205 (Wind) to include 1204 (Snow) and 1206 (Seismic).

See Appendix, page B-136, item 2
See Appendix, page B-138, item 1
See Appendix, page B-140, item 1
See Appendix, page B-145, item 3
See Appendix, page B-156, item 1
See Appendix, page B-157, item 1

67. FEMA 55 (G-13 Certification of Requirements)

STANDARD FOR FLOODPLAIN MANAGEMENT

FEMA 55 should provide parameters for which sections 7 and 8 are appropriate (wind load, height above grade, etc.)

See Appendix, page B-137, item 5

68. MCRB (III.C.5 Debris, Wind Impact, Snow, Ice and Other Live Loads)

STANDARD FOR FLOODPLAIN MANAGEMENT

MCRB should include wind, snow, and seismic loads.

See Appendix, Page B-149, item 1

69. MCRB (Chapter V Basements in Floods)
MCRB (A. Structural Design/Analysis)
MCRB (A.2 Designs, Methods, and Tables)
MCRB (A.2.a Building Model, Dimensions, and Loading)
MCRB (A.2.b Structural Analysis Model) (Wall)
MCRB (A.2.c Structural Plain Concrete)
MCRB (A.2.d Reinforced Concrete)
MCRB (A.2.e Plain Masonry Block)
MCRB (A.2.f Reinforced Masonry Block)
MCRB (A.2.g Flood Waters Above Grade)
MCRB (A.2.h Slab Thickness) (Based on Bending)
MCRB (A.2.i Structural Slab Design) (Ultimate Strength Design)

STANDARD FOR FLOODPLAIN MANAGEMENT

MCRB should not reference a single model code. MCRB should reference only national consensus documents.

See Appendix, Page B-149, item 2

Recommended Changes to FEMA Documents Based on the ICBO Uniform Codes

1. CFR 60.6 — Uniform Building Code
(c)(2)(i) (Flood-proof Walls)

Either the U.B.C. should provide provisions for residential basements or CFR 60.6 should not allow such basements.

See Appendix, page C-8, item 2.

2. FEMA-55 — Uniform Building Code

4.1.1 (Wind)

FEMA-55 should reference the latest edition of the Minimum Design Loads for Buildings and other structures published by the American Society of Civil Engineers (ASCE 7-88, formerly ANSI 58.1).

See Appendix, page C-10, item 1.

3. FEMA-55 — Uniform Building Code

4.1.2 (Corrosion Protection)

FEMA-55 should address roofing details and those of other exterior assemblies.

See Appendix, page C-10, item 2.

4. FEMA-55 — Uniform Building Code

4.2.1.3 (Other Wood Members)

FEMA-55 should require protection of all members that are exposed to these conditions.

See Appendix, page C-12, item 2.

5. FEMA-55 — Uniform Building Code

4.2.1.4 (Preservatives)

FEMA-55 should recommend that the wood preservatives meet approved national and local standards.

See Appendix, page C-12, item 3.

6. FEMA-55 Uniform Building Code

4.3.1 (Foundations)

FEMA-55 should recommend the use of only piles or columns in Coastal High Hazard Zones.

See Appendix, page C-12, item 4.

7. FEMA-55 Uniform Building Code

4.3.1.1 (Soil Conditions)

FEMA-55 should recommend the use of a licensed engineer for the classification of the soil or provide a reference to a document that does require such certification.

See Appendix, page C-14, item 1.

8. FEMA-55 Uniform Building Code

4.3.1.2 (Piles)

FEMA-55 should recommend that the sizing of the piles is done by a licensed engineer or architect or provide a reference to a document that does require such certification.

See Appendix, page C-14, item 2.

9. FEMA-55 Uniform Building Code

4.3.1.3 (Wood Posts)

FEMA-55 should allow the use of wood posts in A zones provided the foundation system is designed by a licensed engineer or architect.

See Appendix, page C-14, item 3.

10. FEMA-55 Uniform Building Code

4.3.1.4 (Masonry Piers)

FEMA-55 should recommend that a licensed engineer or architect design the pier foundation or provide a reference to a document that does require such certification.

See Appendix, page C-14, item 4.

11. FEMA-55 Uniform Building Code

4.3.2.1 (Framing)
4.3.2.2 (Floor Beams)

FEMA-55 should recommend that the design of this type of framing system be done by a licensed engineer or architect, since these areas may also be subject to other lateral forces or provide a reference to a document that does require such certification.

See Appendix, page C-14, item 1.

12. FEMA-55 Uniform Building Code

4.3.3 (Foundation Bracing)

FEMA-55 should recommend that a licensed engineer or architect design these braces and the rest of the foundation system or provide a reference to a document that does require such certification.

See Appendix, page C-17, item 1.

13. FEMA-55 Uniform Building Code

4.3.3.2 (Grade Beams)

FEMA-55 should recognize other methods of foundation restraint.

See Appendix, page C-17, item 3.

14. FEMA-55 Uniform Building Code

4.3.3.4 (Shear Walls)

FEMA-55 should address the use of wood shear walls as an acceptable method of resisting wind and water loads.

See Appendix, page C-18, item 1.

15. FEMA-55 Uniform Building Code

4.3.6 (Utilities)

FEMA-55 should also include the protection of utilities in the "A" flood hazard zone as they subject to similar conditions found in the Coastal High Hazard zone.

See Appendix, page C-20, item 4.

16. FEMA-55 Uniform Building Code

5.5 (Elevated Floors)

FEMA-55 should discuss composite floor systems as these are prevalent in high-rise construction.

See Appendix, page C-22, item 3.

17. FEMA-55 Uniform Building Code

Figure No. A-1 (Number of Piles)

FEMA-55 should recommend that a licensed engineer or architect design the piling system rather than provide specific design criteria for all situations or provide a reference to a document that does require such certification. Also, FEMA-55 should consider the soil conditions at the site when making design recommendations.

See Appendix, page C-23, item 2.

18. FEMA-55 Uniform Building Code

Table No. A-7 (Bolt Capacity of Floor Beam Connections)

FEMA-55 should base their design tables on the materials used in the connection as well as the type of connection.

See Appendix, page C-25, item 2.

19. FEMA-55 Uniform Building Code

B.1 (Knee Bracing)

FEMA-55 should recognize the use of other forms of bracing as well as requiring the use of a licensed engineer or architect in the design of such a system.

See Appendix, page C-27, item 2.

20. FEMA-55 Uniform Building Code

B.2.1.2 (Thread Bar Diagonals)
B.2.2 (Struts)

FEMA-55 should not recommend specific manufacturers.

See Appendix, pages C-28, items 2 and 3.

21. FEMA-55 Uniform Building Code

D.3 - Procedure A-3 (Minimum Embedment of Piles)

FEMA-55 should recommend that a soils engineer be consulted and a soils report be undertaken for each specific site as the soil conditions vary from site to site.

See Appendix, pages C-230, item 1.

22. FEMA-55 Uniform Building Code

Appendix G.4 (Definitions)

FEMA-55 should develop language that correlates the definition of "grade" with the U.B.C. Such as replacing the term "adjoining" with a specific distance from the building at which point the measurement is taken.

See Appendix, page C-33, item 1.

23. FEMA-55 Uniform Building Code

Appendix G.6.2 (Wind Loads)

FEMA-55 should include the latest edition of ANSI Standard A 58.1 which is now ASCE 7-88.

See Appendix, page C-34, item 2.

24. FEMA-55

Uniform Building Code

Appendix G.7.1 (Pile Foundation Design)

FEMA-55 should include a provision for soil investigations to determine the site soil conditions.

See Appendix, page C-34, item 4.

25. FEMA-55

Uniform Building Code

Appendix G.8.3 (Floor and Deck Connections)

FEMA-55 should consider other structurally adequate materials.

See Appendix, page C-36, item 2.

26. FEMA-55

Uniform Building Code

Appendix G.11 (Use of Space Below the Lowest Elevated Floor)

FEMA-55 should not allow enclosed space for vehicular parking unless it is provided by breakaway walls and should recognize that portable or temporary storage of items can be located there.

See Appendix, page C-38, item 1.

27. FEMA-54

Uniform Building Code

Post Embedment

FEMA-54 should recommend the use of a soils investigation report by a licensed soil engineer in the design of the foundation system.

See Appendix, page C-43, item 4.

28. FEMA-54

Uniform Building Code

Building Materials

FEMA-54 should not recommend specific manufacturers or industrial groups for the protection of building materials.

See Appendix, page C-43, item 4.

29. FEMA-54 Uniform Building Code

Wood

FEMA-54 should not recommend specific manufacturers.

See Appendix, page C-44, item 1.

30. FEMA-114 Uniform Building Code

3.14 (Open Foundations)

FEMA-114 should discuss the use of a soils engineer and soils report in determining the embedment length of piles and the soil-bearing pressure in flood-prone areas.

See Appendix, page C-47, item 1.

31. FEMA-114 Uniform Building Code

6.5 (Technical Design Criteria)

FEMA-114 should recognize the authority of the local building codes, rather than recommend the use of standards which may not be recognized by the jurisdiction.

See Appendix, page C-48, item 1.

32. Bulletin No. 85-1 Uniform Building Code

I. Definition

FEMA Bulletin No. 85-1 should state that this method of floodproofing is only acceptable for the retrofitting of existing buildings.

See Appendix, page C-78, item 1.

Recommended Changes to FEMA Document
Based on NFPA Standards

1. FEMA 44 (59.1 (c)) NFPA 70

Delete:
"400 square feet or less when measured at the largest horizontal projection."

See Appendix, page D-6, par 1.

2. FEMA 54 (Utility Service, Pages 92,93) NFPA 70

Add a qualification in utility services:
"Electrical conduits and cables are to be suitable for an expected wet environment and the corrosive environment presented by salt water and spray in coastal areas."

See Appendix, page D-6, par 2.

3. FEMA 54 (Service Mounting, Pages 92,93) NFPA 70

Add a sentence to read:
"Electric equipment shall be securely fastened to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials shall not be used. Underground electric supply conduits or cables should not be fastened to walls, or structures intended to breakaway under flood conditions. NFPA 70, The National Electric Code should be consulted for full installation requirements."

See Appendix, page D-6. par 3.

4. FEMA 54 (Raceways, Pages 92,93) NFPA 70

Add the following:
"Electrical conduits supplying the structure when installed underground should be sealed. The sealant should be installed at a location in the system so arranged as to prevent entrance of water due to flood conditions. Underground electrical conduits or cables should be protected against damage from flooding or scouring by burying to a depth that will provide protection under expected flood conditions. NFPA 70, The National Electric Code in Section 230-8, 230-32, and 300-5 contain specific design guidelines."

See Appendix, page D-6, par 4.

5. FEMA 54 (Electrical service location, Pages 92,93) NFPA 70

Add the following:
"All switches and circuit breakers shall be located so that they can be operated from a readily accessible place. They should be located so that the center of the operating handle is not more than 6 1/2 feet above the floor or platforms. Where necessary, a platform may be installed to provide accessibility where devices are located above the flood plain."

See Appendix, page D-7, par 1.

6. FEMA 55 (4.36,par 5, sentence 2) NFPA 70

Insert:

"Since the enclosure or raceway for the electric utilities is subject to physical damage, it should be installed in rigid metal conduit, intermediate metal conduit, or schedule 80 rigid nonmetallic conduit."

See Appendix, page D-7, par 2.

7. FEMA 55 (5-1.3.1) NFPA 70

Add the following:

" Fire barrier requirements for property or life protection may require the maintenance of fire barriers to grade."

See Appendix, page D-11, par 2.

8. FEMA 85 (Chapter IV, Page 69, Utility Service) NFPA 70

Add the following:

"Electric equipment shall be securely fastened to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials shall not be used. Underground electric supply conduits or cables should not be fastened to walls, or structures intended to break-away under flood conditions. Electrical supply conduits and cables should be suitable for the environment they are likely to be exposed."

See Appendix, page D-7, par 3.

9. FEMA 85 (Chapter IV, Page 69, Utility Service) NFPA 70

Add the following:

" Where electrical conduits supplying the structure are installed underground, the conduit should be sealed. The sealant should be installed at a location in the system so arranged as to prevent entrance of water due to flood conditions. Underground electrical conduits or cable should be protected against damage by burying them to a depth which would minimize their shifting under flood conditions. Means should be provided to protect electrical supply conduits emerging from underground to the bottom of the structure from floating debris during flood conditions. All switches and circuit breakers should be located so they can be operated from a readily accessible place. They should be located so that the center of the operating handle is not more than 6 1/2 feet above the floor or platforms. Where necessary, a platform may be installed to provide accessibility where devices are located above the flood plain."

See Appendix, page D-8, par 1.

10. FEMA 85-1 (II Protection Goals) NFPA 58

Revise to read:

"LP-Gas or liquid transfer should be performed in accordance with NFPA 58, Standard for the Storage and Handling of Liquified Petroleum Gases."

See Appendix, page D-5, par 1.

11. FEMA 85-1 (IV A.9, par 2) NFPA 70

Revise adding:

"Where electrical supply lines cannot be elevated above flood level, they should be installed to arrange for draining away from panelboards, controllers, switches, or other electrical equipment in accordance with NFPA 70, sections 110-1 and 110-17."

See Appendix, page D-8, par 2.

12. FEMA 85-1 (Protection of Interior Finishes) NFPA 101

Add the following:

" Interior finishes may have fire resistance requirements which must be met under other codes separate from water resistance requirements."

See Appendix, page D-13, par 1.

13. FEMA 85-3 NFPA 70

Refer to FEMA 55 utility requirements as they relate to breakaway walls.

See Appendix, page D-10, par 3.

14. FEMA 102 (page 11, par 2) NFPA 101

Add the following:

"The force to open doors under means of egress requirements should be maintained for exit doors. Latching requirements for exterior doors may include the use of fire exit hardware in educational or assembly occupancies."

See Appendix, page D-12, par 1.

15. FEMA 102 (Chapter IV D. Wet Floodproofing Techniques, par 4, sentence 2) NFPA 70

Add the following:

"Where electrical supply lines cannot be elevated above the Design Flood Level, they must be installed to arrange for draining away from panelboards, controllers, switches, or other electrical equipment."

See Appendix, page D-8, par 3.

16. FEMA 102 (General) NFPA (General)

Expand the definition of Building Code to include the referencing of other standards and codes to properly include NFPA Codes and Standards.

See Appendix, page D-12, par 2.

17. FEMA 114 (8.7, par 3, sentence 3) NFPA 70

Revise to read:

"The power receptacle outlet and associated equipment should be of the grounding type and be labeled and listed by a recognized testing laboratory."

See Appendix, page D-9, par 1.

18. FEMA 114 (9.3) NFPA 70B

Revise the section to reference NFPA 70B, Electrical Equipment Maintenance.

See Appendix, page D-9, par 2.

19. FEMA 114 (9.4) NFPA 70

Add the following:

"Where electric service conductors are located within flood level range, most type services can be installed to raise the electrical service above flood level range."

See Appendix, page D-9, par 3.

20. FEMA 114 (Chapter 9) NFPA 54

Add references to NFPA 54, National Fuel Gas Code.

See Appendix, page D-2, par 1.

21. FEMA 114 (9.4) NFPA 58

Add references to NFPA 58, Standard for the Storage and Handling of Liquefied Petroleum Gases.

See Appendix, page D-4, par 2.

22. FEMA 165 NFPA 58

Add references to NFPA 58, Standard for the Storage and Handling of Liquefied Petroleum Gases.

See Appendix, page D-4, par 3.

Recommended Changes to FEMA Documents Based on Manufactured Housing Codes and Standards

1. NFIP Regulations

Manufactured Home Construction
& Safety Standards
HUD Handbook 4930.3

Add a definition for "modular housing."

See Appendix, pages E-1, item 1, and E-3, item 1.

2. NFIP Regulations

Manufactured Home Construction
& Safety Standards

Change §60.3(b)(8) as follows:

. . . Acceptable methods of anchoring for resistance to flood forces include the use of bolts, cables and ties to adequately designed foundations.

See Appendix, page E-1, item 1.

3. NFIP Regulations

Manufactured Home Construction
& Safety Standards

In §60.3(a)(3), add to the end of (iv) . . . this provision is not applicable to manufactured housing.

See Appendix, page E-2, item 1.

Note that in the opinion of NCSBCS, FEMA 85 should be replaced with a new document, a more prescriptive, and thus more site-enforceable standard. The performance recommendations of FEMA 85 are too vague to enable jurisdictions to perform the kind of service expected. The recommendations that follow are in the spirit of the contractual agreement.

4. FEMA 85

Manufactured Home Construction
& Safety Standards
Manufactured Housing Institute
Model Installation Manual

Change the first paragraph at the top of page 4 to read:

Manufactured homes have been designed for placement on permanent foundations. Care must be taken to assure the safe transfer of all loads (gravity, wind, and flood), so as to not distress the structure.

See Appendix, pages E-22, item 1, and E-36, item 1.

5. FEMA 85

Manufactured Home Construction
& Safety Standards

On page 15, add a sentence to the first **Hydrodynamic forces** paragraph: ". . . downstream side. The illustration below shows the forces acting on a home installed with the floor below the Basic Flood Line. In order to comply with the NFIP, homes must be installed above the flood line. The foundations and anchorage must be installed to resist damage."

See Appendix, page E-23, item 1.

6. **FEMA 85** — Manufactured Home Construction & Safety Standards

On page 22, change the caption for Figure 3.11 to include the statement: "Dry stacked blocks commonly approved by Manufactured Housing Producers are not acceptable under the NFIP."

See Appendix, pages E-23, item 4; E-25, item 3; E-26, item 1; and E-27, items 1-6.

7. **FEMA 85** — Manufactured Home Construction & Safety Standards; Manufactured Housing Institute Model Installation Manual

Further research/study is recommended to determine the capacity of anchors under saturated soil conditions. In FEMA 85, on page 30, add a sentence to the end of the paragraph that ends at the top of the right column: "If test data or certified capacity charts are not available for saturated soil, the ground anchors should not be used."

See Appendix, pages E-24, item 1; E-25, item 5; E-31, item 4; E-38, item 2; and E-39, item 6.

8. **FEMA 85** — Manufactured Home Construction & Safety Standards; Manufactured Housing Institute Model Installation Manual

On page 52, Figure 4.32, change the orientation of the ground anchor to show it coaxial with the cable and add the following to the caption:

Ground anchors must be installed as tested. Ground anchor tests are usually for anchors applied in the same axis as the cable. If test data or certified capacity charts are not available for applications in saturated soil, the ground anchors should not be used.

See Appendix, pages E-26, item 1, and E-40, item 1.

9. **FEMA 85** — Manufactured Home Construction & Safety Standards

Further study is recommended on the structural procedures that are recommended in Appendix D. It appears that higher margins of safety against overturning and sliding may be appropriate.

See Appendix, pages E-28, item 4, and E-29, item 2.

10. **FEMA 85** — Manufactured Home Construction & Safety Standards; HUD Handbook 4930.3

Further study is recommended to collect state-of-the-art test results for ground anchor applications in various types of soils, saturated, and unsaturated, as well as the effects of varying the angle of pull and use of concrete collars. The results of that effort should be used to update Appendix E.

See Appendix, pages E-29, item 1; E-31, item 4; and E-33, item 2.

11. **FEMA 85** — HUD Handbook 4930.3

On page 5, add the following to the second from the last paragraph:

The design methods and procedures for flood damage abatement are contained in this manual.

On page 6, either eliminate the Type 2 System from Figure 1.13 or explain that this system is unstable and is not allowed.

See Appendix, page E-30, item 2.

12. FEMA 85 HUD Handbook 4930.3

Change the first paragraph, second column, page 18 to read as follows:

Because it is highly unlikely that maximum wind forces and maximum flood loads will occur simultaneously on one structure, designs should be prepared separately for the two loads (wind and flood). The most critical design is that which should be used.

See Appendix, page E-31, item 1.

13. FEMA 85 HUD Handbook 4930.3

Add a new paragraph beneath Figure 4.2 in column 2:

FEMA recommends that foundations designed to resist combinations of wind and flood loads be designed to resist the wind loads in ASCE-7.

See Appendix, pages E-31, item 6, and E-32, items 2 and 4.

14. FEMA 85 HUD Handbook 4930.3

Add a paragraph beneath the chart in column 2 of page 45:

The chart above was developed based upon test results for ground anchors in dry soil. FEMA recommends that ground anchors not be used for flooding conditions unless data for anchors in saturated soil is presented to the building official to show safe working loads of the anchors that exceed 2200#.

See Appendix, page E-32, item 3.

15. FEMA 85 Manufactured Home Construction & Safety Standards HUD Handbook 4930.3

In Appendix E, change Table E.1 and add a footnote to Table E.1, page 99; place an asterisk next to each Water Height Difference >6" so that the headline reads:

1 2 3 4 5 6 9* 12* 42* 48*

* Floor-to-frame screw anchorage exceeds the wind uplift requirements of the Federal Manufactured Housing Construction and Safety Standards. Additional screws are needed. Use a screw design force equivalent to the T_v for the actual design minus T_v for 6" Difference in Water Height. Example: 24 Wide Home, 42" Water Height Difference, use 2380.8#-124.4#=2256#.

See Appendix, pages E-29, item 1, and E-33, item 2.

16. FEMA 85 CABO OTFDC, Appendix C

On page 22, add a last sentence to the paragraph above Figure 3.10:

Exception: The requirement for 30" burial can be waived in those situations where scouring is not expected. Place footings at a depth of 12", or the frost line, whichever is deeper.

See Appendix, page E-34, item 3.

Recommended Changes to FEMA Documents Based on the CABO One and Two Family Dwelling Code

1. 44 CFR 59.1 (Definitions) — CABO OTFDC

NFIP should expand definition of manufactured home to include dimensional parameters.

See Appendix, page F-1, item 1

2. 44 CFR 60.3 (e) (4) Pilings, — CABO OTFDC
FEMA 54 (Performance Criteria)
FEMA 55 (4.2.1.1 Pilings, Wood)
FEMA 55 (G-8 Anchoring Standards)
FEMA 114 (Appendix C - Forces)
No. 85-2 (Flood Forces)
No. 85-3 (II. Wind and Water Forces)

NFIP, FEMA 54, FEMA 55, FEMA 114, No. 85-2, and No. 85-3 should address snow and seismic loads. FEMA 55 should not prohibit toe nailing if the connection is adequate for the calculated loads. FEMA 114 should update the wind speed maps to the latest editions. No. 85-3 should update reference to ASCE 7-88.

See Appendix, page F-2, item 4
See Appendix, page F-8, item 1
See Appendix, page F-10, item 3
See Appendix, page F-21, item 3
See Appendix, page F-28, item 5
See Appendix, page F-41, item 1
See Appendix, page F-42, item 1

3. FEMA 54 (Shear Walls and Floor Diaphragm) — CABO OTFDC

FEMA 54 should address the use of shear walls and floor diaphragms as a method of bracing but should permit the building designer to choose the method.

See Appendix, page F-5, item 2

4. FEMA 54 (Floor Beams) — CABO OTFDC

FEMA 54 should provide better nailing and splice location requirements.

See Appendix, page F-5, item 4

5. FEMA 54 (Cantilevers) — CABO OTFDC

FEMA 54 should delete the "rule of thumb" or add better guidance for the design of the cantilever.

See Appendix, page F-5, item 5

6. FEMA 54 (Wood) CABO OTFDC

FEMA 54 should include "decay resistant wood."

See Appendix, page F-7, item 1

7. FEMA 55 (4.1.1 Wind) CABO OTFDC
FEMA 55 (G-14 Reference Documents)
FEMA 114 (Appendix C - Forces)
No. 85-3 (II. Wind and Water Forces)
No. 88-1

FEMA 55, No. 85-3, and No. 88-1 should update its reference and confirm that the wind load provisions are consistent with ASCE 7-88. The 1992 OTFDC does reference ASCE 7-88.
FEMA 114 should update the wind speed maps to the latest editions.

See Appendix, page F-9, item 2
See Appendix, page F-23, item 1
See Appendix, page F-28, item 5
See Appendix, page F-42, item 1
See Appendix, page F-43, item 1

8. FEMA 55 (4.1.4 Effects of Forces on Higher and Larger Structures) CABO OTFDC

FEMA 55 should provide velocity pressures (psf) for varied wind speeds and building height.

See Appendix, page F-10, item 1

9. FEMA 55 (4.2.1.2 Main Supporting Members Wood, Beams) CABO OTFDC

FEMA 55 should provide more specific nailing and splice details. OTFDC should provide more specific splice details.

See Appendix, page F-10, item 4

10. FEMA 55 (4.2.1.4 Wood Preservative) CABO OTFDC

FEMA 55 should list some of the AWPA standards.

See Appendix, page F-11, item 1

11. FEMA 55 (4.2.2 Masonry Materials and Concrete) CABO OTFDC

FEMA 55 should add reference to ACI 318.

See Appendix, page F-11, item 2

12. FEMA 55 (4.3.1.2 Piles) CABO OTFDC

FEMA 55 should emphasize that type of pile, pile depth, and method of installation should be based on the soil's investigation.

See Appendix, page F-12, item 3

13. FEMA 55 (4.3.1.4 Piers) CABO OTFDC

FEMA 55 should clarify that the reinforcing, footing size, and grade beam size should be based on the design forces.

See Appendix, page F-12, item 5

14. FEMA 55 (4.3.2.2 Beams) CABO OTFDC

FEMA 55 should provide nailing requirements for built-up members.

See Appendix, page F-13, item 2

15. FEMA 55 (4.3.2.3 Joists and Rafters) CABO OTFDC

FEMA 55 should delete the reference to rafters.

See Appendix, page F-13, item 3

16. FEMA 55 (4.3.2.4 Subflooring) CABO OTFDC

The provisions are compatible. FEMA 55 should provide some recommended nail spacing and spans. FEMA 55 should permit the use of particleboard subfloors.

See Appendix, page F-13, item 4

17. FEMA 55 (4.3.2.5 Studs) CABO OTFDC

FEMA 55 should address the length of the stud in addition to the number of stories which the stud supports.

See Appendix, page F-14, item 1

18. FEMA 55 (4.3.2.6 Wall Sheathing) CABO OTFDC

FEMA 55 should provide additional information addressing the wind speed in addition to height above grade.

See Appendix, page F-14, item 2

19. FEMA 55 (4.3.2.7 Wall Bracing) CABO OTFDC

FEMA 55 should combine 4.3.2.6 Wall Sheathing and 4.3.2.7 Wall Bracing into one section and address the design requirements for the wall bracing method chosen.

See Appendix, page F-14, item 3

20. FEMA 55 (4.3.3.4 Knee Bracing) CABO OTFDC

FEMA 55 should emphasize that the wood foundation piles should be designed for the additional moment introduced into the pile from the knee brace.

See Appendix, page F-15, item 1

21. FEMA 55 (4.3.3.2 Grade Beams) CABO OTFDC

FEMA 55 should emphasize the need to design the grade beams to assure that they are actually providing lateral support of the piles.

See Appendix, page F-15, item 2

22. FEMA 55 (4.3.3.3 Truss Bracing) CABO OTFDC

FEMA 55 should emphasize the need to design the bracing members.

See Appendix, page F-15, item 3

23. FEMA 55 (4.3.3.4 Shear Walls) CABO OTFDC

FEMA 55 should address wood shear walls for wood pile foundation.

See Appendix, page F-15, item 4

24. FEMA 55 (4.3.4.4 Floor Beam to Pile, Post, or Pier) CABO OTFDC

FEMA 55 should provide some design values or wind speeds for which the connections are appropriate.

See Appendix, page F-16, item 1

25. FEMA 55 (4.3.7 Wind and Storm Protection of Interior) CABO OTFDC
FEMA 55 (4.3.7.1 Window Selection)

FEMA 55 should reference the window standards and require the windows to be designed for the wind pressures.

See Appendix, page F-16, item 4
See Appendix, page F-17, item 1

26. FEMA 55 (4.3.7.4 Roof Materials) CABO OTFDC

FEMA 55 should emphasize the need to have the roof covering to withstand the uplift from the wind.

See Appendix, page F-17, item 4

27. FEMA 55 (G-3 Scope) CABO OTFDC

Since market value is a variable based on location, economy, etc., FEMA 55 should require compliance for all improvements since noncompliance of any part of the structure makes the entire structure out of compliance.

See Appendix, page F-20, item 1

28. FEMA 55 (G-6 Determination of Loading Forces) CABO OTFDC

FEMA 55 should update its reference to ASCE 7-88. FEMA 55 should also address snow and seismic loads. The 1992 OTFDC does reference ASCE 7-88.

See Appendix, page F-20, item 4

29. FEMA 55 (G-9 Roof Sheathing) CABO OTFDC

FEMA 55 should permit particleboard roof sheathing provided it is of the appropriate strength and does not deteriorate in the moist coastal environment.

See Appendix, page F-21, item 4

30. FEMA 55 (G-13 Certification Requirements) CABO OTFDC

FEMA 55 should provide parameters for which sections 7 and 8 are appropriate (wind load, height above grade, etc.

See Appendix, page F-22, item 4

31. MCRB (III.A.1 Unreinforced Block) CABO OTFDC
MCRB (III.A.2 Reinforced and Grouted Block)

MCRB should reference BIA and ACI/ASCE 530.

See Appendix, page F-30, item 1
See Appendix, page F-30, item 2

32. MCRB (III.A.4 Reinforced Concrete) CABO OTFDC

MCRB should reference ACI 318.

See Appendix, page F-30, item 4

33. MCRB (III.B.1 Basement Slab) CABO OTFDC

MCRB **should** provide site preparation requirements, minimum compressive strength, and vapor barrier requirements.

See Appendix, page F-32, item 1

34. MCRB (III.B.9 Anchorage) CABO OTFDC

The MCRB should be changed to comply with current model codes.

See Appendix, page F-34, item 1

35. MCRB (III.C.5 Debris, Wind, Impact, Snow, Ice, and Other Live Loads) CABO OTFDC

MCRB should include wind, snow, and seismic loads.

See Appendix, page F-35, item 5

36. MCRB (V.A. Structural Design/Analysis) CABO OTFDC
MCRB (V.A.2 Designs, Methods, and Tables)
MCRB (V.A.2.a Building Model, Dimensions, and Loading)
MCRB (V.A.2.b Structural Analysis Model (Wall))
MCRB (V.A.2.c Structural Plain Concrete)
MCRB (V.A.2.d Reinforced Concrete)
MCRB (V.A.2.e Plain Masonry Block)
MCRB (V.A.2.f Reinforced Masonry Block)
MCRB (V.A.2.g Flood Waters Above Grade)
MCRB (V.A.2.h Slab Thickness (Based on Bending))
MCRB (V.A.2.i Structural Slab Design (Ultimate Strength Design))

MCRB should not reference a single model code. MCRB should reference only national consensus documents.

See Appendix, page F-36, item 1

CHAPTER 5

RECOMMENDED CODE CHANGE LANGUAGE

Recommended Changes to the BOCA National Building Code

FEMA	BNBC	Analysis
NFIP 44 CFR 59.1 Technical Bulletin 85-3	1109.4 1112.0 2101.6.4.2	Both FEMA and BOCA require the wall to be capable of breaking away without effecting the structural integrity of the structure. FEMA requires break-away walls to resist wind loads but fail in response to combined wind and hydrodynamic loading. BOCA requires all structures to resist such loads except for coastal high-hazard zones where break-away walls are permitted. FEMA references ANSI A58.1, 1982 for wind loads. BOCA references ASCE 7, 1982, the same document by another name.

Recommendation: Provide exception to BOCA Section 1109.4 to address breakaway walls. See also recommendation to 44 CFR 60.3(e)(5).

Suggested Code Change:

1109.4 Hydrodynamic loads:

For buildings located in flood-hazard zones (A Zones) or high-hazard zones (V Zones), all structural components located below the base flood elevation shall be designed to resist hydrodynamic forces resulting from velocity waters during flooding to the base flood elevation.

Exception: Walls designed to break away or collapse as permitted in Section 2101.6.4.2.

FEMA	BNBC	Analysis
NFIP 44 CFR 60.3	2101.6.4.3	FEMA's provisions (Zone V) do not permit the use of fill for structural support. BOCA does not include this limitation. Also, the FEMA requirements include subclassifications of zones (i.e. V1, VE, etc) while BOCA addresses the zones as Zone V.

Recommendation: It would be appropriate to propose a revision to BOCA to include this prohibition. See also 44 CFR 59.1 - Elevated buildings.

Suggested Code Change:

2101.6.4.3 Foundations:

All buildings or structures erected in high-hazard zones shall be supported on pilings or columns and shall be adequately anchored to such pilings or columns. The piling shall have adequate soil penetration to resist the combined wave and wind loads (lateral and uplift) to which such piles are likely to be subjected during a flood to the base flood elevation. Pile embedment shall include consideration of decreased resistance capacity caused by scour of soil strata surrounding the piling. Pile system design and installation shall also be made in accordance with provisions of Section 1213.0 and 1214.0. Mat or raft foundations which support columns shall not be permitted where soil investigations required in accordance with Section 1202.1 indicate that soil material under the mat or raft is subject to scour or erosion from wave-velocity flow conditions. The use of fill for structural support shall be prohibited.

FEMA	BNBC	Analysis
FEMA-54, 55 Technical Bulletin 85-1 Technical Bulletin 88-2	1802.3 1801.4	BOCA states that steel shall be protected for exterior use with a shop or field coat to prevent corrosion. BOCA and FEMA require structural steel work and formed steel members to be corrosion protected but BOCA does not specifically address connectors. FEMA recommends the use of hot-dipped galvanizing for structural steel and the use of stainless steel. FEMA recommends regular inspection and maintenance of metal parts. No regular inspection parameters are stipulated in BOCA. FEMA recommends that the use of dissimilar metals be avoided due to potential for rapid corrosion.
	1502.6 1503.1 1503.3.2 1506.6.3	BOCA requires that admixtures, if used, shall follow requirements of ACI 318, ASTM C260, ASTM C618 and ASTM C989 depending on the type used. FEMA does not include requirements for the use of admixtures.
		BOCA cites that concrete shall be proportioned to provide the average compressive strength as prescribed by ACI 318, not less than 2500 psi. FEMA does not include the standard. FEMA acknowledges the effects of concrete exposed to salt laden air but does not provide criteria. BOCA prescribes minimum concrete properties (w/c, fc) for concrete exposed to sea water. BOCA and FEMA require increased concrete cover to reinforcement but neither stipulates the increase.
	1401.11 1402.6	FEMA acknowledges the effects of salt laden air on mortar but does not provide types of mortar which are acceptable. BOCA also does not prescribe specific masonry mortar types for masonry exposed to salt laden air. BOCA requires that mortar is to comply with ASTM C270.
	1701.1 1702.1 1703.2.6 1704.1.1 1702.5.3 (Supp) Appd. C	BOCA requires that pressure treated wood shall conform with standards AWPA C1, C2 and C9. BOCA references NFoPA NDS which requires galvanized sheet for metal plate connector joints (8.10.3). BOCA requires galvanized steel connections when the frame is more than one story in height and the studs are not continuous from the sill to the roof. FEMA requires all connections to be corrosion resistant. FEMA states that wood shall be treated to resist fungus, insects, bacteria, and rot and the treatment must be designed to keep water out. FEMA and BOCA's preservative treated wood fastener requirements similar.

FEMA	BNBC	Analysis
		FEMA recommends either 1x4 or 1x6 boards laid diagonally over joists or exterior type plywood following the guidelines of APA "Plywood Construction Guide". BOCA includes floor sheathing tables. FEMA stipulates an exterior glue while BOCA requires exterior, waterproof type plywood in all exterior uses, but allows either interior type, moisture-resistant type, or exterior type in interior applications. BOCA does not stipulate glue between layers for plywood. FEMA stipulates annular ring nails or deformed shank nails while BOCA's recommended fastening schedule (Appendix C) permits common nails.
	2103.3.10	Flashing requirements similar.
	2102.5	BOCA requires that exterior walls of alternative materials be weather-resistant but does not mention corrosion resistance.
	2101.6.6 2101.6.3.3	BOCA includes a general performance regulation which requires "All buildings... shall be constructed with materials resistant to flood damage..." BOCA makes no explicit provision to evaluate finishes intended to be periodically submerged. FEMA requires finishes to withstand immersion for 160 hours without damage.
	1901.1	FEMA recommends a 0.7 mil. anodizing finish and/or vinyl finish for aluminum elements such as doors, windows, gutters and flashings. BOCA references AA-SAS30 and AA-ASM35 for aluminum used for structural purposes. No similar requirements.

Recommendation: Both codes acknowledge the effects salt laden air and moisture have on building components. FEMA and BOCA require corrosion resistant fasteners for pressure treated wood but neither provide definitive criteria for masonry or concrete. It is recommended that FEMA include a general provision to address moisture protection and BOCA revise its current text. Suggested language is: Construction materials, including connections, shall be resistant to water damage such that conditions of corrosion, deterioration or decay will not occur.

Additionally, FEMA should consider referencing the applicable standards for wood preservatives, concrete and masonry. Also, BOCA should include performance related text to address FEMA requirements for finishes.

Suggested Code Change:

2101.6.6 Construction materials, methods, and practices:

All buildings or structures erected on flood-hazard zones (A zones) or in high-hazard zones (V Zones) shall be constructed with materials resistant to flood damage and be constructed by methods and practices that minimize flood damage. Construction materials, including connections, shall be resistant to water damage such that conditions of corrosion, deterioration or decay will not occur ~~in accordance with the provisions of Sections 1207.0, 1209.2, 1224.4, 1603.4, 1702.1.1, 1702.3, 1702.6.3 and 1702.6.6~~. Interior wall finishes and trim subject to direct contact with flood waters shall be of a type able to withstand inundation for a minimum of 160 hours without damage.

FEMA	BNBC	Analysis
FEMA-55	1219.0 1218.0	FEMA recommends minimum timber pile sizes and cites the advantages of square vs. round piles. FEMA recommends concrete piles when higher capacity or longer lengths are needed. BOCA does no stipulate minimum timber pile sizes but rather relies on a design. BOCA specifies a minimum lateral dimension for precast concrete piles of 10". BOCA relies on a designed system to support the loads.
	1213.0 1214.0 2101.6.4.3	FEMA cites the effects pile embedment has on the structural capacity of the pile. FEMA provides recommended pile penetrations. BOCA does not stipulate minimum pile embedments, but rather relies on a design. BOCA requires pile embedment to consider scouring in high hazard zones (V Zone) only.
	1215.0 1219.0	FEMA provides details of typical methods to install piles. BOCA does not prescribe the installation details for piles with the exception of cast-in-place concrete piles.

Recommendation: FEMA requires scour around piles to be evaluated for all pile installations while BOCA specifically cites scour for V Zones. It is recommended that BOCA include text for A Zones similar to that for V Zones relative to scour.

Suggested Code Change:

2101.6.3.2 Anchorage:

The structural system of all buildings or structures shall be designed, connected,and anchored to resist flotation, collapse, or permanent lateral movement due to structural loads and stresses from flooding equal to the base flood elevation and shall be designed in accordance with Sections 1109.3 and 1109.4. Foundation design shall include consideration of decreased structural capacity and stability caused by scour of soil strata surrounding the foundation system.

FEMA	BNBC	Analysis
FEMA-114	2101.6.3.2 2101.6.4.3 1703.2.11	Anchor bolts of a 1/2" diameter with a maximum spacing of 4 feet and an embedment depth of 18" are required by FEMA. BOCA's embedment depths are 8" (concrete) and 15" (grouted masonry). The total reaction force due to hydrostatic, hydrodynamic and/or impact loads must be transferred through anchor bolts into the supporting system. FEMA permits expansion anchors as a equivalent means of anchorage. BOCA includes performance criteria which requires the anchors to resist floatation, collapse or lateral movement. However, BOCA's anchorage provision for wood specifies that the anchorage must resist wind uplift and the maximum spacing is 8 feet.

Recommendation: BOCA should revise the provisions of Section 1703.2.11 to reference the design as being capable of resisting both uplift and lateral forces due to flooding (and wind). See also FEMA-54-Pier foundation connections.

Suggested Code Change:

('92 Supp) 1703.2.11 Foundation anchorage:

Wall sill plates, minimum of 2-inch by 4-inch members, shall be sized and anchored to foundation walls or piers and at intermediate intervals as required to resist wind uplift. Wall sill plates located below the base flood elevation in accordance with Section 2101.6 shall be sized and anchored in accordance with Section 1109.4. Foundation anchorage shall be by the use of anchor bolts or other approved anchoring method. Anchor bolts shall be a minimum diameter of 1/2 inch. The bolts shall be embedded in foundations to a depth of not less than 8 inches (203 mm) of poured-in-place concrete, and not less than 15 inches (381 mm) in grouted unit masonry. There shall be a minimum of two anchor bolts per section of plate and anchor bolts shall be placed 12 inches (305 mm) from the end of each section of plate with intermediate bolts spaces a maximum of 4 feet (1219 mm) on center.

Exception: All buildings or structures located in seismic map areas having a peak velocity-related acceleration (A_v) equal to or less than 0.05 in accordance with Section 1113.1 and buildings of Use Group R-3 located in seismic map areas having a peak velocity-related acceleration (A_v) less than 0.15 and agricultural storage buildings which are intended only for incidental human occupancy are permitted to have maximum intermediate bolt spacing of 8 feet (2438 mm).

FEMA	BNBC	Analysis
Technical Bulletin 88-4	2101.6.5	FEMA recommends that elevator equipment be located above the BFE or be water-resistant. Further, elevators should be interlocked to ensure that the cab automatically stays above flood water. BOCA requires all mechanical/electrical equipment to be placed above the BFE or protected to prevent water entering the equipment or system during floods up to the BFE.

Recommendation: Add a subsection to BOCA 2606.2 "Emergency operation of elevator" to require elevators to automatically move to a predetermined level above the BFE in the event of flooding.

Suggested Code Change:

('92 Supp) 2606.2.4 Activation in the event of flooding:

In areas prone to flooding an approved float switch shall be interlocked with the control circuit so that the elevator cab automatically rises to the first level above the base flood elevation.

FEMA	BNBC	Analysis
Technical Bulletin 90-4	120.4 620.3.1 2101.6 2101.6.3.2 2101.6.4.3 2101.6.5 2101.6.7 2101.6.9	FEMA requires manufactured (mobile) homes to be placed so that the lowest floor is either above the BFE, or placed on 36" piers (above grade), or in an existing park. FEMA describes various foundation/anchorage methods and speaks to soil bearing capacity and proper embedment of piles to resist scour. FEMA requires that any encroachments into a floodway be certified that such encroachment would not raise the BFE. Such provisions which prescribe acceptable land use are outside the scope of the BOCA Code. BOCA requires manufactured housing to be designed and built to resist the same flood forces as site built, which does not provide for 36" piers and/or placement below the NFE for residential occupancies.

Recommendation: To create separate and conflicting performance requirements for factory-built structures simply because they are not constructed on-site is contrary to BOCA's code development history and resulting policy on this matter. Therefore no recommendation is made to carry FEMA's separate treatment of manufactured housing into BOCA code text. Recommendation is made however, to revise BOCA Code Section 620.3.1 to refer to flood forces and/or reference Section 2101.6.7 of the BOCA Code.

Suggested Code Change:

620.3.1 Anchorage and tie-down:

Every parking space for mobile units shall be provided with devices for anchoring the unit to prevent overturning or uplift. The owner of the parking space shall anchor or cause to be anchored all mobile units located on the parking space. Where concrete platforms are provided for the parking of mobile units, anchorage shall be provided by eyelets embedded in the concrete with adequate anchor plates or hooks, or other suitable means. The anchorage shall be adequate to withstand forces and uplift as required in Article 11 for buildings and structures, based upon the size and weight of the units, and elevated as required by Section 2101.6.7 for flood prone areas.

Recommended Changes to the SBCCI Standard Codes

Standard Building Code

NFIP	SBC	Analysis
60.3(b)(8) Manufactured Home Installations	H105.3	NFIP requires manufactured homes to be installed to resist flotation, collapse, and lateral movement to minimize flood damage in addition to anchoring requirements for wind. SBC requires only anchorage for wind.

Recommendation: None since SBC does not address flotation as a force. Appendix H should reference the SBCCI Standard for Floodplain Management.

Suggested Code Change [or addition]:

H105.3.6 Floodplain For manufactured homes located within the regulatory floodplain, refer to the SBCCI Standard for Floodplain Management.

FEMA 55	SBC	Analysis
4.2.3.2 Steel(Page 4-11)	Chapter 15	FEMA 55 addresses the problem of corrosion of unprotected steel shapes and anchoring devices (nails, bolts, etc.) and the need for regular inspection, maintenance, and replacement of corroded metal parts. SBC requires the design of steel construction to comply with the appropriate standards. SBC does not address corrosion in coastal environments.

Recommendation: SBC should address corrosion protection in coastal areas.

Suggested Code Change [or addition]:

1502 PROTECTION FROM CORROSION

Structural steel exposed directly to the weather or subject to salt corrosion in coastal areas shall be hot-dipped galvanized after fabrication.

(Renumber existing 1502 through 1511)

FEMA 55	SBC	Analysis
4.3.7.4 Roofing Materials (Page 4-54)	1205.1 3202	FEMA 55 emphasizes the need to use self-sealing, heavyweight shingles to avoid the possible loss of roofing material in high winds. SBC requires all parts of the building to be designed to withstand the appropriate wind loads.

Recommendation: FEMA 55 should emphasize the need to have a roof covering designed to withstand the uplift from the wind. SBC should emphasize that the roof covering should be designed to 1205.

Suggested Code Change [or addition]:

3202.1.1 Roof coverings shall be designed to withstand the minimum design loads in Chapter 12.

(Renumber existing 3202.1.1 and 3202.1.2)

FEMA 102	SBC	Analysis
Appendix D Floodproofing Performance Criteria Appendix D.B Design Loads (Pages 182-186)	Chapter 12	FEMA 102 lists the type of loads which the floodproofed structure may be subjected. SBC requires the structure to be of sufficient strength to support the loads and forces encountered.

Recommendation: None since both FEMA 102 and SBC require the structure to be designed for the loads and forces encountered. SBC should address hydrostatic, hydrodynamic, and buoyance forces in floodplain areas.

FEMA 114	SBC	Analysis
6.2 Considerations (Floodwalls) (Pages 111-114)	1201.1	FEMA 114 addresses the use of floodwalls to protect structures from flooding and emphasizes that tremendous forces are created by high water levels and velocities. SBC does not address floodwalls but does require structures to be designed for the loads and forces encountered.

Recommendation: SBC should address hydrostatic, hydrodynamic and buoyance forces in floodplain areas.

FEMA 114	SBC	Analysis
Appendix C - Forces (Pages 197-207)	Chapter 12	FEMA 114 addresses hydrostatic loads, hydrodynamic loads, impact loads, and wind loads. FEMA 114 also provides definitions, application and methodology for design. SBC requires design for all forces encountered but does not provide methodology. Section 900.4 of the SBCCI Standard for Floodplain Management addresses hydrostatic and hydrodynamic loads.

Recommendation: FEMA 114 should update the wind speed maps to the latest editions and address snow and seismic loads. SBC should address hydrostatic, hydrodynamic, and buoyancy forces in floodplain areas.

Suggested Code Change [or addition]:

1209 FLOODPLAIN

1209.1 General
For construction located within the regulatory floodplain, refer to the SBCCI Standard for Floodplain Management.

1209.2 Structural Safety
In addition to the minimum design loads of this chapter, provisions shall be made for hydrostatic, hydrodynamic, and buoyancy forces.

FEMA 55	SBC	Analysis
4.1.2 Salt Air, Moisture, and Wind-Driven Rain (Pages 4-7, 4-8)	1703	FEMA 55 provides general discussion of the hazards of salt air, moisture, and wind-driven rain on wood, bolts, nails, and connectors. SBC requires wood subject to damage from decay and termites to be naturally durable or pressure treated. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: SBC should address corrosion.

FEMA 55	SBC	Analysis
G-8.1 Connector and Fasteners (Page G-5)	1201.1	Both FEMA 55 and SBC require the connectors to support the loads and forces encountered. FEMA 55 does not permit toe nailing. FEMA 55 requires metal connectors and fasteners to have corrosion protection.

Recommendation: FEMA 55 should not prohibit toe nailing if the connection is adequate for the calculated loads. SBC should address corrosion protection of metal connectors.

FEMA 55		SFM	Analysis
G-8	Anchoring Standards	601.1	Both FEMA 55 and SFM all components to be securely fastened and adequately interconnected to resist the loads anticipated during flooding. FEMA 55 requires corrosion protection for connectors in exposed locations. SFM does not address corrosion protection.
G-8.1	Connector and Fasteners	801.1	
G-8.2	Beam to Pile Connections	801.3	
G-8.3	Floor to Deck Connections		
G-8.4	Exterior Wall Connections		
G-8.5	Ceiling Joist/Rafter Connections		
G-8.6	Projecting Members		
(Pages G-5, G-6)			

Recommendation: SFM should address corrosion protection of metal connectors.

Suggested Code Change [or addition]:

1705.4 Floodplain Areas

Metal plates, connectors, screws, bolts, and nails exposed directly to the weather or subject to salt corrosion in coastal areas shall be stainless steel or hot-dipped galvanized, after the fastener or connector is fabricated.

NFIP	SMC	Analysis
60.6 – Variances and Exceptions 60.6(c)(2)(i) Flood-Proof Wall	302 303	NFIP requires the basement area, together with utilities and sanitary facilities below the floodproofed design level, to be watertight with walls that are impermeable to the passage of water without human intervention. The SMC allows underflow installation but does not specify minimum elevations for equipment. This is addressed in 602.1.2, 602.5, and Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: The SMC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 54	SMC	Analysis
Mechanical Equipment (Page 93, Paragraph 2)	302 303	FEMA 54 requires all mechanical equipment to be elevated above expected flood waters, with indoor components preferably installed in attics. The SMC allows attic installation but does not specify minimum elevations for equipment.

Recommendation: These sections of the SMC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 55	SMC	Analysis
Chapter 4 - Structural Design Section 4.3.6 Utilities (Pages 4-50 to 4-52)	Ch. 3 607 607.3.1.5 302 303	FEMA 55 requires all mechanical equipment to be elevated above BFE, and fuel piping be on the leeward side of columns/piers or enclosed in shaft. The SMC allows attic installation of equipment, but does not specify minimum elevations for equipment. The SMC requires fuel piping to be supported and protected from physical damage.

Recommendation: (1) For equipment location - the SMC should be revised to reference the SBCCI Standard for Floodplain Management (2) for fuel pipe protection - None both address the issue only in different directions. FEMA - prescriptive SMC - performance.

FEMA 55	SMC	Analysis
Appendix G "Sample Coastal Construction Code" 12. Utilities (Page G-8)	302 303	FEMA 55 requires all mechanical equipment to be elevated above expected flood waters. The SMC allows such installations, but does not specify minimum equipment elevations.

Recommendation: The SMC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 102	SMC	Analysis
Ch. IV Other Floodproofing Measures C. Utilities (Pages 99-105)	302 303	FEMA 102 requires mechanical equipment to be elevated above BFE or "floodproofed". Floodproofing entails a watertight enclosure, with all penetrations into the building pressure sealed. The SMC allows such installations, with proper access and clearance to combustibles.
	308	FEMA 102 requires mechanical exhaust fans discharging below the BFE to be protected by flood shields. The SMC requires exhaust to discharge outdoors at a point where it "will not cause a nuisance" or 10 ft. above a public walkway.

Recommendation: (1) Revise SMC to reference the SBCCI Standard for Floodplain Management (2) Revise FEMA 102 to reference the locally adopted model code for installation clearances.

FEMA 102	SMC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (A) Location (Page 192)	302 303	FEMA 102 requires that all mechanical equipment be installed above BFE, or be enclosed in water-tight rooms. The SMC allows elevated or enclosed installation but requires access and clearance to combustibles.

Recommendation: (1) Revise FEMA 102 to reference the local model codes for access and clearance. (2) Revise SMC to reference the SBCCI Standard for Floodplain Management.

FEMA 102	SMC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (B) Heating and Air Conditioning (Page 192)	607	FEMA 102 requires that fuel systems below the BFE be equipped with automatic shutoff valves activated by rising water. The SMC would not require or prohibit such valves.
	306.2	FEMA 102 requires all heating equipment be vented to a level above BFE. SMC requires vent/chimney termination 3 ft. above roof and 2 ft. higher than any portion of the roof within 10 ft.

Recommendation: Revise SMC to reference the SBCCI Standard for Floodplain Management.

FEMA 102	SMC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (C) Ventilation (Page 193)	307 308 Ch. 5	FEMA 102 requires all ductwork located below BFE to slope to drainage openings. The SMC does not require conditioned air ducts to slope for drainage.
	Ch. 5	FEMA 102 requires all ductwork located below BFE to be anchored against floodwaters. The SMC requires adequate support per SMACNA, or ASHRAE.
	510	FEMA 102 requires all penetrations of the building envelope by air ductwork to have a closure assembly. The SMC requires fire dampers at certain firewalls.

Recommendation: The SMC should be revised to reference the SBCCI Standard Floodplain Management.

FEMA 102	SMC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (D) Fuel Tanks and Lines (Page 193)	607	FEMA 102 requires that fuel tanks and lines to be located above BFE or anchored and protected from floodwater velocity/surge with a factor of safety of 1.5. The SMC allows installation of fuel storage tanks either inside or outside buildings but does not address uplift forces. The SMC states that the piping shall be protected from physical damage.

Recommendation: The SMC should reference tank location, uplift forces, and the SBCCI Standard for Floodplain Management.

FEMA 114	SMC	Analysis
Ch. 9 Protection of Utilities 9.4 Permanent Protective Measures (Pages 160-163)	Ch. 3	FEMA 114 requires utility connections to be above flood level shielding for basement appliances, elevated installation for exterior appliances, suspension for underfloor equipment, and anchoring for fuel storage tanks. The SMC allows these types of installations but requires minimum clearances to combustibles and access which is ignored by FEMA 114.

Recommendation: (1) Change FEMA to reference locally adopted model codes for clearances to combustible materials and minimum access (2) changes the SMC to reference the SBCCI Standard for Floodplain Management.

FEMA 114	SMC	Analysis
Ch. 9 Protection of Utilities 9.8 Storage Tank Anchorage (Page 166)	607	FEMA 114 requires anchorage of fuel storage tanks. The SMC allows installation of fuel storage tanks inside or outside structures, but does not specifically address uplift forces.

Recommendation: Revise the SMC to reference the SBCCI Standard for Floodplain Management and add a section of fuel tank anchorage.

No. 85-1	SMC	Analysis
IV. Guidelines for implementation A10 HVAC (Page 11)	302 303	No. 85-1 requires that mechanical equipment either be elevated or enclosed for protection. The SMC allows enclosed installations, but does not specify minimum elevations for equipment.

Recommendation: The SMC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 88-4	SMC	Analysis
Recommendation #1 (Page 3)	Ch. 3	No. 88-4 requires location of elevator equipment above base flood elevation. The SMC allows such installation but does not specify minimum equipment elevations.

Recommendation: Revise the SMC to reference the SBCCI Standard for Floodplain Management.

Suggested Code Change [or addition]:

301.4 Equipment Installed in Floodplain Areas
All mechanical equipment and related accessories installed in the regulatory floodplain shall be installed to satisfy this code and the SBCCI Standard for Floodplain Management.

Suggested Code Change [or addition]:

607.4 Fuel Tanks
Fuel storage tanks installed in the regulatory floodplain shall be installed above the base flood elevation or anchored and protected from uplift and forces due to velocity/surge pressure with a 1.5 or greater factor of safety. Fuel storage tanks and fuel supply lines shall be installed to satisfy the SBCCI Standard for Floodplain Management.

NFIP	SGC	Analysis
60.6 – Variances and Exceptions 60.6(c)(2)(i) Flood-Proof Walls	Chapter 4	NFIP requires the basement area, together with utilities and sanitary facilities below the floodproofed design level, to be watertight with walls that are impermeable to the passage of water without human intervention. The SGC defers to the SMC for access and clearance, but does specify minimum combustion air and venting criteria. Utility location and floodproofing are addressed in 602.1.2, 602.5, and Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: The SGC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 54	SGC	Analysis
Figure 4.48 Protective Utility Shaft (Page 92)	Ch.3 308	FEMA 54 requires gas piping serving an elevated structure to be installed on the leeward side of post/columns or enclosed in a protective shaft. The SGC requires piping to be supported and allows a shaft enclosure.

Recommendation: The SGC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 54	SGC	Analysis
Mechanical Equipment (Page 93, Paragraph 2)	Ch. 4 402.4	FEMA 54 requires all gas-fired mechanical equipment to be elevated above expected flood waters with indoor components preferably installed in attic. The SGC defers to the SMC for access and clearance, but does specify minimum combustion air and venting criteria. Ductwork is covered in the SMC.

Recommendation: (1) Revise FEMA to caution that fuel-fired equipment must be installed to local codes (2) Revise SGC to reference the SBCCI Standard for Floodplain Management.

FEMA 55	SGC	Analysis
Chapter 4 - **Structural** Design Section 4.3.6 **Utilities** (Pages 4-50 to **4-52)**	Ch. 3, 308 Ch. 4, 402.4	FEMA 55 requires all gas-fired equipment to be elevated above expected flood water and gas piping to be installed on the leeward side of posts/columns or enclosed in shafts. The SGC defers to the SMC for access requirements, but does specify minimum combustion air and venting. The SGC requires piping to be supported and would allow the shaft.

Recommendation: (1) For elevation revise the SGC to reference the SBCCI Standard for Floodplain Management (2) For fuel supply - revise FEMA to reference model codes for installation.

FEMA 55	SGC	Analysis
Appendix G "Sample Coastal Construction Code" 12 Utilities (Page G-8)	Ch. 4	FEMA 55 requires all gas-fueled mechanical equipment to be elevated above flood waters. The SGC allows elevated installations but also requires minimum combustion air and venting criteria.

Recommendation: (1) Revise SGC to reference the SBCCI Standard for Floodplain Management. (2) Revise FEMA 55 to reference local model codes for installation.

FEMA 102	SGC	Analysis
Chapter IV Other Floodproofing Measures C. Utilities (Pages 99-105)	402 611	FEMA 102 gas-fired mechanical equipment to be elevated above "BFE" or "floodproofed." Floodproofing entails a watertight enclosures for equipment with all penetrations of the building envelope pressure sealed. The SGC allows equipment enclosure with proper access. Adequate combustion air and proper venting.
	611	FEMA 102 requires exterior gas natural draft vents below BFE to be protected by flood shields. The SGC allows very limited exterior venting.

Recommendation: (1) Revise the SGC to reference the SBCCI Standard for Floodplain Management (2) Revise FEMA 102 to reference the locally adopted model code for installation criteria.

FEMA 102	SGC	Analysis
Appendix D "Floodproofing Performance Criteria Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning and Ventilation (A) Location (Page 192)	Ch. 4 402.4	FEMA 102 requires that all gas-fired mechanical equipment be installed above BFE, or be enclosed in water-tight rooms. The SGC allows elevated or enclosed installation, but specifies minimum combustion air and venting.

Recommendation: (1) Revise SGC to reference the SBCCI Standard for Floodplain Management. (2) Revise FEMA to reference locally adopted model codes for installation requirements.

FEMA 102	SGC	Analysis
Appendix D "Floodproofing Performance Criteria Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (B) Heating and Air Conditioning (Page 192)	Ch. 4 Ch. 5 Ch. 6 608.3	FEMA 102 requires that gas delivery systems installed below BFE be equipped with automatic shutoff valves, activated by rising water. The SGC would not require or prohibit such valves. FEMA 102 requires all gas heating equipment be vented to a level above BFE. The SGC requires natural draft gas vents to terminate at least 2 ft. above roof and 2 ft. above any portion of the roof within 10 ft.

Recommendation: Revise SGC to reference the SBCCI Standard for Floodplain Management.

FEMA 102	SGC	Analysis
Appendix D "Floodproofing Performance Criteria Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (D) Fuel Tanks and Lines (Page 193)	Ch. 3 Ch. 9	FEMA 102 requires fuel storage tanks and lines to be located above BFE or anchored and protected against floodwaters by a factor of safety of 1.5. The SGC does not address uplift forces on storage tanks.

Recommendation: (1) Revise SGC to reference the SBCCI Standard for Floodplain Management; and address buoyancy forces on storage tanks.

FEMA 114	SGC	Analysis
Ch. 9 Protection of Utilities 9.4 Permanent Protective Measures (Pages 160-163)	Ch. 4 Ch. 5	Section 904 of FEMA 114 requires utility connections to be above flood level, shielding for basement appliances, elevated exterior appliances, suspension for underfloor equipment and anchoring of fuel storage tanks. The SGC allows such installation but requires adequate combustion air and venting.

Recommendation: Revise SGC to reference the Standard for Floodplain Management.

No. 85-1	SGC	Analysis
IV. Guidelines for Implementation A.10 HVAC (Page 11)	Ch. 4 Ch. 5	No. 85-1 requires gas-fired mechanical equipment to be elevated or enclosed for protection. The SGC allows enclosed installation but requires combustion air and clearances to combustible construction.

Recommendation: The SGC should be revised to reference the Standard for Floodplain Management.

Suggested Code Change [or addition]:

301.1 Fuel Supply in Floodplain Areas
All fuel-fired equipment installed in regulatory floodplain shall be installed to satisfy this Code and the SBCCI Standard for Floodplain Management.

Suggested Code Change [or addition]:

401.1 Installations of Fuel-fired Equipment in the Floodplain
All fuel-fired equipment installed in regulatory floodplain shall be installed to satisfy this Code and the SBCCI Standard for Floodplain Management.

FEMA 114	SGC	Analysis
Ch. 9 Protection of Utilities 9.8 Storage Tank Anchorage (Page 166)	Ch. 3	Section 9.8 of FEMA 114 requires anchorage of fuel storage tanks. The Sgc does not address uplift on LPG tanks.

Recommendation: Revise SGC to address uplift on LPG storage tanks.

Suggested Code Change [or addition]:

903.3 Fuel Tanks
Fuel storage tanks installed in the regulatory floodplain shall be installed above the base flood elevation or anchored and protected from uplift and forces due to velocity/surge pressure with a 1.5 or greater factor of safety. Fuel storage tanks and fuel supply lines shall be installed to satisfy the SBCCI Standard for Floodplain Management.

Standard Plumbing Code

NFIP	SPC	Analysis
60.6 – Variances and Exceptions 60.6(c)(2)(i) Floodproof Walls	301.12 1204.1	NFIP requires the basement area, together with utilities and sanitary facilities below the floodproofed design level, to be watertight with walls that are impermeable to the passage of water without human intervention. The SPC prohibits deleterious discharge of sewage or other waste and requires the water distribution system to be protected against backflow. This is addressed in 602.1.2, 602.6, 602.7, and Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: The SPC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 54	SPC	Analysis
Figure 4.48 Protective Utility Shaft (Page 92)	407	FEMA 54 requires water and DWV piping serving an elevated structure to be attached to the leeward side of posts/columns or enclosed in a protective shaft. The SPC requires piping to be protected from physical damage.

Recommendation: The SPC should be revised to reference the SBCCI for Floodplain Management.

FEMA 54	SPC	Analysis
Septic Tanks (Page 93, Paragraph 3)	Appendix E 301.12	FEMA 54 requires that septic tanks be floodproofed to stop floating and potential discharge of effluent. The SPC requires proper installation and prohibits deleterious discharge.

Recommendation: None since both approach the problem from different directions. FEMA - prescriptive SPC - performance. The SPC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 55	SPC	Analysis
Chapter 4 - Structural Design Section 4.3.6 Utilities (Pages 4-50 to 4-52)	407	FEMA 55 requires water and DWV piping serving elevated structures to be attached to the leeward side of posts/columns or enclosed in a protective shaft. The SPC requires piping be protected from physical damage.

Recommendation: The SPC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 55	SPC	Analysis
Appendix G "Sample Coastal Construction Code" 12 Utilities (Page G-8)	301.10 808 Ch. 13	FEMA 55 requires sanitary sewer and storm drainage systems with openings below the BFE to have backflow valves where the lines pass through the building envelope. The SPC requires a backwater valve only where a drainage system may be subject to a backflow sewage.

Recommendation: Revise the SPC to reference the SBCCI Standard for Floodplain Management and include specific criteria for the isolation of these lines.

FEMA 102	SPC	Analysis
Chapter IV Other Floodproofing Measures C. Utilities (Pages 99 - 105)	1302 1308	FEMA 102 requires that backwater valves be installed on the building sewer at a point where the piping is strong enough to resist the flood induced pressures. A backwater valve is usually a swing-check valve. As an alternate, all gravity sewer openings below the BFE may be routed to a sump, then pumped above BFE to the lowest entrance to the sewer (Figure IV - 8). FEMA also requires wells to be equipped with a watertight casing that extends from one ft. above grade to 25 ft. below grade to minimize contamination. The SPC would allow the backwater valve, but would prohibit the sump in situations where gravity sewer is available. (1308.1) The SPC does not address well construction.

Recommendation: (1) Revise SPC to reference the SBCCI Standard for Floodplain Management. (2) Revise SPC to allow sumps and ejectors for flood areas even where gravity drainage is available.

FEMA 102	SPC	Analysis
Appendix D "Floodproofing Performance Criteria" Criteria #7 "Plumbing Systems" (B) Sanitary Sewer Systems (Page 193)	301.10	FEMA 102 requires on-site sewage disposal systems to be designed to minimize floodwater effects. Sanitary sewer systems which must remain in operation during a flooding event should be designed with a sealed holding tank sized at 150% of anticipated demand. All vents should extend above BFE. The SPC will allow, in limited instances, air admittance valves in lieu of venting termination above roof.

Recommendation: Revise SPC to reference the SBCCI Standard for Floodplain Management and to prohibit air admittance valves below BFE.

FEMA 102	SPC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #7 "Plumbing Systems" (C) Water Supply Systems (Page 193)	1204	FEMA 102 requires that potable water supply systems be protected from contamination during flooding. The SPC requires protection of potable water.

Recommendation: The SPC should reference the SBCCI Standard for Floodplain Management.

FEMA 102	SPC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #7 "Plumbing Systems" (D) Backflow Prevention (Page 193)	301.10 Ch. 13	FEMA 102 requires backwater valves on storm drain, sewage and potable water supply lines installed at wells or building exits. The SPC allows such valves but only requires them for sewage backflow.

Recommendation: Revise the SPC to reference the SBCCI for Floodplain Management.

MCRB	SPC	Analysis
Chapter III Basement Construction (Pages 13-75) Chapter V Basements in Floods (Page 88-126) Chapter VII Appendix A-Soils Data (Pages 164, 166) Chapter VIII Builder's Guide (Pages 198, 206, 209, 211-262) Hydraulic/Hydrologic Manual (Pages 7-10)	301.12 1204.1	The majority of the MCRB does not address plumbing. However, III.B.8 does address plumbing materials, sewer systems, and potable water supply systems. MCRB requires gate valves on the sanitary sewer outlets from the house, and the potable water supply system to be designed in such a manner to prevent contamination from flood waters. The SPC prohibits deleterious discharge of sewage or other waste and requires the water distribution system to be protected against backflow. This is addressed in 602.6 and 602.7 of the SBCCI Standard for Floodplain Management.

Recommendation: The SPC should be revised to reference the SBCCI Standard for Floodplain Management.

No. 85-1	SPC	Analysis
A.11 Plumbing and Water (Not in Scope) (Page 12)	Ch. 12 1204	No. 85-1 Section A.11 requires that interruptible water supply sources be protected from contamination by a check valve. The SPC does require backflow prevention.
	301.10	No. 85-1 requires a sealed holding tank for those disposal systems required to remain in operation during a flooding event. Sewage systems should have a manual valve or a backwater valve at building penetration. The SPC requires a backflow valve for sewage reversal only.

Recommendation: (1) Revise SPC to reference the SBCCI Standard for Floodplain Management; (2) Revise SPC to add a principle for flood plain areas.

No. 90-3	SPC	Analysis
Section D-2 (Pages 1-6)	N/A	No. 90-3 requires utilities to be (1) above design flood or (2) completely enclosed by the building's watertight walls or (3) be completely watertight. The SPC would not prohibit such installation, but only regulates size of space for setting fixtures.

Recommendation: Revise SPC to reference the SBCCI Standard for Floodplain Management.

Suggested Code Change [or addition]:

301.23 Principle No. 23
All plumbing systems in the regulatory floodplain shall be installed to satisfy this Code and the SBCCI Standard for Floodplain Management.

Suggested Code Change [or addition]:

1308.1 Building Drains Below Sewer
Building drains which cannot be discharged to the sewer by gravity flow shall be discharged into a tightly covered and vented sump from which the liquid shall be lifted and discharged into the building gravity drainage system by automatic pumping equipment or by any equally efficient method approved by the Plumbing Official.

EXCEPTION: In the regulatory floodplain where gravity drainage sewers are below the base flood elevation, a sump and ejector system satisfying this section and the SBCCI Standard for Floodplain Management may be used.

Suggested Code Change [or addition]:

1403.2.3 In regulatory floodplain, all vent terminals shall be above the base flood elevation or protected in accordance with the SBCCI Standard for Floodplain Management.

Suggested Code Change [or addition]:

E101.4 All septic tanks installed in the regulatory floodplain shall be in conformance with both this Code and the SBCCI Standard for Floodplain Management.

FEMA 54	SPC	Analysis
Septic Tanks (Page 93, Paragraph 3)	501.2 602.7	FEMA 54 requires septic tanks to be floodproofed to prevent the tank from rising out of the ground. FEMA 54 and SFM requires the tank to be designed to minimize or eliminate discharge of effluent into the floodwaters.

Recommendation: SFM should address buoyancy forces on tanks.

Suggested Code Change [or addition]:

602.7 Sanitary Sewage Systems
New and replacement sanitary sewage systems shall be designed to resist flotation and to minimize or eliminate infiltration of flood waters into the system and discharges from the system into flood waters.

FEMA 55		SFM	Analysis
G-8	Anchoring Standards	601.1	Both FEMA 55 and SFM all components to be securely fastened and adequately interconnected to resist the loads anticipated during flooding. FEMA 55 requires corrosion protection for connectors in exposed locations. SFM does not address corrosion protection.
G-8.1	Connector and Fasteners	801.1	
G-8.2	Beam to Pile Connections	801.3	
G-8.3	Floor to Deck Connections		
G-8.4	Exterior Wall Connections		
G-8.5	Ceiling Joist/Rafter Connections		
G-8.6	Projecting Members		

(Pages G-5, G-6)

Recommendation: SFM should address corrosion protection of metal connectors.

Suggested Code Change [or addition]:

1705.4 Floodplain Areas

Metal plates, connectors, screws, bolts, and nails exposed directly to the weather or subject to salt corrosion in coastal areas shall be stainless steel or hot-dipped galvanized, after the fastener or connector is fabricated.

FEMA 114	SFM	Analysis
9.8 Storage Tank Storage (Page 166)	N/A	FEMA 114 addresses the need for proper anchorage of tanks to prevent their flotation from the buoyancy forces. SFM does not address anchorage of storage tanks.

Recommendation: SFM should address anchorage of storage tanks.

Suggested Code Change [or addition]:

602.8 Storage Tanks
Storage tanks shall be properly anchored to prevent movement and discharges from the tank into flood waters.

No. 88-1	SFM	Analysis
Pages 1-5	801.1	Both No. 88-1 and SFM address wind loads. No. 88-1 contains a reference to ANSI A58.1-1982. SFM references 1205 of the Standard Building Code which contains basic wind speed map, velocity pressure, and coefficients in addition to referencing ASCE 7-88.

Recommendation: No. 88-1 should update reference to ASCE 7-88 and address snow and seismic loads. Section 801.1 of the Standard for Floodplain Management should reference Chapter 12 instead of only 1205 (Wind) to include 1204 (Snow) and 1206 (Seismic).

Suggested Code Change [or addition]:

801.1 Anchoring
All new construction and substantial improvements within an area identified as a coastal high hazard area shall be elevated on pilings or columns in accordance with 800.2, and securely anchored to resist flotation, collapse and permanent lateral movement due to the effects of wind, snow, seismic, and water loading values shall be that which equals or exceeds the 100 year recurrence interval. The minimum design ~~wind loading values~~ loads shall be that specified in ~~Section 1205~~ Chapter 12 of the Standard Building Code.

Recommended Changes to ICBO Documents

FEMA-55	U.B.C.	Analysis
4.2.2- Masonry	Chapters 23 and 26 Appendix Chapter 23, Division IV.	FEMA-55 has a brief paragraph on the use of masonry and concrete in corrosive environments. The U.B.C. has specific design requirements for concrete on corrosive environments but does not address masonry in similar situations.

Recommendation: The U.B.C. should discuss the use of masonry in corrosive environments.

Suggested Code Change: Section 2393 (e), first sentence. Revise as follows: When buildings or structures . . . . components and the protection of all exposed elements from corrosion. Balance to remain unchanged.

Also: Section 2394 (e), first sentence. Revise as follows: When buildings or structures . . . . and connection components to comply with the requirements of Section 2394 (d) and showing the protection of all elements from the effects of corrosion. Balance of paragraph to remain unchanged.

FEMA-55	U.B.C.	Analysis
4.2.3.1- Aluminum	Chapter 28 Appendix Chapter 23.	FEMA-55 discusses the protection of aluminum trim, windows, etc. in corrosive environments. The U.B.C. does not address the use of these types of aluminum products in corrosive situations.

Recommendation: The U.B.C. should address the protection of all materials exposed to corrosive environments in Appendix Chapter 23.

Suggested Code Change: See suggested code change for 4.2.2.

FEMA-55	U.B.C.	Analysis
4.2.3.2- Steel	Chapter 27 Sec. 2510.	FEMA-55 discusses the protection of exposed steel in corrosive environments and recommends regular inspection and maintenance of same. The U.B.C. does not discuss the protection of steel members.

Recommendation: See recommendation for Section 4.2.3.1.

Suggested Code Change: See suggested code change for 4.2.2.

FEMA-55	U.B.C.	Analysis
4.3.7- 4.3.7.1 4.3.7.2 4.3.7.3 4.3.7.4- Protection of the Interior	Sec. 1708 Sec. 2516 Sec. 3201 Sec. 3205 Sec. 4205 Appendix Chapter 23, Division IV.	FEMA-55 discusses the protection of the interior of a structure from wind and water action. The U.B.C. requires that openings below the base flood elevation (BFE) be protected and that exterior assemblies provide a weather-resistive barrier.

Recommendation: The U.B.C. should address the protection of openings above the BFE from wind and water action.

Suggested Code Change: Section 2396. Add Subsection (g). (g) **Protection of Openings.** Openings subject to wind driven rain and wave action shall be watertight to protect the interior from water damage.

FEMA-55	U.B.C.	Analysis
Appendix G.8 Anchoring Standards	Appendix Chapter 23, Division IV Appendix Chapters 24 and 25.	FEMA-55 requires that the entire structural system be tied together to prevent flotation collapse or a permanent lateral movement due to a base flood event concurrent with the one-hundred-year design wind velocity. The U.B.C. requires that the structural system of a building or structure shall be tied together to resist the flotation, collapse, or permanent lateral movement due to loads to flooding equal to the base flood elevation. Another provision requires that the structure be designed and tied together to resist basic wind speeds from 80 to 110 miles per hour.

Recommendation: The U.B.C. should consider one-hundred-year design wind velocities concurrently with the base floor elevation forces.

Suggested Code Change: Section 2396 (b). Revise first sentence as follows: ". . . and hydrostatic loads and one-hundred-year design wind speeds."

FEMA-55	U.B.C.	Analysis
Appendix G.10 Protection of Openings	None.	FEMA-55 requires that exterior openings be designed and detailed to withstand high wind speeds and recommends additional protection such as storm shutters. The Uniform Building Code has no such provision.

Recommendation: The Uniform Building Code should address the protection of exterior openings from wind and water action that are above the base flood elevation.

Suggested Code Change: See suggested code change for 4.3.7.

FEMA-55	U.B.C.	Analysis
Appendix G.11.2 Certification of Breakaway Walls	Appendix Chapter 23, Division IV.	FEMA-55 allows the use of breakaway walls designed for greater loads than twenty pounds per square foot if designed by a licensed architect or engineer. The Uniform Building Code does not allow the use of breakaway walls that are designed above twenty pounds per square foot.

Recommendation: The Uniform Building Code should recognize that the design of breakaway walls with a higher loads considered may be appropriate under certain circumstances.

Suggested Code Change: Section 2396 (f). Add a sentence as follows: Higher breakaway wall loads may be used when approved by the building official.

FEMA-54	U.B.C.	Analysis
Steel	Chapter 1 Chapter 27 Appendix Chapter 23, Division IV.	FEMA-54 discusses the protection of steel structural members that are exposed to a corrosive environment. The U.B.C. does not have a specific requirement for the protection of steel. Rather, it requires that a structure be maintained in a safe condition which also has been interpreted as being protected from corrosive environments.

Recommendation: The U.B.C. should address the protection of steel structural elements specifically in Appendix Chapter 23, Division IV.

Suggested Code Change: See suggested code change for 4.2.2.

FEMA-114	U.B.C.	Analysis
6.2 Flood Wall Considerations	None.	FEMA-114 discusses the use of flood walls in the protection of residential structures. the U.B.C. requires that such buildings are elevated above the base flood elevation and has no provisions for such retrofitting of existing residential structures.

Recommendation: The U.B.C. should develop some provisions for the retrofitting of existing buildings or at least refer to approved national standards.

Suggested Code Change: Section 2396. Add Subsection (h) as follows: (h) **Existing Buildings.** Existing buildings may be floodproofed using flood walls, wet floodproofing or other approved methods when approved by the building official.

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Recommended Changes to NFPA Standards
NATIONAL ELECTRICAL CODE (NFPA 70)

FEMA-54	NFPA 70	Analysis
Service Mounting P. 92 P. 93	110-13	Secure mounting of utilities and mechanical equipment are addressed in FEMA-54. NFPA 70 requires electric equipment to be securely fastened to the surface on which it is mounted.

Recommendation: Revise FEMA-54 to clarify that electric equipment shall be securely fastened to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials shall not be used. Underground electric supply conduits or cables should not be fastened to walls, or structures intended to break-away under flood conditions.

Suggested Code revision:
NFPA 70 (110-13(a), 300-5(d)).
Add the following sentence: Buildings designed with breakaway walls shall have electric services secured to the sides of interior piles or within flood proof enclosures attached to interior poles.

Recommended Changes to Manufactured Housing Codes and Standards

1989 CABO OTFDC, Appendix C

NFIP	CABO App. C	Analysis
§60.3		CABO App. C does not contain any special provisions for the installation of manufactured homes in flood hazard areas.

Recommendation: CABO Appendix C should be revised to include a reference to the NFIP for manufactured home installation in flood hazard areas.

Suggested Code Change [or addition]: Add to Appendix C Section C-101 - Scope, last §, last sentence: Refer to National Flood Insurance Program for installations in flood hazard areas.

FEMA 114	CABO App. C	Analysis
3.5 Extended foundation walls	C-503.2	Appendix C itself does not cover foundation walls; however Section C-503.2 refers to other provisions in CABO by stating that retaining walls used as permanent perimeter enclosure must conform to the code provisions for foundation walls. Section R-304, Foundation Walls, prescribes specific designs for masonry, concrete and stone foundation walls. [Reference Tables R-304.3a, 3b.] None of the prescribed designs in the CABO Tables are usable to resist hydrostatic, hydrodynamic, or impact loads specified in FEMA 114. Hydraulic venting of the foundations, as provided in FEMA 114, is not specified in CABO. R-304.5 in CABO prescribes all wood foundation wall designs. The comparisons noted above are applicable.

Recommendation: Clarification is needed for the CABO tables to state that designs subject to flood loads require special consideration for such loads that have not been accommodated in the tabulated designs.

Suggested Code Change [or addition]: Add a sentence to the end of §R-304.4:

R-304.4 Design required: . . . accepted engineering practices. Note that designs subject to flood loads require special consideration. Flood loads have not been accommodated in the designs in Tables R-304.3a and R-304.3b.

FEMA 114		CABO App. C	Analysis
3.13	Technical design criteria – Anchorage of superstructure to foundation	C-605	CABO C-605 requires that "wood floor support systems shall be fixed to perimeter foundations in accordance with this code." CABO Figure R-303 specifies the anchorage of sill plates to concrete foundations using ½"ϕbolts, 6' o.c. maximum. CABO Table R-402.3a specifies joists secured to sills using 3-8d nails, toe nailed. No provision is made to resist hydrostatic lift-off of the floor.

Recommendation: Clarification is needed in CABO C-605 that additional anchorage may be needed to resist hydrostatic lift in flood-prone areas. Reference to FEMA 85 may suffice.

Suggested Code Change [or addition]: In §C-605, add a sentence that follows the second sentence in the second paragraph:

. . . resist the wind load stated in this code. Note that additional anchorage is needed to resist buoyancy due to flooding in those areas where applicable.

FEMA 114		CABO App. C	Analysis
3.14	Technical design criteria – Open foundations	C-602, C-603, C604, C-605	CABO C-602 (Pier Construction) specifically excludes lateral wind and earthquake loads from consideration in the application of the piers specified in this code. Note that the typical manufactured housing foundation system uses diagonal ties that are secured to ground anchors for lateral load resistance. CABO C-603 (Height of Piers) specifies construction details for three height ranges of pier application. Each of these designs is to be used with the anchors and ties specified in Sections C-604 and C-605 respectively. The reliability of ground anchors in flooded soils has not been demonstrated. It would be prudent at this time to specifically disallow their use in the flood plains.

Recommendation: Clarification is needed in CABO to caution that the ground anchor system specified is generally not rated for flooding or for high open foundations.

Suggested Code Change [or addition]: At the end of §C-604.1,add: The use of ground anchors is permitted in the floodplain only when substantiating data are provided that satisfy the authority having jurisdiction.

FEMA 85		CABO App. C	Analysis
Pg. 22	Piers	C-602	a) FEMA 85 requires the bottom of the pier footing to extend a minimum of 30 in. below grade. CABO only requires the footings to extend a minimum of 12 in. below finished grade. Both require the footing to extend below the frost line. b) FEMA 85 requires built-up piers to be laid with type M or S mortar. In addition to types M or S, CABO permits Type N mortar. No incompatibilities.

Recommendations: Since the 30 inch requirement would be excessive for piers located in areas where scouring is not a problem, two separate requirements in FEMA 85 and CABO for minimum pier depths should be made depending on the flow conditions likely to be encountered.

Suggested Code Change [or addition]: In §C-602, add to the last sentence . . . wind, flood pressure, scouring, or earthquake forces.

FEMA 85		CABO App. C	Analysis
Pg. 53	Posts and Piles		CABO generally covers time-tested construction methods. It does not cover seldom-used systems such as posts or pile construction methods. The requirements are compatible as long as it is understood that CABO Appendix C is not applicable to flood loads.

Recommendation: Change CABO Appendix C to clarify that it does not consider flood loads.

Suggested Code Change [or addition]: In §C-602, add to the last sentence . . . wind, flood pressure, scouring, or earthquake forces.

FEMA 114	HUD 4930.3	Analysis
3.5 Extended foundation walls	102-2.C Standards	HUD 4930.3 references FEMA 85 for manufactured homes on elevated foundations.
	201-2.B	HUD 4930.3 provides that homes built on elevated foundations must comply with requirements of the NFIP and to refer to FEMA 85 for Manufactured Home Installation in Flood-Hazard Areas.
	402	Chapter 4 in HUD 4930.3 makes no provision for the application of hydrostatic, hydrodynamic, or impact loads.

Recommendation: Since provision is made for coastal wind forces in Section 402.3 of HUD 4930.3, it is advisable to include in HUD 4930.3 either complete design provisions for flooding, or a notice that additional lateral, hydrostatic, hydrodynamic, and impact loads need to be included for foundation walls subjected to flooding.

Suggested Change [or addition]: (a) Change §201-2.B.2 to read: "Homes built on elevated foundations in communities that are part of the National Flood Insurance Program (NFIP) must comply with the NFIP."

(b) Change §402-3.B to add item #3: If the site is in a floodplain, hydrostatic, hydrodynamic, and impact loads must be considered. Refer to FEMA 85 for guidance.

FEMA 114		HUD 4930.3	Analysis
3.12	Technical design criteria – Extended wall foundations	App. H12	The Wind Speed Map, H-12, in HUD 4930.3 corresponds with the 50-year mean recurrence map in Figure C-5b of FEMA 114.
		App. H1	The Flood Map, H-1, in HUD 4930.3 does not provide any provisions for hydrostatic, hydrodynamic, static loads.

Recommendation: On the flood map in HUD 4930.3, it is necessary to include a notice to design for lateral, hydrostatic, hydrodynamic, and impact loads for foundation walls subjected to flooding. Reference to FEMA 85 will suffice.

Suggested Change [or addition]: Revise the Flood Map on Page H-1 to include the following:

Note: 1. Consult with local Building or Planning Office to determine whether home is in the floodplain.
2. See FEMA 85 for recommended hydrostatic, hydrodynamic, and impact loads to be applied to foundation walls subject to flood.

FEMA 114	HUD 4930.3	Analysis
3.13 Technical design criteria – Anchorage of superstructure to foundation	App. B	The designs in HUD 4930.3 are apparently to resist wind and gravity loads only. No provision has been made for buoyancy. The loads given for vertical uplift in Table B-2 of HUD 4930.3 would be ample for approximately 1.7' water depth above the top of the foundation.

Recommendation: Include a notice in Appendix B, Table B1 of HUD 4930.3 that additional anchorage may be required in areas subject to flooding in order to resist hydrostatic, hydrodynamic, and impact loads.

Suggested Change [or addition]: Provide a note at the end of the first paragraph in Appendix B:

Note: Additional anchorage may be required to resist hydrostatic, hydrodynamic, and impact loads in areas subject to flooding. Refer to FEMA 85.

FEMA 114	HUD 4930.3	Analysis
3.14 Technical design criteria – Open foundations	203	HUD 4930.2identifies "unstable clays" as a possible cause for foundation instability, while the FEMA 114 favors clay soils for their resistance to scouring. These provisions are incompatible.

Recommendation: Further research/study is recommended to reconcile the limits for foundations in clay soil. This study should be undertaken in a collaborative effort by HUD, FEMA, and the manufactured housing industry.

FEMA 114	HUD 4930.3	Analysis
6.2 Considerations	301-1	The provision in HUD 4930.3,"provide the best available routing of run-off water to assure that buildings or other important facilities will not be endangered by the path of a major emergency flood run-off which would occur if the site storm drainage is exceeded," does not provide notice that this might require the use of flood walls. FEMA 114 discusses the fact that flood wall design is dependent upon the type of flooding expected.

Recommendation: In HUD 4930.3,Section 301-1,include a statement that adequate flood walls provide one way to accomplish the rerouting of run-off water.

Suggested Change [or addition]: Add a sentence to the end of §301-1:

One way to accomplish rerouting of run-off water in retrofitting is to use flood walls. Refer to FEMA 114 for examples.

Note: Flood walls are not acceptable for new installations.

FEMA 114	HUD 4930.3	Analysis
9.4 Permanent protective measures	Chapter 7	There is no provision in HUD 4930.3 for flood protection of utilities. The overall emphasis of this publication is on structural aspects. The scope of Chapter 7 (Final Check) is limited to foundation design.

Recommendation: In HUD 4930.3,refer to FEMA 85 for home installations in flood-prone areas in order to provide protection of utilities.

Suggested Change [or addition]: Add a Section 7004:

700-4 Flood Protection of Utilities

For homes subject to flooding, verify that provisions have been made in the design to protect utilities. Refer to FEMA 85 for methods.

FEMA 85	HUD 4930.3	Analysis
pg. 48 Piers	App. A	FEMA 85 prescribes designs for piers, and cautions that, due to the likelihood of scouring, pier systems should not be used in areas where flooding velocity is anticipated. Appendix A of HUD 4930.3 recommends Foundation Type C2 [reinforced masonry or concrete piers] for high wind and indicates that engineering design is not required. While the Flood-Prone Sites exclusions provided in Section 201-2 might be sufficient for some designers, it seems prudent that it be repeated in the Appendices.

Recommendation: The design appendices in HUD 4930.3 should repeat the references to the FEMA documents and caution that the designs presented have not taken flood conditions into account.

Suggested Change [or addition]: Add a sentence to Paragraph B, Page A-1: Note that none of the charted designs takes flood loads into account. Refer to FEMA 85 for design loads and procedures.

Manufactured Housing Institute
Model Installation Manual [MHI-MIM]

FEMA 85	MHI-MIM	Analysis
pg. 17 Wind hazards	4.4.2 5.4 5.4.1 5.4.2	FEMA 85 and MHI-MIM are not incompatible; FEMA 85 reiterates the same lateral and uplift design wind pressures as the MHCSS. The requirements of MHI-MIM are based on the design wind loads in the MHCSS. Please note, however, that Section 5.4 in MHI-MIM states that, "... the installer should secure the home against the wind *unless the local jurisdiction permits otherwise*." (emphasis added) It appears that FEMA 85 requires the anchoring of homes against wind loads under all circumstances.

Recommendation: It is not intended that a participant in the NFIP (i.e., local jurisdiction) would not require that a home not be anchored against wind loads. However, the compatibility of the documents would be enhanced by a revision to MHI Section 5.4 to state that anchorage of the unit against wind forces is always required.

Suggested Change [or addition]: Change Paragraph **5.4 Anchoring Instructions**. After blocking and leveling, the installer should secure the home to resist the wind forces required in this manual or higher wind forces if required by the authority having jurisdiction.

MCRB	MHI-MIM	Analysis
	4.5	The MHI-MIM provides a list of important reference documents. The Manual for the Construction of Residential Basements in Non-Coastal Flood Environs is not included in the list.

Recommendation: Change the "List of Important Documents" in MHI-MIM to include Manual for the Construction of Residential Basements in Non-Coastal Flood Environs.

Suggested Code Change [or addition]: Add to the "List of Important Documents" in MHI-MIM the following: Manual for the Construction of Residential Basements in Non-Coastal Flood Environs.

ANSI A225.1-1987
Manufactured Home Installations [A225.1]

FEMA 85	A225.1	Analysis
pg. 33 Design of elevated foundations	Appendix B B-4.1	FEMA 85 and A225.1 use the roof live loads and wind loads from the HUD MHCSS. A225.1 states that areas where recurrent winds up to 90 miles per hour (25 psf) are experienced should use similarly designed manufactured homes.

Recommendation: ANSI A225.1 should define the specific areas where wind loads of higher magnitude than the 25 psf limit are needed.

Suggested Standard Change [or addition]: Change Paragraph **B-4.1 The Wind Zone Map**, last sentence as follows: Consult the authority having jurisdiction. Note that an enlarged supplementary map of the Gulf and Atlantic Coastal areas has been supplied in order to more reliably determine the high wind zones. Provide such a map.

FEMA 85	A225.1	Analysis
pp 47-48 Vertical support members	Appendix B	FEMA 85 provides design charts for dead load, live load, snow load, and wind load calculations. The charts use snow and wind loads from the HUD MHCSS. [Homes manufactured since 1976 under the HUD Standards are themselves certified to those loads] A225.1 uses the same live, snow, and wind loads as FEMA 85.

Recommendation: Revise ANSI A225.1, Appendix B, to incorporate ASCE-7 snow and wind loads.

Suggested Standard Change [or addition]: Add a Paragraph:

B-4.3 Flood Loads:

Refer to FEMA 85 for flood loading. The loads in these Tables do not include loads attributable to flooding.

FEMA 85	A225.1	Analysis
pg. 48 Piers	Appendix C	FEMA 85 prescribes designs for piers, and cautions that, due to the likelihood of scouring, pier systems should not be used in areas where flooding velocity is anticipated. Appendix C of A225.1 provides designs for pier foundations and issues no cautions concerning scouring. (Note that overall A225.1 is not for homes sited in flood- prone areas.)

Recommendation: Appendix C of A225.1 should reference the FEMA documents and caution that the designs presented have not taken flood conditions into account.

Suggested Standard Change [or addition]: Add a paragraph after the introductory paragraph to Appendix C, second column:

Flood Designs:

Refer to FEMA 85 for flood designs and design methods. These designs do not include loads attributable to flooding.

Manufactured Home Construction and Safety Standards (MHCSS)

FEMA 114	MHCSS	Analysis
3.12 Technical design criteria – Extended wall foundations	§3280.305(c)	Section 3.12 of FEMA 114 refers to Appendix C for design loads, which in turn refers to the three model building codes for determination of wind loading characteristics. The wind design data presented in Appendix C is not necessarily in agreement with the wind design criteria in §3280.305(c) of the MHCSS. While §3280.305(c)(2)(ii) states that HUD may establish more stringent requirements in areas with 125 mph and greater recorded wind velocity, HUD has not been known to establish more stringent requirements than those specified in §3280.305(c)[25 psf lateral, 15 psf uplift].

Recommendation: Further research/study is recommended to determine: a) if the wind design criteria in MHCSS is adequate for areas of high wind velocity; and/or b) if stronger recommendations against siting such homes in flood prone areas are in order. This study should be undertaken by HUD and the manufactured housing industry.

FEMA 114	MHCSS	Analysis
3.13 Technical design criteria – Anchorage of superstructure to foundation	§3280.305(c)	Section 3.13 of FEMA 114 covers the importance of the floor diaphragm in maintaining the stability of the foundation walls and cautions against using connections that pull out if the underside of the floor is subjected to upward hydrostatic forces. Hydrostatic forces are not covered in the HUD MHCSS. However, Zone II (hurricane) homes when designed in accordance with §3280.305(c) are connected to the steel frame - chassis so as to sustain 15 psf uplift. (Caution, this is not sufficient for hydrostatic pressures in excess of 3" water column.)

Recommendation: FEMA research on the effects of hydrostatic pressure on manufactured homes has resulted in the requirement to elevate above BFE. If HUD and the manufactured housing industry were to embark on a program to set construction standards for homes sited in flood prone areas, a method of certification similar to the wind zone map and label used in the present MHCSS needs to be devised to provide notice on the homes that identifies the flood intensity for which the home is constructed.

FEMA 114	MHCSS	Analysis
C.4 Wind loads	§3280.305(c)(1) and (2)	MHCSS specifies that the wind design forces for homes designated for Zone I, non-hurricane, shall be 15 psf lateral and 9 psf uplift, and the wind design forces for Zone II, hurricane, shall be 25 psf lateral and 15 psf uplift. In FEMA 114, wind zones are delineated in wind velocities (mph) according to the ANSI A58.1 map for 50-year recurrence. When applying the formulas from ANSI A58.1, the resulting wind pressures in high wind zones may exceed the MHCSS minimum pressures. §3280.305(c)(2)(ii) states that HUD may establish more stringent requirements than those specified in §3280.305(c) for areas with 125 mph and greater wind velocities.

Recommendation: Further research/study is recommended to determine: a) if the wind design criteria in MHCSS is adequate for areas of high wind velocity; and/or b) if stronger recommendations against siting such homes in flood prone areas are in order. This study should be undertaken by HUD and the manufactured housing industry.

Recommended Changes to the One and Two Family Dwelling Code

NFIP	OTFDC	Analysis
60.3(c)(5) Flood Openings	R-311	NFIP requires fully enclosed areas below the lowest floor, other than basements, to be provided with flood openings to equalize hydrostatic flood forces. OTFDC does not address floodplain management; however, it does require openings for crawl space ventilation.

Recommendation: OTFDC should address openings for floodwater and equalize hydrostatic forces.

Suggested Code Change [or addition]:

R-311.5 **Floodplain:** All elevated buildings that include fully enclosed areas formed by foundation and other exterior walls below the base flood elevation shall be designed to allow for the entry and exit of floodwaters to automatically equalize hydrostatic flood forces on exterior walls. Designs for meeting this requirement must either be certified by a professional engineer or meet the following minimum criteria: a minimum of two openings having a total net area of no less than 1 square inch for every square foot of enclosed area subject to flooding shall be provided. The bottom of all openings shall be no higher than 1 ft above grade. Openings may be equipped with screens, louvers, valves or other coverings or devices provided they permit the automatic flow of floodwaters in both directions.

FEMA 55	OTFDC	Analysis
4.1.2 Salt Air Moisture and Wind-Driven Rain (Pages 4-7, 4-8)	R-309 R-404.14.1	FEMA provides general discussion of the hazards of salt air, moisture, and wind-driven rain on wood, nails, and connectors. OTFDC requires wood subject to decay damage to be naturally durable or pressure treated but does not address nails or connectors. OTFDC does address corrosion protection of joint reinforcement, anchor ties, and wire fabric for use in masonry wall construction.

Recommendation: OTFDC should address corrosion protection.

FEMA 55	OTFDC	Analysis
4.2.3.2 Steel (Page 4-11)	R-403 R-605 R-705.1	FEMA 55 addresses the problem of corrosion of unprotected steel shapes and anchoring devices (nails, bolts, etc.) and the need for regular inspection, maintenance, and replacement of corroded metal parts. OTFDC requires the steel to comply with the appropriate standards. OTFDC does not address corrosion in coastal environment.

Recommendation: OTFDC should address corrosion protection.

Suggested Code Change [or addition]:

R-402.3 Construction: Exterior walls of wood-frame construction shall be in accordance with Figure Nos. R-402.3a and R-402.3b. Components of exterior walls shall be fastened in accordance with Table No. R-402.3a. Walls of wood frame construction shall be designed and constructed in accordance with the NFoPA "National Design Specification for Wood Construction," listed in Section S-26.402.

Exterior walls shall be effectively braced with let-in bracing, plywood in accordance with Table No. R-402.3b, particleboard in accordance with Table No. R-402.3c or other approved materials.

Exterior walls subject to wind pressures greater than 30 pounds per square foot, as established in Table No. R-201.2, shall be designed in accordance with accepted engineering practice.

Metal plates, connectors, screws, bolts, and nails exposed directly to the weather or subject to salt corrosion in coastal areas shall be stainless steel or hot-dipped galvanized, after the fastener or connector is fabricated.

Suggested Code Change [or addition]:

SECTION R-605 – METAL

Steel and aluminum structural elements shall be constructed of materials and designed in accordance with the AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" and AASAS30, respectively, listed in Section S-26.605. Steel elements may be hot-rolled or cold-formed structural steel. Members shall be straight and free of any defects which would affect their performance.

Structural steel exposed directly to the weather or subject to salt corrosion in coastal areas shall be hot-dipped galvanized after fabrication.

Suggested Code Change [or addition]:

R-705.1 Steel elements: Steel structural elements in roof-ceiling construction may be either hot-rolled structural steel shapes or members cold formed to shape from steel strip or plate or a fabricated combination thereof. Members shall be straight and free of any defects which would significantly affect their structural performance. Steel structural members in roof-ceiling construction shall be designed in accordance with the AISC "Specification for the Design, Fabrication and Erection of Structural Steel for Buildings" listed in Section S-26.705.

Structural steel exposed directly to the weather or subject to salt corrosion in coastal areas shall be hot-dipped galvanized after fabrication.

APPENDIX 1

PROJECT PARTICIPANTS

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APPENDIX 2

ACRONYMS

AA	Aluminum Association
ACI	American Concrete Institute
AISC	American Institute of Steel Construction
ANSI	American National Standards Institute
ASCE	American Society of Civil Engineers
ASHRAE	American Society of Heating, Refrigerating and Air-Conditioning Engineers
ASTM	American Society for Testing and Materials
AWPA	American Wood-Preservers' Association
BCMC	Board for the Coordination of the Model Codes
BFE	Base flood elevation
BOCA	Building Officials and Code Administrators International
CABO	Council of American Building Officials
CFR	Code of Federal Regulations
FEMA	Federal Emergency Management Agency
HUD	Department of Housing and Urban Development
HVAC	Heating, ventilating and air-conditioning
ICBO	International Conference of Building Officials
LP	Liquified petroleum
LPG	Liquified petroleum gas(es)
MCRB	Manual for the Construction of Residential Basements in Non-Coastal Environs
MHCSS	Manufactured Housing Construction Safety Standards

MHI	Manufactured Housing Institute
MHIM	Manufactured Housing Installation Manual
NCSBCS	National Conference of States on Building Codes and Standards
NFIP	National Flood Insurance Program
NFPA	National Fire Protection Association
NFoPA	National Forest Products Association
OTFDC	One and Two Family Dwelling Code
SBC	Standard Building Code
SBCCI	Southern Building Code Congress International
SFM	Standard for Floodplain Management
SGC	Standard Gas Code
SMACNA	Sheet Metal & Air Conditioning Contractors National Association
SMC	Standard Mechanical Code
SPC	Standard Plumbing Code
UBC	Uniform Building Code

APPENDIX 3

SUMMARIES OF NFIP FLOOD RESISTANT DESIGN STANDARDS AND TECHNICAL GUIDANCE DOCUMENTS

National Flood Insurance Program Regulations for Floodplain Management and Flood Hazard Identification (44 CFR 59.1, 60.3 & 60.6)

These three sections of the Federal regulations that govern the NFIP contain general flood resistant design standards (60.3), flood resistant design standards for basements (60.6), and associated definitions (59.1). These are the regulations that a community must adopt and enforce in order to participate in the NFIP.

Coastal Construction Manual (FEMA-55)

This document is applicable to new residential structures, principally detached single-family, attached single family (townhouses), low-rise (three story or less) multi family houses and similar sized non-residential structures in coastal areas of the United States. The manual is based on evaluation of existing beach houses, current construction practices along U.S. coastlines and various building codes applicable to construction. The document primarily addresses design of wood-frame structures for flood and wind resistance, and is meant to serve as a parallel to model building codes. The information presented is based upon values of forces and properties of materials taken from standard engineering references and conventional building codes. Generally, conservative approaches and values have been used to provide conformance with most applicable national building codes. A limited range of sizes and configurations for single-family residences has been assumed for purposes of establishing design criteria and tables. A sample building code is provided for local jurisdictions that wish to develop a coastal construction code to supplement their governing building code.

Elevated Residential Structures (FEMA-54)

This manual is limited to the special design issues confronted in elevated construction. Readers are assumed to have knowledge of conventional residential construction practice. The techniques described for the design and construction of elevated residential structures is based on accepted building practices. Generally, a conservative approach has been taken to ensure compliance with building codes most widely used in the United States. This document also contains a set of performance criteria applicable to all structural materials and construction methods used in flood hazard areas. Traditional or conventional solutions, as well as innovative techniques, are acceptable so long as the performance requirements and criteria are satisfied.

Retrofitting Flood-Prone Residential Structures (FEMA-114)

This manual describes the application of permanent retrofitting measures particularly elevation, floodwalls and closures that can be implemented in a residential structure to reduce flood damage. Elevation techniques described in the manual are not addressed in the model codes and standards, however, the altered structure is treated by the codes as a new structure.

Floodproofing Non-Residential Structures (FEMA-102)

This document illustrates a broad range of floodproofing techniques that can be used to reduce flood damage to existing or proposed non-residential (industrial, commercial and institutional) structures in riverine flooding and flooding in no-wave velocity coastal areas. These structures range from wood-frame to multi-story concrete and steel structures. Much of the information regarding design criteria, the properties of materials, the values of flood water design forces, and other considerations have been adopted from standard engineering references, building codes, and other documents. This manual is intended to serve as a general technical guide on the selection of alternative floodproofing techniques. Actual design and construction should involve the services of a registered professional engineer, architect or experienced contractor. An appendix provides floodproofing performance criteria for the design and evaluation of floodproofing measures.

Manufactured Home Installation in Flood Hazard Areas (FEMA-85)

This document primarily addresses techniques for elevating manufactured homes above anticipated flood levels. Chapter 1 states that siting and installation requirements for manufactured homes are generally a state or local regulatory responsibility and are not within the scope of the Manufactured Housing Construction Safety Standards (MHCSS). However, the MHCSS require the installation procedures be incorporated in the owner's manual supplied with each new manufactured home. Installation procedures in both the owner's manual and ANSI A225.1-82 are not considered adequate in cases where flood forces are anticipated. (This statement needs to be tested for ANSI A225.1-87.)

Alluvial Fans: Hazards and Management (FEMA-165)

This document contains very general guidelines for building in flood-prone areas on alluvial fans which are found in arid western regions. With the exception of provisions for window and door locations, these guidelines are covered in greater detail in the other FEMA publications.

Design Guidelines for Flood Damage Reduction (FEMA-15)

This document describes an overview of the flood regulatory program and site considerations. As it does not address design and construction, it will not utilized as a source of technical guidelines for this project.

Manual for the Construction of Residential Basements in Non-Coastal Flood Environs

This manual provides practical guidance and specific design options to assist in meeting the requirements of the NFIP for floodproofed residential basements. It is intended also as a tool for those called upon to certify that floodproofed residential basements meet the standards of the program. The manual presents two basic systems for waterproofing residential basements. One system envisions the

use of conventional wall and slab surface treatments along with a total drain, sump, and pump operation to keep water away from basement walls. The other system envisions the use of a more water-tight wall and slab surface treatment without a sump or pump. A "builder's guide" is also included for use by contractors.

Technical Standards Bulletin: Wet Floodproofing, No. 85-1

This document provides basic information concerning the application of wet floodproofing (intentional internal flooding) techniques to new and existing non-residential construction. Sections of the bulletin also address operational procedures to reduce vulnerability to damage. Guidance presented is the result of a review of state of the art and actual field experience with such techniques.

Technical Standards Bulletin: Foundation Wall Openings, No. 85-2

This document addresses the structural requirements of a building's foundation system that may be subject to flood forces by placing a number of permanent openings in the foundation wall. The guidelines are applicable to solid load bearing walls which elevate the building or any type of enclosure constructed around the foundation.

Technical Standards Bulletin: Breakaway Walls, No. 85-3

This document addresses the design of breakaway walls defined as walls which are not part of the structural support of the building and are intended to collapse under specific lateral loads with causing damage to the building. Breakaway wall designs are based on the premise of connection failures. Breakaway walls may be used to enclose spaces below the flood elevation meant for parking of vehicles, building access and storage.

Technical Standards Bulletin: Hurricane Damage Patterns: A Focus on Pile Foundations, No. 86-1

This document represents an introductory approach to pile design and repeats information more thoroughly described in other publications. Thus, it will not be utilized for comparisons with codes and standards documents.

Technical Standards Bulletin: Wind Design Standards and the NFIP, No. 88-1

This document describes the application of ANSI A58.1 which describes wind loads and speeds. The document states that all three model building codes have adopted some version of this standard.

Technical Standards Bulletin: Flood Resistant Materials, No. 88-2

This document provides data and guidance on what constitutes materials resistant to flood damage and how they should be used to improve a structure's ability to withstand flooding. The most common use of this requirement is with regard to construction below a structure's lowest habitable floor which is required to be elevated above the base flood elevation, and with applications of wet floodproofing. This requirement means that all construction below the lowest floor, which can be used for parking, building access and limited storage must consist of flood resistant materials in order to withstand

inundation by flood waters.

Technical Standards Bulletin: Free of Obstruction Requirement in Coastal High Hazard Areas, No. 88-3

This document provides guidance on the NFIP requirement to keep the space below the lowest floor free of obstruction.

Technical Standards Bulletin: Protection of Elevator Equipment in Flood Hazard Areas, No. 88-4

This document provides an explanation of elevators, their related equipment, and practical methods of protecting them from flood damage.

Technical Standards Bulletin: NFIP Pile or Column Requirement in Coastal High Hazard Areas, No. 90-1

This document represents an introductory approach to pile design and repeats information more thoroughly described in other publications. Thus, it will not be utilized in for comparisons with codes and standards documents.

Technical Standards Bulletin: NFIP Requirements for Below Grade Parking Garages in Flood Hazard Areas, No. 90-2

This document provides technical guidance on the design of below grade parking garages in flood hazard areas. A below grade parking garage is an enclosed area below a building used for parking. The floor of the enclosed area is subgrade or below ground on all sides.

Technical Standards Bulletin: Non-Residential Floodproofing Certification Requirements of the National Flood Insurance Program, No. 90-3

This document details the design and construction considerations necessary to comply with the floodproofing certification requirements of the NFIP for non-residential structures. It also describes operation and maintenance procedures for floodproofing.

Technical Standards Bulletin: Installation of Manufactured Homes in Special Flood Hazard Areas, No. 90-4

This document provides the application of floodplain management regulations affecting the installation of manufactured homes and general technical guidance in constructing elevated manufactured home foundations.

APPENDIX 4

SUMMARIES OF MODEL CODES AND STANDARDS

BOCA National Building Code (1990)

This code controls all matters concerning the construction, alteration, addition, repair, removal, demolition, use, location, occupancy and maintenance of all buildings and structures. For this study the code addresses administration and enforcement (Chapter 1), height and area (Chapter 5), anchorage (Chapter 6), insulating materials (Chapter 9), structural considerations (Chapter 11), foundations (Chapter 12), construction materials (Chapters 14, 15, 17, 18 & 19), exterior walls (Chapter 21), glass (Chapter 22), and roofs (Chapter 23). Fire safety is covered in primarily in Chapters 5 and 9. Wind and seismic requirements are covered in Chapter 11.

BOCA National Fire Prevention Code (1990)

This code applies to the hazards of fire and explosion arising from the storage, handling or use of substances, materials or devices and from conditions hazardous to life, property, or public welfare in the use or occupancy of buildings structures and sheds. For this study the code addresses floodproofing of underground storage tanks (Chapter 28). Seismic considerations are not explicitly addressed in this chapter.

BOCA National Mechanical Code (1990)

This code applies to the design, installation, maintenance, alteration and inspection of mechanical systems, including, heating, ventilating, cooling, and steam and hot water heating systems, water heaters, process piping, and other systems. For this study the code addresses plenums and ducts (Chapters 3 and 5), hazardous and outdoor locations of mechanical equipment (Chapter 4), and floodproofing of water, gas and other fluid piping (Chapters 7, 8 & 9). Fire, wind and seismic considerations are not explicitly addressed in these chapters.

BOCA National Plumbing Code (1990)

This code applies to the design and installation of plumbing systems, including sanitary and storm drainage, sanitary facilities, water supplies, and storm water and sewage disposal in buildings. For this study this code addresses the floodproofing provisions for piping (Chapter 3), connections (Chapter 5), drainage piping (Chapter 6), manholes (Chapter 11), and water service (Chapter 15 and 16). Fire, wind and seismic considerations are not explicitly addressed in these chapters.

BOCA National Property Maintenance Code (1990)

This code applies to existing structures, residential and nonresidential, and on all existing premises by establishing minimum requirements and standards for premises, structures, buildings, equipment, and facilities for light, ventilation, space, heating, sanitation, protection from the elements, life safety, safety from fire and other hazards and for safe and sanitary maintenance. For this study the code addresses the exterior structure (Article 3) and mechanical equipment (Article 6). Fire, wind and seismic considerations are not explicitly addressed in these chapters.

Standard Building Code (1991)

This code applies to the construction, alteration, repair, equipment, use, occupancy, location, maintenance, removal and demolition, of every building or structure or any appurtenances connected or attached to such buildings or structures. For this study the code addresses parking (Chapter 4), standby power and accessibility (Chapter 5 and Appendix I), unusable space and open parking structures (Chapter 6), chutes and tanks (Chapter 7), chimneys, plumbing and plenums (Chapter 8), egress and exits (Chapter 11), structural requirements (Chapter 12), foundations (Chapter 13), masonry construction (Chapter 14), wood construction (Chapter 17), one and two family dwellings (Appendix C), and manufactured homes (Appendix H). Fire safety is covered in primarily in Chapters 6, 7, 8 and 11. Wind, snow and seismic requirements are covered in Chapter 12.

Standard for Floodplain Management (1989)

This code provides criteria to meet the minimum, floodplain construction requirements as required by the National Flood Insurance Program. Fire, wind, snow and seismic considerations are not explicitly addressed in this document.

Standard Mechanical Code (1991)

This code provides minimum requirements for mechanical installations, including alteration, repair, replacements, equipment, appliances, fixtures, fittings and appurtenances. For this study the code addresses under floor installations (Chapter 3), condenser and compressor units (Chapter 4), duct systems (Chapter 5), and piping (Chapter 6). Fire, wind, snow and seismic considerations are not explicitly addressed in these chapters.

Standard Gas Code (1991)

This code provides minimum requirements for installation of gas piping and appliances. For this study the code addresses meter location and piping (Chapter 3), air for combustion and ventilation (Chapter 4), furnaces (Chapter 5), and butane and propane piping (Chapter 9). Although fire safety requirements are not explicitly stated, one of the purposes of the gas code is to prevent fires, particularly explosions. Wind, snow and seismic considerations are not explicitly addressed in these chapters.

Standard Plumbing Code (1991)

This code provides minimum requirements for plumbing installations, including alteration, repair, replacements, equipment, appliances, fixtures, fittings and appurtenances. For this study the code addresses protection of pipes and sewage systems (Chapter 4 and Appendix E), traps and cleanouts (Chapter 7), hangers and supports (Chapter 10), water supply (Chapter 12), drainage systems (Chapter 13), and storm drains (Chapter 15). Fire, wind, snow and seismic considerations are not explicitly addressed in these chapters.

Uniform Building Code (1991)

This code regulates and controls the design, construction, installation, quality of materials, use and occupancy, location, and maintenance of all buildings and structures. For this study, the code addresses definitions (Chapter 4), general requirements for all occupancies (Chapter 5), general design requirements of construction materials (Chapter 23), specific requirements for materials (Chapters 24 through 28), foundations (Chapter 29), accessibility (Chapter 31), exits (Chapter 33), wall and ceiling coverings (Chapter 47), and excavations and grading (Chapter 70). Fire safety is primarily addressed in Chapters 5, 31 and 33, while wind and seismic requirements are addressed in Chapter 23 and its appendices.

Uniform Mechanical Code (1991)

This code regulates and controls the design, construction, installation, quality of materials, location, operation and maintenance or use of heating, ventilating , cooling, refrigeration systems, incinerators and other miscellaneous heat producing appliances. For this study, the code addresses heating, ventilating and cooling equipment in general (Chapter 5), and refrigeration equipment (Chapter 15). Fire, wind and seismic considerations are not explicitly addressed in these chapters.

Uniform Plumbing Code (1991)

This code applies to the erection, installation, alteration, repair, relocation, replacement, addition to, and use of maintenance of plumbing systems. For this study the code addresses drainage systems described in Chapter 4. Fire, wind and seismic considerations are not explicitly addressed in this chapter.

NFPA 101 - 1991 Life Safety Code

This code establishes the minimum requirements that will provide a reasonable degree of safety from fires in buildings. For this study the code addresses means of egress (Chapter 5), construction and compartmentalization and special hazards (Chapter 6), elevators and chutes (Chapter 7), special structures and high-rise buildings (Chapter 30), and operation and maintenance (Chapter 31). Applicable code provisions for each new occupancy listed in the document (Chapters 8 through 29) are also part of the study. Wind and seismic considerations are not explicitly addressed in these chapters.

NFPA 70 - 1990 National Electrical Code

This code addresses the practical safeguarding of persons and property from hazards arising from the use of electricity. The code covers installations of electric conductors and equipment within or on buildings and manufactured homes. For this study the code addresses electrical service (Chapter 2), wiring (Chapter 3), lighting, motors, and transformers (Chapter 4), and emergency systems (Chapter 7). Fire, wind and seismic standards are not explicitly referenced, however, one of the purposes of the electrical code is the prevention of electrical fires.

NFPA 54 - 1988 National Fuel Gas Code

For this study, this code offers general criteria for the installation of gas piping (Part 3) and gas equipment (Part 6). Although fire safety requirements are not explicitly stated, one of the purposes of the gas code is to prevent fires, particularly explosions. No specific wind or seismic standards are addressed.

NFPA 58 - 1989 Standard for the Storage and Handling of Liquified Petroleum Gases

This standard applies to liquified petroleum gas(es) also known as "LP-gas" and "LPG." The gases are composed predominately of propane, propylene, butane and butylene by themselves or as mixtures. For this study the standard applies to the design and construction (Chapter 2), installation (Chapter 3) and operation (Chapters 2 and 3) of all LP-gas systems excluding natural gas processing plants, frozen ground containers, utility gas plants, chemical plants, and LP-gas used with oxygen of covered by other standards. Chapter 7 addresses buildings or structures housing LP-gas distribution facilities. Fire safety requirements are listed for certain kinds of operations and for the structures described in Chapter 7. No specific wind or seismic standards are addressed.

ANSI A225.1-1987 Manufactured Home Installations

This standard covers the installation of manufactured homes on site and references fire safety requirements for the installation of manufactured homes. For this study, all chapters and selected appendices will be utilized. Chapter 1 describes the scope and intent of the document; Chapter 2 describes installation standards. Chapters 3 and 4 reference installation of plumbing systems and mechanical equipment, respectively. In Chapter 7, NFPA 501A is referenced for fire safety requirements, and in Chapter 6, NFPA 70 is referenced for electrical systems. A wind zone map in Appendix B provides horizontal and uplift loads to be used in determining anchoring requirements. No seismic standards are referenced.

Manufactured Home Construction and Safety Standards, Part 3280

This standard covers all equipment and installations in the design, construction, fire safety, plumbing, heat producing and electrical systems of manufactured homes. For this study sections have been referenced on materials (304), structural design (305), windows (403), egress windows (404), heating, cooling and fuel burning systems (Part H), and electrical systems (Part I). Interpretative bulletins are also part of the study. Fire safety requirements addressing egress are found in section 404. Sections 305 and 306 provide standards for anchoring and windstorm protection. Subsection 305 provides the same wind zone map found in ANSI A225.1-1987. No seismic standards are referenced.

Permanent Foundations Guide for Manufactured Housing, 4930.3

This handbook provides guidelines on the design of foundations for manufactured homes. For this study sections have been referenced on flood-prone sites (Chapter 2), fill (Chapter 3), design loads (Chapter 4), and foundation design (Chapters 5 and 6). Appendices describes foundation design in more detail. Chapter 4 addresses wind and seismic considerations.

Model Manufactured Home Installation Manual

This manual contains detailed installation instructions, including specifications and procedures for erection and hookup of a manufactured home. For this study chapters have been referenced on foundations (Chapter 4), anchoring (Chapter 5), comfort cooling systems (Chapter 7) connections for water supply, drainage systems, gas supply, and electrical systems (Chapter 8), and oil tank installations (Chapter 8). Chapters 4 and 5 also provides guidelines for windstorm and flood protection.

NFPA 501A - 1987 Standard for Firesafety Criteria for Manufacture Home Installations, Sites and Communities

This standard covers firesafety requirements for the installation of manufactured homes and manufactured homesites including accessory buildings, structures and communities. For this study sections have been referenced on gas supply connections and oil tank installations (Chapter 2), and life and firesafety (Chapter 4). In Chapter 3, NFPA 70 is referenced for electrical systems. No seismic standards are referenced.

CABO One and Two Family Dwelling Code (1989) with 1990/1991 Amendments

The provisions of this code apply to the construction, prefabrication, alteration, repair, use, occupancy and maintenance of detached one- or two-family dwellings and one-family townhouses not more than three stories in height and their accessory structures. For this study the code addresses building planning (Chapter 2), foundations (Chapter 3), wall construction (Chapter 4), exterior wall coverings (Chapter 5), floor framing (Chapter 6), masonry chimneys (Chapter 9), mechanical systems (Chapters 11 through 17 & 19), and plumbing systems (Chapters 20, 22, 24 & 25). Seismic requirements are covered in Appendix A; wind requirements in Appendix B. Manufactured housing is addressed in Appendix C. Fire safety requirements are implicit in all chapters.

Code Compatibility Report

Appendices A and B

Federal Insurance Administration
Federal Emergency Management Agency

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APPENDIX A

COMPARISON BETWEEN THE BOCA NATIONAL CODES AND THE NFIP STANDARDS AND TECHNICAL GUIDELINES

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BOCA NATIONAL BUILDING CODE COMPARISON

NFIP Regulations for Floodplain Management and Flood Hazard Identification (44 CFR 59.1, 60.3 & 60.6)

44 CFR 59.1	BOCA Code	Analysis
Appurtenant Structure	201.0	FEMA definition relates to incidental structures while BOCA uses the term relative to systems used to support equipment. Although not literally compatible, this term should not cause conflicts relative to the code requirements.

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
Base flood	2101.6.1	Both FEMA and BOCA describe the base flood as being a flood with a one percent chance of being exceeded.

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
Basement	201.0 2101.6.3.1	FEMA indicates basements to be entirely below grade while BOCA's definition would consider a portion below grade as constituting a basement. However, both documents include requirements for unoccupied spaces below the BFE which is the key consideration. See analysis of 44 CFR 60.3 (c)(2) and (c)(3) for comparison of requirements.

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
Breakaway wall	1109.4 2101.6.4.2	Both FEMA and BOCA require the wall to be capable of breaking away without effecting the structural integrity of the structure.

Recommendation: Provide exception to BOCA Section 1109.4 to address breakaway walls. See also recommendation to 44 CFR 60.3 (e)(5).

44 CFR 59.1	BOCA Code	Analysis
Building-See structure	201.0	FEMA definition distinguishes between flood plain requirements and insurance coverage and also indicates the building is "walled". BOCA's definition of "building" does not mandate a wall while BOCA's definition of structure is something "that is built or constructed". Given the application of these terms in their respective documents there are no conflicts relative to BOCA and FEMA requirements.

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
Critical feature	None	FEMA identifies this term as a key consideration in the flood protection system while BOCA contains no definition. BOCA does not differentiate between key components and non-key components but rather defines the required system performance.

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
Development	None	FEMA definition indicates a man made change. BOCA does not define the term as it is not relevant to the application of the code.

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
Elevated buildings	2101.6.3.1 2101.6.3.3 2101.6.4.1	FEMA contains prescriptive requirements and attributes which are used to evaluate whether a building is considered an elevated building. For purposes of FEMA, an elevated building is one in which the floor elevation is above the ground level or the perimeter walls have sufficient openings to allow flood water in or the walls are breakaway. BOCA does not include a definition but rather contains prescriptive requirements for structures in A and V zones which mirror the definition in FEMA. Also, the FEMA definition includes subclassifications of zones (i.e. A1, AE, etc.) and zones such as B, C, X, and D while BOCA requirements only identify A and V zones.

Recommendation: FEMA should provide direction to the model codes concerning the need to include the subclassification of flood zones versus the current zones found in the model codes.

44 CFR 59.1	BOCA Code	Analysis
Existing construction	103.0	FEMA definition is used to determine rates and is a function of a start of construction date relative to FIRM or 1/1/1975. BOCA would consider any structure existing on the date of adoption of the BOCA code as an existing structure.

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
Existing structures - See existing construction	103.0	See "existing construction"

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
Flood	2101.6	FEMA provides a definition which addresses the idiosyncracies of water over normally dry land including mud slides and subsidence. BOCA's provisions do not define the term flood and solely rely on the Flood Insurance Rate Map to determine the applicability of the flood provisions. BOCA does not address mud slides or subsidence. The utility of this definition relative to enforcing code requirements is not apparent. Reliance on the map is the key consideration.

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
Flood plain or flood prone areas	2101.6	See "flood"

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
Lowest Floor	2101.6.3.1 2101.6.3.3 2101.6.4.1	This term as defined in FEMA relates to the term "elevated building", also defined in FEMA. This term references a basement which has been previously identified in this comparison. The criteria which identifies how a space can be used and not be considered the lowest floor is similar to BOCA with the key consideration being whether the space is used for human occupancy.

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
Manufactured home	201.0	FEMA's definition is consistent with BOCA's definition of "mobile unit".

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
100-year flood - see base flood	2101.6.1	See "base flood"

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
Storm cellar	None	The term is not defined in BOCA since there are no requirements for this type of use.

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
Structure	201.0	See "building".

Recommendation: None

44 CFR 59.1	BOCA Code	Analysis
Substantial improvement	2101.6.9	FEMA uses this term to identify when the construction equals or exceeds 50% of the market value. BOCA does not define this term since the requirements in BOCA are stated in 2101.6.9 and also require the entire structure to be upgraded if the reconstruction or restoration exceeds 50% of replacement cost.

Recommendation: FEMA to evaluate whether the criteria to determine compliance should be based on "market value" or "replacement cost".

44 CFR 60.3	BOCA Code	Analysis
(b)(8) Manufactured home installation	2101.6.7	FEMA requires manufactured homes in Zone A to be installed to minimize damage by elevating and anchoring the structure. BOCA's requirements do not distinguish between manufactured homes versus site built and would also require the home to be located above the BFE. Also BOCA would permit these in either Zone A or V.

Recommendation: None. FEMA has indicated that these installations are not prohibited in either zone as a result of a 1986 rule change.

44 CFR 60.3	BOCA Code	Analysis
(c)(2) Elevation for residential structures	2101.6.3.1 103.3 2101.6.9 2101.6.2 2101.6.3 2101.6.4 2101.6.6	FEMA's provisions (Zone A) require the lowest floor (including basement) to be above the BFE. This is consistent with BOCA. Additionally, this section cites "substantial improvements" which are defined based on a cost consideration for determining applicability. BOCA invokes the 50 percent replacement cost to require the entire structure to comply with the current provisions. Also, the FEMA requirements include subclassifications of zones (i.e. A1, AE, etc.) while BOCA addresses these zones as Zone A.

Recommendation: See 44 CFR 59.1 - Elevated buildings.

44 CFR 60.3	BOCA Code	Analysis
(c)(3) Elevation for non-residential structures	2101.6.3.1 2101.6.3.4 103.3 2101.6.2 2101.6.3 2101.6.4 2101.6.6	FEMA's provisions (Zone A) require the lowest floor (including basement) to be either above the BFE or the space designed to be watertight. This is consistent with BOCA. However, FEMA cites "substantial improvements" - see discussion for FEMA (c)(2). Also, the FEMA requirements include subclassifications of zones (i.e. A1, AE, etc., while BOCA addresses the zones as Zone A.

Recommendation: See 44 CFR 59.1 - Elevated buildings.

44 CFR 60.3	BOCA Code	Analysis
(c)(5) Flood Openings	2101.6.3.3	FEMA's provisions (Zone A) are requirements for enclosed spaces below the BFE and are consistent with BOCA. However, FEMA cites "substantial improvements" - see discussion for FEMA (c)(2).

Recommendation: None

44 CFR 60.3	BOCA Code	Analysis
(e)(4) Pilings	2101.6.4.1 2101.6.11.3 2101.6.6 2101.6.2 2101.6.3	FEMA's provisions (Zone V) require the lowest horizontal structural member to be above the BFE with the foundation system of piles and columns to be designed to withstand the loads. This is consistent with BOCA. However, FEMA cites "substantial construction" - see discussion for FEMA (e)(2). Also, the FEMA requirements include subclassifications of zone (i.e., V1, VE, etc.) while BOCA addresses the zones and Zone V. Both FEMA and BOCA require a design by a registered professional.

Recommendation: See 44 CFR 59.1 - Elevated buildings.

44 CFR 60.3	BOCA Code	Analysis
(e)(5) Breakaway walls	2101.6.4.1 2101.6.4.2 2101.6.11.3	FEMA's provisions (Zone V) require the lowest horizontal structural member to be above the BFE with the space below free of obstructions or constructed of breakaway construction or open lattice. This is consistent with BOCA with the exception that FEMA provides a design safe loading resistance of 10-20 psf. BOCA does not provide this criteria. Additionally, FEMA cites "substantial improvements" - see discussion for FEMA (e)(2). Also, the FEMA requirements include subclassifications of zones (i.e., V1, VE, etc.) while BOCA addresses the zones as Zone V. Both FEMA and BOCA require a design by a registered design professional.

Recommendation: FEMA should conduct the necessary research to support the 10-20 psf design loading for breakaway walls. A system designed in this load range may breakaway under a design wind condition. Upon resolution of this issue, it would then be appropriate to prepare a code change which reflects the results of the research as design criteria to be included in BOCA. See also 44 CFR 59.1 - Elevated buildings and FEMA-55 Section 4.3.5.1.

44 CFR 60.3	BOCA Code	Analysis
(e)(6) Fill	2101.6.4.3	FEMA's provisions (Zone V) do not permit the use of fill for structural support. BOCA does not include this limitation. Also, the FEMA requirements include subclassifications of zones (i.e. V1, VE, etc) while BOCA addresses the zones as Zone V.

Recommendation: It would be appropriate to propose a revision to BOCA to include this prohibition. See also 44 CFR 59.1 - Elevated buildings.

44 CFR 60.6	BOCA Code	Analysis
(c)(2)(i) Flood-proof walls	107.2 107.4 2101.6.3 2101.6.3.1 2101.6.3.2 2101.6.3.3	FEMA provides criteria for local communities to evaluate relative to granting requests for variances of residential buildings in Zone A. Included in this section is requirements for basements below the BFE to be flood proofed with watertight walls designed to resist flood waters. BOCA requires residential basements to be located above the BFE. The only exceptions being basements not used for human occupancy. The BOCA codes, however, provide for evaluating alternative methods and materials to that required by the code but do not provide prescriptive criteria. Any alternative approval must be shown to comply with the intent of the code and approved by the local code official.

Recommendation: None

44 CFR 60.6	BOCA Code	Analysis
(c)(2)(ii) Basement top floor elevation	103.3 107.2 107.4 2101.6.3 2101.6.3.1 2101.6.3.2 2101.6.3.3	FEMA's variance criteria requires the top floor of the residential basement in Zone A to be no lower than 5 feet below the BFE. See analysis to 44 CFR 60.6 (c)(2)(i).

Recommendation: None

44 CFR 60.6	BOCA Code	Analysis
(c)(2)(iii) Fill	103.3 107.2 107.4 2101.6.3 2101.6.3.1 2101.6.3.2 2101.6.3.3	FEMA's variance criteria requires the surrounding grade to be filled around the residential basement to above the BFE in Zone A. See analysis to 44 CFR 60.6 (c)(2)(i).

Recommendation: None

44 CFR 60.6	BOCA Code	Analysis
(c)(2)(iv) Use of registered professional	103.3 107.2 107.4 2101.6.3 2101.6.3.1 2101.6.3.2 2101.6.3.3 2101.6.11.3	FEMA's variance criteria requires a registered professional engineer or architect to design the structure (Zone A). BOCA requires a registered professional only for V-Zones. See analysis to 44 CFR 60.6 (c)(2)(i).

Recommendation: None

44 CFR 60.6	BOCA Code	Analysis
(c)(2)(v) Building inspection	109.0 110.0	FEMA and BOCA both require inspections to ascertain compliance with the permit although BOCA's requirement is applicable to all types of construction projects.

Recommendation: None

Elevated Residential Structures (FEMA-54)

FEMA-54	BOCA Code	Analysis
P.68 Posts	1207.2	FEMA requires concrete collars or bearing pad. BOCA requires the poles to be treated in accordance with AWPA C2 or C4. The wood foundation system shall be designed in accordance with NFoPA TR7 and all lumber in accordance with AWPB-FDN.

Recommendation: None

FEMA-54	BOCA Code	Analysis
Pgs. 69-70 Post Embedment	1207.1 1205.1	BOCA and FEMA both require the depth of the embedment to be below the frost line. FEMA states that special loading such as the forces from flooding, and debris which is carried in a flood be taken into account when designing. FEMA cites prescriptive criteria for embedment of the posts and for subsequent backfill. BOCA cites design criteria.

Recommendation: None

FEMA-54	BOCA Code	Analysis
P. 75 Piers	1212.0 2101.6.4.3	FEMA requires that the piers resist the effects from horizontal and uplift loads due to wind and water as does BOCA. Concrete and brick piers shall be used when elevating 1-1/2 to 6' off the ground. BOCA requires that plain concrete piers be constructed in accordance with ACI 318. If steel shells are used, the thickness shall be a minimum of 1/4" thick. BOCA also states dewatering specifications.

Recommendation: None

FEMA-54	BOCA Code	Analysis
P. 77 Piers	1205.0 1203.0	FEMA states that footings shall be poured in place or rest on the soil if the proper soil conditions exist. The footing size is a function of the soil bearing load capacity. BOCA uses design conditions for analysis of placement and size. In addition BOCA requires that soils testing be done prior to the addition of a footing.

Recommendation: FEMA should require a geotechnical report to ensure sufficient load bearing capacity of the soil.

FEMA-54	BOCA Code	Analysis
P. 79 Shear Walls and Floor Diaphragms	1109.4	FEMA requires that shear walls be used in parallel to brace against low-medium velocity flooding. Floor diaphragms should be aligned to resist horizontal forces. Flood areas should include additional bracing for wind and rain conditions . FEMA also cites design guide "Design and Construction Manual for Residential Buildings in Coastal High Hazard Areas". BOCA requires that all buildings in flood hazard zones be designed to resist the hydrodynamic forces which occur in the area.

Recommendation: None

FEMA-54	BOCA Code	Analysis
Pgs. 84 and 85 Pier Foundation Connections	1703.2.11	FEMA allows the piers to be attached to the floor by metal straps and bolts and offers diagrams describing the uses of piers. FEMA prescribes embedment of 12" for concrete piers and 16" for masonry piers. BOCA designates 8" embedment for concrete piers and 15" for masonry. The BOCA code also prescribes 2 anchor bolts be placed from the end. FEMA and BOCA require embedment which differs slightly.

Recommendation: This is a minor conflict, which if necessary, would require FEMA to conduct an evaluation of the relevant standards to determine if a "correct" embedment can be ascertained.

FEMA-54	BOCA Code	Analysis
P. 88 Concrete and Wood Flooring Systems	1703.2.4.1	FEMA requires that all members be tied and secured. Ends of beams shall rest or bend not less than 4 inches or be supported by metal stirrups or hangers. BOCA requires that metal connector straps shall be used for every other joist and wall studs shall be anchored.

Recommendation: None

FEMA-54	BOCA Code	Analysis
P. 92 Related Design Considerations	2202.1 2101.6.8 2101.6.3.4	FEMA requires glass windows to be protected from wind and changes in pressure. FEMA states that utilities should also be protected or elevated and sanitary systems should be designed to alleviate discharge due to flooding. BOCA does not require glass protection but relies on properly designed glass for the specified loads. BOCA also acknowledges utility protection/elevation and the need for properly designed sewage systems. See also Analysis of BOCA National Mechanical Code.

Recommendation: None

FEMA-54	BOCA Code	Analysis
P.93 Building Materials	1701.1 1703.2.6 1702.5.2.3 (Supp.) 1702.6.3 1801.4 1802.3 1503.3.2 1506.6.3 2106.6.6	FEMA identifies that preservative treatment is required for wood, steel requires corrosion protection, admixtures are required for concrete to improve freeze-thaw and strength. FEMA does not provide specific recommendations to achieve the desired results but rather includes names and addresses of associations to be contacted for guidance. See BOCA analysis to FEMA-54 Wood, Steel, Concrete and Masonry and FEMA-55 Sections 4.1.2 and 4.2.1.4.

Recommendation: See FEMA-54 Wood, Steel, Concrete, and Masonry and FEMA-55 Sections 4.1.2 and 4.2.1.4.

FEMA-54	BOCA Code	Analysis
Pgs. 94 and 95 Wood, Steel, Concrete and Masonry	1802.3 1702.6	BOCA requires that pressure treated wood shall conform with standards AWPA C1, C2 and C9 and AWPB-FDN. Preservatives to conform to AWPA P1, P2, P5, P8 and P9. Section 1802.3 states that steel shall be protected for exterior use with a shop or field coat to prevent corrosion. FEMA states that steel shall be protected for exterior use with a shop or field coat to prevent corrosion.
Admixtures	1502.6	BOCA requires that admixtures, if used, shall follow requirements of ACI 318, ASTM C260, ASTM C618 and ASTM C989 depending on the type used. FEMA does not include requirements for the use of admixtures.
	1503.1	BOCA cites that concrete shall be proportioned to provide the average compressive strength as prescribed by ACI 318, not less than 2500 psi. FEMA does not include the standard.
	1401.11	Mortar shall comply with the requirements of ASTM C270. FEMA states that wood shall be treated to resist fungus, insects, bacteria and rot. In addition the treatment must be designed to keep water out. Steel should be painted and bolts should be galvanized. Concrete and masonry units should have surface treatments and should also include additives.

Recommendation: See FEMA-55 Section 4.1.2. Also, FEMA should consider referencing the applicable standards for wood preservatives, concrete, and masonry.

FEMA-54	BOCA Code	Analysis
Pgs. 95 and 96 Insulation	928.0	BOCA states that when insulation is installed specific flame spread ratings and smoke developed ratings are required to be adhered to. A vapor retarder shall be installed on the warm side of the building having a performance not exceeding 1. FEMA requires insulation exposed to flood conditions to be impermeable and able to withstand submersion.

Recommendation: None

FEMA-54	BOCA Code	Analysis
Pgs. 113-115 Glossary	1109.4	Hydrodynamic loads in Zones A and V shall be incorporated into the design of these buildings and structures. FEMA defined all the flood zones in relation to 100 year floor. Hydrodynamic and hydrostatic loads are described without the use of equations.

Recommendation: None

FEMA-54	BOCA Code	Analysis
Pgs. 125 and 135 Performance Criteria	1102.1 1109.3 1109.4	BOCA relies upon the design calculations for all components of the structures. FEMA defined design loads, soil loads citing that each case should be dealt with individually and specifically approved by the code official.

Recommendation: None

Coastal Construction Manual (FEMA-55)

FEMA-55		BOCA Code	Analysis
4.1	Environmental forces	2101.6.1 1109.4	No differences

Recommendation: None

FEMA-55		BOCA Code	Analysis
4.1.1	Wind	1112.0	Both FEMA and BOCA follow ANSI A58.1-1982. FEMA-55 requires an importance factor of 1.11 for all structures while BOCA's factor reflects ANSI A58.1 and requires a 1.05 factor for non-essential facilities (i.e., offices, residential) and buildings of assembly with less than 300 people.

Recommendation: The provisions are compatible for certain types of buildings such as assembly buildings and essential facilities (hospitals, fire station, etc.) It is recommended that FEMA-55 revise its importance factor to correlate with ANSI A58.1-1.05 for all buildings other than essential facilities and assembly buildings with less than 300 occupants.

FEMA-55		BOCA Code	Analysis
4.1.2	Salt air, moisture and wind-driven rain	1801.4 1802.3	BOCA and FEMA require structural steel work and formed steel members to be corrosion protected but BOCA does not specifically address connectors.
		1701.1 1703.2.6 1704.1.1	BOCA references NFoPA NDS which requires galvanized sheet for metal plate connector joints (8.10.3). BOCA requires galvanized steel connections when the frame is more than one story in height and the studs are not continuous from the sill to the roof. FEMA requires all connections to be corrosion resistant.
		1702.5.2.3 (Supp)	Preservative treated wood fastener requirements similar.
		2103.3.10	Flashing requirements similar.
		1402.6	FEMA acknowledges the effects of salt laden air on mortar but does not provide types of mortar which are acceptable. BOCA also does not prescribe specific masonry mortar types for masonry exposed to salt laden air.
		2102.5	BOCA requires that exterior walls of alternative materials be weather-resistant but does not mention corrosion resistance.

FEMA-55	BOCA Code	Analysis
4.1.2 (cont.)	1503.3.2 1506.6.3	FEMA acknowledges the effects of concrete exposed to salt laden air but does not provide criteria. BOCA prescribes minimum concrete properties (w/c, f'c) for concrete exposed to sea water. BOCA and FEMA require increased concrete cover to reinforcement but neither stipulates the increase.
	2101.6.6	BOCA includes a general performance regulation which requires "All buildings ... shall be constructed with materials resistant to flood damage...".

Recommendation: Both codes acknowledge the effects salt laden air and moisture have on building components. FEMA and BOCA require corrosion resistant fasteners for pressure treated wood but neither provide definitive criteria for masonry or concrete. It is recommended that FEMA include a general provision to address moisture protection and BOCA revise its current text. Suggested language is: Construction materials, including connections, shall be resistant to water damage such that conditions of corrosion, deterioration or decay will not occur.

FEMA-55		BOCA Code	Analysis
4.1.3	Water, waves & debris	1109.4	FEMA and BOCA require the structures to resist the imposed loads. BOCA does not include design considerations for a 300 lb. object (debris) impacting the structure which is included in FEMA.

Recommendation: None. After consultation with FEMA, it was determined that a revision to the BOCA code would be premature given the provision has yet to be incorporated into NFIP.

FEMA-55		BOCA Code	Analysis
4.1.4	Effects of forces on higher & larger structures	1109.4 1112.0 108.1 2101.6.11.3	FEMA indicates applicability to residential structures up to 22 feet above grade. BOCA requirements would be applicable to all building types which are properly designed to withstand the water and wind forces. FEMA recommends the use of a qualified architect or engineer for design (with no mention of zone) while BOCA relies on state statutes and regulations to determine if a registered architect or engineer is required to do the design. BOCA does, however, require an engineer's or architect's design for the foundation design and breakaway enclosures for buildings in high hazard zone. (Zone V).

Recommendation: Registration laws for engineers and architects vary from state to state and FEMA should acknowledge these laws. Additionally, the requirements for professional registration (V-zones) should be coordinated between NFIP and FEMA-55.

FEMA-55		BOCA Code	Analysis
4.2	Construction Materials	None	FEMA acknowledges the benefits/drawbacks of different construction materials. BOCA does not provide recommendations as to the appropriate type of material to be used.

Recommendation: None

FEMA-55		BOCA Code	Analysis
4.2.1	Wood	-	-
4.2.1.1	Piling	1213.0 1214.0 1219.0 2101.6.4.3	No differences

Recommendation: None

FEMA-55		BOCA Code	Analysis
4.2.1.2	Main supporting members (beams)	1701.1 1702.6 2106.6.6	FEMA provides limited direction for the design of structural beams. BOCA references NFoPA NDS for the design of wood structures with structural design required to meet the design loads.

Recommendation: None

FEMA-55		BOCA Code	Analysis
4.2.1.3	Other wood construction members	2106.6	FEMA does not require floor joists, studs, plates, etc., to be preservative treated. BOCA requires all construction materials for structures in flood hazard zones to be resistant to water damage.

Recommendation: Main supporting members are critical to the structural integrity of a building but so are joists and other structural elements. It is not clear why FEMA only requires certain structural elements to be preservative treated. FEMA should revise its' criteria to include a requirement for pressure preservative treatment for all structural members subject to flooding.

FEMA-55	BOCA Code	Analysis
4.2.1.4 Wood preservatives	2106.6.6 1702.6.3 1219.2	FEMA requires wood to be pressure preservative treated but does not provide criteria. BOCA requires pressure preservative treatment in accordance with AWPA C2 and C9 for above grade construction and AWPA C3, and AWPB MP1, MP2, MP4 for timber piles.

Recommendation: FEMA should consider referencing the appropriate standards.

FEMA-55	BOCA Code	Analysis
4.2.2 Masonry materials and concrete	1402.6 1503.3.2 1506.6.3	See comments to FEMA Section 4.1.2

Recommendation: See FEMA Section 4.1.2.

FEMA-55	BOCA Code	Analysis
4.2.3 Metals	-	-
4.2.3.1 Aluminum	1901.1	FEMA recommends a 0.7 mil. anodizing finish and/or vinyl finish for aluminum elements such as doors, windows, gutters and flashings. BOCA references AA-SAS30 and AA-ASM35 for aluminum used for structural purposes. No similar requirements.

Recommendation: See FEMA Section 4.1.2

FEMA-55	BOCA Code	Analysis
4.2.3.2 Steel	1801.4 1802.3 1702.5.2.3 (Supp)	FEMA recommends the use of hot-dipped galvanizing for structural steel and the use of stainless steel. FEMA recommends regular inspection and maintenance of metal parts. BOCA requires hot-dipped galvanized for fasteners used for preservative treated wood. BOCA requires steel members to be painted or provided with an approved corrosion resistant coating. No regular inspection parameters are stipulated in BOCA.

Recommendation: See FEMA Section 4.1.2.

FEMA-55	BOCA Code	Analysis
4.2.3.3 Dissimilar metals	None	FEMA recommends that the use of dissimilar metals be avoided due to the potential for rapid corrosion.

Recommendation: This issue is one of providing materials which are not subject to corrosion. See FEMA Section 4.1.2.

FEMA-55		BOCA Code	Analysis
4.3	Design details	-	-
4.3.1	Foundations	1215.0 1217.0 1218.0 1219.0	FEMA cites advantages of different foundation systems and typical design approaches. BOCA does not provide recommendations for the appropriate type of foundation pile but rather provides criteria to be used to design the pile.

Recommendation: None

FEMA-55		BOCA Code	Analysis
4.3.1.1	Soil conditions	1201.1 1202.1 1201.3 1213.1	FEMA provides rules of thumb for evaluating soil conditions and cites the advantages and disadvantages of one soil type over another. FEMA includes a design table of pile capacities for 4 different soil types and includes common foundation scenarios. BOCA requires a foundation analysis to determine the soil capacity for pile foundations. Presumptive bearing values used for spread footings are provided in BOCA which range from 2,000-12,000 psf for the different soils listed. BOCA relies on a designed system to determine the structural acceptability of the building foundation supported by the soil.

Recommendation: FEMA should require a geotechnical report to ensure sufficient load bearing capacity of the soil.

FEMA-55	BOCA Code	Analysis
4.3.1.2 Piles Pile selection	1219.0 1218.0	FEMA recommends minimum timber pile sizes and cites th advantages of square vs. round piles. FEMA recommend concrete piles when higher capacity or longer lengths are needed BOCA does not stipulate minimum timber pile sizes but rathe relies on a design. BOCA specifies a minimum lateral dimensio for precast concrete piles of 10". BOCA relies on a designe system to support the loads.
Pile embedment	1213.0 1214.0 2101.6.4.3	FEMA cites the effects pile embedment has on the structura capacity of the pile. FEMA provides recommended pil penetrations. BOCA does not stipulate minimum pil embedments, but rather relies on a design. BOCA requires pil embedment to consider scouring in high hazard zones (V Zone only.
Pile installation	1215.0 1219.0	FEMA provides details of typical methods to install piles. BOCA does not prescribe the installation details for piles with the exception of cast-in-place concrete piles.

Recommendation: FEMA requires scour around piles to be evaluated for all pile installations while BOCA specifically cites scour for V Zones. It is recommended that BOCA include text for A Zones similar to that for V Zones relative to scour.

FEMA-55	BOCA Code	Analysis
4.3.1.3 Posts	None	FEMA recommends that wood posts should not be used in V Zones or A Zones subject to wave/scour. BOCA does not stipulate that wood posts should not be used but rather relies on a designed system.

Recommendation: It seems overly restrictive to preclude the use of a building material. If adequately designed, wood posts should be considered acceptable. It is recommended that FEMA relax their recommendation of material types in favor of a designed system of material of the designer's choice when such materials can be shown to be suitable for their intended use.

FEMA-55	BOCA Code	Analysis
4.3.1.4 Piers	1212.0 1205.1 1209.0	FEMA recommends minimum footing sizes and embedment depth. BOCA does not prescribe minimum footing sizes, depth, or reinforcement but rather relies on a designed system.

Recommendation: None

FEMA-55	BOCA Code	Analysis
4.3.2 Framing	None	FEMA for information only.

Recommendation: None

FEMA-55	BOCA Code	Analysis
4.3.2.1 Framing methods	None	FEMA cites the different types of wood framing methods and the benefits associated with one system over another. BOCA does not address the different types of construction (platform vs. pole) nor does it acknowledge the benefits associated with one over the other. BOCA relies on a designed system.

Recommendation: None

FEMA-55	BOCA Code	Analysis
4.3.2.2 Beams	None	FEMA cites the different types of wood beams (i.e, solid, built-up, glulam), preferred orientation (i.e., parallel to flow), and splice locations. BOCA does not prescribe any requirements for the beams but rather relies on a designed system.

Recommendation: None

FEMA-55	BOCA Code	Analysis
4.3.2.3 Joists and rafters	1703.2.9.2	FEMA recommends cross bridging for all floor joists located in the velocity zone. FEMA and BOCA require bridging on 8 centers. BOCA also requires bridging at the supp[illegible] if adequate lateral support is not provided. For Use Grou[illegible]-2 (i.e., apartments) and R-3 (single family or multiple single family) dwellings, bridging is only required when the joist depth exceeds 12" or the live load exceeds 40 psf.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.2.4 Subflooring	1702.1 Appendix C	FEMA recommends either 1x4 or 1x6 boards laid diagonally over joists or exterior type plywood following the guidelines of APA "Plywood Construction Guide". BOCA includes floor sheathing tables. FEMA stipulates an exterior glue for plywood while BOCA requires exterior, waterproof type plywood in all exterior uses, but allows either interior type, moisture-resistant type, or exterior type in interior applications and does not stipulate glue between layers for plywood. FEMA stipulates annular ring nails or deformed shank nails while BOCA's recommended fastening schedule (Appendix C) permits common nails.

Recommendation: See FEMA-55 Section 4.1.2 and FEMA 88-2.

FEMA-55	BOCA Codes	Analysis
4.3.2.5 Studs	1703.2.2 1703.2.3 Table 1702.1.2.5	FEMA acknowledges the common use of 2x4 or 2x6 wood studs at 16" o.c. and the increased use of metal studs configured similarly to wood studs. BOCA does not prescribe wall material, but requires that bearing walls be designed to provide adequate support for the materials and to provide for transfer of all lateral loads to the foundation. BOCA permits 24" stud spacing for bearing walls and 48" stud spacing for non-bearing walls. Other maximum stud spacings are given dependent on the plywood sheathing panel span rating. Also, a single top plate may be used only if specific requirements are met.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.2.6 Wall Sheathing	2103.3 1703.2.8 Table 1702.1.2.5	FEMA cites plywood as the typical sheathing material and prescribes exterior grade plywood of at least 15/32" or 3/4" thick. BOCA requires wall sheathing of any approved material. Plywood sheathing is required to be at least 5/16" thick. Appendix C Attachment and fastening requirements are similar.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.2.7 Wall Bracing	1703.2.5	BOCA and FEMA require wall bracing but neither specifies a particular method to be used. BOCA permits plywood sheathing, let-in bracing or any other approved equivalent whereas FEMA recommends plywood.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.2.8 Roof Details Roof Trusses Roof Construction	1702.1.2.1	The BOCA codes gives maximum span of roof sheathing allowed. Similar provisions are absent from FEMA.
	1703.2.10 1703.2.10.1	FEMA indicates typical considerations for roof design. BOCA requires that rafter spans comply with NFoPA Span Tables for Joists and Rafters and that plate connected roof trusses be designed in accordance with TPI Design Specifications for Metal Plate Connected Wood Truss and NFoPA NDS. Trusses must also be braced. Roof deck sheathing must be constructed of an approved material.
	1110.4	BOCA requires that flat roofs be designed to support the maximum possible depth of water assuming all means of roof drainage are blocked while FEMA does not include a similar requirement.
	1102.1	FEMA cites benefits of one roof configuration over another. BOCA does not acknowledge the benefits of one roof configuration (gable, hip, etc.) over another, but rather relies on the roof configuration to be designed to the appropriate loading conditions (i.e., wind, snow, and ponding). BOCA provides specific design provisions for roof overhangs.

Recommendation: FEMA should consider including design tables for roof sheathing and also ponding provisions in the roof design. Alternatively, FEMA could reference the model codes for roof sheathing design tables.

FEMA-55	BOCA Codes	Analysis
4.3.3 Foundation Bracing	1213.4 1213.6	BOCA requires that all piles be designed such that lateral stability is provided in all directions. BOCA does not require bracing for the length of pile above grade (regardless of the height) but rather stipulates that the pile is to be designed as a column to withstand the vertical (compression or uplift) and lateral (water/wind) loads. Bracing (knee braces, trusses, shear walls) would be considered as a design option but is not mandated. FEMA recommends bracing the piles but does not guarantee that this measure alone will make the structure storm resistant. 1109.4 BOCA requires that buildings located in flood-hazard and high hazard zones be designed to resist all hydrodynamic forces. 2101.6.4.3 BOCA requires that all buildings located in high hazard zones be supported on pilings or columns and be adequately anchored to such.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.3.1 Knee Braces	1213.4 1213.6	FEMA recommends that piles be braced. BOCA requires bracing of all piles but does not specify a particular method.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.3.2 Grade Beams	1213.4 1213.6 2101.6.3.2 2101.6.4.3	FEMA recommends the use of grade beams. BOCA permits but does not require the use of grade beams.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.3.3 Truss Bracing	1213.4 1213.6	FEMA prescribes the use of truss bracing systems when th structure is elevated about 10' or more above grade. BOC requires sufficient bracing but does not specify a particula method.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.3.4 Shear Walls	2101.6.3.3 2101.6.4.2	FEMA acknowledges the use of shear walls. BOCA does no allow walls which structurally support the building to be locate below the base flood elevation in high hazard zones.

Recommendation: FEMA should revise their provisions to include the prohibition of shear walls and other walls whic are part of the structural frame below the BFE in V-zones.

FEMA-55	BOCA Codes	Analysis
4.3.4 Connections	2101.6.3.2 1701.1 1102.1	No significant difference.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.4.1 Roof to Wall	1112.2 1112.3 1701.1 2101.6.3.2	Appendix C BOCA requires that all structural members and connections be of sufficient size or capacity to meet or exceed the forces exerted upon them. ANSI A58.1 (ASCE 7) is used as a referenced standard. BOCA does not include provisions for positive connection from the ridge line through interior stud walls to the foundation. FEMA determines the wind uplift force from its own tables and states that toe-nailing alone may not provide a sufficient connection.

Recommendation: It is recommended that FEMA reference the design values of ANSI A58.1-1982.

FEMA-55	BOCA Codes	Analysis
4.3.4.2. Wall to Floor Joist	1112.2 1112.3 1701.1 2101.6.3.2	BOCA requires connections of sufficient size and strength be provided. FEMA prescribes that plywood sheathing be well anchored from the top plate of the stud wall to the floor joists and band beams below.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.4.3 Floor Joist to Floor Beam	1112.2 1112.3 1701.1 2101.6.3.2	Appendix C FEMA recommends the use of either metal or wood connections to anchor joist to beams. BOCA uses the performance oriented language and requires that all connections be of sufficient size and capacity. The recommended fastening schedule (Appendix C) acknowledges 3 toe nails as a connection, however, this would be required to be confirmed by design.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.4.4 Floor Beam to Pile, Post, or Pier	1701.1 2101.6.3.2	FEMA recommends that wood piles be notched no more than 50% of the original bearing area. BOCA relies on a designed system in accordance with accepted engineering practice and NFoPA NDS which is the referenced standard for wood construction. The flood-resistant construction provisions of Section 2101.6 require the structural system to be anchored but this design is left to the designer. BOCA, however does include prescriptive requirements for permitted boring, cutting and notching (1703.2.1), bearing (1703.2.4) and anchorage of sill plates (1703.2.11). BOCA requires a 15" embedment of anchor bolts into grouted masonry while FEMA stipulates 16".

Recommendation: FEMA should reference the design standard for wood, namely, NFoPA NDS-1986 with 1987 revisions and 1988 Supplement - Design Values for Wood Construction.

FEMA-55	BOCA Codes	Analysis
4.3.5 Breakaway Walls	2101.6.3.3 2101.6.4.2 2101.6.11.3	BOCA's requirements for enclosures below the base flood elevation are a function of the flood hazard zone (A vs V). Flood hazard Zone A structures with enclosed spaces are not required to have breakaway construction but are required to have a minimum amount of openings such that the space is designed to equalize the hydrostatic forces on the exterior by allowing the entry and exit of flood waters. Flood hazard Zone V structures are permitted to have enclosed spaces provided the walls and partitions are not part of the structural support of the building and are designed and constructed to breakaway or collapse.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.5.1 Breakaway Wall Designs Screening Lattice Wood Stud Walls Metal Stud Walls Masonry Walls	2101.6.3.3 2101.6.4.2 107.4	BOCA requires that non-bearing walls below the BFE in flood-hazard zones (A Zones) be equipped with sufficient openings to allow for entry and exit of fluid waters. FEMA does not differentiate between these type walls in Type A and Type V Zones. Also, FEMA states (p 4-45) that reinforced masonry walls, due to their "loading resistance" creates an unusual condition and therefore should be designed by a professional engineer or architect. This may be misleading in that all w in V-zones require a design and not just based on construction material.FEMA regulations provide design considerations for designing breakaway walls. BOCA requires an engineer or architect to design the system (V-zones).

Recommendation: See recommendation to 44 CFR 60.3 (e)(5). Also, FEMA may wish to clarify that break-away walls are allowed in A-zones provided the opening criteria is met. This would also be a viable option under the alternate approval provisions of BOCA.

FEMA-55	BOCA Codes	Analysis
4.3.5.2 Design Considerations for Breakaway Walls Connections Working/Ultimate Strength of Fastener Distribution of Wall Loads Bracing Considerations	1109.3 1109.4 1112.0	No difference.
	2101.6.4.2 2101.6.3.3	BOCA requires openings in non-structural solid walls below the BFE for buildings located in flood-hazard (A Zones). FEMA does not have different recommendations for applications in A-Zones and V-Zones. BOCA does not stipulate the breakaway force design criteria while FEMA stipulates 20 psf unless the wind force exceeds this value. If the wind pressure exceeds this value, FEMA requires the enclosure below the base flood elevation to be designed to withstand the wind forces. BOCA does not include provisions for "wave runup" or recommended foundation configurations. FEMA expands on the distribution of wind and water loads below the BFE and recommends design procedures to be followed. BOCA does not promote one design method over another but requires that all load conditions be evaluated and designed for by a registered professional engineer or architect. See also FEMA Section 4.3.5.

Recommendation: See recommendation for 44 CFR 60.3 (e)(5).

FEMA-55	BOCA Codes	Analysis
4.3.6 Utilities	2101.6.5 2101.6.8	FEMA does not allow electrical distribution panels below the BFE. BOCA does allow placement of electrical components below the BFE as long as they are adequately protected and the provisions of NFiPA 70 are met. BOCA requires HVAC systems be protected from the entrance and accumulation of water. FEMA prescribes that duct work be sloped and have emergency openings to allow drainage of accumulated water.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.7 Wind and Storm Protection of Interior	2202.1	BOCA requires windows to be designed in accordance with the wind loads of ANSI A58.1-1982 for the loads associated wit components and cladding. BOCA does not require protective window coverings.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.7.1 Window Selection	2202.1	FEMA recommends that individual panel widths be limi to three feet and the maximum open wall area (doors and win s) be 30%. BOCA does not limit the size of glazed panels as long as they can withstand the wind design pressures. BOCA only limits door and window percentages due to fire hazards and not wind considerations.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.7.2 Operable Shutters	2202.1	FEMA strongly recommends some type of storm protection for glazed openings. BOCA does not require this type of window covering but rather relies on the window to be designed for the wind load for the location in question.

Recommendation: FEMA should determine the appropriate performance criteria for the shutters and stipulate when and what type of shutters are required. This could then be considered by BOCA.

FEMA-55	BOCA Codes	Analysis
4.3.7.3 Gable and Eave Vents	709.1	BOCA has minimum size requirements for vents in enclosed roof spaces. FEMA identifies attic ventilation as an important feature. FEMA also mentions that many standard ventilation products are inadequate for coastal locations with wind-driven rain.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
4.3.7.4 Roofing Material	2303.0 2304.0 2305.0	Both FEMA and BOCA acknowledge the effects rain may have on roof systems and require some type of roof covering. However, FEMA does not provide specific material types. BOCA requires all roofs to be covered with approved coverings which will resist wind and rain. In addition to asphalt shingles, BOCA acknowledges the use of asbestos cement, clay or cement tile, metal, slate, wood and wood shakes. BOCA provides prescriptive installation requirements which address underlayment, fasteners, and permitted roof slopes. BOCA requires installation in accordance with approved manufacturer's installation instructions.
	2306.0	BOCA requires that flashing be installed at all roof openings, gutters, intersections of wall and roof and at change in roof slope or direction. FEMA does not identify specific flashing locations.

Recommendation: FEMA should stipulate the locations which require flashing.

FEMA-55		BOCA Codes	Analysis
4.3.8	Maintenance	Property Maintenance	See Analysis of BOCA National Property Maintenance Code.
		1702.6.6	No significant difference.
		1802.3.2	FEMA recommends that exposed steel be hot-dipped galvanized BOCA requires exposed steel to be protected from exposure i not fabricated from approved corrosion-resistant or galvanizec steel.
			FEMA recommends that the underside of raised building (beams and joists) be covered with sheathing. BOCA leaves the specifics of the design up to the architect/engineer.

Recommendation: None

FEMA-55		BOCA Codes	Analysis
5.1	General Design Considerations - Ground Level Obstructions	2101.6.3.3 2101.6.4.2	Both FEMA and BOCA do not Permit occupied spaces below the base flood elevation.

Recommendation: None

FEMA-55		BOCA Codes	Analysis
5.1	General Design Considerations -Corrosion Protection	1503.3.5 1506.6.3	No significant difference.

Recommendation: None

FEMA-55		BOCA Codes	Analysis
5.1	General Design -Wind Considerations	1109.3 1109.4 1112.0	No significant difference.

Recommendation: None

FEMA-55		BOCA Codes	Analysis
5.2	Foundations - Piles	1213.10 1213.0-1221.0	BOCA allows piles of any approved materials. The materials and installation methods must comply with specific code requirements.

Recommendation: None

FEMA-55		BOCA Codes	Analysis
5.2	Foundations - Other Foundations	1205.0 - 1212.0	FEMA recommends that "strip" foundations be aligned perpendicular to the shoreline. BOCA requires footing design to be in accordance with the appropriate standard (AWPA C2 or C3, ACI 318) and does not require a specific orientation.

Recommendation: FEMA should consider referencing applicable standards for footing designs.

FEMA-55		BOCA Codes	Analysis
5.3	Slabs at Grade	1502.0-1506.0 1509.0	FEMA recognizes a difference between essential (structural) and non-essential (non structural) slab on grade. BOCA permits a minimum slab thickness of 3 1/2 inches and requires a vapor barrier under most installations. BOCA also references ACI 318 concerning the materials, design and installation of concrete.

Recommendation: FEMA should consider referencing ACI 318 for slab on grade design.

FEMA-55		BOCA Codes	Analysis
5.3	Grade Beams	1213.6	No significant difference.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
5.4 Superstructure	1102.0 1305.0	FEMA provides a discussion of the basic elements of low-to-mid size and high rise construction (design loads, piles, pile caps columns, beams, and shear walls). BOCA has no prescriptive requirements for the type of construction materials used in a structure. BOCA does not indicate a benefit of one materia over another but requires that all structures be designed for the appropriate loading conditions (wind, hydrostatic, hydrodynam etc.)
	2101.6.6	BOCA requires that buildings in high-flood or high-hazard zones be constructed of materials resistant to flood damage using construction methods to minimize flood damage.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
5.5 Elevated Floors	1102.0 1305.0	FEMA cites reinforced concrete and precast concrete as typical systems used for floor construction. BOCA does not require a specific method of construction nor the use of specific materials. BOCA requires that all structural components, connections and system be designed for the forces exerted upon them.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
5.6 Exterior walls	1102.0 1305.0	See FEMA-55 Section 5.5 comment.
	2101.6.3.3 2101.6.4.2	No difference
	None	FEMA requests that all fasteners be determined by the designer and not left to the discretion of the installer. FEMA recommends that manufacturer's installation standards and appropriate safety factors be applied to powder-activated fasteners used with concrete. BOCA does not stipulate responsibility or standards for these types of fasteners.

Recommendation: None

FEMA-55		BOCA Codes	Analysis
5.7	Recommendations Use of a Design Professional	108.1 2101.6.11.2 2101.6.11.3 2101.6.3.3	FEMA recommends an experienced design professional to be responsible for mid-and high-rise design. BOCA requires all design for new construction work, alteration repair, expansion addition or modification work involving the practice of professional architecture or engineering be prepared by registered professional architects or engineers as certified by the state in which the project is to be located. All plans specifications and computations must be signed and sealed by the responsible engineer or architect.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
Appendix A - Design Tables Figure A-1 Number of Piles Required Table A-1 Downward Loads per Pile Table A-2 Horizontal Wind Loads per Pile Table A-3 Minimum Embedment Depth of Piles Table A-4 Maximum Unbraced Height of Piles Supporting Breakaway Walls Table A-4.1 Maximum Unbraced Height of Piles Table A-5 Uplift Loads per Foot of Wall Table A-6 Uplift Loads per Pile Table A-7 Capacity of bolt of Floor Beam Connections Table A-8 Concrete Masonry Unit Piers Table A-9 Concrete Piers Figure A-2 Concrete Pier Cross Section Figure A-3 Grade Beams and Slabs Table A-10 Fastener Capacities in Shear Table A-11 Fastener Schedule for Breakaway Walls	1102.0 1109.3 1109.4 2101.6.3.2 2101.6.4.3	FEMA provides loading and design tables to assist in the design of coastal construction. Appendices D and E provide raw calculations and computer programs from which the values in Appendix A were derived. BOCA does not contain design and loading tables by which to design a structure. The performance language of the code states the minimum design requirements that must be met by the design professional. BOCA references many standards (ACI 318, ANSI A58.1, NFoPA NDS, etc.) that shall be used in the design of a building.

Recommendation: None

FEMA-55	BOCA Codes	Analysis
Appendix B -Bracing	1102.0	FEMA provides further discussion of bracing options and loading tables to assist in the design of coastal construction. BOCA does not prescribe specific methods or procedures to follow in designing structural bracing. The performance oriented language of the code requires that all structural members and connections be designed to withstand the forces exerted upon them. BOCA references national standards (ACI 318, ANSI A58.1, NFoPA NDS etc.) to aid the designer.
B.1 Knee Bracing	1109.3	
B.2 Truss Bracing	1109.4	
B.2.1 Diagonals	1213.6	
B.2.1.1 Lumber Diagonals	2101.6.3.2	
B.2.1.2 Threadbar Diagonals	2101.6.4.3	
B.2.2 Struts		
B.3 Grade Beams		
Table B-1 Horizontal Water Loads per pile		
Table B-2 Loads of Transverse Truss Members		
Table B-3 Allowable Loads for Single 2-by-8 Diagonals		
Table B-4 Allowable Loads for Single 3-by-8 Diagonals		

Recommendation: None

FEMA-55	BOCA Codes	Analysis
Appendix D - Design Equations and Procedures	1102.0	FEMA compiles a series of basic design equations and procedures to follow in the design of coastal construction. All values found in Appendix A were derived from these equations based on the assumptions stated. These equations may be used for design in unique situations where the general assumptions do not hold true. Being a performance oriented code, BOCA does not prescribe specific design equations and procedures. However, the code requires that all structural members and connection be designed to withstand the forces exerted upon them. BOCA references many national standards to guide the designer in measuring the code compliance of structures.
D.1 Procedure A-1: Downward Loads per Pile	1109.3	
D.2 Procedure A-2: Horizontal Wind Loads per Pile	1109.4	
D.3 Procedure A-3: Minimum embedment Depth of Piles	1213.0	
D.4 Procedure A-4: Maximum Unbraced Height of Piles	2101.6.3.2	
D.5 Procedure A-4.1: Maximum Unbraced Height of Piles Supporting Breakaway Walls	2101.6.4.3	
D.6 Procedure A-5: Uplift Loads per Foot of Walls		
D.7 Procedure A-6" Uplift Loads per Pile		
D.8 Procedure B-1: Horizontal Water Loads per Pile		
D.9 Procedure B-2: Loads Transferred to Foundation Truss Members		

Recommendation: FEMA should require a geotechnical report to ensure sufficient load bearing capacity of the soil.

FEMA-55	BOCA Codes	Analysis
Appendix G - Sample Coastal Construction Code		FEMA incorporates the discussions, insights and recommendations found in Chapters 1 through 5 into enforceable code language. This sample code is intended as a base which local jurisdictions may amend to create their own coastal construction code as a supplement to the governing building code.
2. Purpose	100.0 2101.6	No difference.
3. Scope	100.2	FEMA applies only to new construction, additions to and improvements of single family, duplex, and multi-family residential structures.
4. Definitions	201.0	FEMA defines terms relative to flood provisions (i.e. base flood, dead load, etc) which are compatible with the application in BOCA. However, BOCA does not define all the terms listed in FEMA.
5. Elevation Standards	2101.6.3.1 2101.6.3.3 2101.6.4.1 2101.6.4.2	No differences
6. Determination of Loading Forces	1100.1	BOCA does not prescribe specific design procedures. BOCA identifies minimum performance requirements of a structure.
6.1 Water Loads 6.2 Wind Loads	1109.3 1109.4 1112.0	
7. Foundation Standards	1100.1 2101.6.3 2101.6.4 1205.0 - 1220.0	FEMA does not allow the use of spread footings and fill for structural support purposes.
7.1 Pile Foundation Design	1100.1 1213.0-1220.0	BOCA does not prescribe a specific method of pile design.
7.2 Column Foundation Design	1212.0	BOCA does not prescribe a specific method of pier design.
8. Anchoring Standards	2101.6.3.2	No difference

Recommendation: None

FEMA-55	BOCA Codes	Analysis
8.1 Connectors and Fasteners	Appendix C	FEMA does not permit toe-nailing as a principal method of connection. All metal connectors and fasteners are to be galvanized.
8.2 Beam to Pile Connectors		Refer to FEMA 55 Section 4.3.4.4 analysis.
8.3 Floor and Deck Connectors		Refer to FEMA 55 Section 4.3.4.3 and 4.3.2.4 analysis.
8.4 Exterior Wall Connection		Refer to FEMA 55 Section 4.3.2.2 and 4.3.2.6 analysis.
8.5 Ceiling Joist/Rafter Connections		Refer to FEMA 55 Section 4.3.2.8 analysis.
8.6 Projecting Members	None	BOCA does not restrict the size of the eaves or other overhangs.
9. Roof Sheathing	2303.1 2304.0 2305.0	FEMA requires roof sheathing at least 15.32 inch thick. All attaching devices shall be corrosion resistant material. FEMA prescribes that roof be sloped as steeply as practicable.
10. Protection of Openings		Refer to FEMA-55 Section 4.3.7.1 and 4.3.7.2.
11. Use of Space Below the Lowest Elevated Floor	2101.6.3.3 2101.6.4.2	BOCA does not prescribe specific design procedures for breakaway walls.
11.1 Breakaway Wall Design Standards		Relocate to FEMA 55 Section 4.3.5, 4.3.5.1 and 4.3.5.2 analysis.
11.2 Certification of Breakaway Walls		Relocate to FEMA 55 Section 4.3.5, 4.3.5.1 and 4.3.5.2 analysis.
12. Utilities		Relocate to FEMA 55 Section 4.3.6 analysis.
13. Certification Requirements	1102.2	Refer to FEMA 55 Section 5.7 analysis.
14. Reference Documents		BOCA references ANSI A58.1-1982 as does FEMA.

Recommendation: None

Manufactured Homes Installation in Flood Hazard Areas (FEMA-85)

FEMA-85		BOCA Codes	Analysis
Chapter III	Elevation on Fill (p.19)	1201.0 1202.0 1203.0	FEMA has prescriptive requirements on the use of fill material to raise the elevation of the manufactured home. However, Section (e)(6) of 44 CFR 60.3 prohibits the use of structural fill in V zones. The requirements address the use of fill under various floodwater conditions and include site preparation and fill placement. BOCA requires that the bearing value of soils is established through testing.
		2101.6.3.2 2101.6.4.3 2101.6.11.2 2101.6.11.3	BOCA requires that a registered professional architect or engineer provide plans and specifications indicating that the proposed foundation design will adequately resist any loads caused by flooding which may cause flotation, collapse, or permanent lateral movement of the structure, or which will scour or erode the soil material. FEMA limits the use of fills for elevating the manufactured home to areas where the floodwater velocity will not exceed 10 feet per second (fps). BOCA does not address maximum floodwater velocity.

Recommendation: FEMA-85 and 44 CFR 60.3 require coordination relative to the use of structural fill.

FEMA-85		BOCA Codes	Analysis
Chapter III	Elevated Foundations Piers (p.22)	1205.1 1212.0	FEMA states that the use of piers is inappropriate in areas subject to floodwater velocity. FEMA's requirements are specification oriented. FEMA limits pier height to 10 times least horizontal dimension; BOCA states maximum of 12 times least dimension for other than single family structures and light structures. BOCA would rely on a designed system in accordance with the referenced standards.

Recommendation: This is a minor conflict, which, if necessary would require FEMA to conduct an evaluation of the relevant standards to determine a "correct" maximum pier height.

FEMA-85		BOCA Codes	Analysis
Chapter III	Posts (p.23)	1207.2 2101.6.3.2 2101.6.4.3	FEMA states some general requirements for the use of wood, steel, or concrete posts. BOCA says pole buildings shall be designed in an approved manner. The provisions of BOCA are not geared to any specific type of structure but rather structures in general. Poles shall be treated accordingly to AWPA C2 or C4 for decay resistance.

Recommendation: None

FEMA-85		BOCA Codes	Analysis
Chapter III	Piles (p.25)	1213.0 1214.0 1215.0 1216.0 1217.0 1218.0 1219.0 1220.0 1221.0 2101.6.4.3	FEMA states that the use of piles is appropriate in areas having high floodwater velocities. Details are given on how to drive the pile and how to increase lateral force resistance. BOCA provides design and driving requirements for different types of piles.

Recommendation: None

FEMA-85		BOCA Codes	Analysis
Chapter III	Horizontal Beams (p.26)	1102.1	FEMA and BOCA both require that the loads associated with the manufactured home are safely transferred to the foundation system.

Recommendation: None

FEMA-85		BOCA Codes	Analysis
Chapter III	Bracing Elevated Foundations (P. 26)	1102.1 1213.4 1213.6	Both FEMA and BOCA require bracing to resist lateral loads.

Recommendation: None

FEMA-85		BOCA Codes	Analysis
Chapter III	Perimeter Enclosure (p.27)	2101.6.3.3 2101.6.4.2 2101.7.1.1	FEMA requires that the skirting around the manufactured home be designed to yield under the forces of floodwaters and not transfer loads to the foundation, BOCA requires the same.

Recommendation: None

FEMA-85		BOCA Codes	Analysis
Chapter 23	Anchoring (P.28)	620.3.1 1109.3 1109.4 1112.0 2101.6.3.2 2101.6.7	FEMA expounds on the various methods available to anchor a Manufactured home so it can resist wind forces. BOCA relies upon the design and certification by an architect or engineer without specifying specific methods.

Recommendation: None

FEMA-85		BOCA Codes	Analysis
Chapter IV A	Flood Forces and Their Application	1102.0 - 1104.0 1106.0 - 1107.0 1104.3 - 1109.4 1111.0 - 1115.0	FEMA provides overviews of specific engineering calculations used to determine the hydrostatic and hydrodynamic forces including impact from debris and scour due to moving floodwater. Roof live load and wind load maps of the United States are also included. BOCA relies upon a professional engineer or architect to design the structure to support all applicable loads in accordance with acceptable engineering practice. FEMA provides a roof load and wind zone map. The snow loads indicated in FEMA are higher than BOCA and the wind load map is also different from BOCA. BOCA's maps are based on ANSI A58-1 - 1982 (ASCE 7).

Recommendation: FEMA should update their wind and snow load maps to the latest currently published by ASCE.

FEMA-85		BOCA Codes	Analysis
Chapter IV B	Evaluation of Elevated Foundations	108.1 Article 11	FEMA discussed the application of design loads to manufactured housing foundation systems. BOCA relies upon the registered engineer or architect to design the structure to resist all required design loads for all structures.
		1201.0 1202.0 1203.0	FEMA discusses the bearing values associates with various soils. BOCA contains similar information.
		108.1 1212.0 1406.0	FEMA specifies pier dimensions and location of reinforcement bars for acceptable pier design for various design considerations BOCA relies upon a system designed by a registered architect or engineer in accordance with the code and its referenced standards.
		108.1 1213.0 1214.0 1801.0	FEMA provides information necessary for the design of pile foundations to provide support for manufactured homes, and also states that a registered professional engineer should design the pile foundation under certain circumstances. BOCA relies upon an engineered design, but also provides details on pile-driving, spacing, splicing, etc.

Recommendation: None. The differences between FEMA and BOCA are related to the specification or performance nature FEMA and BOCA respectively.

FEMA-85	BOCA Codes	Analysis
Chapter IV C Bracing Support and Connections for Elevated Foundations	108.1 1213.6 1214.1 1214.6	FEMA provides design requirements and formulas for determining the size and location of lateral bracing and horizontal support beams for posts and piles. BOCA requires that all bracing methods be designed by an engineer or architect.
	108.1 1102.1 1109.5 1113.11 1303.1 1701.1	FEMA provides design information for all connections. BOCA relies upon an engineered system using materials which have the necessary properties and dimensions to support all loads.

Recommendation: None

FEMA-85	BOCA Codes	Analysis
Chapter IV D Additional Design Considerations	801.1 805.2 2101.6.8	FEMA indicates that an access and egress path must be provided to allow evacuation and rescue. BOCA's general egress requirements address maintenance of exits, however, BOCA specifically permits portions of the means of egress to be below the base flood elevation which would probably render the exit unusable.

Recommendation: It is not clear how the recommendations found in FEMA would be implemented relative to providing a means of evacuation and/or rescue during a flood event. In all likelihood, compliance with these recommendations would preclude a structure from being built in an area prone to flooding.

FEMA-85	BOCA Codes	Analysis
Appendix D	108.1 Article 12	FEMA provides formulas and equations for calculating loads for the design of structural members. BOCA relies upon a design and supporting calculations prepared by a registered professional engineer or architect, and references nationally recognized standards to be used for the design of structural members made of specific materials.

Recommendation: None. It is presumed that the registered engineer or architect will rely upon accepted engineering practice as does FEMA.

FEMA-85	BOCA Codes	Analysis
Appendix E	108.1 620.3 2101.6.3.2 2101.6.4.3 2101.6.7	FEMA provides design information for determining the necessary anchorage for a manufactured home to resist buoyancy and drag forces cause by flooding. BOCA relies on a design and supporting calculations prepared by a registered professional engineer or architect.

Recommendation: None. It is presumed that the registered engineer or architect will rely upon accepted engineering practice as does FEMA.

Floodproofing Non-Residential Structures (FEMA-102)

FEMA-102	BOCA Codes	Analysis
Chapter I E. Contingent Floodproofing Measures	107.4 108.1 2101.6.3.4 2101.6.4.2	FEMA discusses the possibility of utilizing specific contingent floodproofing measures. BOCA permits the use of such contingent floodproofing measures as flood shields and watertight doors for buildings in A Zones only.

Recommendation: None

FEMA-102	BOCA Code	Analysis
Chapter I F. Types of Contingent Measures	107.4 108.1 2101.6.3.3 2101.6.3.4 2101.6.11.2	FEMA addresses the use of flood shields, watertight doors, and moveable floodwalls. BOCA permits these types of devices to be used in Flood-Hazard (A-Zones), but not in high-hazard (V Zones).

Recommendation: None

FEMA-102	BOCA Codes	Analysis
Chapter III Floodproofing Design Permanent and Contingent Measures B. Elevation on Fill	1201.0 1202.0 1203.0	FEMA has prescriptive requirements for the use of fill material to raise the elevation of the manufactured home. However, Section (e)(6) of 44 CFR 60.3 prohibits the use of structural fill in V zones. The requirements address the use of fill for various floodwater conditions and include site preparation and fill placement. BOCA requires the bearing value of soils to be established through testing.
	1224.0 2101.6.3.2 2101.6.3.4 2101.6.4.3 2101.6.6 2101.6.11.2 2101.6.11.3	BOCA requires that a registered professional architect or engineer provide plans and specifications indicating that the proposed foundation design will adequately resist any loads caused by flooding which may cause flotation, collapse, leakage, or permanent lateral movement of the structure, or which will scour or erode the soil material. FEMA limits the use of fills for elevating the manufactured home to areas where the floodwater velocity will not exceed 10 feet per second (fps). BOCA does not address maximum floodwater velocity.

Recommendation: FEMA-102 and 44 CFR 60.3 require coordination relative to the use of structural fill.

FEMA-102	BOCA Codes	Analysis
Chapter III C. Elevation on Posts, Piles, Piers, or Walls	1207.2 1406.0 1801.0 2101.6.3.7 2101.6.4.3 2101.6.6	FEMA states some general requirements for the use of wood, steel, or concrete posts. BOCA says pole buildings shall be designed in an approved manner. Poles shall be treated accordingly to AWPA C2 or C4 for decay resistance.

Recommendation: FEMA should include a reference to the appropriate reference standard for pressure preservative treatment of wood.

FEMA-102	BOCA Codes	Analysis
Piles	1213.0 1214.0 1215.0 1216.0 1217.0 1218.0 1219.0 1220.0 1221.0 1702.6 1802.3 2101.6.4.3 2101.6.6	FEMA states that the use of piles is appropriate in areas having high floodwater velocities. Details are given on how to drive the pile and how to increase lateral force resistance. BOCA provides design and driving requirements for different materials and types of piles. BOCA relies upon material standards for pile materials.

Recommendation: None

FEMA-102	BOCA Codes	Analysis
Piers and Walls	1205.0 1209.0 1212.0 2101.6.6	FEMA provides specifications for the minimum dimensions of piers. BOCA specifies material standards and relies on an engineered design for piers.

Recommendation: None

FEMA-102	BOCA Codes	Analysis
Bracing	1102.1 1213.4 1213.6 2101.6.6	FEMA specifies materials for bracing. BOCA requires bracing to be part of the engineered design.

Recommendation: None

FEMA-102	BOCA Codes	Analysis
Maintenance	2101.6.6 2101.6.9	FEMA requires that regular maintenance be performed o specific materials used for elevating structures. BOCA state that after a flood, the structure is permitted to be repaired to its original state and must always be inspected to obtain its certificate of occupancy.

Recommendation: FEMA should evaluate how the provisions in FEMA-102 correlate with the NFIP requirements relative to "substantial improvement".

FEMA-102	BOCA Codes	Analysis
Chapter III D. Waterproof Construction	108.1	FEMA provides design aids but requires a design professional t accomplish the design. BOCA requires design by a registere professional engineer or architect.
Wall Strength	108.1 2101.6 Article 14 Article 15	FEMA discusses the general principles involved with designin a masonry or concrete wall to resist flood loads, but defers to a registered professional engineer or architect for the actual design, just as BOCA does.

Recommendation: None

FEMA-102	BOCA Codes	Analysis
Floor Strength and Structural Stability	108.1 Article 15	FEMA states that cast-in-place concrete is the only m ia which can adequately resist hydrostatic uplift pressures. BOCA relies upon a system designed by a registered professional engineer or architect.

Recommendation: None

FEMA-102	BOCA Codes	Analysis
Counteracting of Hydrostatic Forces	108.1 1224.2.1 1224.3 1224.4 1224.5 Article 15	FEMA and BOCA address subsoil drainage as a method of reducing hydrostatic uplift pressure. FEMA also provides outlines of other methods such as the use of impervious cutoffs pressure relief systems, and anchorage to reduce hydrostatic uplift pressures. BOCA specifies none of the above but relies upon a system designed by a registered professional engineer or architect.

Recommendation: None

FEMA-102	BOCA Codes	Analysis
Waterproofing	107.4 108.1 1224.4.2 Article 14 Article 15	FEMA addresses the use of impervious concrete, sealants and membranes. BOCA specifies membrane protection for the wall and an approved method for joints and penetrations, but the method is subject to approval by the code official.

Recommendation: None

FEMA-102	BOCA Codes	Analysis
Watertight Cores	107.4 108.1	FEMA includes this method of protection as an alternative to waterproofing the exterior walls. BOCA does not directly address this method of waterproofing.

Recommendation: None

FEMA-102	BOCA Codes	Analysis
Closures and Flood Shields	108.1 2101.6.3.4	FEMA provides details for construction, testing and storing effective flood shields and closures. BOCA permits such flood shields and closures to be used in flood hazard zones (A Zones) only, and they must be designed by a registered professional engineer or architect.

Recommendation: None

FEMA-102	BOCA Codes	Analysis
Floodwall Design	108.1 2101.6.6 Article 14 Article 15	FEMA provides the engineering basis for designing a stable floodwall. BOCA relies upon a registered professional engineer or architect to design the floodwall.

Recommendation: None

FEMA-102	BOCA Codes	Analysis
Floodwall Maintenance	Property Maintenance	See Analysis to BOCA Property Maintenance Code.

Recommendation: None

FEMA-102	BOCA Codes	Analysis
Chapter IV C Floodproofing Utilities	2101.6.5 2101.6.8	The requirements of FEMA and BOCA are similar. FEMA describes prescriptive approaches to protecting utilities, and BOCA relies upon the design of a professional engineer or architect to achieve the desired results.

Recommendation: None

FEMA-102	BOCA Codes	Analysis
Appendix B Glossary	Article 2	BOCA does not contain the terms in Appendix B of FEMA, with the exception of "backflow preventer" and "structure", BOCA's definition of "backflow preventer" is similar to FEMA but FEMA defines "structure" as a walled and roofed building (or tank) and BOCA's definition is "that which is built or constructed."

Recommendation: None

FEMA-102	BOCA Codes	Analysis
Appendix D Floodproofing Performance Criteria B. Design Loads	1102.0 1109.3 1109.4 2101.6.1 2101.6.3.2 2101.6.4.3 2101.6.6 2101.6.11	FEMA describes in detail the loads on a structure caused by floodwaters. BOCA provides information for determining the appropriate snow, live, wind, and seismic loads, but does not address the calculation of floodwater loads.

Recommendation: FEMA should provide data for determining floodwater depth and velocity for use in hydrostatic and hydrodynamic load calculations. If no such data exists, a research effort should be undertaken to establish such data as the basis to develop specific hydrodynamic design loads for incorporation into the model codes.

FEMA-102	BOCA Codes	Analysis
Appendix D Performance Criteria	Article 11 2101.6.3.2 2101.6.4.3 2101.6.5 2101.6.6 2101.6.8 2101.6.11	FEMA addresses load combinations and construction techniques, as well as designing for the effects of floodwaters. FEMA requires that continuous lighting and operation of other emergency equipment be made available in some structures during and after a flood. FEMA provides specific performance criteria for all building systems, BOCA relies upon a design prepared by a registered professional engineer or architect. BOCA stipulates that the equipment must be above the BFE or if below, than it must be designed to resist the flood waters and remain operational. Both FEMA and BOCA require the sanitary sewer system to be designed to prevent sewage from discharging during a flood.

Recommendation: None

Design Manual for Retrofitting Flood Prone Structures (FEMA-114)

FEMA-114	BOCA Codes	Analysis
3.5 Elevation Onto Extended Foundation System	1112.3. 1113.4 1109.3 1206.1 2101.6.3.2 2101.6.4.3	FEMA states that footings and foundations shall be able tc withstand the loading due to flooding. This may necessitate the existing foundation to be upgraded. The foundation should be vented with 1 square inch of opening for every square foot of floor area of the enclosure. Foundations shall also have a rodent barrier, extended backfill and in some cases, breakaway walls. FEMA does not differentiate between the A-zone requirements and V-zone requirements. BOCA states that foundations shall be designed for all loads imposed on the foundation. Section 1109.3 states that all foundations and footings subjected to water pressure shall be designed for a uniform distributed uplift equal to the full hydrostatic pressure.

Recommendation: FEMA requires a revision to clarify when openings to equalize flood waters are required (A zones) versus breakaway walls (V zones).

FEMA-114	BOCA Codes	Analysis
3.12 Technical Design Criteria - Extended Wall Foundations	1109.4 1500.1	FEMA requires walls to be extended to provide the necessary resistance to flood waters impacting elevated walls. Bonding of extensions to existing walls requires a clean wall surface which is free from dirt, debris and loose particles. Hydrostatic and hydrodynamic impact and dead loads shall be considered. BOCA Section 1500.1 BOCA references the concrete sta d, ACI 318 and 1109.4 requires elevated structures and components to be designed to resist hydrodynamic forces in A or V Zones.

Recommendation: None

FEMA-114	BOCA Codes	Analysis
3.13 Technical Design Criteria - Anchorage of Superstructure to Foundation	2101.6.3.2 2101.6.4.3 1703.2.11	Anchor bolts of a 1/2" diameter with a maximum spacing of 4 feet and an embedment depth of 18" are required by FEMA. BOCA's embedment depths are 8" (concrete) and 15" (grouted masonry). The total reaction force due to hydrostatic, hydrodynamic and/or impact loads must be transferred through anchor bolts into the supporting system. FEMA permits expansion anchors as a equivalent means of anchorage. BOCA includes performance criteria which requires the anchors to resist floatation, collapse or lateral movement. However, BOCA's anchorage provision for wood specifies that the anchorage must resist wind uplift and the maximum spacing is 8 feet.

Recommendation: BOCA should revise the provisions of Section 1703.2.11 to reference the design as being capable of resisting both uplift and lateral forces due to flooding (and wind). See also FEMA-54 - Pier Foundation Connections.

FEMA-114	BOCA Codes	Analysis
3.14 Technical Design Criteria - Open Foundations	1212.0 1213.0	FEMA defines piers as vertical structural members with a height to least-lateral dimension of less than 3. Columns, defined by FEMA, have a height to least lateral dimension of 3 or more. Piles are defined as long slender structural members embedded to support loading. BOCA does not define the terms and the height to the thickness ratios prescribed by BOCA for piers are used to design the structural element in accordance with the referenced concrete or masonry standard.

Recommendation: None. Differences between FEMA and BOCA text are due to prescriptive requirements versus performance requirements which result in comparable levels of performance.

FEMA-114		BOCA Codes	Analysis
6.1, 6.2, 6.3	Floodwalls	1201.1 1203.1 1109.4	FEMA specifies that a floodwall is to be designed based on the type of flooding expected, erosion potential, possible obstructions and impact on flooding of adjacent property. Accordingly, closures must be constructed and drainage shall be provided for. Also, FEMA states that floodwalls shall have a water collection system and the soil should be evaluated for it's ability to support the loads imposed and seepage. BOCA also requires a soil test and does not specifically state floodwalls as an option but relies on a designed system to resist the loads.

Recommendation: None

FEMA-114	BOCA Codes	Analysis
6.5 Technical Design Criteria	1109.4 1102.1	Building Code Requirements for Concrete Masonry Structures & ACI 531-70 are listed as standards in FEMA. This section also includes many design considerations for the design of floodwalls. BOCA relies on the 1988 edition of ACI 530 and does not provide specifics but rather relies on a designed system to withstand the loads.

Recommendation: FEMA should update to the latest referenced standard for masonry - ACI 530/ASCE 5-88.

FEMA-114	BOCA Codes	Analysis
7.1 and 7.2 Closures	1109.3 1109.4 1223.1	FEMA cites that closures (temporary or permanent) are used for openings such as doors and windows. BOCA Sections 1109.3, 1109.4 and 1223.1 require buildings to be constructed in areas where flooding occurs to resist the hydrostatic and hydrodynamic loadings but does not require prescriptive requirements for the openings.

Recommendation: None

FEMA-114	BOCA Codes	Analysis
7.3 Low Profile Permanent Closures	1109.3 1109.4 1223.1 1224.4	FEMA requires that permanent floodwalls be built to protec various openings in the building. These floodwalls shall be buil of brick or concrete and be constructed tight to the structure. Sealants may also be required for seepage. BOCA states tha the walls exposed to possible hydrostatic pressure condition shall be waterproofed with two-ply hot-mopped felts not les than 6 mil. polyvinyl chloride, 40 mil polymer modified asphal 6 mil polyethylene or an approved material. BOCA does not require closures for the openings but if provided, the design o the wall would be based on the hydrostatic and hydrodynamic forces in accordance with accepted engineering principles.

Recommendation: None

FEMA-114	BOCA Codes	Analysis
7.4 Closure materials and Construction	1109.3 1223.1 1109.4 1224.4	FEMA requires that the construction of closures for openings are required to resist the flood pressures incurred. The closure should be made watertight through the use of neoprene and rubber. See Section 7.3 for BOCA analysis.

Recommendation: None

FEMA-114	BOCA Codes	Analysis
7.6 Technical Design Criteria	1109.3 1223.1 1109.4	FEMA stipulates that the closure must resist hydrostatic, hydrodynamic and impact loading. Formulas for stress and strain are provided. In addition the Plywood Design Specification was cited as a reference. See Section 7.3 for BOCA analysis.

Recommendation: None

FEMA-114	BOCA Codes	Analysis
8.1 and 8.2 Sealants	1224.0 1109.4	FEMA states that based on an investigation from the U.S. Army Corps. of Engineers, buildings may tend to float or structural elements buckle if constructed of brick or masonry and the flood depth is 2-3 feet. Impact loads caused from debris should also be considered in addition to uplift loading. BOCA does not identify potential problem scenarios but rather relies on a designed system.

Recommendation: None

FEMA-114	BOCA Code	Analysis
8.3 Sealing Techniques	1306.1 1224.0 1109.4	FEMA describes the proper construction for waterproofing brick faced walls. FEMA also describes the possible uses of polyurethanes. Drainage systems are also described. BOCA does not provide any sealing techniques but rather relies on a designed system.

Recommendation: None

FEMA-114	BOCA Codes	Analysis
8.4 Closures	1109.3 1109.4 1224.0	FEMA states that closures used for retrofitting typically include a waterproofing gasket in conjunction with a reinforced door jamb. Shields can also be used for windows. BOCA does not provide prescriptive methods for constructing closures but rather relies on a designed system.

Recommendation: None

FEMA-114	BOCA Codes	Analysis
8.5 Design details	1109.3 1109.4 1224.0	FEMA cites studies of the performance of block walls under hydrostatic pressure and indicates the need for a structural engineer to design the system. Again BOCA requires all designs to be done through accepted engineering practice.

Recommendation: None

FEMA-114	BOCA Codes	Analysis
8.7 Technical Design Criteria	1224.5.2 1202.0 1222.0 1500.0	FEMA states that existing basements may require additional reinforcing when subjected to the forces of soil and water. Foundation walls consisting of concrete shall conform to the requirements of ACI 318. Anchorage of the foundation as well as drainage systems should be analyzed by an engineer. BOCA requires foundation walls to be designed to resist the imposed loads and also references ACI 318.

Recommendation: None

FEMA-114	BOCA Codes	Analysis
9.1, 9.2, 9.3, 9.4 Protection of Utilities	2101.6.5	Both BOCA and FEMA discuss precautions required to prevent damage to utilities such as gas and electrical service. Such techniques include installation of utility connections above the flood level. Utilities within the building basement may be shielded with floodwalls or suspended from platforms.

Recommendation: None

FEMA-114	BOCA Codes	Analysis
9.5 Utility Relocations to Existing Space	2101.6.5	FEMA states that relocation of the utilities is another option which the homeowner may take. This would also be an option under BOCA but is not stated as such.

Recommendation: None

FEMA-114	BOCA Codes	Analysis
9.6 Utility Relocations to New Space	2101.6.5	FEMA indicates that utilities may be stored in an elevated room if there is not an area within the residence which is available. This would also be an option under BOCA as well but is not stated as such.

Recommendation: None

FEMA-114	BOCA Code	Analysis
10.4 Floating Structures	None	FEMA identifies a unique type of structural approach to floodproofing - a floating structure. This structure is permitted to rise and fall with the floodwaters but is restrained from lateral movement. Utility connections are made with flexible connections. BOCA does not indicate provisions for this type of structure but as a performance code, this would be permitted as approved by the code official.

Recommendation: None

FEMA-114	BOCA Code	Analysis
Appendix C Forces	1109.4	FEMA provides design equations for hydrostatic pressure, buoyancy, hydrodynamic pressure, etc., coupled with examples. BOCA relies on a design system in accordance with accepted engineering principles.

Recommendation: None

Alluvial Fans: Hazards and Management (FEMA-165)

FEMA-165		BOCA Code	Analysis
P.10 #6	Windows and Doors	2101.6.4 2101.6.4.2	FEMA recommends that windows and doors not be used on the uphill side of the structure; but if they are, they should be reinforced to strengthen resistance against debris and hydrodynamic forces. BOCA does not contain specific requirements for alluvial fan flooding, but this type of flooding is usually included in high-hazard zones (V Zones). BOCA requires that spaces below the base flood elevation are not used for human occupancy and must be constructed to allow the walls and partitions to break away under the forces of wind and water loads.

Recommendation: BOCA does not currently address flooding due to alluvial fans, per se, which occurs mostly at the base of mountain fronts in the Western United States (as stated on page 1 of FEMA-165). Because alluvial fan flooding has not been shown to be a relevant problem in areas governed by BOCA, it is recommended that no change be made to the National Codes.

MCRB	BOCA Code	Analysis
III.A.1 Unreinforced block	1109.3 1009.4 1222.0 Article 14	FEMA provides a general description of unreinforced masonr basement walls (8"-10" thick) and also recommends they only b used for "minimal loadings." BOCA includes requirements fo these walls (mortar, minimum thickness, etc.), references AC 530/ASCE-88, and requires a system designed to resist impose loads.

Recommendation: FEMA should reference the masonry design standard, ACI 530/ASCE-88 and should reconsider it recommendation that masonry be used only for "minimal loadings" when the system is properly designed.

MCRB	BOCA Code	Analysis
III.A.2 Reinforced and grouted block	1109.3 1109.4 1222.0 Article 14	FEMA provides a general description of reinforced masonr basement walls. See Analysis to MCRB III.A.1.

Recommendation: See MCRB Section III.A.1.

MCRB	BOCA Code	Analysis
III.A.3 Unreinforced concrete	1109.3 1109.4 1222.0 Article 15	FEMA provides a general description of unreinforced concrete basement walls (8"). BOCA includes requirements for these walls (f'_c, admixtures, placing, etc.), references ACI 318.1-[illegible] nc requires a designed system.

Recommendation: FEMA should reference the plain concrete design standard, ACI 318.1-89.

MCRB	BOCA Code	Analysis
III.A.4 Reinforced concrete	1109.3 1109.4 1222.0 Article 15	See Analysis to MCRB III.A.3. Additionally, BOCA references ACI 318-89.

Recommendation: FEMA should reference the reinforced concrete design standard, ACI 318-89.

MCRB	BOCA Code	Analysis
III.A.5 Stone,cribbing and planking	1109.3 1109.4 1222.2.4	FEMA acknowledges the past use of rubble stone but does not provide criteria for use. BOCA requires a designed system.

Recommendation: None

MCRB	BOCA Code	Analysis
III.A.6 Treated wood foundations	1109.3 1109.4 1207.3	FEMA indicates a lack of data for wood foundations under flooded conditions. BOCA references NFoPA TR7 for wood foundation systems.

Recommendation: FEMA should review the referenced standard NFoPA TR7-87 to determine applicability to flooded conditions.

MCRB	BOCA Code	Analysis
III.A.7 Variations of foundations	1109.3 1109.4 1222.0 Article 14 Article 15	FEMA summarizes the differences/benefit of partially reinforced masonry, unreinforced masonry, plain concrete and reinforced concrete. BOCA requires a designed system.

Recommendation: None

MCRB	BOCA Code	Analysis
III.A.8 Excavation and backfilling	1109.5 1201.1 1202.1 1205.1 1206.1 1206.2	FEMA provides general guidelines for excavation and backfilling. Both FEMA and BOCA require the foundation to be below the frost depth and the soil to be capable of supporting the loads.

Recommendation: None

MCRB	BOCA Code	Analysis
III.A.9 Formwork	1505.0	Both FEMA and BOCA require the formwork to be designed and constructed to withstand the imposed loads and to prevent leakage of cement paste.

Recommendation: None

MCRB	BOCA Code	Analysis
III.B.1 Basement slab	1109.3 1509.1	FEMA cites a 4" concrete slab thickness for basement slabs and acknowledges the use of 3" and less. FEMA also cites the use (but does not mandate) wire mesh. BOCA requires a 3½" slab thickness with no requirement for mesh but would require the slab thickness to be verified as adequate if subjected to hydrostatic pressures.

Recommendation: None

MCRB	BOCA Code	Analysis
III.B.2 Structural basement slab	1109.3 1509.1	FEMA requires a 6 inch slab with rebar for "undrained systems" and 4 inch slab with wire mesh for "drained systems." BOCA does not include requirements for a "drained" versus "undrained" systems but rather relies on a designed system to resist hydrostatic loads.

Recommendation: None

MCRB	BOCA Code	Analysis
III.B.3 Footing	1109.3 1109.4 1206.1 1209.3	FEMA cites a typical wall footing as 8 by 16 inches and stipulates a depth below frost. BOCA requires a minimum 6 inches thickness for single family houses with the width based on the allowable bearing pressure. BOCA's 6 inch minimum would require the footing thickness to be verified as adequate if subjected to hydrostatic pressures. BOCA also requires a depth below frost.

Recommendation: None

MCRB	BOCA Code	Analysis
III.B.4 Underdrain system (sumps and pumps)	1109.3 1109.4 1224.0	FEMA cites the benefits of a "gravel collector" adjacent to the bottom of the foundation wall but does not require drain tile. FEMA states that tile, if used, should be 4"-6" in diameter with open joints or perforated pipe. FEMA requires an adequate outlet (sump, sewer, gravity, etc.). BOCA requires a g d water table investigation. If hydrostatic pressure will not o r, BOCA requires "dampproofing" and cites dampproofing materials and the need for a foundation drain. If hydrostatic pressure exists, BOCA requires "waterproofing" and cites waterproofing materials. It should be noted that in flood prone areas, BOCA requires the residential basement to be above the BFE if used for human occupancy and therefore the provisions for dampproofing and waterproofing are only intended to abate the hazards of ground water.

Recommendation: The FEMA MCRB Manual discusses the design and construction of residential basement walls subjected to hydrostatic and hydrodynamic loads (i.e. below the BFE). The BOCA code does not permit the water-resistant design option for residential structures with floors usable for human occupancy below the BFE-this option is acceptable for all uses except residential. FEMA NFIP 44 CFR 60.3 (c)(2) also requires "residential structures...(including basements) to be elevated to or above the base flood level..."-unless a variance is granted in accordance with NFIP 44 CFR 60.6. Therefore, FEMA should clarify the use of the MCRB with respect to residential basements used as occupiable spaces.

MCRB	BOCA Code	Analysis
III.B.5.a Ground surface slope-site investigation	1224.2	FEMA and BOCA require an evaluation of the ground water table.

Recommendation: None

MCRB	BOCA Code	Analysis
III.B.5.b Grading and surface drainage	1224.8	FEMA requires the grade to be sloped 6 inches in 10 feet from the basement wall and splash blocks (3 feet) to direct rain water from downspouts. BOCA also requires drainage from the foundation but does not prescribe the slope or details.

Recommendation: None

MCRB	BOCA Code	Analysis
III.B.6 Seepage quantities	1224.5.3	FEMA contains a typical flow analysis procedure to size the sump and pump. BOCA requires the drainage system to discharge into an approved system but does not provide a basis for the design. See also Analysis of BOCA National Plumbing Code.

Recommendation: None

MCRB	BOCA Code	Analysis
III.B.7.a Penetrations	1224.4.3 2101.6.5 2101.6.8	FEMA requires penetrations to be pressure sealed and utility services (except water and sanitary sewer) to enter the house above the BFE. BOCA requires service utilities to be above the BFE or protected and capable of resisting the imposed loads. See also Analysis of BOCA National Plumbing Code.

Recommendation: None

MCRB	BOCA Code	Analysis
III.B.7.b Cracks and joints	Article 15	FEMA states problems of concrete cracking due to shrinkage and areas of stress concentrations. FEMA contains recommendations to reduce cracking: limiting slump, types of aggregate, placement, consolidation, air entraining admixtures, curing, reinforcement, and joints (control, isolation and construction). BOCA relies on a reference to ACI 318-89, and referenced standards for cement and aggregate (see Analysis to FEMA-54, pages 94-95). BOCA prescribes f'_c, air entrainment for freeze thaw only, mixing requirements, curing requirements, concrete acceptance criteria, cover to reinforcement, etc. BOCA does not include requirements for control or isolation joints - this is left up to the designer.

Recommendation: FEMA should consider referencing the applicable standards for concrete.

MCRB	BOCA Code	Analysis
III.B.7.c Waterproofing	None	See Analysis to Sections III.B.4 and III.B.6

Recommendation: None

MCRB	BOCA Code	Analysis
III.B.8 Plumbing subsystems	2101.6.5 2101.6.8	FEMA recommends a sump pump size. FEMA and BOCA require plumbing materials to be capable of resisting the loads and require back flow prevention. See Analysis to BOCA National Plumbing Code.

Recommendation: None

MCRB	BOCA Code	Analysis
III.B.9 Anchorage	1109.3 1109.4 2101.6.3.2	FEMA provides an example for determining the forces due to flood waters and requires the structure to resist such forces. BOCA also requires adequate anchorage but provides no example.

Recommendation: See MCRB Section V.B.1.

MCRB	BOCA Code	Analysis
III.B.10 Concrete construction practices	1504.0	Both FEMA and BOCA provide requirements for placement of concrete although FEMA's provisions are more in general terms while BOCA provides definitive specific requirements.

Recommendation: See MCRB Section III.B.7b

MCRB	BOCA Code	Analysis
III.B.11 Block construction practices	Article 14	FEMA provides general requirements for masonry construction while BOCA references ACI-530/ASCE 5. Both FEMA and BOCA require either type M or type S mortar.

Recommendation: See MCRB Section III.A.1.

MCRB	BOCA Code	Analysis
III.C.1.a-l.d Soil loads	1109.3 1109.4 1201.1	FEMA provides guidelines for soil classification (sand, silt, clay) to determine lateral pressures and includes a design example. FEMA also acknowledges expansive soils, permeability and saturation of soil but provides no criteria. BOCA only requires a soils report to determine the properties of the soil in order for the designer to anticipate the conditions of use and design accordingly.

Recommendation: None

MCRB	BOCA Code	Analysis
III.C.1.e Erosion	1224.8	FEMA addresses the use of vegetation and proper drainage to avoid erosion. BOCA also requires measures to be taken to prevent soil erosion but does not provide criteria.

Recommendation: None

MCRB	BOCA Code	Analysis
III.C.1.f Backfill	1109.1 1201.1 1222.2.2	FEMA discusses the different types of soil materials - clays, cohesionless soils, and cohesive soils as they relate to lateral earth pressures. FEMA provides presumptive design equivalent fluid weights for different soil types. BOCA requires soil testing and the test results to be used in the determination of the appropriate equivalent fluid weight. It should be noted that the empirical foundation wall requirements in BOCA are based on a maximum equivalent fluid weight of 30 pcf.

Recommendation: None

MCRB	BOCA Code	Analysis
III.C.2 Water table	None	FEMA relates the water table to soil stresses.

Recommendation: None

MCRB	BOCA Code	Analysis
III.C.3 Superstructure loads and buoyancy	1102.1 1104.1 1106.0 1107.0 1109.3 1110.0 1111.0	FEMA provides a design example to calculate the gravity load of the dwelling on the supporting soil (superstructure and basement) and compares this load to the force of buoyancy due to the water table. This is used to determine the anchorage requirements for buoyancy. BOCA does not provide examples but rather relies on a designed system. Upon cursory review of the FEMA design example, it would be considered unconservative to include live loads (10 psf first floor) in the buoyancy calculations due to the fact that these loads may not always be present which may lead to an unconservative anchorage design.

Recommendation: FEMA should review the calculations relative to the inclusion of live load in buoyancy considerations.

MCRB	BOCA Code	Analysis
III.C.4.d Flood velocity	1109.4	FEMA and BOCA require flood velocity waters to be considered in the design.

Recommendation: None

MCRB	BOCA Code	Analysis
III.C.4.e Sediment	2101.6.5 2101.6.6	FEMA cites the problems caused to contents and equipment due to flood water-deposited sediment. BOCA requires placement of mechanical and electrical systems above the BFE or to be protected. BOCA includes a general requirement for buildings to be constructed of materials resistant to flood damage.

Recommendation: None

MCRB	BOCA Code	Analysis
III.C.4.f Rate of rise	1102.1 1109.3 11009.4 2101.6.3.2	FEMA recommends that rate-of-rise information be considered in the design. BOCA does not specifically acknowledge this consideration but this would fall under the general requirement for a design to resist flooding.

Recommendation: None

MCRB	BOCA Code	Analysis
III.C.4.g Hydraulic relations	1102.1 1109.3 1109.4 2101.6.3.2	FEMA cites design considerations of flood water velocity, erosion, sediment, depth, and watershed hydrology. BOCA does not specifically acknowledge these considerations but this would fall under the general requirements for a design to resist flooding.

Recommendation: FEMA should study the conditions of flood water velocity, erosion, sediment, depth, and watershed hydrology in order to provide a comprehensive set of requirements for inclusion in ASCE 7.

MCRB	BOCA Code	Analysis
III.C.5 Debris, wind, impact, snow, ice, and other live loads	Article 11 2101.6	FEMA states that the designs indicated in the manual would not be effected by conditions of "wind, snow, ice and other live loads", but debris and impact may be severe. The manual does not address debris considerations. BOCA requires all structures to be evaluated for all loading conditions.

Recommendation: The basis for FEMA's assertion that loads other than impact and debris will not "appreciably alter the designs recommended" requires substantiation. Additionally, the manual takes the position that debris is not considered but other documents such as FEMA-54 (pages 69-70) and FEMA-55 (Section 4.1.3) require this type of loading to be evaluated. FEMA needs to clarify the effect this has on the use of the manual.

MCRB	BOCA Code	Analysis
V.A.2.a Building model, dimensions and loading	1223.2	FEMA presents a classic model of equivalent fluid design as applied to foundation walls. BOCA requires that walls be designed to resist the pressure of the retained material.

Recommendation: None

MCRB	BOCA Code	Analysis
V.A.2.b Structural analysis model	1223.2	FEMA presents a calculation method for calculating the lateral load capacity of a residential basement wall. BOCA requires calculations without specifying the method of calculation.

Recommendation: None

MCRB	BOCA Code	Analysis
V.A.2.c Structural plain concrete	1222.2.2 1223.2	FEMA presents tabular values for plain concrete basement walls. BOCA provides a prescriptive method for sizing basement foundation walls of plain concrete for unbalanced heights up to 7'-0" with a maximum equivalent fluid pressure of 30 pcf, beyond either parameter walls must be designed by structural analysis.

Recommendation: None

MCRB	BOCA Code	Analysis
V.A.2.d Reinforced concrete	1223.2 1500.1	FEMA presents tabular values for ultimate strength design of reinforced concrete basement walls. BOCA requires walls to be designed to resist the imposed loads. BOCA requires structural members of reinforced concrete to be designed in accordance with ACI 318.

Recommendation: See MCRB Section III.A.4

MCRB	BOCA Code	Analysis
V.A.2.e Plain masonry block	1222.2.2 1223.2 1400.2	FEMA provides a calculation method and design values drawn from the 1970 UBC and NCMA TEK 34 respectively. BOCA prescribes the size of a masonry basement wall with up to 7' of unbalanced height and 30 pcf maximum equivalent fluid pressure. Beyond those parameters Section 1223.2 requires calculations based on masonry design stresses in accordance with ACI 530.

Recommendation: See MCRB Section III.A.1.

MCRB	BOCA Code	Analysis
V.A.2.f Reinforced masonry block	1223.2 1400.2	FEMA provides a calculation method and design values for reinforced masonry block walls. BOCA requires such walls to be designed to resist the imposed loads and relies on design stresses contained in the referenced standard, ACI 530.

Recommendation: See MCRB Section III.A.1.

MCRB	BOCA Code	Analysis
V.A.2.g Flood waters above grade	1109.3 1223.2	FEMA contains an analysis of lateral loads imposed by floo water above grade level in addition to soil loads. BOCA require the design to the resist loads, which specifically includ hydrostatic loads due to flooding. See Analysis to MCRB Sectio III.B.4.

Recommendation: None

MCRB	BOCA Code	Analysis
V.A.2.h Slab thickness	1109.3 1223.2	FEMA provides an analysis of the slab thickness necessary t resist buoyancy loads. BOCA requires design to resist hydrostati loads.

Recommendation: FEMA presents an oversimplified view that a 6 inch thick reinforced slab is adequate (rebar size and placement not described). FEMA should either provide a series of prescriptive design solutions for a broad range of conditions or simply require structural calculations in accordance with the current edition of ACI 318-89.

MCRB	BOCA Code	Analysis
V.A.2.i Structural slab design	1500.1	FEMA provides a derivation of a structural floor slab design to resist hydrostatic loads. BOCA references ACI 318-89 for structural slab design.

Recommendation: See MCRB Section III.A.4.

MCRB	BOCA Code	Analysis
V.B.1 Weir level load	1109.3 1224.4	FEMA assumes maximum head of 5 ft. above floor eleva[illegible] on basement walls. BOCA requires that structural components resist all hydrostatic loads. See Analysis to MCRB Section III.B.4.

Recommendation: FEMA should provide a comprehensive list of hydrostatic design loads for inclusion in ASCE 7.

MCRB	BOCA Code	Analysis
V.B.2 Buoyancy	1109.3 1224.4	FEMA discusses the 5 ft. maximum assumed head as a "practical cut-off." BOCA simply requires design to resist anticipated buoyancy loads for each specific project under consideration. See Analysis to MCRB Section III.B.4.

Recommendation: See MCRB Section V.B.1

MCRB	BOCA Code	Analysis
V.B.3 Slab bending	1109.3 1500.1	FEMA describes the assumption that the span length of the slab is limited to ½ the width of the house. BOCA requires a slab design in accordance with ACI 318-89 to resist imposed loads.

Recommendation: See MCRB Section III.A.4.

MCRB	BOCA Code	Analysis
V.B.4 Wall loads	1109.3	FEMA states that a hydrostatic load is assumed to be acting on walls. BOCA requires walls to be designed to resist all hydrostatic loads. See Analysis to MCRB Section III.B.4.

Recommendation: None

MCRB	BOCA Code	Analysis
V.B.5 Water infiltration protection	1224.4	FEMA states the need to prevent water infiltration in basements. See Analysis to MCRB Section III.B.4.

Recommendation: None

MCRB	BOCA Code	Analysis
V.B.5.a Drained or sump system	1224.5 1224.6 1224.7	FEMA discusses the drained system. BOCA provides requirements for subsoil drainage systems, foundation drainage, placement of backfill and site grading. See Analysis to MCRB Section III.B.4.

Recommendation: None

MCRB	BOCA Code	Analysis
V.B.5.b Undrained or barge system	1109.3 1224.4	FEMA describes details of water-tight basement construction. BOCA requires proper structural design, penetration protection, and use of waterproofing materials. See Analysis to MCRB Section III.B.4.

Recommendation: None

MCRB	BOCA Code	Analysis
VII. Allowable bearing pressures	1201.3	Both FEMA and BOCA provide presumptive soil bearing values.

Recommendation: None

MCRB	BOCA Code	Analysis
VII. Allowable soil pressures beneath footings	1201.1 1201.3 1202.1	FEMA provides soil pressures as a function of footing design and surcharge. BOCA provides presumptive bearing values or requires soil testing to determine the actual bearing values.

Recommendation: None

MCRB	BOCA Code	Analysis
VIII.A.2.a Soil and water loading	1222.2.2	FEMA provides a table containing the weight of saturated soil types. BOCA states where equivalent fluid weight of soils exceeds 30 pcf, foundation walls shall be designed by analysis.

Recommendation: None

MCRB	BOCA Code	Analysis
VIII.A.2.c Waterproofing systems	1224.4 1224.5 1224.6 1224.7	FEMA illustrates drained and undrained systems. BOCA contains provisions for either system. See Analysis to MCRB Section III.B.4.

Recommendation: None

MCRB	BOCA Code	Analysis
VIII.A.2.d Wall design	1109.3 1224.4.2	FEMA illustrates the design of a reinforced masonry block wall. BOCA requires basement walls to be designed to resist hydrostatic loads. See Analysis to MCRB Section III.B.4.

Recommendation: None

MCRB	BOCA Code	Analysis
VIII.A.2.e Slab design	1224.4.1	FEMA illustrates slab design. BOCA requires floors to be designed and constructed to resist hydrostatic loads.

Recommendation: None

MCRB	BOCA Code	Analysis
VIII.B. Acceptable wall designs	1222.2.2	FEMA provides "design curves" for various wall types which allow the determination of the allowable height of hydrostatic loading. BOCA requires walls to be designed to resist the pressure of the retained saturated soil.

Recommendation: None

MCRB	BOCA Code	Analysis
VIII.B.1 Structural plain concrete wall	1222.2.2	FEMA provides "design curves" for unreinforced concrete walls. BOCA requires walls to be designed to resist imposed loading in accordance with ACI 318.1-89.

Recommendation: See MCRB Section III.A.3.

MCRB	BOCA Code	Analysis
VIII.B.2 Reinforced concrete wall	1500.1	FEMA provides "design curves" for reinforced concrete walls. BOCA requires design in accordance with ACI 318.

Recommendation: See MCRB Section III.A.4.

MCRB	BOCA Code	Analysis
VIII.B.3 Unreinforced masonry block wall	1400.3	FEMA provides "design curves" for unreinforced concrete masonry walls. BOCA references ACI 530.

Recommendation: See MCRB Section III.A.1

MCRB	BOCA Code	Analysis
VIII.B.4 Reinforced masonry block walls	1400.2	FEMA provides "design curves" for reinforced concrete masonry walls. BOCA references ACI 530.

Recommendation: See MCRB Section III.A.2.

MCRB	BOCA Code	Analysis
VIII.B.5 Buoyancy wall	1109.3 1224.4.2	FEMA provides illustrative examples of walls designed to brace the basement floor slab against hydrostatic loads. BOCA requires the slab to be designed to resist such loads, which could include consideration of the mitigating effects of such supplemental structural elements. See Analysis MCRB Section III.B.4.

Recommendation: None

MCRB	BOCA Code	Analysis
VIII.C. Reinforced concrete slab	1224.4.1	FEMA provides "design curves" for undrained system floor slabs. BOCA requires design for imposed loads.

Recommendation: None

MCRB	BOCA Code	Analysis
VIII.D.1 Control joints	1224.4.3	FEMA provides details of wall and floor control joints. BOCA requires all joints and penetrations to be water tight. Control joints (if any) are located at the discretion of the designer.

Recommendation: None

MCRB	BOCA Code	Analysis
VIII.D.2 Sump pump underdrain	1224.5.3	FEMA provides details of typical underslab drainage sump details. BOCA requires an approved drainage system complying with the BOCA National Plumbing Code. See Analysis to BOCA National Plumbing Code.

Recommendation: None

MCRB	BOCA Code	Analysis
VIII.D.3.a Waterproofed undrained slab and wall system	1109.3 1224.4	FEMA provides illustrations of design details of undrained basement wall and floor systems. BOCA requires waterproofing and design to resist imposed hydrostatic loads. See Analysis to MCRB Section III.B.4.

Recommendation: None

MCRB	BOCA Code	Analysis
VIII.D.3.b Waterproofed drained slab and wall system	1224.5	FEMA provides illustrative details of drained slab and wall systems. BOCA requires dampproofing in conjunction with subsoil drainage systems. See Analysis to MCRB Section III.B.4

Recommendation: None

MCRB	BOCA Code	Analysis
VIII.D.3.c Slab/wall footing juncture	2101.6.3.2	FEMA provides details of connections between slabs, footings and walls. BOCA requires structural systems to be designed connected and anchored to resist flotation, collapse, or lateral movement.

Recommendation: None

MCRB	BOCA Code	Analysis
Hydraulic/Hydrologic Manual		
I.B.4 Flood Velocity	1109.4	FEMA offers an analytical method for computing velocity loads on structures based on a wind load analogy. BOCA requires design to resist hydrodynamic loads.

Recommendation: FEMA should develop a table of hydrodynamic loads for inclusion into ASCE 7.

MCRB	BOCA Code	Analysis
Hydraulic/Hydrologic Manual		
I.B.5 Sediment	2101.6.6 2101.6.5	See Analysis to MCRB Section III.C.4.e.

Recommendation: None

Technical Standards Bulletin (FEMA 85-1)

FEMA 85-1	BOCA Code	Analysis
Intentional internal flooding	2101.6.3.2 2101.6.3.3	BOCA & FEMA both provide for evaluation of pressure by allowing for the entry and exit of flood waters.

Recommendation: None

FEMA 85-1	BOCA Code	Analysis
Protection goals	2101.6.3.3	BOCA provides for the equalization of hydrodynamic forces and protection of mechanical and electrical systems and water resistant materials, as does FEMA. FEMA also speaks to protection of contents which are outside the scope of the BOCA Codes.

Recommendation: None

FEMA 85-1	BOCA Code	Analysis
Structural features	2101.6.3.2 2101.6.3.3 2101.6.5 2101.6.6	In addition to the above, BOCA provides for foundation anchorage to resist flood loads. FEMA considers all the above as well as referencing specific materials which can be accepted under their text.

Recommendation: None

FEMA 85-1	BOCA Code	Analysis
Building activity and use	2101.6.3.3	BOCA limits spaces below base flood elevation to uses not involving human occupancy. FEMA says to consider the use of such spaces carefully as they are designed to be flooded.

Recommendation: None

FEMA 85-1	BOCA Code	Analysis
Foundations	2101.6.3.2 1109.4	BOCA requires foundations to be designed to resist hydrodynamic and buoyancy forces, as does FEMA.

Recommendation: None

FEMA 85-1	BOCA Code	Analysis
Cavity wall construction	1109.4 2101.4 2101.6.6	BOCA requires design to resist hydrodynamic loads. FEMA requires careful detailing of wall assemblies to mitigate effects of flooding.

Recommendation: None

FEMA 85-1	BOCA Code	Analysis
Solid wall construction	1109.4 2101.4 2101.6	Same as above, except FEMA emphasizes surface deterioration due to freeze-thaw action on porous surfaces.

Recommendation: None

FEMA 85-1	BOCA Code	Analysis
Interior walls	1109.4 2101.4 2101.6	Same as above

Recommendation: None

FEMA 85-1	BOCA Code	Analysis
Interior wall finishes	2101.6.3.3 2101.6.6	BOCA makes no explicit provision to evaluate finishes intended to be periodically submerged. FEMA requires finishes to withstand immersion for 160 hours without damage.

Recommendation: Add performance based text to Section 2101.6.6 to reflect the FEMA requirement.

FEMA 85-1	BOCA Code	Analysis
Floors	2101.6.3.3 2101.6.6	Same as above

Recommendation: None. The preceding recommendation will provide the needed correlation.

FEMA 85-1	BOCA Code	Analysis
Ceilings & Roofs	2101.6.3.2 2101.6.3.3	FEMA requires water-resistant finishes, relief vents and anchorage of the roof structure. BOCA does not provide specifically for relief venting of air trapped by rising flood waters, but general provisions of 2101.6.3.2 require design to resist all structural loads and stresses resulting from flooding.

Recommendation: None

FEMA 85-1	BOCA Code	Analysis
Building Envelope Penetrations	2101.6.3.3 2101.6.6	FEMA requires materials to resist flooding and high humidity Additionally, FEMA addresses needs for protective screens o impact resistant glazing and vents in multiple glazed windows BOCA provides general, performance based text in 2101.6. which speaks to the overall issue.

Recommendation: None

FEMA 85-1	BOCA Code	Analysis
Electrical System	2101.6.5 2700.3	FEMA essentially desires that the portion of the electrical systen subject to flooding be designed for same. BOCA references th National Electrical Code which, in turn, provides detaile requirements for "wet locations."

Recommendation: None

FEMA 85-1	BOCA Code	Analysis
HVAC	2101.6.5	FEMA requires HVAC equipment to be elevated above the bas flood level as does BOCA. BOCA also requires the duc insulation to be elevated above the base flood elevation. See also Analysis of BOCA National Mechanical Code.

Recommendation: None

Technical Standards Bulletin (FEMA 85-2)

FEMA 85-2	BOCA Code	Analysis
Flood Forces	1109.3 1109.4 2101.6.3.2 2101.6.3.4	FEMA addresses hydrostatic, hydrodynamic & buoyancy forces, as does BOCA.

Recommendation: None

FEMA 85-2	BOCA Code	Analysis
Openings Design Criteria	2106.3.3 107.4	FEMA requires two openings with a total area not less than 1 square inch for every square foot of enclosed area subject to flooding to equalize pressure as does BOCA. FEMA and BOCA would also permit an approved alternative design. BOCA also requires the design to be performed by a registered professional architect or engineer.

Recommendation: None

Technical Standards Bulletins (FEMA-85-3)

FEMA 85-3	BOCA Code	Analysis
Wind and Water Forces	1109.4 1112.0 2101.6.4.2	FEMA references ANSI A58.1, 1982 for wind loads. BOCA references ASCE 7, 1982, the same document by another name FEMA requires break-away walls to resist wind loads but fail in response to combined wind and hydrodynamic loading. BOCA requires all structures to resist such loads except for coastal high-hazard zones where break-away walls are permitted.

Recommendation: Modify Section 1109.4, "Hydrodynamic loads" to reference Section 2101.6.4.2.

FEMA 85-3	BOCA Code	Analysis
Design Approach	1109.4	FEMA provides specific criteria for evaluating "break-away" walls. BOCA requires structural elements be designed to resist hydrodynamic loads except in coastal high-hazard flood zones where break-away walls are required to resist wind loads but not wind and water loads acting simultaneously.

Recommendation: See above

FEMA 85-3	BOCA Code	Analysis
Design Considerations	108.1 1109.4 1213.1 1213.4 1213.5 1213.6 1214.6 1400.2 1400.3 1401.11 1702.1 1703.2 1802.1 2101.6.4.2 2101.6.4.3	FEMA addresses the materials and connectors used in break-away walls and provides specific details. FEMA also addresses the effects of "scour" on embedment depth for piles, use of [illegible] beams and orientation of floor beams/joists relative to direction of force from wave action as well as bracing of piles, as does BOCA. BOCA provides for the structural analysis of all structural elements including break-away walls, but does not provide for specifics of break-away wall action or design, relying on professional certification of the adequacy of such designs.

Recommendation: See recommendation for Wind and Water Forces. Additionally, please note that the 8th sentence under "Masonry walls" in 85-3 is probably incorrect for most conditions. This sentence states "Once the pins fail, the wall will cantilever with the reinforcing bars at the bottom of the wall, providing additional resistance to failure until the wall's capacity is reached." What is more likely, is that a load sufficient to cause the failure, in shear, at connecting pins at the top of the wall, can be expected to result in an immediate failure, in bending, at the bottom. We therefore recommended this statement be deleted or modified.

Technical Standards Bulletin (FEMA 88-1)

FEMA 88-1	BOCA Code	Analysis
Wind design standards & the NFIP	1112.3.1 1113.0 2101.6.1 2101.6.3.1 2101.6.4.1 2101.6.4.3 2101.6.4.2	FEMA restricts construction in areas subject to 100 year flood (1 percent chance per year). FEMA requires elevation of the lowest horizontal structural member above base flood elevation in coastal high-hazard flood zones. FEMA requires consideration of the simultaneous effect of wind and water loads in such areas, relying on ANSI A58.1, 1982 to determine wind loads. BOCA is consistent with these provisions. FEMA does not address the resistance of structures to seismic loads. BOCA requires seismic loading appropriate to geographical location to be considered.

Recommendation: None

Technical Standards Bulletin (FEMA 88-2)

FEMA 88-2	BOCA Code	Analysis
Flood Resistant Materials	2101.6 2101.6.6	FEMA provides for the review of all permits for construction in a flood zone as well as requirements for flood resistant construction, so does BOCA. FEMA defines "flood resistant material" and provides a preliminary list of materials classified as to their perceived resistance to the effects of flooding. BOCA addresses this material evaluation by referencing applicable material standards for certain construction materials.

Recommendation: FEMA should conduct the necessary research to indicate in 88-2 which of the materials referenced by Section 2101.6.6 of the BOCA National will "withstand direct and prolonged contact with flood waters without sustaining significant damage. The criteria by which significant damage is assessed is especially important to establish. Such information can then provide a technical basis for proposed changes to the model codes which will establish a regulatory basis for requiring flood damage resistant material. Modify 2101.6.6 to add a performance criterion for flood resistant materials such as referenced under "What Constitutes Flood Damage Resistant Material" in 88-2.

Technical Standards Bulletin (FEMA 88-3)

FEMA 88-3	BOCA Code	Analysis
Lower area obstructions	2101.6.4.1 2101.6.4.2 2101.6.4.3 2101.6.11.3	FEMA prohibits elements of the structure located below the BFE except for slabs, pile caps, and bracing and except as specifically analyzed and certified by a professional engineer or architect. BOCA is entirely consistent with these provisions.

Recommendation: None

FEMA 88-3	BOCA Code	Analysis
Obstructions outside the perimeter of the coastal building	2101.6.4.2 2101.6.4.3	FEMA discusses the effect of potential obstructions adjacent to buildings on the hydrodynamic loads which such buildings must be designed to resist. BOCA simply limits such adjacent structures to incidental storage of portable or mobile items readily moved in the event of a storm. BOCA requires piles to be adequately embedded to resist combined water and wind loads despite scour of soil strata surrounding the piling.

Recommendation: None

FEMA 88-3	BOCA Code	Analysis
Obstructions attached to but outside the building perimeter	2101.6.3.1	FEMA states that any "construction item" such as a swimming pool, deck, or accessory structure attached to a coastal building must be above the BFE or constructed with non-supporting break-away walls. BOCA permits only means of egress, incidental storage and parking to be located below the BFE. Attached structures must either be incidental storage readily moved in the event of a storm or constructed of break-away walls and partitions.

Recommendation: None

Technical Standards Bulletin (FEMA 88-4)

FEMA 88-4	BOCA Code	Analysis
Protection of elevator equipment in flood hazard areas	2101.6.5	FEMA recommends that elevator equipment be located above the BFE or be water-resistant. Further, elevators should be interlocked to ensure that the cab automatically stays above floo water. BOCA requires all mechanical/electrical equipment to b placed above the BFE or protected to prevent water entering th equipment or system during floods up to the BFE.

Recommendation: Add a subsection to 2606.2 "Emergency operation of elevators" to require elevators to automaticall move to a predetermined level above the BFE in the event of flooding.

Technical Standards Bulletin (90-2)

FEMA 90-2	BOCA Code	Analysis
NFIP requirements for below grade parking garages in flood hazard areas	2101.6.3.4 2101.6.4	FEMA generally does not permit below grade garages in flood hazard areas. Below grade parking is not permitted in V-zones. Similarly, floodproofing is not permitted in V-zones. Below grade parking is permitted in A-zones for non-residential buildings provided the building is floodproofed to the BFE. FEMA permits enclosed parking areas under residential and non-residential structures elevated on piers or piles as long as enclosing walls are designed as break-away walls. BOCA likewise does not permit residential uses below the BFE, but specifically does provide for garages. BOCA prescribes the options of flood proofing or break-away walls.

Recommendation: None

Technical Standards Bulletin (90-3)

FEMA 90-3	BOCA Code	Analysis
Non-residential flood-proofing certification requirements of the National Flood Insurance Program	1109.3 1109.4 2101.6.1.1 2101.6.3.1 2101.6.3.2 2101.6.3.4 2101.6.3.5 2101.6.5 2101.6.6 2101.6.8 2101.6.11	FEMA requires flood zones to be determined by the flood insurance rate map. FEMA permits flood proofing of non-residential uses only. Such structures must resist hydrostatic and hydrodynamic loads which are specified. FEMA requires protection of utilities (plumbing, mechanical, electrical). Professional certification is required. BOCA is consistent with these requirements.

Recommendation: None

Technical Standards Bulletin (90-4)

FEMA 90-4	BOCA Code	Analysis
Installation of manufactured homes in special flood hazard areas	120.4 620.3.1 2101.6 2101.6.3.2 2101.6.4.3 2101.6.5 2101.6.7 2101.6.9	FEMA requires manufactured (mobile) homes to be placed s that the lowest floor is either above the BFE, or placed on 36 piers (above grade), or in an existing park. FEMA describe various foundation/anchorage methods and speaks to soil bearin capacity and proper embedment of piles to resist scour. FEMA requires that any encroachments into a floodway be certified tha such encroachment would not raise the BFE. Such provision which prescribe acceptable land use are outside the scope of th BOCA Code. BOCA requires manufactured housing to b designed and built to resist the same flood forces as site built which does not provide for 36" piers and/or placement below th BFE for residential occupancies..

Recommendation: To create separate and conflicting performance requirements for factory-built structures simply because they are not constructed on-site is contrary to BOCA's code development history and resulting policy on this matter. Therefore, no recommendation is made to carry FEMA's separate treatment of manufactured housing into BOCA code text. Recommendation is made however, to revise BOCA Code Section 620.3.1 to refer to flood forces and/or reference Section 2101.6.7 of the BOCA Code.

BOCA NATIONAL FIRE PREVENTION CODE COMPARISON

FEMA-54	BOCA Codes	Analysis
P. 93 Building Materials	F-2806.4 F-2806.8	FEMA identifies that corrosion protection is required for structures constructed of steel. BOCA requires corrosion protection and also includes the reference standards (STI stiP. or ULC S603.1-M) for protection of underground tanks.

Recommendation: See BOCA National Building Code Comparison recommendation to FEMA-54 - Building materials.

FEMA-102	BOCA Codes	Analysis
Appendix D Part (6d)	F-2806.4	FEMA requires fuel tanks to be above the design flood level or anchored and protected to resist floodwater (buoyancy, velocity and impact) forces. The anchorage system must have a safety factor of 1.5 against flotation. BOCA requires anchorage to resist hydrodynamic and hydrostatic forces also.

Recommendation: None

44 CFR 59.1, 60.3 and 60.6, FEMA-55, 85, 114, 165, Manual for the Construction of Residential Basements in Non-Coastal Flood Environments and the Technical Standards Bulletins do not include provisions which require corr on with the BOCA National Fire Prevention Code

Elevated Residential Structures (FEMA-54)

FEMA-54	BOCA Code	Analysis
P. 93 Utilities and Mechanical equipment	M-301.1.2 M-305.4 M-703.1 M-805.6 M-806.2 M-906.4 M-907.2	BOCA provides for flood-proofing of plenums, underground ducts, piping, underground tanks and fuel oil equipment. FEMA requires HVAC equipment to be elevated above base flood level as does BOCA. See also analysis to BOCA National Plumbing Code.

Recommendation: None

Manufactured Home Installation in Flood Hazard Areas (FEMA-85)

FEMA-85	BOCA Code	Analysis
Chapter IV Additional Design Considerations	M-405.1 M-703.1 M-805.6 M-806.2 M-906.4 M-907.2	Both FEMA and BOCA require that mechanical and plumbing systems be protected from exposure to floodwaters or designed to resist floodwater forces.

Recommendation: None

Technical Standards Bulletins (FEMA 85-1)

FEMA-85-1	BOCA Code	Analysis
HVAC	M-301.1.2 M-305.4 M-703.1 M-805.6 M-806.2 M-906.4 M-907.2	BOCA provides for flood-proofing of plenums, underground ducts, piping, underground tanks and fuel oil equipment. FEMA requires HVAC equipment to be elevated above base flood level as does BOCA. BOCA does not provide for "pop-out-panels" to allow pressures to equalize in ducts subject to flooding, requiring instead prohibition against water entering or accumulating in the system.

Recommendation: None

44 CFR 59.1, 60.3 and 60.6, FEMA-55, 102, 114, 165 and Manual for the Construction of Residential Basements in Non-Coastal Flood Environments do not include provisions which require correlation with the BOCA National Mechanical Code

Elevated Residential Structures (FEMA-54)

FEMA-54	BOCA Code	Analysis
P. 93 Utilities and Mechanical Equipment	P-308.6 P-500.6 P-602.6 P-1106.3 P-1502.3 P-1604.8 P-1604.9 P-1605.1	FEMA states that sanitary sewer and on-site waste disposa systems should be designed to prevent sewage or waste fro discharging during a flood or tank from becoming buoyant BOCA contains general performance criteria which mandate protection for all piping, tanks and equipment.

Recommendation: None

Manufactured Home Installation in Flood Hazard Areas (FEMA-85)

FEMA-85	BOCA Code	Analysis
Chapter IV D Additional Design Considerations	P-308.6 P-500.6 P-602.6 P-1502.3 P-1604.8 P-1604.9 P-1605.1	FEMA states that waterproofing joints and connections and using backflow preventers for all piping beneath the design flood level may be necessary, and to consult local codes. BOCA requires that all piping and joints be designed to resist hydrostatic and hydrodynamic forces. Wells for potable water must have covers and casings which are located 1 foot above the base flood elevation or are sealed to resist flood forces.

Recommendation: None

Floodproofing Non-residential Structures (FEMA-102)

FEMA-102	BOCA Code	Analysis
Chapter IV C Floodproofing Utilities	P-308.6 P-500.6 P-602.6 P-1106.3 P-1502.3 P-1604.8 P-1604.9 P-1605.1	FEMA states that waterproofing joints and connections and using backflow preventers for all piping beneath the design flood level may be necessary, and to consult local codes. BOCA requires that all piping joints be designed to resist hydrostatic and hydrodynamic forces. Wells for potable water must have covers and casings which are located 1 foot above the base flood elevation or are sealed to resist flood forces.

Recommendation: None

FEMA-102	BOCA Code	Analysis
Appendix D Performance Criteria	P-308.6 P-500.6 P-602.6 P-1106.3 P-1502.3 P-1604.8 P-1604.9 P-1605.1	FEMA states that sanitary sewer and on-site waste disposal systems should be designed to prevent sewage or waste from discharging during a flood. Systems that must remain in operation during a flood should be provided with a holding tank to accommodate 150% of the demand. Potable water supplies should be designed to prevent contamination from floodwater. Backflow prevention should be provided for potable water lines and storm and sanitary sewer lines. BOCA requires all piping and joints to be designed to resist hydrostatic and hydrodynamic flood forces. Requirements are similar for wells used to provide potable water.

Recommendation: None

Manual for the Construction of Residential Basements in Non-Coastal Flood Environments (MCRB)

MCRB	BOCA Code	Analysis
III.B.5.b Grading and Surface Drainage	P-801.1	FEMA requires the grade to be sloped 6 inches in 10 feet from the basement wall and splash blocks (3 feet) to direct rain water from downspouts. BOCA also requires drainage from the foundation but does not prescribe the slope or details.

Recommendation: None

MCRB	BOCA Code	Analysis
III.B.6 Seepage quantities	P-804.2 P-804.3	FEMA contains a typical flow analysis procedure to size the pump and sump. BOCA requires a designed system with input from the sump pump manufacturer.

Recommendation: None

MCRB	BOCA Code	Analysis
III.B.7a Penetrations	P-308.1 P-308.6 P-309.1 P-500.6 P-602.6 P-1502.3	FEMA requires penetrations to be pressure sealed and utility services (except water and sanitary sewer) to enter the house above the BFE. BOCA requires sleeved penetrations with approved caulking. BOCA requires the piping to be capable of resisting the imposed loads.

Recommendation: None

MCRB	BOCA Code	Analysis
III.B.8 Plumbing subsystems	P-308.6 P-309.1 P-500.6 P-602.6 P-804.2 P-804.3 P-1003.2 P-1502.3	FEMA requires backflow valves at sanitary sewer ou BOCA requires that all piping and joints be designe hydrostatic and hydrodynamic forces. BOCA's requir backwater valves is not a function of flood prone areas a general requirement for backwater valves to be insta fixtures are subject to backflow from the public sewr

Recommendation: None

MCRB	BOCA Code	Analysis
VIII.D.2 Sump pump and underdrain	P-804.2 P-804.3	See MCRB Section III.B.6.

Recommendation: None

44 CFR 59.1, 60.3 and 60.6 FEMA-55, 114, 165 and the Technical Standards Bulletins do not include provisic require correlation with the BOCA National Plumbing Code.

BOCA NATIONAL PROPERTY MAINTENANCE CODE COMPARISON

Coastal Construction Manual (FEMA-55)

FEMA-55	BOCA Code	Analysis
4.3.8 Maintenance	PM-302.0 PM-302.1 PM-302.3 PM-601.4	Both FEMA and the BOCA National Property Maintenance Code require structural members to be maintained free of deterioration, exterior walls and roof to be weatherproof, chimneys to be in good repair, windows to be free of cracks, and mechanical equipment to be maintained in safe working condition. BOCA does not require yearly inspections (as does NFIP) but rather provides the code official with the authorization to inspect when deemed appropriate.

Recommendation: None.

Floodproofing Non-Residential Structures (FEMA-102)

FEMA-102	BOCA Code	Analysis
Floodwall Maintenance	PM-302.3	Both FEMA and BOCA require that structural members be maintained to properly resist the design loads.

Recommendation: None

44 CFR 59.1, 60.3 and 60.6, FEMA-54, 85, 114, 165, Manual for the Construction of Residential Basements in Non-Coastal Flood Environments, and the Technical Standards Bulletins do not include provisions which require correlation with the BOCA National Property Maintenance Code.

APPENDIX B

COMPARISON BETWEEN THE SBCCI STANDARD CODES AND THE NFIP STANDARDS AND TECHNICAL GUIDELINES

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STANDARD BUILDING CODE (SBC) COMPARISON

NFIP (Regulations for Floodplain Management and Flood Hazard Identification) (44 CFR 59.1, 60.3, and 60.6)

59.1 - Definitions

NFIP	SBC	Analysis
Appurtenant Structure Base Flood Breakaway Wall Critical Feature Development Elevated Structure Existing Construction Existing Structures Flood Floodplain or Flood-Prone Area Lowest Floor Manufactured Home 100-year Flood Storm Cellar Substantial Improvement	1209	NFIP contains definitions which only apply to floodplain management. SBC does not address floodplain management. This is addressed in the SBCCI Standard for Floodplain Management.

Recommendation: None since NFIP addresses only flood-prone areas.

NFIP	SBC	Analysis
Basement Building Structure	202	The definitions of "basement" are compatible. The definitions of "building/structure" are similar but NFIP requires the building to have walls and a roof while SBC only requires the building to be used for sheltering its occupancy.

Recommendation: None since NFIP only applies to "enclosed" buildings.

60.3 - Floodplain Management Criteria for Flood-Prone Areas

NFIP	SBC	Analysis
60.3(b)(8) Manufactured Home Installations	H105.3	NFIP requires manufactured homes to be installed to resist flotation, collapse, and lateral movement to minimize flood damage in addition to anchoring requirements for wind. SBC requires only anchorage for wind.

Recommendation: None since SBC does not address flotation as a force. Appendix H should reference the SBCCI Standard for Floodplain Management.

NFIP	SBC	Analysis
60.3(c)(2) Elevation for Residential Structures	N/A	NFIP requires the lowest floor of residential structures to be elevated to or above the base flood level in A-zones. SBC does not address floodplain management. This is addressed in 602.1, 604.2, and 800 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

NFIP	SBC	Analysis
60.3(c)(3) Elevation for Non-Residential Structures; Flood-Proof Walls for Non-Residential Structures	N/A	NFIP requires the lowest floor of non-residential structures to be elevated to or above the base flood level or flood-proof the structure that is below the base flood level. SBC does not address floodplain management. This is addressed in 602.1 and 604.4 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

NFIP	SBC	Analysis
60.3(c)(5) Flood Openings		NFIP requires fully enclosed areas below the lowest floor, other than basements, to be provided with flood openings to equalize hydrostatic flood forces. SBC does not address floodplain management. This is addressed in 602.2 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

NFIP	SBC	Analysis
60.3(e)(4) Pilings	N/A	NFIP requires structures in V-zones to be elevated to or above the base flood level and anchored to resist flotation, collapse, and lateral movement due to the effects of wind and water loads acting simultaneously. SBC does not address Floodplain Management. This is addressed in 801.1 and 801.3 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

NFIP	SBC	Analysis
60.3(e)(5) Breakaway Walls	N/A	NFIP requires areas below the lowest floor to be free of obstruction or constructed with nonsupporting breakaway walls, open wood lattice, or insect screening intended to collapse under wind and water loads. SBC does not address Floodplain Management. This is addressed in 801.4 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

NFIP	SBC	Analysis
60.3(e)(6) Fill	N/A	NFIP prohibits the use of fill material to support building within flood-prone areas. SBC does not address floodplain management. This is addressed in 801.5 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

60.6 – Variances and Exceptions

NFIP	SBC
60.6(c)(2)(i) Floodproof Walls	N/A
60.6(c)(2)(ii) Basement Top of Floor Elevation	
60.6(c)(2)(iii) Fill	
60.6(c)(2)(iv) Use of a Registered Professional	
60.6(c)(2)(v) Building Inspection	

Analysis

NFIP requires the basement area, together with utilities and sanitary facilities, below the floodproofed design level, to be watertight with walls that are impermeable to the passage of water without human intervention. NFIP permits the basement floor to be up to five feet below the elevation of the base flood. NFIP permits the area surrounding the structure to be protected by fill material to or above the elevation of the base flood. NFIP requires the floodproofing measures to be certified by a registered professional engineer or architect. NFIP requires the authority having jurisdiction to verify that the provisions of the standards are satisfied. SBC does not address floodplain management. This is addressed in Chapter 4, 600.1, 604.2, 800.2, 801.5, 900.3, and 900.4 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

Elevated Residential Structures (FEMA 54)

FEMA 54	SBC	Analysis
Posts (Page 68)	N/A	FEMA 54 addresses the use of wood, concrete, or steel posts as the foundation to elevate residential structures. General commentary is made about installation, handling, and lateral resistance. SBC does not address post foundations but does address pile foundations in 1303 through 1311 and contains specific requirements for eight types of piles. Pile foundations are covered on pages 72-75 of FEMA 54.

Recommendation: FEMA 54 should combine post foundations and pile foundations into one section with more prescriptive requirements.

FEMA 54	SBC	Analysis
Post Embedment (Pages 68-70)	N/A	FEMA 54 provides general requirements for hole depth, end bearing, hole size, and backfilling of posts. SBC does not address post foundations but does address pile foundations in 1303 through 1311 and contains specific requirements for eight types of piles. Pile foundations are covered on pages 73-75 of FEMA 54.

Recommendation: FEMA 54 should combine post foundations and pile foundations into one section with more prescriptive requirements.

FEMA 54	SBC	Analysis
Post Anchorage (Page 71)	N/A	FEMA 54 provides general requirements for anchorage of post foundations. SBC does not address post foundations but does address pile foundations in 1303 through 1311 and contains specific requirements for eight types of piles. Pile foundations are covered on pages 72-75 of FEMA 54.

Recommendation: FEMA 54 should combine post foundations and pile foundations into one section with more prescriptive requirements.

FEMA 54	SBC	Analysis
Piers (Page 75)	N/A	FEMA 54 describes the suitability of pier foundations and types of pier foundations which are suitable for the flood areas with low velocity and minimal erosion. SBC does not address suitability of any type of foundation system.

Recommendation: None.

FEMA 54	SBC	Analysis
Brick and Concrete Masonry Piers (Pages 75, 76)	1405.6 1702.2.1	FEMA 54 provides minimum reinforcing, minimum dimensional requirements, maximum height, spacing, and recommended shape. FEMA 54 requires the piers to be filled with concrete. SBC bases the height on least dimension and whether the pier is filled with concrete or not. SBC does not require reinforcing. FEMA permits the maximum spacing to be 8 ft or 12 ft. SBC permits only 8 ft unless an engineering analysis is performed. Sections 1405.6 and 1702.2.1 of SBC is for conventional construction with light loads and locations in noncoastal areas.

Recommendation: FEMA 54 and SBC are in general agreement, however FEMA 54 provides more detailed requirements. FEMA 54 should provide reason for 12 ft spacing of piers in the direction parallel to the floor joists.

FEMA 54	SBC	Analysis
Concrete Piers (Page 77)	Chapter 13	FEMA 54 provides a general description and discussion of poured-in-place concrete piers. FEMA 54 and SBC requires foundations to be based on a structural analysis.

Recommendation: None since both basically require the foundation to be based on a structural analysis.

FEMA 54	SBC	Analysis
Pier Footings (Page 77)	1302.4	Both FEMA 54 and SBC require the footing sizes to be based on the properties of the soil.

Recommendation: None.

FEMA 54	SBC	Analysis
Shear Walls and Floor Diaphragms (Page 79)	1201	FEMA 54 addresses the use of plywood shear walls and floor diaphragm to brace piles or post foundations. SBC requires the structure to be of sufficient strength to support the loads and forces encountered.

Recommendation: FEMA 54 should address the use of shear walls and floor diaphragms as a method of bracing but should permit the building designer to choose the method.

FEMA 54	SBC	Analysis
Pier Foundation Connection (Pages 84, 85)	1201, 1408.3, 1706.1	FEMA 54 addresses anchorage of platform framing construction to pier foundations. SBC requires the structure to be of sufficient strength to support the loads and forces encountered. SBC addresses continuous wall foundations and not pier foundation anchorage. Sections 1408.3 and 1706.1 of the SBC is for conventional construction with light loads and locations in noncoastal areas.

Recommendation: FEMA 54 should provide wind load values or forces for which the anchorage is adequate.

FEMA 54	SBC	Analysis
Floor Beams (Page 86, Paragraph 2)	1706.2, 1705.1	FEMA 54 provides a general discussion of built up floor beams, (nailing, location of splices, and size.) SBC provides more detail for nailing and location of splices. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: FEMA 54 should provide better nailing and splice location requirements.

FEMA 54	SBC	Analysis
Cantilevers (Pages 86, 87)	1701.2	FEMA 54 describes a cantilevered beam with general discussion of why cantilevers are used. FEMA 54 provides a "rule of thumb" for the length of the cantilever. SBC requires the design of wood members to conform to good engineering practice. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: FEMA 54 should delete the "rule of thumb" or add better guidance for the design of the cantilever.

FEMA 54	SBC	Analysis
Floor Beam to Floor Joist Connection (Page 88)	1201, 1701.2	FEMA 54 requires positive connection between the floor joists and floor beams with a general discussion of the connection and connectors. SBC requires the design of the wood members and their fastenings to conform to good engineering practice. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: None.

FEMA 54	SBC	Analysis
Figure 4.48, Protective Utility Shaft (Page 92)	N/A	FEMA 54 requires protection of utility connections. SBC does not address utilities. This is addressed in 602.5 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 54	SBC	Analysis
Mechanical Equipment (Page 93, Paragraph 2)	N/A	FEMA 54 requires the mechanical equipment to be elevated above the expected floodwaters. SBC does not address mechanical equipment. This is addressed in 602.5 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 54	SBC	Analysis
Septic Tanks (Page 93, Paragraph 3)	N/A	FEMA 54 requires septic tanks to be floodproofed to prevent the tank from rising out of the ground as well as to prevent against discharge of effluent. SBC does not address septic tanks. This is addressed in 602.7 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 54	SBC	Analysis
Building Materials (Pages 93, 94)	N/A	FEMA 54 requires protection of the building materials which may be exposed to floodwaters. SBC does not address exposure to flood waters.

Recommendation: None.

FEMA 54	SBC	Analysis
Wood (Page 94)	1703	FEMA 54 requires wood exposed to the elements to be preservative treated. SBC requires the wood to be "naturally durable wood" or "preservative-treated wood."

Recommendation: FEMA 54 should include "naturally durable wood."

FEMA 54	SBC	Analysis
Steel (Pages 94, 95)	1503	FEMA 54 addresses the need for galvanization of steel exposed to the elements to prevent corrosion. SBC requires all structural members of cold-formed steel to be protected against corrosion with an acceptable shop coat of paint, enamel, or other approved protection.

Recommendation: None.

FEMA 54	SBC	Analysis
Concrete and Masonry (Page 95)	Chapter 14 Chapter 16	FEMA 54 addresses the need to increase the durability of reinforced concrete and masonry by the use of chemical additives and coatings. SBC does not address increase of durability but requires compliance with the appropriate ANSI, ASTM, ACI, and NCMA standards.

Recommendation: None.

FEMA 54	SBC	Analysis
Insulation (Pages 95, 96)	N/A	FEMA 54 addresses the need for insulation on the exposed floor of an elevated residence. SBC does not address insulation. This is addressed in the CABO Model Energy Code.

Recommendation: None.

FEMA 54	SBC	Analysis
Glossary (Pages 113-115)	1209	FEMA 54 contains definitions of terms which are relevant to floodplain management. SBC references the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 54	SBC	Analysis
Performance Criteria (Page 125-135)	Chapter 12	FEMA 54 addresses performance criteria used to design buildings to withstand the design flood (1) without causing unacceptable risks to its occupants or to adjacent property owners, (2) without causing unacceptable health hazards to its occupants, or (3) without sustaining damage of unacceptable magnitude. SBC requires every building to be of sufficient strength to support the loads and forces encountered, without exceeding in any of the structural elements, the stresses prescribed in the Code.

Recommendation: FEMA 54 should include snow and seismic loads. The use of the phrases "unacceptable risks", "unacceptable health hazards", and "unacceptable magnitude" are too subjective.

STANDARD BUILDING CODE (SBC) COMPARISON

Coastal Construction Manual (FEMA 55)

FEMA 55	SBC	Analysis
4.1 Flood Frequency (Page 4-1, Paragraph 4)	1209	FEMA 55 addresses the wave crest elevation that would be present during the base (100 year) flood. SBC does not address floodplain management. SBC references SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 55	SBC	Analysis
4.1.1 Wind (Page 4-1, Paragraph 6 & 7 Page 4-2, Figure 4-1, Page 4-3, Paragraph 2 & 3, Page 4-6)	1205	FEMA 55 references the procedures of ANSI A58.1-1982 for design with particular emphasis placed on elevation of the roof above grade and high wind pressures at the corners of the house, at and under roof eaves, and at the peak of the roof. SBC permits ASCE 7-1988 (formerly ANSI A58.1-1982) to determine the wind forces but also provides the actual velocity pressure (psf), use factors, and coefficients to address the higher wind pressures at the corners, at and under roof eaves, and at the peak of the roof.

Recommendation: FEMA 55 should update reference to ASCE 7-1988.

FEMA 55	SBC	Analysis
4.1.2 Salt Air, Moisture, and Wind-Driven Rain (Pages 4-7, 4-8)	1703	FEMA 55 provides general discussion of the hazards of salt air, moisture, and wind-driven rain on wood, bolts, nails, and connectors. SBC requires wood subject to damage from decay and termites to be naturally durable or pressure treated. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: SBC should address corrosion.

FEMA 55	SBC	Analysis
4.1.3 Water, Waves, and Debris (Page 4-8, Paragraph 4)	1201	FEMA 55 addresses the impact loads exerted on the piles as the result in the movement of debris (fences, porches, stairs, utility poles, etc.) FEMA 55 has provided for the collision of a 300 pound object moving at surface water velocity and decelerating over a maximum distance of 0.5 ft. SBC requires the building to be of sufficient strength to support the loads and forces encountered without exceeding in any of its structural elements, the stresses prescribed in the Code. SBC also requires the structural system to be able to sustain local damage or failure with the overall structure remaining stable.

Recommendation: None since both address the issue of damage only from different directions: FEMA - prescriptive, SBC - performance.

FEMA 55	SBC	Analysis
4.1.4 Effects of Forces on Higher and Larger Structures (Page 4-9)	1201, 1205	FEMA 55 discusses the higher wind forces, uplift and overturning with respect to the height of the building. SBC requires buildings to be of sufficient strength to support the loads and forces encountered. 1205 of SBC provides velocity pressures (psf) and coefficients which address the height of the building above grade.

Recommendation: FEMA 55 should provide velocity pressures (psf) for varied wind speeds and building height.

FEMA 55	SBC	Analysis
4.2 Construction Materials (Page 4-9)	Chapters 13, 15, 16 and 17	FEMA 55 provides a general discussion of the types of construction materials (wood, steel, concrete) and their use in the coastal environment. SBC provides requirements for the use of these materials in any environment. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: None.

FEMA 55	SBC	Analysis
4.2.1.1 Pilings (Wood) (Pages 4-9, 4-10)	1309	FEMA 55 provides general comments on the use of wood pilings (species and decay resistance). SBC addresses the ASTM standard, preservative treatment, and allowable stresses for round timber piles.

Recommendation: FEMA 55 should provide additional information such as ASTM standard preservative treatment and allowable stresses of timber piles.

FEMA 55	SBC	Analysis
4.2.1.2 Main Supporting Members (Beams, Wood) (Page 4-10)	1706.2 Table 1705.1	Both FEMA 55 and SBC address the use of built-up beams and girders. FEMA 55 provides general nailing requirements and splice location. SBC provides specific nailing requirements and splice location. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: FEMA 55 should provide more specific nailing and splice details.

FEMA 55	SBC	Analysis
4.2.1.3 Other Wood Construction Members (Page 4-10)	1703.1.1.3	FEMA 55 does not require preservative treatment of miscellaneous wood members but highly recommends it. SBC requires wood subject to decay to be a naturally durable species resistant or pressure treated.

Recommendation: None.

FEMA 55	SBC	Analysis
4.2.1.4 Wood Preservatives (Page 4-10)	1701.4.6	FEMA 55 requires wood members to be treated to resist insect infestation, dry rot, decay fungi, and the effects of exposure to salt air and water and provides general discussions of wood preservatives. SBC requires wood which is subject to decay and termites to be preservative treated.and provides a list of AWPA standards.

Recommendation: FEMA 55 should list some of the AWPA standards.

FEMA 55	SBC	Analysis
4.2.2 Masonry Materials and Concrete (Page 4-11)	Chapter 14 Chapter 16	FEMA 55 addresses the general use of masonry and concrete in the coastal environment. SBC provides reference to ASTM, ACI, and NCMA standards along with mixing, placing, formwork, embedded items, details of reinforcing, etc.

Recommendation: FEMA 55 should add references to ACI 318 and ACI/ASCE 530.

FEMA 55	SBC	Analysis
4.2.3.1 Aluminum (Page 4-11)	Chapter 28	FEMA 55 addresses the problem of corrosion of aluminum in the coastal environment. SBC addresses the use of aluminum structurally in buildings and references aluminum standards.

Recommendation: None.

FEMA 55	SBC	Analysis
4.2.3.2 Steel (Page 4-11)	Chapter 15	FEMA 55 addresses the problem of corrosion of unprotected steel shapes and anchoring devices (nails, bolts, etc.) and the need for regular inspection, maintenance, and replacement of corroded metal parts. SBC requires the design of steel construction to comply with the appropriate standards. SBC does not address corrosion in coastal environments.

Recommendation: SBC should address corrosion protection in coastal areas.

FEMA 55	SBC	Analysis
4.2.3.3 Dissimilar Metals (Page 4-11)	N/A	FEMA 55 addresses the corrosion which occurs when dissimilar metals are placed in contact with each other (brass screws and aluminum frame). SBC does not address dissimilar metals.

Recommendation: None.

FEMA 55	SBC	Analysis
4.3.1 Foundations (Design Details) (Pages 4-11, 4-12)	Chapter 13	FEMA 55 recommends foundation types which are suitable for supporting elevated structures in coastal high hazard areas. SBC permits any type of foundation provided it is designed. This is addressed in 801.1 of the SBCCI Standard for Floodplain Management.

Recommendation: None since FEMA 55 is "prescriptive" and SBC is "performance" oriented.

FEMA 55	SBC	Analysis
4.3.1.1 Soil Conditions (Pages 4-12, 4-13)	1302.2, 1302.3	Both FEMA 55 and SBC address the need to determine the quality of the soil for foundation purposes. FEMA 55 provides commentary type information also.

Recommendation: None.

FEMA 55	SBC	Analysis
4.3.1.2 Piles (Pages 4-13 to 4-18)	1303, 1304	FEMA 55 provides general information on types of piles, the need for sufficient pile embedment, and methods of pile installation. SBC requires a foundation investigation and report which will include recommended pile type, driving criteria, installation procedures, pile load test requirements, durability of pile materials, and designation of bearing strata.

Recommendation: FEMA 55 should emphasize that type of pile, pile depth, and method of installation should be based on the soils investigation.

FEMA 55	SBC	Analysis
4.3.1.3 Posts (Wood) (Page 4-18)	N/A	FEMA 55 explains that wood posts are not recommended in areas subject to wave forces and/or scour and erosion. SBC does not address post foundations but does address pile foundations in 1303-1311.

Recommendation: FEMA 55 should combine post foundations and pile into one section with more prescriptive requirements.

FEMA 55	SBC	Analysis
4.3.1.4 Piers (Pages 4-18 to 4-20)	1201 1405.6	FEMA 55 addresses the use of piers to elevate structures and the need for reinforcing and anchorage to the footing in V zones and coastal A zones. FEMA 55 also provides general construction guidelines. SBC requires that an appropriate structural analysis be performed for the piers. SBC provides maximum height to the least dimension ratio for unreinforced masonry piers.

Recommendation: FEMA 55 should clarify that the reinforcing, footing size, and grade beam size should be based on the design forces.

FEMA 55	SBC	Analysis
4.3.2.1 Framing Methods (Pages 4-20, 4-21)	1701.2.5 1706 1707.4	Both FEMA 55 and SBC address platform framing and pole construction. FEMA 55 addresses pole construction and provides commentary on the types of construction. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: None.

FEMA 55	SBC	Analysis
4.3.2.2 Beams (Pages 4-21, 4-22)	1706.2 Table 1705.1	FEMA 55 addresses the preferable direction of floor beams to reduce the impact force of the storm water. FEMA 55 and SBC address built-up beams and solid members. FEMA 55 mentions "glulam" beams. SBC provides nailing requirements for the built-up members. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: FEMA 55 should provide nailing requirements for built-up members.

FEMA 55	SBC	Analysis
4.3.2.3 Joists and Rafters (Page 4-22)	1706.3	The title of the section in FEMA 55 is joists and rafters but rafters are not addressed. FEMA 55 describes manufactured wooden I-beams, recommends cross bridging for all floor joists located in the V-zone, and describes typical cross bridging methods. SBC does not address manufactured wooden I-beams and only requires bridging or blocking if the depth to thickness ratio exceeds six or the design live load in excess of 40 psf. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: FEMA 55 should delete the reference to rafters or add information on rafters.

FEMA 55	SBC	Analysis
4.3.2.4 Subflooring (Pages 4-22, 4-23)	1706.6	Both FEMA 55 and SBC permit the use of lumber and plywood subflooring. SBC also permits the use of particleboard subfloors. FEMA 55 recommends the use of plywood with exterior glue and annular ring nails or deformed shank nails. FEMA 55 recommends nailing and gluing of plywood with tongue-and-groove joints to avoid the need for blocking and to produce a stronger diaphragm. SBC permits the use of common, annular, or spiral thread nails with no mention of gluing. SBC provides minimum thickness, span of subfloor, and nail spacing. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: The provisions are compatible. FEMA 55 should provide some recommended nail spacing and spans.

FEMA 55	SBC	Analysis
4.3.2.5 Studs (Page 4-23)	1707.1.1 1707.1.2	FEMA 55 recognizes that 2x4 wood studs at 16 inches on center are commonly used and permits 2x6 wood studs and metal studs. SBC addresses the use of wood studs based on lateral unsupported stud height, spacing of studs, and number of stories. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: FEMA 55 should address sizing of studs including number of stories which the stud supports or limits for the use of 2x4 studs.

FEMA 55	SBC	Analysis
4.3.2.6 Wall Sheathing (Page 4-23)	1707.2, 1201.1	FEMA 55 provides the minimum thickness and nail spacing for plywood wall sheathing for two cases 1) structures elevated not more than 10 ft and 2) structures elevated more than 10 ft above grade. SBC lists approved methods of wall bracing and requires the structure to be designed for the loads and forces encountered. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: FEMA 55 should provide additional information addressing the wind speed in addition to height above grade.

FEMA 55	SBC	Analysis
4.3.2.7 Wall Bracing (Page 4-24)	1707.2, 1201.1	Both FEMA 55 and SBC permit the use of let-in diagonal wood bracing, diagonal boards, and plywood. SBC also permits particleboard, fiberboard, and gypsum sheathing. SBC also requires the structure to be designed for the loads and forces encountered. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: FEMA 55 should combine 4.3.2.6 Wall Sheathing and 4.3.2.7 Wall Bracing into one section and address the design requirements for the wall bracing method chosen.

FEMA 55	SBC	Analysis
4.3.2.8 Roof Details (Pages 4-24 to 4-27)	N/A	FEMA 55 discusses the use of trusses, gable roofs, hip roofs, flat roofs, gambrel roofs, roof overhangs and porches and their performance in high wind conditions. SBC does not provide details or discuss performance of specific designs.

Recommendation: None.

FEMA 55	SBC	Analysis
4.3.3 Foundation Bracing (Pages 4-27 to 4-29)	1201.1 1303	FEMA 55 addresses the need for bracing wood foundation piles. SBC requires the wood foundation system to be designed for the loads and forces encountered.

Recommendation: None.

FEMA 55	SBC	Analysis
4.3.3.1 Knee Braces (Page 4-29)	1201.1 1303	FEMA 55 recommends the use of knee braces for wood foundation piles even though bracing may not be needed. SBC requires the wood foundation piles to be designed for the loads and forces encountered.

Recommendation: FEMA 55 should emphasize that the wood foundation piles should be designed for the additional moment introduced into the pile from the knee brace.

FEMA 55	SBC	Analysis
4.3.3.2 Grade Beams (Pages 4-29, 4-30)	1201.1 1303	FEMA 55 emphasizes the need for lateral support of the piles at the ground line. SBC requires the piles to be designed for the loads and forces encountered.

Recommendation: FEMA 55 should emphasize the need to design the grade beams to assure that they are actually providing lateral support of piles.

FEMA 55	SBC	Analysis
4.3.3.3 Truss Bracing (Pages 4-30, 4-31)	1201.1 1303	FEMA 55 recommends the use of truss bracing of the piles when the structure is 10 ft or more above grade and the design wind speed is 100 mph or greater. SBC requires the piles to be designed for the loads and forces encountered.

Recommendation: FEMA 55 should emphasize the need to design the bracing members.

FEMA 55	SBC	Analysis
4.3.3.4 Shear Walls (Page 4-31)	1201.1	FEMA 55 addresses only reinforced concrete or reinforced masonry shear walls. SBC requires the structure to be designed for the loads and forces encountered.

Recommendation: FEMA 55 should address wood shear walls for wood pile foundations.

FEMA 55	SBC	Analysis
4.3.4 Connections 4.3.4.1 Roof to Wall 4.3.4.2 Wall to Floor Joists 4.3.4.3 Floor Joist to Floor Beam (Pages 4-31 to 4-35)	1201.1	FEMA 55 provides commentary type language for connections but does require the anchorage to be sufficient to withstand the anticipated forces. FEMA 55 provides commentary type language for roof to wall, wall to floor joist, and floor joist to floor beam connection and requires the connections to be designed in high wind speed areas. SBC requires the structure to be designed for the loads and forces encountered.

Recommendation: None since both FEMA 55 and SBC require sufficient connection.

FEMA 55	SBC	Analysis
4.3.4.4 Floor Beam to Pile, Post, or Pier (Pages 4-35 to 4-40)	1201.1	FEMA 55 provides commentary type language and typical details for floor beams to pile, post, or pier connections, but permits other methods provided they are designed. SBC requires the structure to be for the loads and forces encountered.

Recommendation: FEMA 55 should provide some design values or wind speeds for which the connections are appropriate.

FEMA 55	SBC	Analysis
4.3.5 Breakaway Walls 4.3.5.1 Breakaway Wall Designs 4.3.5.2 Design Considerations for Breakaway Walls (Pages 4-41 to 4-49)	N/A	FEMA 55 permits breakaway walls to enclose the space below the lowest elevated floor and provides commentary type language for different types of breakaway walls. FEMA 55 provides breakaway wall designs and details for screening, lattice, wood stud walls, metal stud walls, and masonry walls. FEMA 55 provides the design process for breakaway walls and commentary type language for wind forces, water forces, working/ultimate strength of fasteners, distribution of wall loads, and bracing considerations for breakaway walls. SBC does not address breakaway walls. This is addressed in 801.4 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 55	SBC	Analysis
4.3.6 Utilities (Pages 4-50 to 4-52)	N/A	FEMA 55 requires the protection of utilities from the potential damage from flooding and wave impact. SBC does not address utilities. This is addressed in 602.5 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 55	SBC	Analysis
4.3.7 Wind and Storm Protection of Interior (Page 4-52)	N/A	FEMA 55 provides commentary on the need to protect the buildings from glass breakage in order to prevent water damage. SBC does not address glass breakage; it requires the windows to be designed as components and cladding or be considered an "opening."

Recommendation: None.

FEMA 55	SBC	Analysis
4.3.7.1 Window Selection (Pages 4-52, 4-53)	1205	FEMA addresses the importance of window selection to reduce water infiltration. SBC requires the windows to be designed as components and cladding or be considered an "opening." SBC does not address water infiltration.

Recommendation: FEMA 55 should address the design of the windows for the wind load pressures.

FEMA 55	SBC	Analysis
4.3.7.2 Operable Shutters (Pages 4-53, 4-54)	1205	FEMA 55 addresses the need for shutters to protect against wave and wind action. SBC requires the windows to be designed as components and cladding or be considered an "opening." SBC does not address the use of shutters.

Recommendation: FEMA should address the need to design the shutters for the wind load pressures.

FEMA 55	SBC	Analysis
4.3.7.3 Gable and Eave Vents (Page 4-54)	1205.1 1708.7	FEMA 55 addresses the vulnerability of vents to wind and wind-driven rain and emphasizes the importance for the careful selection of attic ventilators in order to assure that they will withstand the wind loads. SBC requires ventilation of the attic space based on a ratio of free ventilating area. SBC requires parts of the building to be designed to withstand the appropriate wind loads. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: None since FEMA 55 and SBC both require the design of the vents to withstand the appropriate wind loads.

FEMA 55	SBC	Analysis
4.3.7.4 Roofing Materials (Page 4-54)	1205.1	FEMA 55 emphasizes the need to use self-sealing, heavyweight shingles to avoid the possible loss of roofing material in high winds. SBC requires all parts of the building to be designed to withstand the appropriate wind loads.

Recommendation: FEMA 55 should emphasize the need to have a roof covering designed to withstand the uplift from the wind. SBC should emphasize that the roof covering should be designed to 1205.

FEMA 55	SBC	Analysis
4.3.8 Maintenance (Pages 4-54, 4-55)	N/A	FEMA 55 emphasizes the need for maintenance of all parts of buildings exposed to the coastal environment because of the accelerated deterioration. SBC does not address maintenance but does require repairs or rehabilitation to comply with the requirements of the SBC for new construction.

Recommendation: None.

FEMA 55	SBC	Analysis
5.1 General Design Considerations (Pages 5-1, 5-2)	1201.1 1607.6.3	FEMA 55 prohibits enclosure for habitation below BFE mid-rise and high-rise structures in coastal high hazard areas. SBC does not address this issue. This is addressed in 602.3 of the SBCCI Standard for Floodplain Management. FEMA 55 and SBC require thicker concrete cover over reinforcing steel to provide added corrosion protection of the reinforcing steel in corrosive environments or severe exposure conditions. SBC requires compliance with ACI 318 and the minimum cover in 1607.6. FEMA 55 addresses the need to design for wind and water forces. SBC requires the structure to be sufficient to support the loads and forces encountered.

Recommendation: FEMA 55 should address snow and seismic loads.

FEMA 55	SBC	Analysis
5.2 Foundations (Page 5-2)	1303	FEMA 55 emphasizes the need for pile foundations that are embedded deeply to provide a safety margin against scour. FEMA 55 lists the common types of piles as precast/prestressed concrete, cast-in-place concrete, steel, and timber. FEMA 55 shows a typical pile/pile cap/column/grade beam detail. FEMA 55 permits strip footings and mat foundations in zones of reduced velocity and wave action. SBC does not address scour. SBC requires foundations to be designed and installed on the basis of a foundation investigation. SBC provides standards for all of the types of piles listed in FEMA 55.

Recommendation: None.

FEMA 55	SBC	Analysis
5.3 Slabs at Grade (Pages 5-3, 5-4)	1303, 1608	FEMA 55 suggests that slabs supported on soil are thin (minimum of 4 inches thick) with minimal reinforcing in the form of welded wire fabric and are expected to be lost in the event of a storm. SBC requires the minimum thickness of 3 1/2 inches and does not require welded wire fabric. FEMA 55 also addresses the use of designed slabs and grade beams to laterally support the pile foundation system. SBC permits the engineer to design the foundation system.

Recommendation: The minimum slab thickness in FEMA 55 should be changed to 3 1/2 inches and delete the requirement for welded wire fabric.

FEMA 55	SBC	Analysis
5.4 Superstructure (Pages 5-4 to 5-7)	N/A	FEMA 55 provides commentary type language and typical details of the superstructure of a building. This includes columns, beams, slabs, and shear walls. SBC is a performance code and not a commentary.

Recommendation: None.

FEMA 55	SBC	Analysis
5.5 Elevated Floors (Pages 5-7, 5-8)	Chapter 16	FEMA 55 provides commentary type language for elevated concrete floors. FEMA 55 addresses one-way and two-way slabs, perimeter beams, and the transfer of lateral forces to the pile foundation. SBC requires structural members of reinforced concrete to be designed and constructed in accordance with Chapter 16 and ACI 318.

Recommendation: None.

FEMA 55	SBC	Analysis
5.6 Exterior Wall Systems (Pages 5-8, 5-9)	1201.1	FEMA 55 provides commentary type language on exterior wall systems of masonry or metal studs and the fastening method of the walls. FEMA 55 and SBC require that the walls be designed to resist the lateral forces encountered.

Recommendation: None since both requires the walls to be designed for the lateral forces encountered; however, FEMA 55 should address seismic loads.

FEMA 55	SBC	Analysis
5.7 Recommendations (Page 5-9)	103.2.3	FEMA 55 requires mid-rise and high-rise structures to be designed by a "design professional." SBC requires a "design professional" to design all structures three stories or more high and structures 5000 sq ft or more in area.

Recommendation: None since both require a design professional.

FEMA 55	SBC	Analysis
Appendix A Design Tables Figure A-1 number of piles required Table A-1 downward loads per pile Table A-2 horizontal wind loads per pile in 80 mph winds Table A-3 minimum embedment depth of piles Table A-4 maximum unbraced height of piles in 80 mph winds and flood forces Table A-4.1 maximum unbraced height of piles supporting breakaway walls Table A-5 uplift loads per foot of wall in 80 mph winds Table A-6 uplift loads per pile in 80 mph winds Table A-7 capacity per bolt of floor beam connections Table A-8 concrete masonry unit piers Table A-9 concrete piers Figure A-2 concrete pier cross section Figure A-3 grade beams and slabs Table A-10 fastener capacities in shear Table A-11 fastener schedule for breakaway walls (Pages A-1 to A-47)	Chapters 12, 13, 14, 15, 16, and 17	FEMA 55 provides design tables. SBC is a performance code and not a specification type code. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: None.

FEMA 55	SBC	Analysis
Appendix B - Bracing B.1 knee bracing B.2 truss bracing B.2.1 diagonals B.2.1.1 lumber diagonals B.2.1.2 threadbar diagonals B.2.2 struts B.3 grade beams Table B-1 horizontal water loads per pile in 80 mph winds Table B-2 loads of transverse truss members Table B-3 allowable loads for single 2x8 diagonals Table B-4 allowable loads for single 3x8 diagonals (Pages B-1 to B-15)	Chapters 12, 13, 14, 15, 16, and 17	FEMA provides various recommendations and details for bracing methods. SBC is a performance code and not a specification type of code. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: None.

FEMA 55	SBC	Analysis
Appendix D - Design Equations and Procedures D.1 Procedure A-1: downward loads per pile D.2 Procedure A-2: horizontal wind loads per pile D.3 Procedure A-3: minimum embedment depth of piles D.4 Procedure A-4: maximum unbraced height of piles D.5 Procedure A-4.1: maximum unbraced height of piles supporting breakaway walls D.6 Procedure A-5: uplift loads per foot of walls D.7 Procedure A-6: uplift loads per pile D.8 Procedure B-1: horizontal water loads per pile D.9 Procedure B-2: loads transferred to foundation truss members (Pages D-1 to D-32)	N/A	FEMA 55 contains design equations and procedures which are needed to evaluate individual designs. SBC is a performance code with design being based on good engineering practice.

Recommendation: None.

FEMA 55	SBC	Analysis
G-2. Purpose (Page G-1)	101.2	FEMA 55 states that the purpose of the Coastal Code is to provide minimum standards for the design and construction of residential structures in Coastal High Hazard Areas and where wave action can be expected. SBC is declared remedial and is intended to secure the beneficial interests and purposes of the Code which are public safety, health and general welfare.

Recommendation: None since the intent of both FEMA 55 and SBC is to provide minimum requirements for structures.

FEMA 55	SBC	Analysis
G-3. Scope (Page G-2)	101.3 101.5	Both FEMA 55 and SBC apply to new construction and improvements or additions to existing structures. FEMA 55 permits improvements up to 49% of the market value of the structure without compliance with the Coastal Construction Code but the SBC requires all improvements to comply with the Code.

Recommendation: Since market value is a variable based on location, economy, etc., FEMA should require compliance for all improvements since noncompliance of any part of the structure makes the entire structure out of compliance.

FEMA 55	SBC	Analysis
G-4. Definitions (Pages G-2, G-3)	202	FEMA 55 contains only definitions which are related to coastal construction. SBC contains definitions which are applicable to all types of structures and occupancies in any location. Dead load, grade, live load, and structure have similar definitions.

Recommendation: None.

FEMA 55	SBC	Analysis
G-5. Elevation Standards. (Page G-3)	N/A	FEMA 55 prohibits new construction or substantial improvements from being seaward of an established setback line and requires it to be elevated above the BFE. SBC does not prohibit construction in any location. This is addressed in 801.6 of the SBCCI Standard for Floodplain Management.

Recommendation: None since these types of requirements are local specific and should addressed on the local level.

FEMA 55	SBC	Analysis
G-6. Determination of Loading Forces G-6.1 Water Loads G-6.2 Wind Loads (Page G-3)	1201.1 1205	Both FEMA 55 and SBC require the structure to be of sufficient strength to support the loads and forces encountered. FEMA 55 references ANSI A58.1-1982 for the wind load provisions. SBC contains a basic wind speed map, use factors, velocity pressures, and coefficients for wind design. SBC also permits wind design based on ASCE 7-88.

Recommendation: FEMA 55 should update reference to ASCE 7-88.

FEMA 55	SBC	Analysis
G-7. Foundation Standards (Page G-4)	Chapter 12 Chapter 13	Both FEMA 55 and SBC require the foundations to be designed to support the loads and forces encountered.

Recommendation: FEMA 55 should address snow and seismic loads.

FEMA 55	SBC	Analysis
G-7.1 Pile Foundation Design (Pages G-4, G-5)	Chapter 12 Chapter 13	FEMA 55 requires the pile spacing to pile diameter ratio to not be less than 8:1 with a maximum spacing of 12 ft while SBC requires the minimum center to center spacing of piles to be not less than twice the average diameter of a round pile nor less than 1 3/4 times the diagonal dimension of a rectangular pile. FEMA 55 provides minimum embedment of foundation piles based on mean sea level and BFE while SBC requires embedment to be based on a foundation investigation. Both FEMA 55 and SBC requires the piles to be analyzed as a column for the unsupported length. FEMA 55 provides dimensional criteria for round and square wood piles. SBC references the appropriate ASTM standard. FEMA 55 requires the minimum compressive strength of the concrete for reinforced concrete piles to be 5000 psi while SBC requires only 4000 psi. The reinforcement requirements for reinforced concrete piles are the same for both FEMA 55 and SBC. FEMA 55 lists three methods of pile installation. FEMA 55 provides commentary type language for methods of bracing piles to resist the horizontal forces while SBC requires the piles to be designed for the horizontal forces which are encountered.

Recommendation: FEMA 55 should emphasize that pile spacing and embedment should be based on the foundation investigation. FEMA 55 should reduce the minimum compressive strength of the concrete for reinforced concrete piles to 4000 psi, since 4000 psi has been a building code requirement since 1980.

FEMA 55	SBC	Analysis
G-7.2 Column Foundation Design (Page G-5)	1201.1 Chapter 13 1405.6	FEMA 55 requires reinforcing of masonry piers or poured-in-place concrete piers. SBC requires piers to be designed for the forces encountered.

Recommendation: None.

FEMA 55	SBC	Analysis
G-8. Anchoring Standards (Page G-5)	1201.1	FEMA 55 requires anchorage to prevent flotation, collapse, or permanent lateral movement during the base flood concurrent with the 100 year design wind velocity. SBC requires every structure to support the loads and forces encountered. SBC does not address flotation. This is addressed in 601.1 and 801.1 of the SBCCI Standard for Floodplain Management.

Recommendation: FEMA 55 should address snow and seismic loads.

FEMA 55	SBC	Analysis
G-8.1 Connector and Fasteners (Page G-5)	1201.1	Both FEMA 55 and SBC require the connectors to support the loads and forces encountered. FEMA 55 does not permit toe nailing. FEMA 55 requires metal connectors and fasteners to have corrosion protection.

Recommendation: FEMA 55 should not prohibit toe nailing if the connection is adequate for the calculated loads. SBC should address corrosion protection of metal connectors.

FEMA 55	SBC	Analysis
G-8.2 Beam to Pile Connections (Pages G-5, G-6)	1201.1	FEMA 55 provides prescriptive requirements for the beam to pile connection. SBC requires the structure to support the loads and forces encountered.

Recommendation: FEMA 55 should permit the designer to design the connection.

FEMA 55	SBC	Analysis
G-8.3 Floor to Deck Connections (Page G-6)	1201.1 Chapter 17	FEMA 55 provides prescriptive requirements for the connection of floor joists to floor beam/girders, cross bridging, subflooring, and attic flooring. SBC permits connections to be designed and subflooring to any material permitted by Chapter 17. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: FEMA 55 should permit the designer the leeway to meet performance requirements.

FEMA 55	SBC	Analysis
G-8.4 Exterior Wall Connections (Page G-6)	1201.1 Chapter 17	FEMA 55 provides prescriptive requirements for the exterior wall connection. SBC permits the designer to design the exterior wall connection. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: FEMA 55 should permit the designer the leeway to meet performance requirements.

FEMA 55	SBC	Analysis
G-8.5 Ceiling Joist/Rafter Connections (Page G-6)	1201.1 1708	Both FEMA 55 and SBC requires a continuous tie across the building and the joist and rafters securely fastened at their intersection. FEMA 55 requires metal or wood connectors at alternate ceiling joist/rafter connections to the wall top plate and blocking in gable roofs. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: FEMA 55 should permit the designer to design the connection.

FEMA 55	SBC	Analysis
G-8.6 Projecting Members (Page G-6)	1201.1	Both FEMA 55 and SBC require cantilevers and projecting members to be designed to support the loads and forces encountered.

Recommendation: None.

FEMA 55	SBC	Analysis
G-9. Roof Sheathing (Pages G-6, G-7)	1708	FEMA 55 requires the roof sheathing to be a minimum of 15/32 inch thick plywood. SBC also permits particleboard of 3/8 inch thickness. FEMA 55 requires corrosion resistant fasteners and the application of waterproof industrial adhesive to all bearing surfaces of plywood used in the sheathing of corners, gable end, or roof overhang. FEMA 55 also provides commentary type language addressing the roof slopes and construction at points of discontinuity of the roofing surface. Chapter 17 of the SBC is for light frame conventional construction having light loads and located in noncoastal areas.

Recommendation: FEMA 55 should permit particleboard roof sheathing provided it is of the appropriate strength.

FEMA 55	SBC	Analysis
G-10. Protection of Openings (Page G-7)	1205.1.4 2703.3	Both FEMA 55 and SBC require exterior openings to be designed to withstand the appropriate wind loads.

Recommendation: None.

FEMA 55	SBC	Analysis
G-11. Use of Space Below the Lowest Elevated Floor (Page G-7)	N/A	FEMA 55 prohibits the use of the space below the BFE to be used for any other purpose than parking storage or building access. SBC does not prohibit the use of the space below the elevated floor. This is addressed in 602.3 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 55	SBC	Analysis
G-11.1 Breakaway Wall Design Standards (Page G-7)	N/A	FEMA 55 provides the design requirements for breakaway walls. SBC does not address breakaway walls. This is addressed in 801.4 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 55	SBC	Analysis
G-11.2 Certification of Breakaway Walls (Pages G-7, G-8)	N/A	FEMA 55 permits breakaway walls which are designed with a wall strength in excess in that permitted in 11.1 provided the design profession certifies that the wall will fail under water loads less than those that would occur during the base flood and the elevated portion of the building will not be subject to damage due to the effects of wind and water loads acting simultaneously. SBC does not address breakaway walls. This is addressed in 801.4 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 55	SBC	Analysis
G-12. Utilities (Page G-8)	N/A	FEMA 55 requires the utilities to be elevated above the BFE and backflow valves for sanitary sewer and storm drainage systems which have openings below the BFE. SBC does not address utilities. This is addressed in 602.5 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 55	SBC	Analysis
G-13. Certification Requirements (Page G-8)	103.2.3	FEMA 55 requires new and substantial improvements to be designed by a registered professional engineer or architect. SBC requires design by a professional engineer or architect for all group A, E, and I occupancies, structures three stories or more high, and structures 5000 sq ft or more in area. This is addressed in 401.3 and 801.7 of the SBCCI Standard for Floodplain Management.

Recommendation: FEMA 55 should provide parameters for which sections 7 and 8 are appropriate (wind load, height above grade, etc.).

FEMA 55	SBC	Analysis
G-14. Reference Documents (Page G-8)	Chapter 3	FEMA 55 references ANSI A58.1-1982, Shore Protection Manual by the Department of the Army, and the Coastal Construction Manual by FEMA. SBC does not reference any of these documents.

Recommendation: FEMA 55 should update reference to ASCE 7-88.

Manufactured Home Installation In Flood Hazard Areas (FEMA 85)

Chapter III Elevation and Anchoring Techniques

FEMA 85	SBC	Analysis
Elevation and Anchoring Techniques (Page 19)	N/A	FEMA 85 provides general techniques which are used to elevate a manufactured home in riverine or coastal flooding areas. SBC does not provide techniques but does provide performance requirements for piers, piles, and foundations. This is addressed in 600, 601, 603, and 604 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 85	SBC	Analysis
Elevation on Fill (Pages 19-20)	Chapter 13	FEMA 85 provides commentary and prescriptive type language on the use of earth fill to elevate a manufactured home. FEMA 85 prohibits the use of fill material in areas subject to floodwaters having a velocity greater than 10 fps and where it will constrict the flow of floodwaters and cause increased flood elevations or velocity. SBC requires foundations to be built on undisturbed or properly compacted fill material. SBC does address floodplain management. This is addressed in 603.3 and 801.5 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 85	SBC	Analysis
Elevated Foundations (Pages 21-28)	Chapter 13 H105	FEMA 85 addresses structural techniques, such as piers, posts, piles and similar structural arrangements, to elevate a manufactured home above the flood level. FEMA 85 provides prescriptive requirements for these structural techniques while SBC provides performance type of requirements. Both FEMA 85 and SBC requires the foundation to be designed for the anticipated forces. SBC has prescriptive requirements in H105 for piers up to 80 inches in height. SBC has prescriptive requirements in 1405.6 similar to FEMA 85 for masonry piers. SBC does not address post foundations.

Recommendation: None.

FEMA 85	SBC	Analysis
Anchoring (Pages 29-31)	1201.1 H105.3	Both FEMA 85 and SBC require tie-down and anchoring systems to resist the lateral and uplift forces resulting from wind. FEMA 85 provides commentary type language and descriptive details. SBC contains minimum number of ties and anchors based on the length of manufactured home.

Recommendation: FEMA 85 should address minimum number of ties and anchors.

FEMA 85	SBC	Analysis
Design of Elevated Foundations (Page 33)	Chapter 12	FEMA 85 presents an overview of flood-induced loads, tables of calculated forces, governing design equations and specific technical information which can be used to determine an appropriate elevated design for a manufactured home with the manufactured home complying with HUD's Manufactured Home Construction Safety Standards. The wind loads and snow loads in FEMA 85 and SBC are very different.

Recommendation: FEMA 85 and HUD's MHCSS should update the wind and snow loads to ASCE 7-88. FEMA 85 should address seismic loads.

FEMA 85	SBC	Analysis
A. Flood Forces and Their Application (Pages 34-45)	Chapter 12	FEMA 85 addresses the hydrostatic forces, lateral forces, buoyancy forces, hydrodynamic forces, impact forces due to water-borne objects, and scour. SBC does not address "water forces" but does require every structure to be of sufficient strength to support the loads and forces encountered.

Recommendation: None.

FEMA 85	SBC	Analysis
B. Evaluation of Elevated Foundations (Pages 45-58)	Chapter 12	FEMA 85 provides commentary type language in addition to actual design tables and details. SBC is a performance code and does not provide design tables and details. SBC requires every structure to be of sufficient strength to support the loads and forces encountered and permits the designer to choose the technique.

Recommendation: None.

FEMA 85	SBC	Analysis
C. Bracing Support and Connections for Elevated Foundations (Pages 58-68)	Chapter 12	FEMA 85 provides design procedures, tables, and details needed to design bracing and connections. SBC is a performance code and requires the structure to be of sufficient strength to support the loads and forces encountered.

Recommendation: None.

FEMA 85	SBC	Analysis
D. Additional Design Considerations (Pages 68-70)	N/A	FEMA 85 addresses the setup (jacking), utility service, mechanical systems, and access/egress during flooding around the manufactured home. SBC does not address these issues.

Recommendation: None.

FEMA 85	SBC	Analysis
Appendix D - Calculational Procedures for Elevated Foundation Design (Pages 89-97)	N/A	FEMA 85 contains actual design procedures and formulas which were used as a basis of the manual. SBC is a performance code and does not contain engineering analysis procedures.

Recommendation: None.

FEMA 85	SBC	Analysis
Appendix E - Buoyancy and Drag Forces (Pages 99-101)	Chapter 12	FEMA 85 addresses the forces from buoyancy and drag caused by the floodwaters. FEMA 85 contains design tables for vertical tie forces based on home width and water depth. SBC does not address flood water forces but does require the structure to have sufficient strength to support the loads and forces encountered.

Recommendation: None.

STANDARD BUILDING CODE (SBC) COMPARISON

Floodproofing Non-Residential Structures (FEMA 102)

Chapter I Introduction

FEMA 102	SBC	Analysis
I.E. Contingent Floodproofing Measures I.F.1 Flood Shields I.F.2 Watertight Doors I.F.3 Movable Floodwalls (Pages 8-13)	N/A	FEMA 102 addresses the use of contingent floodproofing measures that require some type of installation, activation, or other preparation immediately prior to the occurrence of a flood. These measures include flood shields, watertight doors, and moveable floodwalls. SBC does not address floodproofing. This is addressed in Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

Chapter III Floodproofing Design Permanent and Contingent Measures

FEMA 102	SBC	Analysis
III.B. Elevation on Fill (Pages 37-38)	N/A	FEMA 102 addresses the use of fill material to elevate the building to protect it from flood damages. FEMA 102 contains commentary type language on the design and maintenance of the fill material. SBC does not address floodplain management. Floodplain management is addressed in the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 102	SBC	Analysis
III.C.2 Posts (Pages 39-40)	Chapter 13	FEMA 102 addresses the elevation of the structure on "post" foundations by showing details and design charts. SBC does not address post foundations but does address pile foundations.

Recommendation: FEMA 102 should combine post foundations and pile foundations into one section.

FEMA 102	SBC	Analysis
III.C.3 Piles (Pages 40-44)	Chapter 13	FEMA 102 provides commentary type language describing the general length, maximum design load, application, advantages, disadvantages, typical elevation, and typical cross section. SBC requires pile foundations to be designed and installed on the basis of a foundation investigation and report.

Recommendation: FEMA 102 should emphasize that the length and maximum design load is based on the foundation investigation and report.

FEMA 102	SBC	Analysis
III.C.4 Piers and Walls (Pages 43-46)	1405.6	Both FEMA 102 and SBC limit the height of filled masonry piers to a maximum of ten times their smallest dimension. FEMA 102 provides details of a brick pier, reinforced concrete masonry pier, and reinforced concrete pier, along with commentary type language.

Recommendation: None.

FEMA 102	SBC	Analysis
Table III-1 Minimum Requirements for Reinforced Piers (Page 46)	1405.6 1411	FEMA 102 provides the minimum pier size, minimum footing size, pier spacing, and useful elevation range but does not contain the reinforcing requirements. SBC references ACI/ASCE 530 for reinforced masonry.

Recommendation: FEMA 102 should clarify the soil bearing capacity was used for the minimum footing size and the design loads used for the minimum pier size.

FEMA 102	SBC	Analysis
III.C.6 Maintenance (Page 47)	N/A	FEMA 102 addresses the need to perform maintenance on posts, piles, piers or wall based on the frequency of the flooding. SBC does not address maintenance of foundations.

Recommendation: None.

FEMA 102	SBC	Analysis
III.D Waterproof Construction III.D.1 Introduction III.D.2 Wall Strength (Pages 48-51)	N/A	FEMA 102 addresses floodproofing of a structure to prevent floodwaters from reaching its interior. SBC does not address floodproofing. This is addressed in 401.2 and Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 102	SBC	Analysis
III.D.3 Floor Strength and Structural Stability III.D.4 Counteracting of Hydrostatic Forces (Pages 51-54)	1312	FEMA 102 addresses floodproofing of a structure by the use of a concrete slab or impervious cutoffs, or subsurface drainage to resist the hydrostatic uplift pressures. SBC does not address floodproofing. This is addressed in 401.2 and Chapter 9 of the SBCCI Standard for Floodplain Management. SBC addresses waterproofing of enclosed spaces below finished ground level when hydrostatic pressure conditions exist.

Recommendation: None.

FEMA 102	SBC	Analysis
III.D.5 Waterproofing (Pages 55-58)	1312	FEMA 102 addresses techniques of waterproofing concrete and masonry walls by the use of high-quality concrete, sealant materials, and/or impermeable membranes. SBC addresses waterproofing by the use of a "waterproofing" material. FEMA 102's waterproofing is to protect the interior from floodwaters while SBC's waterproofing is to protect the interior from groundwater conditions. Floodproofing is addressed in 401.2 and Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 102	SBC	Analysis
III.D.6 Watertight Cores (Pages 58-59)	N/A	FEMA 102 addresses the technique of creating a "watertight core" around expensive items which are located together in a small part of the building when it is not feasible to waterproof the exterior walls. SBC does not address watertight cores.

Recommendation: None.

FEMA 102	SBC	Analysis
III.D.7 Closures and Flood Shields (Pages 60-72)	N/A	FEMA 102 addresses the use of closures and flood shields to protect against floodwater intrusion into the structure. SBC does not address floodproofing.

Recommendation: None.

FEMA 102	SBC	Analysis
III.E. Floodwalls and Levees III.E.5 Floodwall Design (Pages 80-85)	Chapter 12	FEMA 102 provides commentary type language on different types of floodwalls (permanent floodwalls, gravity walls, cantilever walls, and movable walls). SBC does not specifically address floodwalls but does require every structure to be of sufficient strength to support the loads and forces encountered.

Recommendation: None.

FEMA 102	SBC	Analysis
III.E.7 Floodwall Maintenance (Page 88)	N/A	FEMA 102 addresses the need to annually inspect floodwalls. SBC does not address the need for inspection of existing structures.

Recommendation: None.

FEMA 102	SBC	Analysis
IV. Other Floodproofing Measures IV.C. Floodproofing Utilities (Pages 99-104)	N/A	FEMA 102 addresses methods to prevent flood damage to exterior utilities. SBC does not address utilities or floodproofing. This is addressed in 602.5 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 102	SBC	Analysis
Appendix B Glossary (Pages 161-166)	202	FEMA 102 contains definitions addressing floodplain management. SBC does not address floodplain management. Floodplain management is addressed in the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 102	SBC	Analysis
Appendix D Floodproofing Performance Criteria Appendix D.B Design Loads (Pages 182-186)	Chapter 12	FEMA 102 lists the type of loads which the floodproofed structure may be subjected. SBC requires the structure to be of sufficient strength to support the loads and forces encountered.

Recommendation: None since both FEMA 102 and SBC require the structure to be designed for the loads and forces encountered. SBC should address hydrostatic, hydrodynamic, and buoyance forces in floodplain areas.

FEMA 102	SBC	Analysis
Appendix D Floodproofing Performance Criteria Appendix D.C Performance Criteria (Pages 187-193)	N/A	FEMA 102 contains performance criteria which represents the objectives that should be achieved in the design of floodproofed non-residential structures and service systems. SBC does not address floodplain management. Floodplain management is addressed in the SBCCI Standard for Floodplain Management. SBC is a performance code.

Recommendation: None since both FEMA 102 and SBC address performance.

STANDARD BUILDING CODE (SBC) COMPARISON

Retrofitting Flood-Prone Residential Structures (FEMA 114)

FEMA 114	SBC	Analysis
3.5 Elevation Onto Extended Foundation Walls (Pages 46-49)	101.5 Chapter 12 Chapter 13	FEMA 114 addresses the method of elevating the structure by increasing the foundation wall height. When this is done, consideration must be taken for the additional load imposed on the footings and the foundation wall. SBC requires alterations to comply with the Code. SBC requires the structure to be of sufficient strength to support the loads and forces encountered. SBC does not address floodplain management. Floodplain management is addressed in SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 114	SBC	Analysis
3.12 Technical Design Criteria Extended Wall Foundations (Pages 61-63)	1201.1	Both FEMA 114 and SBC require the foundation system with the increased foundation wall height to be of sufficient strength to support the loads and forces encountered.

Recommendation: None.

FEMA 114	SBC	Analysis
3.13 Technical Design Criteria Anchorage of Superstructure to Foundation (Pages 63-67)	1201.1 Chapter 17	FEMA 114 provides design details for the anchorage of the superstructure to the foundation system. SBC is a performance code and does not provide design details.

Recommendation: None.

FEMA 114	SBC	Analysis
3.14 Technical Design Criteria Open Foundations (Pages 67-68)	1201.1 Chapter 13	FEMA 114 describes three types of open foundation systems (piers, columns, or piles) and requires them to be designed for the loads encountered. SBC also addresses piers, columns, or piles and requires them to be designed for the loads and forces encountered.

Recommendation: FEMA 114 should address seismic loads.

FEMA 114	SBC	Analysis
6.2 Considerations (Floodwalls) (Pages 111-114)	1201.1	FEMA 114 addresses the use of floodwalls to protect structures from flooding and emphasizes that tremendous forces are created by high water levels and velocities. SBC does not address floodwalls but does require structures to be designed for the loads and forces encountered.

Recommendation: SBC should address hydrostatic, hydrodynamic and buoyance forces in floodplain areas.

FEMA 114	SBC	Analysis
6.3 Construction Techniques and Materials (Floodwalls) (Pages 115-119)	N/A	FEMA 114 addresses techniques and types of materials for the construction of floodwalls. SBC does not address floodwalls or floodplain management. Floodplain management is addressed in the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 114	SBC	Analysis
6.5 Technical Design Criteria (Floodwalls) (Pages 121-129)	Chapters 12, 13, 14, 15 and 16	FEMA 114 contains design criteria for floodwall design which addresses materials, soils, loads, overturning resistance, sliding resistance, and actual foundation dimensions. SBC is a performance code which requires structures to be designed to withstand the loads and forces encountered. SBC provides reference to material specifications in the materials chapters.

Recommendation: None.

FEMA 114	SBC	Analysis
7.2 Considerations (Closures) (Pages 133-134)	N/A	FEMA 114 addresses the use of closures (covering openings such as doors, windows, driveways, etc.) to act as shields to keep water away from the residence or entering the residence. SBC does not address floodplain management. Floodplain management is addressed in SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 114	SBC	Analysis
7.3 Low Profile Permanent Closures 7.4 Closure Materials and Construction 7.6 Technical Design Criteria (Closures) (Pages 133-142)	N/A	FEMA 114 addresses the use of closures (covering openings such as doors, windows, driveways, etc.) to act as shields to keep water away from the residence or entering the residence. SBC does not address floodplain management. Floodplain management is addressed in SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 114	SBC	Analysis
8.2 Considerations (Sealants) 8.3 Sealing Techniques 8.4 Closures (Sealants) 8.5 Design Details (Sealants) 8.7 Technical Design Criteria (Sealants) (Pages 145-156)	N/A	FEMA 114 addresses the sealing, making watertight, or dry floodproofing of the structure to prevent the entry of water during low level flooding. SBC does not address floodplain management. Floodplain management is addressed in the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 114	SBC	Analysis
9.4 Permanent Protective Measures (Utilities) 9.5 Utility Relocations to Existing Space 9.6 Utility Relocations to New Spaces (Pages 160-165)	N/A	FEMA 114 addresses permanent protection of a structure's utility system. SBC does not address utilities. This is addressed in 602.4 and 602.5 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

FEMA 114	SBC	Analysis
9.8 Storage Tank Anchorage (Page 166)	N/A	FEMA 114 addresses the need for proper anchorage of tanks to prevent their flotation from the buoyancy forces. SBC does not address buoyancy forces.

Recommendation: None.

FEMA 114	SBC	Analysis
10.4 Floating Structures (Pages 176-177)	N/A	FEMA 114 permits "floating structures" as a method of floodproofing. SBC does not address "floating structures."

Recommendation: None.

FEMA 114	SBC	Analysis
Appendix C - Forces (Pages 197-207)	Chapter 12	FEMA 114 addresses hydrostatic loads, hydrodynamic loads, impact loads, and wind loads. FEMA 114 also provides definitions, application and methodology for design. SBC requires design for all forces encountered but does not provide methodology. Section 900.4 of the SBCCI Standard for Floodplain Management addresses hydrostatic and hydrodynamic loads.

Recommendation: FEMA 114 should update the wind speed maps to the latest editions and address snow and seismic loads. SBC should address hydrostatic, hydrodynamic, and buoyancy forces in floodplain areas.

Alluvial Fans: Hazards and Management (FEMA 165)

FEMA 165	SBC	Analysis
Windows and Doors (Page 10)	N/A	FEMA 165 prohibits openings on the uphill side of the structure to prevent debris and flood water from entering the building. SBC does not prohibit the location of openings except for fire protection requirements. SBC does not address floodplain management. Floodplain Management is addressed in the SBCCI Standard for Floodplain Management.

Recommendation: None.

STANDARD BUILDING CODE (SBC) COMPARISON

Manual for the Construction of Residential Basements in Non-Coastal Flood Environs (MCRB)

Chapter III Basement Construction

A. Construction Types - Walls

MCRB	SBC	Analysis
III. A.1 Unreinforced Block (Page 13)	1302.6.2 1403.6 1404 1405	MCRB provides commentary type language for minimum thickness, lack of reinforcing, and the lack of resistance to lateral pressures. SBC provides minimum thickness of foundation walls based on type of wall construction and depth of unbalanced fill.

Recommendation: None.

MCRB	SBC	Analysis
III.A.2 Reinforced and Grouted Block (Pages 13, 14)	1302.6.2 1410 1411	MCRB provides commentary and prescriptive type language for minimum thickness, vertical and horizontal reinforcing, bond beam, and the capacity to resistant lateral loads. SBC provides minimum thickness, specification for mortar and grout, construction requirements for both low-lift and high-lift grouted construction, etc. SBC requires reinforced masonry to conform to the provisions of ANSI A41.2 or ACI/ASCE 530.

Recommendation: MCRB should reference ANSI A41.2 and ACI/ASCE 530.

MCRB	SBC	Analysis
III.A.3 Structural Plain Concrete (Page 14)	1302.6.2 1601.1.2 1603.2	MCRB provides commentary and prescriptive type language for minimum thickness, lack of reinforcing, minimum compressive strength, and limits on resistance to lateral pressure. SBC provides minimum thickness of foundation walls based on type of wall construction and depth of unbalanced fill.

Recommendation: None.

MCRB	SBC	Analysis
III.A.4 Reinforced Concrete (Pages 14, 15)	1601.1.1	MCRB provides commentary and prescriptive type of language for minimum thickness, reinforcing, and ability to resist lateral loads. SBC requires structural members of reinforced concrete to be designed in accordance with ACI 318.

Recommendation: MCRB should reference ACI 318.

MCRB	SBC	Analysis
III.A.5 Cut Stone, Rubble Stone, and Cribbing and Planking. (Page 15)	1402.5 1403.2 1407.5	MCRB provides commentary type language and will not consider them any further because they are not commonplace. SBC provides minimal requirements such as minimum compressive strength, minimum thickness, etc.

Recommendation: None.

MCRB	SBC	Analysis
III.A.6 Treated Wood Foundations (Page 15)	1302.8	MCRB explains that sufficient research is not available on treated wood foundations under flooded condition,s therefore, they are not included in the MCRB. SBC requires wood foundations to comply with the provisions of NFoPA Technical Report No. 7.

Recommendation: None.

MCRB	SBC	Analysis
III.A.7 Variations (Pages 15, 16)	N/A	MCRB provides commentary type language for partially reinforced masonry, unreinforced masonry, reinforced masonry, structural plain concrete, and reinforced cast-in-place concrete walls. SBC does not provide commentary language.

Recommendation: None.

MCRB	SBC	Analysis
III.A.8 Excavation and Backfilling (Pages 16-18)	1302.1.1 1302.1.3 1302.1.5 1302.3 1312.4 1608	Both MCRB and SBC require all organic material to be removed from the foundation excavation, the footings to be built on undisturbed or properly compacted soil, the bottom of the footing to be below the depth of frost penetration, foundations on expansive soils to be a mat or raft foundation, and backfill to be placed in lifts and compacted in a manner which does not damage the waterproofing or foundation wall.

Recommendation: None.

MCRB	SBC	Analysis
III.A.9 Formwork (Pages 18, 19)	1606.1 1606.2.4	Both MCRB and SBC require the forms to be substantial and sufficiently tight to prevent leakage of mortar, properly braced to maintain position, and removed in such a manner as not to damage the concrete.

Recommendation: None.

B. Other Construction Features.

MCRB	SBC	Analysis
III.B.1 Basement Slab (Page 19)	1608	MCRB states that basement slabs are typically between 3 and 4 inches thick, with and without steel wire reinforcement. SBC requires a minimum slab thickness of 3 1/2 inches and does not require wire reinforcement.

Recommendation: None.

MCRB	SBC	Analysis
III.B.2 Structural Basement Slab (Pages 19, 20)	1601.1.1 1608	MCRB provides commentary type language on the use of a structural basement slab to resist water pressures up to 5 feet above the bottom of the slab for an "undrained system" and a conventional slab for a "drained system." SBC requires structural members of reinforced concrete to be designed and constructed in accordance with ACI 318. SBC requires the thickness of floor slabs to be a minimum of 3 1/2 inches thick.

Recommendation: None.

MCRB	SBC	Analysis
III.B.3 Footing (Foundation) (Page 20)	1302.1.3 1302.4.2	Both MCRB and SBC require the bottom of the footing to be below the depth of frost penetration. MCRB provides a "typical" size of a footing. SBC is a performance code and does not provide any minimum footing size.

Recommendation: None.

MCRB	SBC	Analysis
III.B.4 Underdrain System-Sumps and Pumps (Pages 20-23)	1312.1 1312.2	Both MCRB and SBC require waterproofing where hydrostatic pressure conditions exist, however MCRB contains commentary type language. MCRB also addresses the use of a sump pump in addition to the waterproofing.

Recommendation: None.

MCRB	SBC	Analysis
III.B.5a Grand Surface Slope - Site Investigation (Pages 23, 24)	N/A	MCRB provides commentary type language addressing site investigation of the soil to determine the drainage method needed to maintain a dry basement.

Recommendation: None.

MCRB	SBC	Analysis
III.B.5b Ground Surface Slope - Grading and Surface Drainage (Pages 24, 25)	1302.1.6 1302.1.7	Both MCRB and SBC require the finish grade to slope away from the foundation for drainage. Both MCRB and SBC require provisions to be made to prevent soil erosion and divert water away from the foundation.

Recommendation: None.

MCRB	SBC	Analysis
III.B.6 Seepage Quantities (Pages 25-31)	N/A	MCRB provides a "flow net analysis" to determine if the drainage system is feasible. SBC is a performance code and does not provide sample calculations.

Recommendation: None.

MCRB	SBC	Analysis
III.B.7a Penetrations, Cracks, Joints, and "Waterproofing" - Utility Openings (Page 31)	1312.2.4	Both MCRB and SBC require penetrations through walls to be watertight.

Recommendation: None.

MCRB	SBC	Analysis
III.B.7b Penetrations, Cracks, Joints, and "Waterproofing" - Techniques that Lessen Cracking in Concrete (Pages 31-34)	N/A	MCRB provides commentary type language addressing crack control. SBC is a performance code and does not provide commentary.

Recommendation: None.

MCRB	SBC	Analysis
III.B.7c Penetrations, Cracks, Joints, and "Waterproofing" - "Waterproofing" Basements (Pages 34, 35)	1312.1 1312.2	Both MCRB and SBC address waterproofing. MCRB addresses the use of drains, sumps, and pumps. SBC addresses the use of "waterproofing" on the basement wall.

Recommendation: None.

MCRB	SBC	Analysis
III.B.8 Subsystems (Plumbing) (Pages 35, 36)	N/A	None. The SBC does not address plumbing.

Recommendation: None.

MCRB	SBC	Analysis
III.B.9 Anchorage (Pages 36, 37)	1408.3 1706.1	MCRB provides calculations to determine the anchorage requirements. MCRB requires a minimum of 1/2 inch anchor bolts spaced a maximum of 8 ft anchored into 2 block courses or 16 inches with a minimum of 2 bolts per plate. SBC requires a minimum of 1/2 inch anchor bolts spaced a maximum of 6 ft embedded at least 6 inches in concrete or 8 inches into masonry units.

Recommendation: The MCRB should be changed to comply with current model codes.

MCRB	SBC	Analysis
III.B.10 Some Concrete Construction Practices (Pages 37-46)	1602.6 1605 1607	Both MCRB and SBC contain provisions for handling and depositing concrete, consolidating concrete, cold weather considerations, additives placing reinforcement, etc. However, MCRB also contains commentary type language.

Recommendation: None.

MCRB	SBC	Analysis
III.B.11 Some Block Construction Practices (Pages 47-50)	Chapter 14	MCRB contains commentary type language addressing ways to improve the waterproofing quality of concrete masonry walls. SBC contains minimum requirements for all types of masonry construction.

Recommendation: None.

C. Loads

MCRB	SBC	Analysis
III.C.1 Soil III.C.1.a Sand, Silt, Clay III.C.1.b Expansive Soils III.C.1.c Permeability III.C.1.d Saturation (Pages 50-57)	1302.2 1302.3	MCRB contains commentary type language on soil types, expansive soils, permeability, and saturation. MCRB contains sample calculations for nonexpansive and expansive soils. SBC contains provisions for soils investigation and expansive soils.

Recommendation: None.

MCRB	SBC	Analysis
III.C.1 Soil III.C.1.e Erosion	1302.1.6	MCRB addresses methods of inhibiting erosion by soil treatment, seeding, and mulching. SBC requires provisions to be made to prevent soil erosion from roof runoff by directing water away from the foundation.

Recommendation: None.

MCRB	SBC	Analysis
III.C.1 Soil III.C.1.f Backfill Material Related to Lateral Pressures (Pages 58-63)	1312.4	MCRB provides commentary type language addressing lateral pressures exerted from backfill material. SBC simply requires the backfill material to be placed in such a manner so as not to damage the foundation wall.

Recommendation: None.

MCRB	SBC	Analysis
III.C.2 Water Table (Page 63)	N/A	None. The SBC does not address the water table.

Recommendation: None.

MCRB	SBC	Analysis
III.C.3 Superstructure Loads and Buoyancy (Pages 63-71)	N/A	MCRB contains sample calculations to determine the superstructure loads imposed by buoyancy. SBC is a performance code and does not provide sample calculations.

Recommendation: None.

MCRB	SBC	Analysis
III.C.4.d Flood Waters - Velocity (Pages 72, 73)	N/A	MCRB provides commentary type language addressing increased structural damage which may result from the high velocity of flood waters. SBC does not address flood waters.

Recommendation: None.

MCRB	SBC	Analysis
III.C.4.e Flood Waters - Sediment (Pages 73, 74)	N/A	MCRB provides commentary type language addressing flood water deposited sediment. SBC does not address sediment deposited by flood waters.

Recommendation: None.

MCRB	SBC	Analysis
III.C.4.f Flood Waters - Rate of Rise (Page 74)	N/A	MCRB provides commentary type language addressing the rate of rise of flood water causing unequal loading on basement walls which could cause damage to the wall. SBC does not address rate of rise of flood waters.

Recommendation: None.

MCRB	SBC	Analysis
III.C.4.g Flood Water - Hydraulic/ Hydrologic Relations (Pages 74, 75)	N/A	MCRB references a separate Hydraulic/Hydrologic manual which could be used to evaluate a site (i.e. for velocity of flood waters, erosion, sediment, flood water depth, and watershed hydrology).

Recommendation: None.

MCRB	SBC	Analysis
III.C.5 Debris, Wind, Impact, Snow, Ice, and Other Live Loads (Page 75)	Chapter 12	MCRB states that other than debris and impact loads; wind, snow, and ice are not considered to alter the designs in the MCRB. SBC requires every building to be of sufficient strength to support the loads and forces encountered.

Recommendation: MCRB should include wind, snow, and seismic loads.

Chapter V Basements in Floods

MCRB	SBC	Analysis
V.A. Structural Design/Analysis V.A.2. Designs, Methods, and Tables V.A.2.a Building Model, Dimensions, and Loading V.A.2.b Structural Analysis Model (Wall) V.A.2.c Structural Plain Concrete V.A.2.d Reinforced Concrete V.A.2.e Plain Masonry Block V.A.2.f Reinforced Masonry Block V.A.2.g Flood Waters Above Grade V.A.2.h Slab Thickness (Based on Bending) V.A.2.i Structural Slab Design (Ultimate Strength Design) (Pages 88-114)	N/A	MCRB contains sample structural calculations. MCRB refers to the UBC in V.A.2.e and V.A.2.f. SBC is a performance code and does not provide sample calculations.

Recommendation: MCRB should not reference a single model code. MCRB should reference only national consensus documents.

MCRB	SBC	Analysis
V.B. Soil/Water Load Philosophy V.B.1 Weir Level Load V.B.2 Buoyancy V.B.3 Slab Bending V.B.4 Wall Loads V.B.5 Clay vs. Sand or Drain and Sump vs. Sealed "Barge" V.B.5.a Drained or Sump System V.B.5.b Undrained or Barge System (Pages 114-126)	N/A	MCRB contains commentary type language addressing the design philosophy of the lateral pressures exerted by soil and/or water loadings. SBC is a performance code and does not contain commentary type language.

Recommendation: None.

VII Appendices

MCRB	SBC	Analysis
Appendix A - Soils Data Allowable Bearing Pressures (Page 164) Allowable Soil Pressures Beneath Footings (Page 166)	N/A	MCRB contains allowable bearing pressures for various soil types. SBC is a performance code. SBC relies on a soils report to determine the allowable bearing capacity.

Recommendation: None.

VIII. Builder's Guide

MCRB	SBC	Analysis
A. Introduction A.2.a Soil and Water Loading on Wall Cross-Section (Page 198) A.2.c "Waterproofing" Systems (Page 206) A.2.d Wall Design (Page 209) A.2.e Slab Design (Page 211) B. Acceptable Wall Designs B.1 Structural Plain Concrete (Unreinforced) B.2 Reinforced Concrete B.3 Unreinforced Masonry Block B.4 Reinforced Masonry Block B.5 Buoyancy Wall (Pages 212-239) C. Acceptable Slab Designs (Pages 240-246) D. Acceptable Control Joint Designs, Underdrain, "Waterproofing" and Seals D.1 Overview and Control Joints D.2 Sump, Pump, and Underdrain (for Drained System) D.3 "Waterproofing" and Seals D.3.a Undrained Slab and Wall System D.3.b Drained Slab and Wall System D.3.c Slab/Wall/Footing Juncture (Pages 247-262)	N/A	MCRB contains details and design charts for wall design, slab design, control joints, sumps, and/or waterproofing. SBC is a performance code and does not contain details or design charts.

Recommendation: None.

MCRB	SBC	Analysis
Hydraulic/Hydrologic Manual I. Introduction I.B Flood Waters I.B.4 Velocity I.B.5 Sediment (Pages 7-9)	N/A	MCRB contains commentary type language addressing increased structural damage which may result from the high velocity of floodwaters and floodwater deposited sediment. SBC does not address floodwaters.

Recommendation: None.

STANDARD BUILDING CODE (SBC) COMPARISON

Technical Standards Bulletin: Wet Floodproofing, No. 85-1

No. 85-1	SBC	Analysis
I. Definition (Page 1)	N/A	No. 85-1 provides a definition of wet floodproofing and explains the justification for this type of floodproofing. SBC does not address floodproofing. This is addressed in Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 85-1	SBC	Analysis
II. Protection Goals (Page 2)	N/A	No. 85-1 explains that wet floodproofing consists of protection of the structure , protection of interior finishes, protection of mechanical and electrical systems, protection of major equipment and machinery, and protection of contents. SBC does not address floodproofing. This is addressed in Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 85-1	SBC	Analysis
III.B. Structural Features (Pages 4-5)	N/A	No. 85-1 addresses the superstructure materials as far as durability, resistance to the deterioration caused by floodwaters, and water resistance. SBC does not address floodproofing. This is addressed in Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 85-1	SBC	Analysis
III.C Building Activity and Use (Pages 5-6)	N/A	No. 85-1 addresses the need to determine the feasibility of wet floodproofing based on building activity and use. SBC does not address floodproofing. This is addressed in Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 85-1	SBC	Analysis
IV.A.1 Foundations (Page 6)	N/A	No. 85-1 emphasizes the importance of the need to investigate the influence of hydrologic and hydraulic conditions on the foundation design when wet floodproofing is used. SBC does not address floodproofing. This is addressed in Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 85-1	SBC	Analysis
IV.A.2 Cavity Wall Construction (Pages 6-7)	N/A	No. 85-1 addresses the need to drain the cavity space at a rate approximately equal to the flood rate. SBC does not address floodproofing. This is addressed in Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 85-1	SBC	Analysis
IV.A.3 Solid Wall Construction (Pages 7-8)	N/A	No. 85-1 addresses the need for the interior and exterior wall cladding to be relatively impervious to prevent the intrusion of the floodwaters into the wall. SBC does not address floodproofing. This is addressed in Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 85-1	SBC	Analysis
IV.A.4 Interior Walls (Page 8)	N/A	No. 85-1 emphasizes that the criteria for cavity wall and solid wall construction applies to interior walls. SBC does not address floodproofing. This is addressed in Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 85-1	SBC	Analysis
IV.A.5 Interior Wall Finishes (Page 8)	N/A	No. 85-1 addresses the need for the interior finishes to be able to withstand inundation for a minimum of 160 hours without damage, not be subject to deterioration from chemicals in the floodwaters, and capable of being easily cleaned. SBC does not address floodproofing. This is addressed in Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 85-1	SBC	Analysis
IV.A.6 Floors (Pages 8-9)	N/A	No. 85-1 addresses the need for floor systems to be capable of withstanding the hydrostatic pressure generated by a water level differential of two feet between the exterior and interior of the structure. SBC does not address floodproofing. This is addressed in Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 85-1	SBC	Analysis
IV.A.7 Ceiling and Roofs (Page 9)	N/A	No. 85-1 addresses the need for the ceiling materials to be of a type to withstand prolonged exposure to moisture and humidity. SBC does not address floodproofing. This is addressed in Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 85-1	SBC	Analysis
IV.A.8 Building Envelope Penetrations (Page 10)	N/A	No. 85-1 addresses the need for building penetrations (doors, louvers, vents, skylights, etc.) to be capable of resisting damage for a minimum of 160 hours of inundation, be essentially nonporous, and be conducive to easy cleaning. SBC does not address floodproofing. This is addressed in Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 85-1	SBC	Analysis
IV.A.9 Electrical System (Pages 10-11)	N/A	No. 85-1 addresses the need to prevent vulnerable electrical components from coming in contact with the floodwaters. SBC does not address floodproofing. This is addressed in 602.5 and Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 85-1	SBC	Analysis
IV.A.10 HVAC (Pages 11-12)	N/A	No. 85-1 emphasizes that the key protective measures for HVAC equipment is elevation and enclosure. SBC does not address protection of HVAC equipment from floodwaters. This is addressed in 602.5 and Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

STANDARD BUILDING CODE (SBC) COMPARISON

Technical Standards Bulletin: Foundation Wall Openings, No. 85-2

No. 85-2	SBC	Analysis
Flood Forces (Pages 1-3)	1201.1	No. 85-2 provides commentary type language on flood forces (hydrostatic and hydrodynamic pressure) and formulas to determine these pressures. SBC requires the structure to be of sufficient strength to support the loads and forces encountered (wind, water, seismic, snow).

Recommendation: No. 85-2 should address snow and seismic loads.

No. 85-2	SBC	Analysis
Openings Design Criteria (Pages 4-6)	1302.6.3	No. 85-2 provides the design criteria to size the openings needed to allow floodwaters into an enclosure for the purpose of equalizing hydrostatic pressures. SBC only addresses crawl space openings needed for ventilation. This is addressed in 602.2 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

STANDARD BUILDING CODE (SBC) COMPARISON

Technical Standards Bulletin: Breakaway Walls, No. 85-3

No. 85-3	SBC	Analysis
II. Wind and Water Forces (Pages 2-3)	1201.1 1205	No. 85-3 addresses wind and flood water loads. SBC requires every structure to be of sufficient strength to support the loads and forces encountered. SBC does not specifically address flood water forces but does address wind, snow, and seismic loads. No. 85-3 references the building codes or ANSI A58.1-1982 for information on wind loads. SBC references ASCE 7-88 in addition to providing a wind load map, velocity pressures and coefficients.

Recommendation: No. 85-3 should update reference to ASCE 7-88 and address snow and seismic loads.

No. 85-3	SBC	Analysis
III. Design Approach (Page 4)	1201.1	No. 85-3 requires the breakaway wall to be designed to withstand at least 10 psf but no more than 20 psf. SBC does not address breakaway walls. SBC requires the structure to be designed for the loads and forces encountered. Breakaway walls are addressed in 801.4 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 85-3	SBC	Analysis
IV. Design Considerations (Pages 4-10)	N/A	No. 85-3 provides commentary type language and details for various types of breakaway walls. SBC does not address breakaway walls. SBC requires the structure to be designed for the loads and forces encountered. Breakaway walls are addressed in 801.4 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

STANDARD BUILDING CODE (SBC) COMPARISON

Technical Standards Bulletin: Wind Design Standards and the NFIP, No. 88-1

No. 88-1	SBC	Analysis
Pages 1-5	1201.1 1205	Both No. 88-1 and SBC address wind loads. No. 88-1 contains a reference to ANSI A58.1-1982. SBC references ASCE 7-88 in addition to containing a wind speed map, velocity pressure table, and coefficients for wind load design. SBC requires the structure to be of sufficient strength to support the loads and forces encountered.

Recommendation: No. 88-1 should update reference to ASCE 7-88 and address snow and seismic loads.

STANDARD BUILDING CODE (SBC) COMPARISON

Technical Standards Bulletin: Flood Resistant Materials, No. 88-2

No. 88-2	SBC	Analysis
Pages 1-7	N/A	No. 88-2 provides data and guidance to determine "materials resistant to flood damage" and how the material should be used to improve a structure's ability to withstand flooding. SBC does not address "flood resistant" materials. This is addressed in 602.4 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

STANDARD BUILDING CODE (SBC) COMPARISON

Technical Standards Bulletin: Free of Obstruction Requirement in Coastal High Hazard Areas, No. 88-3

No. 88-3	SBC	Analysis
Lower Area Obstructions (Pages 2-4)	1201.1	No. 88-3 prohibits the construction of anything; except breakaway walls, open wood latticework, or insect screening; beneath the lowest horizontal structural member in V zones. SBC does not prohibit construction provided it is of sufficient strength to support the loads or forces encountered. This is addressed in 602.3, 800.2 and 801.4 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 88-3	SBC	Analysis
Obstructions Outside the Perimeter of the Coastal Building (Pages 4-6)	1201.1	No. 88-3 requires structures outside the perimeter of the coastal building to be anchored to resist flotation, collapse, and lateral movement due to the combined effects of wind and water loads. SBC requires structures to be of sufficient strength to support the loads and forces encountered. SBC does not address flotation. This is addressed in 801.1 of the SBCCI Standard for Floodplain Management.

Recommendation: None.

No. 88-3	SBC	Analysis
Obstructions Attached to But Outside the Building Perimeter (Page 6)	Chapter 1	No. 88-3 explains that anything attached to the building is considered part of the building and has to meet the same requirements as the building. SBC requires every building or structure to comply with the Code.

Recommendation: None.

STANDARD BUILDING CODE (SBC) COMPARISON

Technical Standards Bulletin: Protection of Elevator Equipment in Flood Hazard Areas, No. 88-4

No. 88-4	SBC	Analysis
Recommendations (Page 3)	N/A	No. 88-4 recommends that the elevator-related hydraulic equipment and elevator-related electrical equipment be located above the BFE. No. 88-4 recommends that electrical equipment that cannot be placed above the BFE to be of water resistant models. No. 88-4 recommends that the elevator cab automatically stay above flood waters by interlocking the controls with "float" switches in the elevator shaft. SBC does not address floodplain management. Floodplain management is addressed in the SBCCI Standard for Floodplain Management.

Recommendation: None.

STANDARD BUILDING CODE (SBC) COMPARISON

Technical Standards Bulletin: NFIP Requirements for Below Grade Parking Garages in Flood Hazard Areas, No. 90-2

No. 90-2	SBC	Analysis
Pages 1-4	N/A	No. 90-2 provides a summary of the National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification) requirements for below grade parking garages in flood hazard areas. SBC does not address floodplain management. Floodplain Management is addressed in the SBCCI Standard for Floodplain Management.

Recommendation: None.

STANDARD BUILDING CODE (SBC) COMPARISON

Technical Standards Bulletin: Non-Residential Floodproofing Certification Requirements of the National Flood Insurance Program, No. 90-3

No. 90-3	SBC	Analysis
Pages 1-6	N/A	No. 90-3 provides a summary of the National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification) requirements to obtain certification by floodproofing the non-residential structure. No. 90-3 also provides the forces that the structure would be subjected to when the structure is subjected to the base flood. SBC does not address floodplain management. Floodplain management is addressed in the SBCCI Standard for Floodplain Management.

Recommendation: None.

STANDARD BUILDING CODE (SBC) COMPARISON

Technical Standards Bulletin: Installation of Manufactured Homes in Special Flood Hazard Areas, No. 90-4

No. 90-4	SBC	Analysis
Pages 3-19	Appendix H	No. 90-4 provides a summary of the National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification) requirements which affect the placement of manufactured homes in flood hazard areas. SBC addresses manufactured home tiedown requirements based on hurricane and nonhurricane zones. SBC does not address floodplain management. Floodplain management is addressed in the SBCCI Standard for Floodplain Management.

Recommendation: None.

STANDARD MECHANICAL CODE (SMC) COMPARISON

NFIP (Regulations for Floodplain Management and Flood Hazard Identification) (44 CFR 59.1, 60.3, and 60.6)

NFIP	SMC	Analysis
59.1 Definitions 60.3 Floodplain Management Criteria for Flood-Prone Areas	N/A	None. These sections of NFIP do not address mechanical equipment or its installation.

Recommendation: None.

60.6 – Variances and Exceptions

NFIP	SMC	Analysis
60.6(c)(2)(i) Flood-Proof Wall	302 303	NFIP requires the basement area, together with utilities and sanitary facilities below the floodproofed design level, to be watertight with walls that are impermeable to the passage of water without human intervention. The SMC allows underfloor installation but does not specify minimum elevations for equipment. This is addressed in 602.1.2, 602.5, and Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: The SMC should be revised to reference the SBCCI Standard for Floodplain Management.

NFIP	SMC	Analysis
60.6(c)(2)(ii) Basement Top of Floor Elevation 60.6(c)(2)(iii) Fill 60.6(c)(2)(iv) Use of a Registered Professional 60.6(c)(2)(v) Building Inspection	N/A	None. NFIP does not address mechanical equipment or its installation.

Recommendation: None.

STANDARD MECHANICAL CODE (SMC) COMPARISON

Elevated Residential Structures (FEMA 54)

FEMA 54	SMC	Analysis
Design and Construction Guidelines posts post embedment post anchorage piers brick and concrete masonry piers concrete piers pier footings shear walls and floor diaphragms pier foundation connections floor beams cantilevers floor joist to floor beam connection (Pages 68-88)	N/A	None. These sections of FEMA 54 do not address mechanical equipment or its installation.

Recommendation: None.

FEMA 54	SMC	Analysis
Figure 4.48 Protective Utility Shaft (Page 92)	607 607.3.1.5	FEMA 54 requires fuel piping serving an elevated structure to be on the leeward side of post/columns or enclosed in a protective shaft. SMC requires piping to be supported and protected against physical damage.

Recommendation: None since both address the issue of damage only in different directions. FEMA - prescriptive SMC - performance.

FEMA 54	SMC	Analysis
Mechanical Equipment (Page 93, Paragraph 2)	302 303	FEMA 54 requires all mechanical equipment to be elevated above expected flood waters, with indoor components preferably installed in attics. The SMC allows attic installation but does not specify minimum elevations for equipment.

Recommendation: These sections of the SMC should be revised to reference the SBCCI Standard for Floodplain Management.

FEMA 54	SMC	Analysis
Mechanical Equipment (Page 93, Paragraph 2) Continued	Ch. 5 504.2	FEMA 54 requires air ductwork to have emergency openings at lowest elevations and a minimum slope on horizontal duct runs to allow drainage. The SMC requires that ducts be suitably protected when placed in locations where they may be subject to damage.

Recommendation: None since both address the issue of damage only in different directions. FEMA - prescriptive SMC - performance.

FEMA 54	SMC	Analysis
Septic Tanks (Page 93, Paragraph 3)	N/A	The SMC does not address septic tanks.

Recommendation: None.

FEMA 54	SMC	Analysis
Building Materials Wood Steel Concrete and Masonry (Pages 93-95)	N/A	None. These sections of FEMA 54 do not address mechanical equipment or its installation.

Recommendation: None.

FEMA 54	SMC	Analysis
Insulation (Pages 95, 96)	506 610	FEMA 54 requires underfloor exposed pipes to be insulated with impermeable or inexpensively replaced insulation. Inexpensive insulation is not defined in FEMA. The SMC requires air duct in nonconditioned areas to be insulated and piping to be insulated for personal protection and for condensation control. This is addressed in 602.4 and 602.5 of the SBCCI Standard for Floodplain Management.

Recommendation: Change FEMA 54 to address insulation of exposed ductwork.

FEMA 54	SMC	Analysis
Glossary (Pages 113-115)	N/A	None. The Glossary section of FEMA 54 does not address mechanical equipment or installation.

Recommendation: None.

FEMA 54	SMC	Analysis
Performance Criteria C.2 (1.3) "Protection Against Unnecessary Damage" (Page 134)	607, 607.3.1.5, 302, 303, Ch. 5, 504.2	See previous sections. This is only a recap.

Recommendation: None.

STANDARD MECHANICAL CODE (SMC) COMPARISON

Coastal Construction Manual (FEMA 55)

FEMA 55	SMC	Analysis
Chapter 4 -Structural Design Section 4.3.6 Utilities (Pages 4-50 to 4-52)	Ch. 3 607 607.3.1.5 302 303	FEMA 55 requires all mechanical equipment to be elevated above BFE, and fuel piping be on the leeward side of columns/piers or enclosed in shaft. The SMC allows attic installation of equipment, but does not specify minimum elevations for equipment. The SMC requires fuel piping to be supported and protected from physical damage.

Recommendation: (1) For equipment location - the SMC should be revised to reference the Standard for Floodplain Management (2) for fuel pipe protection - None both address the issue only in different directions. FEMA - prescriptive SMC - performance

FEMA 55	SMC	Analysis
Ch. 5 - Larger Structures (Pages 5-1 to 5-9) Appendix A - Design Tables (Pages A-1 to A-47) Appendix B - Bracing (Pages B-1 to B-15) Appendix D - Design Equation and Procedures (Pages D-1 to D-32)	N/A	None. These sections of FEMA 55 do not address mechanical equipment or its installation.

Recommendation: None.

FEMA 55	SMC	Analysis
Appendix G "Sample Coastal Construction Code" 12. Utilities (Page G-8)	302 303	FEMA 55 requires all mechanical equipment to be elevated above expected floodwaters. The SMC allows such installations, but does not specify minimum equipment elevations.

Recommendation: The SMC should be revised to reference the Standard for Floodplain Management.

STANDARD MECHANICAL CODE (SMC) COMPARISON

Manufactured Home Installation in Flood Hazard Areas (FEMA 85)

FEMA 85	SMC	Analysis
Chapter III Elevation and Anchoring Techniques (Pages 19-31) Chapter IV Design of Elevated Foundations (Pages 33-70) Appendix D Calculational Procedure for Elevated Foundation Design (Pages 89-97) Appendix E Buoyancy and Drag Forces (Pages 99-101)	N/A	None. These sections of FEMA do not address mechanical equipment or its installation.

Recommendation: None.

Floodproofing Non-Residential Structures (FEMA 102)

FEMA 102	SMC	Analysis
Ch. I Introduction (Pages 8-13) Ch. III Floodproofing Design Permanent & Contingent Measures (Pages 37-72, 80-88)	N/A	None. These sections of FEMA 102 do not address mechanical equipment or its installation.

Recommendation: None.

FEMA 102	SMC	Analysis
Ch. IV Other Floodproofing Measures C. Utilities (Pages 99-105)	302 303	FEMA 102 requires mechanical equipment to be elevated above BFE or "floodproofed". Floodproofing entails a watertight enclosure, with all penetrations into the building pressure sealed. The SMC allows such installations, with proper access and clearance to combustibles.
	308	FEMA 102 requires mechanical exhaust fans discharging below the BFE to be protected by flood shields. The SMC requires exhaust to discharge outdoors at a point where it will not cause a nuisance or 10 ft above a public walkway.

Recommendation: (1) Revise SMC to reference the Standard for Floodplain Management (2) Revise FEMA 102 to reference the locally adopted model code for installation clearances.

FEMA 102	SMC	Analysis
Appendix B "Glossary" (Pages 161-166) Appendix D "Floodproofing Performance Criteria" Parts B and D (Pages 182-193)	N/A	None. These sections of FEMA 102 do not address mechanical equipment or its installation.

Recommendation: None.

FEMA 102	SMC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (A) Location (Page 192)	302 303	FEMA 102 requires that all mechanical equipment be installed above BFE, or be enclosed in water-tight rooms. The SMC allows elevated or enclosed installation but requires access and clearance to combustibles.

Recommendation: (1) Revise FEMA 102 to reference the local model codes for access and clearance. (2) Revise SMC to reference Standard for Floodplain Management

FEMA 102	SMC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating, Air-Conditioning and Ventilation (B) Heating and Air Conditioning (Page 192)	607	FEMA 102 requires that fuel systems below the BFE be equipped with automatic shutoff valves activated by rising water. The SMC would not require or prohibit such valves.
	306.2	FEMA 102 requires all heating equipment be vented to a level above BFE. SMC requires vent/chimney termination 3 ft above roof and 2 ft higher than any portion of the roof within 10 ft.

Recommendation: Revise SMC to reference Standard for Floodplain Management.

FEMA 102	SMC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (c) Ventilation (Page 193)	307 308 Ch. 5	FEMA 102 requires all ductwork located below BFE to slope to drainage openings. The SMC does not require conditioned air ducts to slope.
	Ch. 5	FEMA 102 requires all ductwork located below BFE to be anchored against floodwaters. The SMC requires adequate support per SMACNA.
	510	FEMA 102 requires all penetrations of the building envelope by air ductwork to have a closure assembly. The SMC requires fire dampers at certain firewalls.

Recommendation: The SMC should be revised to reference Standard Floodplain Management.

FEMA 102	SMC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (D) Fuel Tanks and Lines (Page 193)	607	FEMA 102 requires fuel tanks and lines to be located above BFE or anchored and protected from floodwater velocity/surge with a fact of safety of 1.5. The SMC allows installation of fuel storage tanks either inside or outside buildings but does not address uplift forces. The SMC states that the piping shall be protected from physical damage.

Recommendation: The SMC should reference tank location, uplift forces, and the Standard for Floodplain Management.

FEMA 102	SMC	Analysis
Appendix D "Floodproofing Performance Criteria Part C "Performance Criteria" Criteria #7 "Plumbing Systems" (Page 193)	N/A	None. This appendix of FEMA 102 does not address mechanical equipment on its installation.

Recommendation: None.

Retrofitting Flood-Prone Residential Structures (FEMA 114)

FEMA 114	SMC	Analysis
Ch. 3 Elevation (Pages 46-49, 61-68) Ch. 6 Floodwalls (Pages 111-129) Ch. 7 Closures (Pages 133-142) Ch. 8 Sealants (Pages 145-156)	N/A	None. These sections of FEMA 114 do not address mechanical equipment or its installation.

Recommendation: None.

FEMA 114	SMC	Analysis
Ch. 9 Protection of Utilities 9.4 Permanent Protective Measures (Pages 160-163)	Ch. 3	FEMA 114 requires utility connections to be above flood level, shielding for basement appliances, elevated installation for exterior appliances, suspension for underfloor equipment, and anchoring for fuel storage tanks. The SMC allows these types of installations but requires minimum clearances to combustibles and access which is ignored by FEMA 114.

Recommendation: (1) Change FEMA to reference locally adopted model codes for clearances to combustible materials and minimum access (2) change the SMC to reference the Standard for Floodplain Management.

FEMA 114	SMC	Analysis
Ch. 9 Protection of Utilities 9.5 Utility Relocation to Existing Space (Pages 163-164)	Ch. 3	FEMA 114 addresses relocation of mechanical equipment from the basement to upper levels or attics. The SMC allows attic or closet installation as an option, but specifies minimum clearances and access.

Recommendation: Section 9.5 of FEMA 114 should be revised to reference minimum clearances for heat producing appliances according to local model codes.

FEMA 114	SMC	Analysis
Ch. 9 Protection of Utilities 9.6 Utility Relocations to New Space (Pages 164, 165)	Ch. 3	FEMA 114 addresses relocation of mechanical equipment to a newly constructed space. The SMC allows equipment rooms, but specifies minimum clearances and access.

Recommendation: Section 9.6 of FEMA 114 should be revised to encourage obtaining a building permit for new construction/alterations. It should also reference model codes for minimum clearance to combustibles and access to equipment.

FEMA 114	SMC	Analysis
Ch. 9 Protection of Utilities 9.8 Storage Tank Anchorage (Page 166)	607	FEMA 114 requires anchorage of fuel storage tanks. The SMC allows installation of fuel storage tanks inside or outside structures, but does not specifically address uplift forces.

Recommendation: Revise the SMC to reference the Standard for Floodplain Management and add a section on fuel tank anchorage.

FEMA 114	SMC	Analysis
Chapter 10 Special Situations (Pages 176, 177) Appendix C Forces (Pages 197-207)	N/A	None. These sections of FEMA 114 do not address mechanical equipment or its installation.

Recommendation: None.

Alluvial Fans: Hazards and Management (FEMA 165)

FEMA 165	SMC	Analysis
Windows and Doors (Page 10)	N/A	None. This page of FEMA 165 does not address mechanical equipment or its installation.

Recommendation: None.

STANDARD MECHANICAL CODE (SMC) COMPARISON

Manual for the Construction of Residential Basements in Non-Coastal Flood Environs (MCRB)

MCRB	SMC	Analysis
Chapter III. Basement Construction (Pages 13-75) Chapter V. Basements in Floods (Pages 88-126) Chapter VII Appendix A – Soils Data (Pages 164, 166) Chapter VIII Builder's Guide (Pages 198, 206, 209, 211-262) Hydraulic/Hydrologic Manual (Pages 7-10)	N/A	None. MCRB does not address mechanical equipment or its installation.

Recommendation: None.

STANDARD MECHANICAL CODE (SMC) COMPARISON

Technical Standards Bulletin: Wet Floodproofing, No. 85-1

No. 85-1	SMC	Analysis
Definition Protection Goals Considerations for Applicability (Pages 1-6)	N/A	None. These sections of No. 85-1 do not address mechanical equipment or its installation.

Recommendation: None.

No. 85-1	SMC	Analysis
IV. Guidelines for Implementation A.1 Foundations A.2 Cavity Wall Construction A.3 Solid Wall Construction A.4 Interior Walls A.5 Interior Wall Finishes A.6 Floors A.7 Ceilings and Roofs A.8 Building Envelope Penetrations A.9 Electrical Systems (Pages 6-11)	N/A	None. These sections of No. 85-1 do not address mechanical equipment or its installation.

Recommendation: None.

No. 85-1	SMC	Analysis
IV. Guidelines for Implementation 4.A.10 HVAC (Page 11)	302 303	No. 85-1 requires mechanical equipment to be elevated or enclosed for protection. The SMC allows enclosed installations, but does not specify minimum elevations for equipment.

Recommendation: The SMC should be revised to reference the Standard for Floodplain Management.

STANDARD MECHANICAL CODE (SMC) COMPARISON

Technical Standards Bulletin: Foundation Wall Openings, No. 85-2

No. 85-2	SMC	Analysis
Flood Forces (Pages 1-3)	N/A	None. This section of No. 85-2 does not address mechanical equipment or its installation.

Recommendation: None.

No. 85-2	SMC	Analysis
Openings Design Criteria (Pages 4-6)	302 303	No. 85-2 gives sizing criteria for foundation wall openings used to equalize hydrostatic pressures. The SMC addresses crawl space access opening size only where mechanical equipment is installed there. This section of FEMA really doesn't address mechanical equipment installation.

Recommendation: None.

STANDARD MECHANICAL CODE (SMC) COMPARISON

Technical Standards Bulletin: Breakaway Walls, No. 85-3

No. 85-3	SMC	Analysis
II. Wind and Water Forces III. Design Approach IV. Design Considerations (Pages 2-10)	N/A	None. These sections of No. 85-3 do not address mechanical equipment or its installation.

Recommendation: None.

STANDARD MECHANICAL CODE (SMC) COMPARISON

Technical Standards Bulletin: Wind Design Standards and the NFIP, No. 88-1

No. 88-1	SMC	Analysis
Pages 1-5	N/A	None. These pages of No. 88-1 do not address mechanical equipment or its installation.

Recommendation: None.

STANDARD MECHANICAL CODE (SMC) COMPARISON

Technical Standards Bulletin: Flood Resistant Materials, No. 88-2

No. 88-2	SMC	Analysis
Pages 1-7	N/A	None. These pages of No. 88-2 do not address mechanical equipment or its installation.

Recommendation: None.

STANDARD MECHANICAL CODE (SMC) COMPARISON

Technical Standards Bulletin: Free of Obstruction Requirement in Coastal High Hazard Areas, No. 88-3

No. 88-3	SMC	Analysis
Lower Area Obstructions Obstructions Outside the Perimeter of the Coastal Building Obstructions Attached to But Outside the Building Perimeter (Pages 2-6)	N/A	None. These pages of No. 88-3 do not address mechanical equipment or its installation.

Recommendation: None.

STANDARD MECHANICAL CODE (SMC) COMPARISON

Technical Standards Bulletin: Protection of Elevator Equipment in Flood Hazard Areas, No. 88-4

No. 88-4	SMC	Analysis
Recommendation #1 Page 3	Ch. 3	No. 88-4 requires location of elevator equipment above base flood elevation. The SMC allows such installation but does not specify minimum equipment elevations.

Recommendation: Revise the SMC to reference the Standard for Floodplain Management.

STANDARD MECHANICAL CODE (SMC) COMPARISON

Technical Standards Bulletin: NFIP Requirements for Below Grade Parking Garages in Flood Hazard Areas, No. 90-2

No. 90-2	SMC	Analysis
Pages 1-4	N/A	None. These pages of No. 90-2 do not address mechanical equipment or its installation.

Recommendation: None.

STANDARD MECHANICAL CODE (SMC) COMPARISON

Technical Standards Bulletin: Non-Residential Floodproofing Certification Requirements of the National Flood Insurance Program, No. 90-3

No. 90-3	SMC	Analysis
Section D-2 (Pages 1-6)	Ch. 3	No. 90-3 requires all utilities to be (1) Above BFE or (2) completely watertight, or (3) completely enclosed by the building's watertight walls. The SMC allows such installations but requires clearances and access to equipment.

Recommendation: Revise No. 90-3 to reference the local model codes for clearance to combustibles and access to equipment.

STANDARD MECHANICAL CODE (SMC) COMPARISON

Technical Standards Bulletin: Installation of Manufactured Homes in Special Flood Hazard Areas, No. 90-4

No. 90-4	SMC	Analysis
Pages 3-19	N/A	None. These sections of No. 90-4 do not address mechanical equipment or its installation.

Recommendation: None.

STANDARD GAS CODE (SGC) COMPARISON

NFIP (Regulations for Floodplain Management and Flood Hazard Identification) (44 CFR 59.1, 60.3, and 60.6)

NFIP	SGC	Analysis
59.1 Definitions 60.3 Floodplain Management Criteria to Flood-Prone Areas	N/A	None. These sections of NFIP do not address gas-fired equipment.

Recommendation: None.

60.6 – Variances and Exceptions

NFIP	SGC	Analysis
60.6(c)(2)(i) Flood-proof Walls	Chapter 4	NFIP requires the basement area, together with utilities and sanitary facilities below the floodproofed design level, to be watertight with walls that are impermeable to the passage of water without human intervention. The SGC defers to the SMC for access and clearance, but does specify minimum combustion air and venting criteria. Utility location and floodproofing are addressed in 602.1.2, 602.5, and Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: The SGC should be revised to reference the SBCCI Standard for Floodplain Management.

NFIP	SGC	Analysis
60.6(c)(2)(ii) Basement Top of Floor Elevation 60.6(c)(2)(iii) Fill 60.6(c)(2)(iv) Use of a Registered Professional 60.6(c)(2)(v) Building Inspection	N/A	None. NFIP does not address gas-fired equipment.

Recommendation: None.

Elevated Residential Structures (FEMA 54)

FEMA 54	SGC	Analysis
Design and Construction Guidelines posts post embedment post anchorage piers brick and concrete masonry piers concrete piers pier footings shear walls and floor diaphragms pier foundation connections floor beams cantilevers floor joist to floor beam connection (Pages 68-88)	N/A	None. These sections of FEMA 54 do not address gas-fired equipment.

Recommendation: None.

FEMA 54	SGC	Analysis
Figure 4.48 Protective Utility Shaft (Page 92)	Ch. 3 308	FEMA 54 requires gas piping serving an elevated structure to be installed on the leeward side of post/columns or enclosed in a protective shaft. The SGC requires piping to be supported and allows a shaft enclosure.

Recommendation: The SGC should be revised to reference the Standard for Floodplain Management.

FEMA 54	SGC	Analysis
Mechanical Equipment (Page 93, Paragraph 2)	Ch. 4 402.4	FEMA 54 requires all gas-fired mechanical equipment to be elevated above expected flood waters with indoor components preferably installed in attic. The SGC defers to the SMC for access and clearance, but does specify minimum combustion air and venting criteria. Ductwork is covered in the SMC.

Recommendation: (1) Revise FEMA to caution that fuel-fired equipment must be installed to local codes (2) Revise SGC to reference the Standard for Floodplain Management.

FEMA 54	SGC	Analysis
Septic Tanks (Page 93, Paragraph 3)	N/A	None. The SGC does not address septic tanks.

Recommendation: None.

FEMA 54	SGC	Analysis
Building Materials Wood Steel Concrete and Masonry (Pages 93-95)	N/A	None. These sections of FEMA 54 do not address gas-fired mechanical equipment.

Recommendation: None.

FEMA 54	SGC	Analysis
Insulation (Pages 95, 96)	N/A	None. The SGC does not address insulation.

Recommendation: None.

FEMA 54	SGC	Analysis
Glossary (Pages 113-115)	N/A	None. The Glossary section of FEMA 54 does not address gas-fired mechanical equipment.

Recommendation: None.

FEMA 54	SGC	Analysis
Performance Criteria C. 2 (1.3) "Protection Against Unnecessary Damage" (Page 134)	Ch. 3, 308 Ch. 4, 402.4	See previous sections on FEMA 54. This is only a summary.

Recommendation: None.

STANDARD GAS CODE (SGC) COMPARISON

Coastal Construction Manual (FEMA 55)

FEMA 55	SGC	Analysis
Chapter 4 - Structural Design Section 4.3.6 Utilities (Pages 4-50 to 4-52)	Ch. 3, 308, Ch. 4, 402.4	FEMA 55 requires all gas-fired equipment to be elevated above expected flood water and gas piping to be installed on the leeward side of posts/columns or enclosed in shafts. The SGC defers to the SMC for access requirements, but does specify minimum combustion air and venting. The SGC requires piping to be supported and would allow the shaft.

Recommendation: (1) For elevation - revise the SGC to reference the Standard for Floodplain Management. (2) For fuel supply - revise FEMA to reference model codes for installation.

FEMA 55	SGC	Analysis
Ch. 5 Larger Structures (Pages 5-1 to 5-9) Appendix A Design Tables (Pages A-1 to A-47) Appendix B Bracing (Pages B-1 to B-15) Appendix D Design Equations and Procedures (Pages D-1 to D-32)	N/A	None. These sections of FEMA 55 do not address gas-fired mechanical equipment.

Recommendation: None.

FEMA 55	SGC	Analysis
Appendix G "Sample Coastal Construction Code" 12 Utilities (Page G-8)	Ch. 4	FEMA 55 requires all gas-fueled mechanical equipment to be elevated above flood waters. The SGC allows elevated installations but also requires minimum combustion air and venting criteria.

Recommendation: (1) Revise SGC to reference the Standard for Floodplain Management. (2) Revise FEMA 55 to reference local model codes for installation.

Manufactured Home Installation in Flood Hazard Areas (FEMA 85)

FEMA 85	SGC	Analysis
Chapter III Elevation and Anchoring Techniques (Pages 19-31) Chapter IV Design of Elevated Foundations (Pages 33-70) Appendix D Calculational Procedure for Elevated Foundation Design (Pages 89-97) Appendix E Buoyancy and Drag Forces (Pages 99-101)	N/A	None. These sections of FEMA 85 do not address gas-fired mechanical equipment.

Recommendation: None.

STANDARD GAS CODE (SGC) COMPARISON

Floodproofing Non-Residential Structures (FEMA 102)

FEMA 102	SGC	Analysis
Ch. I Introduction (Pages 8-13) Ch. III Floodproofing Design Permanent & Contingent Measures (Pages 37-72, 80-88)	N/A	None. These sections of FEMA 102 do not address gas-fired mechanical equipment.

Recommendation: None.

FEMA 102	SGC	Analysis
Chapter IV Other Floodproofing Measures C. Utilities (Pages 99-105)	402 611	FEMA 102 requires gas-fired mechanical equipment to be elevated above "BFE" or "floodproofed." Floodproofing entails a watertight enclosure for equipment with all penetrations of the building envelope pressure sealed. The SGC allows equipment enclosure with proper access. Adequate combustion air and proper venting.
	611	FEMA 102 requires exterior gas natural draft vents below BFE to be protected by flood shields. The SGC allows very limited exterior venting.

Recommendation: (1) Revise the SGC to reference the Standard for Floodplain Management. (2) Revise FEMA 102 to reference the locally adopted model code for installation criteria.

FEMA 102	SGC	Analysis
Appendix B "Glossary" (Pages 161-166) Appendix D "Floodproofing Performance Criteria Parts B and D (Pages 182-192)	N/A	None. These sections of FEMA 102 do not address gas-fuel appliances.

Recommendation: None.

FEMA 102	SGC	Analysis
Appendix D "Floodproofing Performance Criteria Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning and Ventilation (A) Location (Page 192)	Ch. 4 402.4	FEMA 102 requires that all gas-fired mechanical equipment be installed above BFE, or be enclosed in water-tight rooms. The SGC allows elevated or enclosed installation, but specifies minimum combustion air and venting.

Recommendation: (1) Revise SGC to reference Standard of Floodplain Management. (2) Revise FEMA to reference locally adopted model codes for installation requirements.

FEMA 102	SGC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (B) Heating and Air Conditioning (Page 192)	Ch. 4 Ch. 5 Ch. 6 608.3	FEMA 102 requires that gas delivery systems installed below BFE be equipped with automatic shutoff valves, activated by rising water. The SGC would not require or prohibit such valves. FEMA 102 requires all gas heating equipment be vented to a level above BFE. The SGC requires natural draft gas vents to terminate at least 2 ft above roof and 2 ft above any portion of the roof within 10 ft.

Recommendation: Revise SGC to reference Standard of Floodplain Management.

FEMA 102	SGC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (C) Ventilation (Page 193)	N/A	Ventilation ductwork is addressed in the SMC.

Recommendation: None.

FEMA 102	SGC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning & Ventilation (D) Fuel Tanks and Lines (Page 193)	Ch. 3 Ch. 9	FEMA 102 requires fuel storage tanks and lines to be located above BFE or anchored and protected against floodwaters by a factor of safety of 1.5. The SGC does not address uplift forces on storage tanks.

Recommendation: Revise SGC to reference Standard of Floodplain Management and address buoyancy forces on storage tanks.

FEMA 102	SGC	Analysis
Appendix D "Floodproofing Performance Criteria Part C "Performance Criteria" Criteria #7 "Plumbing Systems" (Page 193)	N/A	None. The SGC does not address plumbing.

Recommendation: None.

Retrofitting Flood-Prone Residential Structures (FEMA 114)

FEMA 114	SGC	Analysis
Ch. 3 Elevation (Pages 46-49, 61-68) Ch. 6 Floodwalls (Pages 111-129) Ch. 7 Closures (Pages 133-142) Ch. 8 Sealants (Pages 145-156)	N/A	None. These sections of FEMA 114 do not address gas-fired mechanical equipment.

Recommendation: None.

FEMA 114	SGC	Analysis
Ch. 9 Protection of Utilities 9.4 Permanent Protective Measures (Pages 160-163)	Ch. 4 Ch. 5	Section 9.4 of FEMA 114 requires utility connections to be above flood level, shielding for basement appliances, elevated exterior appliances, suspension for underfloor equipment and anchoring of fuel storage tanks. The SGC allows such installation but requires adequate combustion air and venting.

Recommendation: Revise SGC to reference the Standard for Floodplain Management.

FEMA 114	SGC	Analysis
Ch. 9 Protection of Utilities 9.5 Utility Relocation to Existing Space (Pages 163, 164)	Ch. 3, 4, 5 and 6	Section 9.5 of FEMA 114 addresses relocation of equipment from the basement to upper levels or attics. The SGC allows such installation but specifies minimum combustion air, venting and clearances.

Recommendation: FEMA 114 should be revised to reference readers to local model codes for other safety considerations.

FEMA 114	SGC	Analysis
Ch. 9 Protection of Utilities 9.6 Utility Relocation to New Space (Pages 164, 165)	Ch. 3, 4, 5, and 6	Section 9.6 of FEMA 114 addresses relocation of gas equipment to a newly constructed space. The SGC allows equipment rooms but specifies minimum combustion air, venting and fuel supply.

Recommendation: Section 9.6 of FEMA 114 should be revised to encourage obtaining of a building permit for new construction/alterations.

FEMA 114	SGC	Analysis
Ch. 9 Protection of Utilities 9.8 Storage Tank Anchorage (Page 166)	Ch. 3	Section 9.8 of FEMA 114 requires anchorage of fuel storage tanks. The SGC does not address uplift on LPG tanks.

Recommendation: Revise SGC to address uplift on LPG storage tanks.

FEMA 114	SGC	Analysis
Chapter 10 Special Situations (Pages 176, 177) Appendix C Forces (Pages 197-207)	N/A	None. These sections of FEMA 114 do not address gas-fired mechanical equipment.

Recommendation: None.

STANDARD GAS CODE (SGC) COMPARISON

Alluvial Fans: Hazards and Management (FEMA 165)

FEMA 165	SGC	Analysis
Windows and Doors (Page 10)	N/A	None. FEMA 165 does not address gas-fired mechanical equipment.

Recommendation: None.

STANDARD GAS CODE (SGC) COMPARISON

Manual for the Construction of Residential Basements in Non-Coastal Flood Environs (MCRB)

MCRB	SGC	Analysis
Chapter III Basement Construction (Pages 13-75) Chapter V Basements in Floods (Pages 88-126) Chapter VII Appendix A-Soils Data (Pages 164, 166) Chapter VIII Builder's Guide (Pages 198, 206, 209, 211-262) Hydraulic/Hydrologic Manual (Pages 7-10)	N/A	None. MCRB does not address gas-fired equipment.

Recommendation: None.

STANDARD GAS CODE (SGC) COMPARISON

Technical Standards Bulletin: Wet Floodproofing, No. 85-1

No. 85-1	SGC	Analysis
Definition Protection Goals Considerations for Applicability (Pages 1-6)	N/A	None. These sections of No. 85-1 do not address gas-fired mechanical equipment.

Recommendation: None.

No. 85-1	SGC	Analysis
IV. Guidelines for Implementation A.1 Foundations A.2 Cavity Wall Construction A.3 Solid Wall Construction A.4 Interior Walls A.5 Interior Wall Finishes A.6 Floors A.7 Ceilings and Roofs A.8 Building Envelope Penetrations A.9 Electrical Systems (Pages 6-11)	N/A	None. These sections of No. 85-1 do not address gas-fired mechanical equipment.

Recommendation: None.

No. 85-1	SGC	Analysis
IV. Guidelines for Implementation A.10 HVAC (Page 11)	Ch. 4 Ch. 5	No. 85-1 requires gas-fired mechanical equipment to be elevated or enclosed for protection. The SGC allows enclosed installation but requires combustion air and clearances to combustible construction.

Recommendation: The SGC should be revised to reference the Standard for Floodplain Management.

STANDARD GAS CODE (SGC) COMPARISON

Technical Standards Bulletin: Foundation Wall Openings, No. 85-2

No. 85-2	SMC	Analysis
Flood Forces (Pages 1-3)	N/A	None. This section of No. 85-2 does not address gas-fired mechanical equipment.

Recommendation: None.

No. 85-2	SGC	Analysis
Openings Design Criteria (Pages 4-6)	402.8	No. 85-2 provides sizing criteria for foundation wall openings used to equalize hydrostatic pressures. The SGC addresses access to appliances, but defers sizes to the SMC. However, this section of No. 85-2 doesn't address equipment installation.

Recommendation: None.

STANDARD GAS CODE (SGC) COMPARISON

Technical Standards Bulletin: Breakaway Walls, No. 85-3

No. 85-3	SGC	Analysis
II. Wind and Water Forces III. Design Approach IV. Design Considerations (Pages 2-10)	N/A	None. These sections of No. 85-3 do not address gas-fired mechanical equipment.

Recommendation: None.

STANDARD GAS CODE (SGC) COMPARISON

Technical Standards Bulletin: Wind Design Standards and the NFIP, No. 88-1

No. 88-1	SMC	Analysis
Pages 1-5	N/A	None. These pages of No. 88-1 do not address gas-fired mechanical equipment.

Recommendation: None.

STANDARD GAS CODE (SGC) COMPARISON

Technical Standards Bulletin: Flood Resistant Materials, No. 88-2

No. 88-2	SGC	Analysis
Pages 1-7	N/A	None. These pages of No. 88-2 do not address gas-fired mechanical equipment.

Recommendation: None.

STANDARD GAS CODE (SGC) COMPARISON

Technical Standards Bulletin: Free of Obstruction Requirement in Coastal High Hazard Areas, No. 88-3

No. 88-3	SGC	Analysis
Lower Area Obstructions Obstructions Outside the Perimeter of the Coastal Building Obstructions Attached to But Outside the Building Perimeter (Pages 2-6)	N/A	None. These pages of No. 88-3 do not address gas-fired mechanical equipment.

Recommendation: None.

STANDARD GAS CODE (SGC) COMPARISON

Technical Standards Bulletin: Protection of Elevator Equipment in Flood Hazard Areas, No. 88-4

No. 88-4	SGC	Analysis
Recommendations (Page 3)	N/A	None. This page of No. 88-4 does not address gas-fired mechanical equipment.

Recommendation: None.

STANDARD GAS CODE (SGC) COMPARISON

Technical Standards Bulletin: NFIP Requirements for Below Grade Parking Garages in Flood Hazard Areas, No. 90-2

No. 90-2	SGC	Analysis
Pages 1-4	N/A	None. These pages of No. 90-2 do not address gas-fired mechanical equipment.

Recommendation: None.

STANDARD GAS CODE (SGC) COMPARISON

Technical Standards Bulletin: Non-Residential Floodproofing Certification Requirements of the National Flood Insurance Program, No. 90-3

No. 90-3	SGC	Analysis
Section D-2 (Pages 1-6)	Ch. 4 Ch. 5	No. 90-3 requires all utilities to be (1) above design flood or (2) completely enveloped by watertight building or (3) completely watertight. The SGC allows such installation but requires venting and combustion air.

Recommendation: Revise No. 90-3 to reference the local model code for venting and combustion air.

STANDARD GAS CODE (SGC) COMPARISON

Technical Standards Bulletin: Installation of Manufactured Homes in Special Flood Hazard Areas, No. 90-4

No. 90-4	SGC	Analysis
Pages 3-19	N/A	None. These pages of No. 90-4 do not address gas-fired mechanical equipment.

Recommendation: None.

STANDARD PLUMBING CODE (SPC) COMPARISON

NFIP (Regulations for Floodplain Management and Flood Hazard Identification) (44 CFR 59.1, 60.3, and 60.6)

NFIP	SPC	Analysis
59.1 Definitions 60.3 Floodplain Management Criteria to Flood-Prone Areas	N/A	None. NFIP does not address plumbing.

Recommendation: None.

60.6 – Variances and Exceptions

NFIP	SPC	Analysis
60.6(c)(2)(i) Flood-proof Walls	301.12 1204.1	NFIP requires the basement area, together with utilities and sanitary facilities below the floodproofed design level, to be watertight with walls that are impermeable to the passage of water without human intervention. The SPC prohibits deleterious discharge of sewage or other waste and requires the water distribution system to be protected against backflow. This is addressed in 602.1.2, 602.6, and 602.7, and Chapter 9 of the SBCCI Standard for Floodplain Management.

Recommendation: The SPC should be revised to reference the SBCCI Standard for Floodplain Management.

NFIP	SPC	Analysis
60.6(c)(2)(ii) Basement Top of Floor Elevation 60.6(c)(2)(iii) Fill 60.6(c)(2)(iv) Use of a Registered Professional 60.6(c)(2)(v) Building Inspection	N/A	None. NFIP does not address plumbing.

Recommendation: None.

STANDARD PLUMBING CODE (SPC) COMPARISON

Elevated Residential Structures (FEMA 54)

FEMA 54	SPC	Analysis
Design and Construction Guidelines posts post embedment post anchorage piers brick and concrete masonry piers concrete piers pier footings shear walls and floor diaphragms pier foundation connections floor beams cantilevers floor joist to floor beam connection (Pages 68-88)	N/A	None. These sections of FEMA 54 do not address plumbing.

Recommendation: None.

FEMA 54	SPC	Analysis
Figure 4.48 Protective Utility Shaft (Page 92)	407	FEMA 54 requires water and DWV piping serving an elevated structure to be attached to the leeward side of posts/columns or enclosed in a protective shaft. The SPC requires piping to be protected from physical damage.

Recommendation: The SPC should be revised to reference the Standard for Floodplain Management.

FEMA 54	SPC	Analysis
Mechanical Equipment (Page 93, Paragraph 2)	N/A	The SPC does not address mechanical equipment.

Recommendation: None.

FEMA 54	SPC	Analysis
Septic Tanks (Page 93, Paragraph 3)	Appendix E 301.12	FEMA 54 requires that septic tanks be floodproofed to stop floating and potential discharge of effluent. The SPC requires proper installation and prohibits deleterious discharge.

Recommendation: None since both approach the problem from different directions. FEMA - prescriptive SPC - performance. The SPC should be revised to reference the Standard for Floodplain Management.

FEMA 54	SPC	Analysis
Building Materials Wood Steel Concrete and Masonry (Pages 93-95)	N/A	None. These sections of FEMA 54 do not address plumbing.

Recommendation: None.

FEMA 54	SPC	Analysis
Insulation (Pages 95, 96)	N/A	The SPC does not address insulation.

Recommendation: None.

FEMA 54	SPC	Analysis
Glossary (Pages 113-115)	N/A	None. The Glossary section of FEMA 54 does not address plumbing.

Recommendation: None.

FEMA 54	SPC	Analysis
Performance Criteria C. 2 (1.3) "Protection Against Unnecessary Damage" (Page 134)	407 Appendix E 301.12	See previous sections on FEMA 54. This is only a summary.

Recommendation: None.

STANDARD PLUMBING CODE (SPC) COMPARISON

Coastal Construction Manual (FEMA 55)

FEMA 55	SPC	Analysis
Chapter 4 - Structural Design Section 4.3.6 Utilities (Pages 4-50 to 4-52)	407	FEMA 55 requires water and DWV piping serving elevated structures to be attached to the leeward side of posts/columns or enclosed in a protective shaft. The SPC requires piping be protected from physical damage.

Recommendation: The SPC should be revised to reference the Standard for Floodplain Management.

FEMA 55	SPC	Analysis
Ch. 5 Larger Structures (Pages 5-1 to 5-9) Appendix A Design Tables (Pages A-1 to A-47) Appendix B Bracing (Pages B-1 to B-15) Appendix D Design Equations and Procedures (Pages D-1 to D-32)	N/A	None. FEMA 55 does not address plumbing.

Recommendation: None.

FEMA 55	SPC	Analysis
Appendix G "Sample Coastal Construction Code" 12 Utilities (Page G-8)	301.10 808 Ch. 13	FEMA 55 requires sanitary sewer and storm drainage systems with openings below the BFE to have backflow valves where the lines pass through the building envelope. The SPC requires a backwater valve only where a drainage system may be subject to a backflow of sewage.

Recommendation: Revise the SPC to reference the Standard for Floodplain Management and include specific criteria for the isolation of these lines.

STANDARD PLUMBING CODE (SPC) COMPARISON

Manufactured Home Installation in Flood Hazard Areas (FEMA 85)

FEMA 85	SPC	Analysis
Chapter III Elevation and Anchoring Techniques (Pages 19-31) Chapter IV Design of Elevated Foundations (Pages 33-70) Appendix D Calculational Procedure for Elevated Foundation Design (Pages 89-97) Appendix E Buoyancy and Drag Forces (Pages 99-101)	N/A	None. FEMA 85 does not address plumbing.

Recommendation: None.

STANDARD PLUMBING CODE (SPC) COMPARISON

Floodproofing Non-Residential Structures (FEMA 102)

FEMA 102	SPC	Analysis
Ch. I Introduction (Pages 8-13) Ch. III Floodproofing Design Permanent & Contingent Measures (Pages 37-72, 80-88)	N/A	None. FEMA 102 does not address plumbing.

Recommendation: None.

FEMA 102	SPC	Analysis
Chapter IV Other Floodproofing Measures C. Utilities (Pages 99 - 105)	1302 1308	FEMA 102 requires that backwater valves be installed on the building sewer at a point where the piping is strong enough to resist the flood induced pressures. A backwater valve is usually a swing-check valve. As an alternate, all gravity sewer openings below the BFE may be routed to a sump, then pumped above BFE to the lowest entrance to the sewer (Figure IV-8). FEMA also requires wells to be equipped with a watertight casing that extends from one ft above grade to 25 ft below grade to minimize contamination. The SPC would allow the backwater valve, but would prohibit the sump in situations where gravity sewer is available. (1308.1) The SPC does not address well construction.

Recommendation: (1) Revise SPC to reference the Standard for Floodplain Management. (2) Revise SPC to allow sumps and ejectors for flood areas even where gravity drainage is available.

FEMA 102	SPC	Analysis
Appendix B "Glossary" (Pages 161-166) Appendix D "Floodproofing Performance Criteria Parts B and D (Pages 182-193)	N/A	None. These sections of FEMA 102 do not address plumbing.

Recommendation: None.

FEMA 102	SPC	Analysis
Appendix D "Floodproofing Performance Criteria Part C "Performance Criteria" Criteria #6 Heating Air-Conditioning and Ventilation (A) Location (Page 192)	N/A	None. The SPC does not address HVAC equipment.

Recommendation: None.

FEMA 102	SPC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #7 "Plumbing Systems" (A) General (Page 193)	903 606.1	FEMA 102 requires that all plumbing system components below BFE should be designed to minimize loss of stability or tightness. The SPC requires fixtures to be securely anchored.

Recommendation: None.

FEMA 102	SPC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #7 "Plumbing Systems" (B) Sanitary Sewer Systems (Page 193)	301.10 Ch. 13	FEMA 102 requires on-site sewage disposal systems to be designed to minimize floodwater effects. Sanitary sewer systems which must remain in operation during a flooding event should be designed with a sealed holding tank sized at 150% of anticipated demand. All vents should extend above BFE. The SPC does not prohibit holding tanks, but makes no provision to size the tank except for engineering. The SPC will allow, in limited instances, air admittance valves in lieu of venting termination above roof.

Recommendation: Revise SPC to reference Standard of Floodplain Management and to prohibit air admittance valves below BFE.

FEMA 102	SPC	Analysis
Appendix D "Floodproofing Performance Criteria" Part C "Performance Criteria" Criteria #7 "Plumbing Systems" (C) Water Supply Systems (Page 193)	1204	FEMA 102 requires that potable water supply systems be protected from contamination during flooding. The SPC requires protection of potable water.

Recommendation: The SPC should reference Standard of Floodplain Management.

FEMA 102	SPC	Analysis
Appendix D "Floodproofing Performance Criteria Part C "Performance Criteria" Criteria #7 "Plumbing Systems" (D) Backflow Prevention (Page 193)	301.10 Ch. 13	FEMA 102 requires backwater valves on storm drain, sewage and potable water supply lines installed at wells or building exits. The SPC allows such valves but only requires them for sewage backflow.

Recommendation: Revise the SPC to reference Standard of Floodplain Management.

Retrofitting Flood-Prone Residential Structures (FEMA 114)

FEMA 114	SPC	Analysis
Ch. 3 Elevation (Pages 46-49, 61-68) Ch. 6 Floodwalls (Pages 111-129) Ch. 7 Closures (Pages 133-142) Ch. 8 Sealants (Pages 145-156)	N/A	None. These sections of FEMA 114 do not address plumbing.

Recommendation: None.

FEMA 114	SPC	Analysis
Ch. 9 Protection of Utilities 9.4 Permanent Protective Measures (Pages 160-163)	N/A	None. This section of FEMA 114 does not address plumbing.

Recommendation: None.

FEMA 114	SPC	Analysis
Ch. 9 Protection of Utilities 9.5 Utility Relocation to Existing Space (Pages 163, 164)	N/A	None. This section of FEMA 114 does not address plumbing.

Recommendation: None.

FEMA 114	SPC	Analysis
Ch. 9 Protection of Utilities 9.6 Utility Relocation to New Space (Pages 164, 165)	N/A	None. This section of FEMA 114 does not address plumbing.

Recommendation: None.

FEMA 114	SPC	Analysis
Ch. 9 Protection of Utilities 9.8 Storage Tank Anchorage (Page 166)	N/A	None. This section of FEMA 114 does not address plumbing.

Recommendation: None.

FEMA 114	SPC	Analysis
Chapter 10 Special Situations (Pages 176, 177) Appendix C Forces (Pages 197-207)	N/A	None. These sections of FEMA 114 do not address plumbing.

Recommendation: None.

Alluvial Fans: Hazards and Management (FEMA 165)

FEMA 165	SPC	Analysis
Windows and Doors (Page 10)	N/A	None. FEMA 165 does not address plumbing.

Recommendation: None.

STANDARD PLUMBING CODE (SPC) COMPARISON

Manual for the Construction of Residential Basements in Non-Coastal Flood Environs (MCRB)

MCRB	SPC	Analysis
Chapter III Basement Construction (Pages 13-75) Chapter V Basements in Floods (Page 88-126) Chapter VII Appendix A - Soils Data (Pages 164, 166) Chapter VIII Builder's Guide (Pages 198, 206, 209, 211-262) Hydraulic/Hydrologic Manual (Pages 7-10)	301.12 1204.1	The majority of the MCRB does not address plumbing. However, III.B.8 does address plumbing materials, sewer systems, and potable water supply systems. MCRB requires gate valves on the sanitary sewer outlets from the house and the potable water supply system to be designed in such a manner to prevent contamination from flood waters. The SPC prohibits deleterious discharge of sewage or other waste and requires the water distribution system to be protected against backflow. This is addressed in 602.6 and 602.7 of the SBCCI Standard for Floodplain Management.

Recommendation: The SPC should be revised to reference the SBCCI Standard for Floodplain Management.

STANDARD PLUMBING CODE (SPC) COMPARISON

Technical Standards Bulletin: Wet Floodproofing Bulletin, No. 85-1

No. 85-1	SPC	Analysis
Definition Protection Goals Considerations for Applicability (Pages 1-6)	N/A	None. These sections of No. 85-1 do not address plumbing.

Recommendation: None.

No. 85-1	SPC	Analysis
IV. Guidelines for Implementation A.1 Foundations A.2 Cavity Wall Construction A.3 Solid Wall Construction A.4 Interior Walls A.5 Interior Wall Finishes A.6 Floors A.7 Ceilings and Roofs A.8 Building Envelope Penetrations A.9 Electrical Systems (Pages 6-11)	N/A	None. These sections of No. 85-1 do not address plumbing.

Recommendation: None.

No. 85-1	SPC	Analysis
IV. Guidelines for Implementation A.10 HVAC (Page 11)	N/A	None. The SPC doesn't address HVAC equipment.

Recommendation: None.

No. 85-1	SPC	Analysis
A.11 Plumbing and Water (Not in Scope) (Page 12)	Ch. 12 1204 301.10	No. 85-1 A.11 requires that interruptible water supply sources be protected from contamination by a check valve. The SPC does require backflow prevention. No. 85-1 requires a sealed holding tank for those disposal systems required to remain in operation during a flooding event. Sewage systems should have a manual valve or a backwater valve at building penetration. The SPC requires a backflow valve for sewage reversal only.

Recommendation: (1) Revise SPC to reference Standard for Floodplain Management; (2) Revise SPC to add a principle for flood plain areas.

STANDARD PLUMBING CODE (SPC) COMPARISON

Technical Standards Bulletin: Foundation Wall Openings, No. 85-2

No. 85-2	SMC	Analysis
Flood Forces (Pages 1-3)	N/A	None. This section of No. 85-2 does not address plumbing.

Recommendation: None.

No. 85-2	SPC	Analysis
Openings Design Criteria (Pages 4-6)	N/A	None. The SPC does not address equipment access or foundation wall openings.

Recommendation: None.

STANDARD PLUMBING CODE (SPC) COMPARISON

Technical Standards Bulletin: Breakaway Walls, No. 85-3

No. 85-3	SPC	Analysis
II. Wind and Water Forces III. Design Approach IV. Design Considerations (Pages 2-10)	N/A	None. No. 85-3 does not address plumbing.

Recommendation: None.

STANDARD PLUMBING CODE (SPC) COMPARISON

Technical Standards Bulletin: Wind Design Standards and the NFIP, No. 88-1

No. 88-1	SMC	Analysis
Pages 1-5	N/A	None. No. 88-1 does not address plumbing.

Recommendation: None.

STANDARD PLUMBING CODE (SPC) COMPARISON

Technical Standards Bulletin: Flood Resistant Materials, No. 88-2

No. 88-2	SPC	Analysis
Pages 1-7	N/A	None. No. 88-2 do not address plumbing.

Recommendation: None.

STANDARD PLUMBING CODE (SPC) COMPARISON

Technical Standards Bulletin: Free of Obstruction Requirement in Coastal High Hazard Areas, No. 88-3

No. 88-3	SPC	Analysis
Lower Area Obstructions Obstructions Outside the Perimeter of the Coastal Building Obstructions Attached to But Outside the Building Perimeter (Pages 2-6)	N/A	None. No. 88-3 does not address plumbing.

Recommendation: None.

STANDARD PLUMBING CODE (SPC) COMPARISON

Technical Standards Bulletin: Protection of Elevator Equipment in Flood Hazard Areas, No. 88-4

No. 88-4	SPC	Analysis
Recommendations (Page 3)	N/A	None. No. 88-4 does not address plumbing.

Recommendation: None.

STANDARD PLUMBING CODE (SPC) COMPARISON

Technical Standards Bulletin: NFIP Requirements for Below Grade Parking Garages in Flood Hazard Areas, No. 90-2

No. 90-2	SPC	Analysis
Pages 1-4	N/A	None. No. 90-2 do not address plumbing.

Recommendation: None.

STANDARD PLUMBING CODE (SPC) COMPARISON

Technical Standards Bulletin: Non-Residential Floodproofing Certification Requirements of the National Flood Insurance Program, No. 90-3

No. 90-3	SPC	Analysis
Section D-2 (Pages 1-6)	N/A	No. 90-3 requires all utilities to be (1) above design flood or (2) completely enclosed by the building's watertight walls or (3) be completely watertight. The SPC would not prohibit such installation, but only regulates size of space for setting fixtures.

Recommendation: Revise SPC to reference the Standard for Floodplain Management.

STANDARD PLUMBING CODE (SPC) COMPARISON

Technical Standards Bulletin: Installation of Manufactured Homes in Special Flood Hazard Areas, No. 90-4

No. 90-4	SPC	Analysis
Pages 3-19	N/A	None. No. 90-4 does not address plumbing.

Recommendation: None.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM;) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

NFIP (Regulations for Floodplain Management and Flood Hazard Identification) (44 CFR 59.1, 60.6, and 60.3)

59.1 – Definitions

NFIP	SFM	Analysis
Appurtenant Structure Critical Feature Storm Cellar	202	NFIP contains a definition of "appurtenant structure" and "critical feature" since it addresses requirements for flood insurance. NFIP contains a definition of a "storm cellar" which is used as a temporary shelter against severe tornado or similar wind storm activity. SFM does not contain these definitions since it does not address flood insurance or temporary shelters against wind storm activity.

Recommendation: None.

NFIP	SFM	Analysis
Base Flood Basement Breakaway Wall Building Development Elevated Building Existing Construction Flood Floodplain or Flood-Prone Area Lowest Floor Manufactured Home 100-year Flood Structure Substantial Improvement	202	The definitions in NFIP and SFM are compatible. NFIP's definition of "manufactured home" does not include a "recreational vehicle" while SFM includes "mobile homes, park trailers, travel trailers, and similar transportable structures placed on a site for 180 consecutive days or longer and intended to be improved property."

Recommendation: None.

60.3 - Floodplain Management Criteria for Flood-Prone Areas

NFIP	SFM	Analysis
60.3(b)(8) Manufactured Home Installation	603	Both NFIP and SFM are compatible however SFM does not permit the placement of a manufactured home within a designated floodway or coastal high hazard area.

Recommendation: In order to avoid confusion, NFIP and SFM should list the zone designation (A, AO, AH, VO, M, etc) along with the word description (floodway, coastal high hazard).

NFIP	SFM	Analysis
60.3(c)(2) Elevation for Residential Structures	602.1.1	Both NFIP and SFM require elevation of the lowest horizontal structural member of the lowest floor including basement to be elevated to or above the base flood level.

Recommendation: None.

NFIP	SFM	Analysis
60.3(c)(3) Elevation for Non-Residential Structures; Floodproof Walls for Non-Residential Structures	602.1.2	Both NFIP and SFM permit the structure to be constructed below the base flood elevation provided the structure is floodproofed up to the base flood level.

Recommendation: None.

NFIP	SFM	Analysis
60.3(c)(5) Flood Openings	602.2	Both NFIP and SFM require two openings in walls below the base flood elevation to allow the entry and exit of floodwaters to automatically equalize hydrostatic flood forces on the exterior walls.

Recommendation: None.

NFIP	SFM	Analysis
60.3(e)(4) Piling	801.1	Both NFIP and SFM requires the structure in a high coastal high hazard area to be elevated on pilings or columns and securely anchored to resist flotation, collapse, and permanent lateral movement due to the effects of wind and water loading.

Recommendation: None.

NFIP	SFM	Analysis
60.3(e)(5) Breakaway Walls	801.4	Both NFIP and SFM require areas below the lowest floor to be free of obstruction or constructed with nonsupporting breakaway walls, open wood lattice, or insect screening intended to collapse under wind and water loads.

Recommendation: None.

NFIP	SFM	Analysis
60.3(e)(6) Fill	801.5	Both NFIP and SFM prohibit the use of fill material for structural support in coastal high hazard areas.

Recommendation: None.

60.6 – Variances and Exceptions.

NFIP	SFM	Analysis
60.6(c)(2)(i) Floodproof Walls 60.6(c)(2)(iv) Use of a Registered Professional	900.3 900.4	Both NFIP and SFM require the basement area together with utilities and sanitary facilities below the floodproofed design level, to be watertight with walls that are impermeable to the passage of water without human intervention. The SFM does not permit floodproofing of walls below the flood level for residential structures. Both NFIP and SFM require the floodproofing measures to be certified by a registered professional engineer or architect.

Recommendation: None, since floodproofing of basements is allowed only in communities that have been granted an exception by FEMA.

NFIP	SFM	Analysis
60.6(c)(2)(ii) Basement Top of Floor Elevation 60.6(c)(2)(iii) Fill	600.1 604.2 604.3 800.2 801.5	NFIP permits the basement floor to be up to five feet below the elevation of the base flood. NFIP permits the area surrounding the structure to be protected by fill material to or above the elevation of the base flood. SFM requires the lowest floor to be located above the base flood elevation. SFM does not permit the use of fill material as a buffer from storm surge in coastal high hazard areas.

Recommendation: None.

NFIP	SFM	Analysis
60.6(c)(2)(v) Building Inspection	Chapter 4	Both NFIP and SFM require the authority having jurisdiction to verify that the provisions of the standard are satisfied.

Recommendation: None.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Elevated Residential Structures (FEMA 54)

FEMA 54	SFM	Analysis
Posts Post Embedment Post Anchorage (Pages 68-71)	801.1	FEMA 54 addresses the use of wood, concrete, or steel posts as the foundation to elevate residential structures. General commentary is made about installation, handling, and lateral resistance. SFM does not address post foundations but references Chapter 13 of the Standard Building Code for pile system design and installation.

Recommendation: FEMA 54 should combine post foundations and pile foundations into one section.

FEMA 54	SFM	Analysis
Piers Brick and Concrete Masonry Piers Concrete Piers Pier Footings Shear Walls and Floor Diaphragms (Pages 75-77, 79)	801.1	FEMA 54 describes the suitability of pier foundations and types of pier foundations suitable for flood areas with low velocity and minimal erosion. FEMA 54 provides minimum reinforcing, minimum dimensional requirements, maximum height, spacing, and recommended shape. FEMA 54 requires the piers to be filled with concrete. FEMA 54 provides a general description and discussion of poured-in-place concrete piers. FEMA 54 requires the footing sizes to be based on the properties of the soil. FEMA 54 addresses the use of plywood shear walls and floor diaphragms to brace piles or post foundations. SFM requires foundations to have adequate soil penetrations to resist the combined wave and wind loads to which they are subject. SFM does not address the actual requirements for the piers.

Recommendation: None.

FEMA 54	SFM	Analysis
Pier Foundation Connection (Pages 84, 85)	801.3	FEMA 54 addresses anchorage of platform framing construction to pier foundations. SFM requires all components including floor frames to be securely fastened and adequately interconnected to resist loads anticipated during flooding.

Recommendation: None.

FEMA 54	SFM	Analysis
Floor Beams Cantilevers (Pages 86, 87)	N/A	FEMA 54 provides a general discussion of built-up floor beams and cantilevered beams. FEMA 54 provides a "rule of thumb" for the length of cantilever. SFM does not address construction materials. Construction materials are addressed in the SBCCI Standard Building Code.

Recommendation: FEMA 54 should delete the "rule of thumb."

FEMA 54	SFM	Analysis
Floor Beam to Floor Joist Connection (Page 88)	801.3	FEMA 54 requires positive connection between the floor joists and floor beams. SFM requires all components of the building to be securely fastened and adequately interconnected to resist loads anticipated during flooding.

Recommendation: None.

FEMA 54	SFM	Analysis
Figure 4.48, Protective Utility Shaft (Page 92)	602.5	FEMA 54 and SFM require utility protection.

Recommendation: None.

FEMA 54	SFM	Analysis
Mechanical Equipment (Page 93, Paragraph 2)	602.5	Both FEMA 54 and SFM require the mechanical equipment to be designed and located so as to prevent water from entering the components.

Recommendation: None.

FEMA 54	SFM	Analysis
Septic Tanks (Page 93, Paragraph 3)	501.2 602.7	FEMA 54 requires septic tanks to be floodproofed to prevent the tank from rising out of the ground. FEMA 54 and SFM requires the tank to be designed to minimize or eliminate discharge of effluent into the floodwaters.

Recommendation: None. SFM should address buoyancy forces on tanks.

FEMA 54	SFM	Analysis
Building Materials Wood Steel Concrete and Masonry Insulation (Pages 93-96)	N/A	FEMA 54 addresses the need for preservative treatment, corrosion protection, and increased durability of building materials exposed to the elements and flood water. FEMA 54 addresses the need for insulation on the exposed floor of an elevated residence. SFM does not address building materials or insulation requirements. This is addressed in the CABO Model Energy Code.

Recommendation: None.

FEMA 54	SFM	Analysis
Glossary (Pages 113-115)	202	Both FEMA 54 and SFM contain some of the same definitions and some different definitions. The definitions are appropriate for each document.

Recommendation: None.

FEMA 54	SFM	Analysis
Performance Criteria (Pages 125-135)	401.3 801.3	FEMA 54 addresses performance criteria used to design buildings to withstand the design flood (1) without causing unacceptable risks to its occupants or to adjacent property owners, (2) without causing unacceptable health hazards to its occupants, or (3) without sustaining damage to unacceptable magnitude. SFM requires the building to be certified by a registered professional engineer or architect that it is designed to withstand velocity waters, wave action, and wind loadings. SFM requires all components to be securely fastened and adequately interconnected to resist the loads anticipated during flooding.

Recommendation: FEMA 54 should include performance criteria for snow and seismic loads. The use of the phrases "unacceptable risks", "unacceptable health hazards", and "unacceptable magnitude" are too subjective.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Coastal Construction Manual (FEMA 55)

FEMA 55	SFM	Analysis
4.1 Flood Frequency (Page 4-1, Paragraph 4)	801.1	Both FEMA 55 and SFM reference the base flood (100 year) as the water force for which the structure must be designed to resist.

Recommendation: None.

FEMA 55	SFM	Analysis
4.1.1 Wind (Page 4-1, Paragraphs 6 & 7 Page 4-2, Figure 4-1 Page 4-3, Paragraphs 2 & 3 Page 4-6)	801	FEMA 55 references the procedures of ANSI A58.1-1982 for design with particular emphasis placed on elevation of the roof above grade and high wind pressures at the corners of the house, at and under roof eaves, and at the peak of the roof. SFM references 1205 of the Standard Building for design wind loads. SBC permits ASCE 7-1988 (formerly ANSI A58.1-1982) in addition to the wind load provisions of 1205.

Recommendation: FEMA 55 should update its reference to ASCE 7-1988.

FEMA 55	SFM	Analysis
4.1.2 Salt Air, Moisture and Wind-Driven Rain (Pages 4-7, 4-8)	N/A	FEMA 55 provides general discussion of the hazards of salt air, moisture and wind driven rain on wood, bolts, rails, and connectors. SFM does not address decay or corrosion of building materials.

Recommendation: None.

FEMA 55	SFM	Analysis
4.1.3 Water, Waves, and Debris (Page 4-8, Paragraph 4)	401.3	FEMA 55 addresses the impact loads exerted on the piles as the result of the movement of debris, (fences, porches, stains, utility poles, etc.) FEMA 55 has provided for the collision of a 300 pound object moving at surface water velocity and decelerating over a maximum distance of 0.5 ft. SFM requires, in coastal high hazard areas, certification from a professional engineer or architect that the building is designed to withstand velocity waters, wave action, and wind loadings.

Recommendation: None since both address the issue of damage only from different directions: FEMA-prescriptive, SBC-performance.

FEMA 55	SFM	Analysis
4.1.4 Effects of Forces on Higher and Larger Structures (Page 4-9)	801.1	FEMA 55 discusses the higher wind forces, uplift and overturning with respect to the height of the building. SFM refers to 1205 of the Standard Building Code, which does address building height, for design wind load values.

Recommendation: FEMA 55 should provide velocity pressures (psf) for varied wind speeds and building height.

FEMA 55	SFM	Analysis
4.2 Construction Materials (Page 4-9)	N/A	FEMA 55 provides a general discussion of the types of construction materials (wood, steel, concrete) and their use in the coastal environment. SFM does not address construction materials.

Recommendation: None.

FEMA 55	SFM	Analysis
4.2.1.1 Pilings (Wood) (Pages 4-9, 4-10)	801.1	FEMA 55 provides general comments on the use of wood pilings (species and decay resistance). SFM refers to Chapter 13 of the Standard Building Code for pile design and installation.

Recommendation: None since neither FEMA 55 or SFM actually contains specifications for timber pilings.

FEMA 55	SFM	Analysis
4.2.1.2 Main Supporting Members (Beams, Wood) (Page 4-10)	401.3	FEMA 55 provides general nailing requirements and splice location. SFM requires the design to be certified that the building will withstand velocity waters, wave action, and wind loadings.

Recommendation: FEMA 55 should provide more specific parameters for which the stated nailing is appropriate.

FEMA 55	SFM	Analysis
4.2.1.3 Other Wood Construction Members (Page 4-10)	N/A	FEMA 55 does not require preservative treatment of miscellaneous wood members but highly recommends it. SFM does not address preservative treatment of wood.

Recommendation: None.

FEMA 55	SFM	Analysis
4.2.1.4 Wood Preservative (Page 4-10)	N/A	FEMA 55 requires wood members to be treated to resist insect infestation, dry rot, decay fungi, and the effects of exposure to salt air and water and provides general discussions of wood preservatives. SFM does not address preservative treatment.

Recommendation: None.

FEMA 55	SFM	Analysis
4.2.2 Masonry Materials and Concrete (Page 4-11)	N/A	FEMA 55 addresses the general use of masonry and concrete in the coastal environment. SFM does not address building materials.

Recommendation: None.

FEMA 55	SFM	Analysis
4.2.3.1 Aluminum (Page 4-11)	N/A	FEMA 55 addresses the problem of corrosion of aluminum in the coastal environment. SFM does not address corrosion on building materials.

Recommendation: None.

FEMA 55	SFM	Analysis
4.2.3.2 Steel (Page 4-11)	N/A	FEMA addresses the problem of corrosion of unprotected steel shapes and anchoring devices (nails, bolts, etc.) and the need for regular inspections, maintenance, and replacement of corroded metal parts. SFM does not address corrosion, regular inspection, maintenance, and replacement of corroded metal parts.

Recommendation: None.

FEMA 55	SFM	Analysis
4.2.3.3 Dissimilar Metals (Page 4-11)	N/A	FEMA 55 addresses the corrosion which occurs when dissimilar metals are placed in contact with each other. SFM does not address dissimilar metals.

Recommendation: None.

FEMA 55	SFM	Analysis
4.3.1 Foundations (Design Details) (Page 4-11, 4-12)	801.1	FEMA 55 recommends foundation types which are suitable for supporting elevated structures in coastal high hazard areas. SFM permits any type of foundation provided it is designed to resist the combined wave and wind loads which it is likely to be subjected.

Recommendation: None since FEMA 55 is "prescriptive" and SBC is "performance" oriented.

FEMA 55	SFM	Analysis
4.3.1.1 Soil Conditions (Pages 4-12, 4-13)	801.1	FEMA 55 addresses the need to determine the quality of the soil for foundation purposes. SFM refers to Chapter 13 of the Standard Building Code which requires a soils investigation for pile foundations.

Recommendation: None.

FEMA 55	SFM	Analysis
4.3.1.2 Piles (Pages 4-13 to 4-18)	801.1	FEMA 55 provides general information on types of piles, the need for sufficient pile embedment, and methods of pile installation. SFM refers to Chapter 13 of the Standard Building Code for pile system design and installation which requires a foundation investigation and report.

Recommendation: FEMA 55 should emphasize that the type of pile, pile depth, and method of installation should be based on the soils investigation.

FEMA 55	SFM	Analysis
4.3.1.3 Posts (Wood) (Page 4-18)	801.1	FEMA 55 explains that wood posts are recommended in areas subject to wave forces and/or scour and erosion. SFM refers to Chapter 13 of the Standard Building Code for pile system design and installation but does not address post foundations.

Recommendation: FEMA should combine post foundations and piles into one section with more prescriptive requirements.

FEMA 55	SFM	Analysis
4.3.1.4 Piers (Page 4-18 to 4-20)	801.1	FEMA 55 addresses the use of piers to elevate structures and the need for reinforcing and anchorage of the footings in V zones and coastal A zones. FEMA 55 also provides general construction guidelines. SFM requires the foundations to have adequate soil penetrations to resist the wave and wind loads to which they are likely to be subjected during a flood.

Recommendation: FEMA 55 should clarify that the reinforcing, footing size, and grade beam should be based on the design forces.

FEMA 55	SFM	Analysis
4.3.2.1 Framing Methods (Pages 4-20, 4-21)	N/A	FEMA 55 addresses platform framing and pole construction. SFM does not address any type of construction.

Recommendation: None.

FEMA 55	SFM	Analysis
4.3.2.2 Beams (Pages 4-21, 4-22)	N/A	FEMA 55 addresses the preferable direction of floor beams to reduce the impact force of the storm water. FEMA 55 addresses built-up and solid beams, and "glulam" beams. SFM does not address any type of construction.

Recommendation: None.

FEMA 55	SFM	Analysis
4.3.2.3 Joists and Rafters (Page 4-22)	N/A	The title of the section in FEMA 55 is joists and rafters but rafters are not addressed. FEMA 55 describes manufactured wooden I-beams, recommends cross bridging for all floor joists located in the V-zone, and describes typical cross bridging methods. SFM does not address joists and rafters.

Recommendation: FEMA 55 should delete the reference to rafters.

FEMA 55	SFM	Analysis
4.3.2.4 Subflooring (Pages 4-22, 4-23)	N/A	FEMA 55 addresses the use of lumber and plywood subflooring. SFM does not address subflooring.

Recommendation: None.

FEMA 55	SFM	Analysis
4.3.2.5 Studs (Page 4-23)	N/A	FEMA 55 recognizes that 2x4 wood studs at 16 inches on center are commonly used and permits 2x6 wood studs and metal studs. SFM does not address studs of any type.

Recommendation: None.

FEMA 55	SFM	Analysis
4.3.2.6 Wall Sheathing 4.3.2.7 Wall Bracing (Pages 4-23, 4-24)	801.1	FEMA 55 provides the minimum thickness and nail spacing for plywood wall sheathing and permits let-in diagonal wood bracing, diagonal boards, and plywood as wall bracing. SFM does not address types of wall sheathing or bracing but does require the design wind loading values to be based on 1205 of the Standard Building Code.

Recommendation: FEMA 55 should combine wall sheathing and wall bracing into one section and address the design requirements for the wall bracing method chosen.

FEMA 55	SFM	Analysis
4.3.2.8 Roof Details 4.3.3 Foundation Bracing 4.3.3.1 Knee Braces 4.3.3.2 Grade Beams 4.3.3.3 Truss Bracing 4.3.3.4 Shear Walls 4.3.4 Connections 4.3.4.1 Roof to Wall 4.3.4.2 Wall to Floor Joists 4.3.4.3 Floor Joist to Floor Beam 4.3.4.4 Floor Beam to Pile, Post, or Pier (Page 4-24 to 4-40)	801.1 801.3	FEMA 55 provides details and recommendations for roofs, bracing, shear walls, and connections. SFM does not address details but does require all buildings and structures to have all components securely fastened and adequately interconnected to resist the loads anticipated during flooding.

Recommendation: FEMA 55 should provide some design values or wind speeds for which the connections and details are appropriate.

FEMA 55	SFM	Analysis
4.3.5 Breakaway Walls 4.3.5.1 Breakaway Wall Designs 4.3.5.2 Design Considerations for Breakaway Walls (Page 4-41 to 4-49)	801.4	Both FEMA 55 and SFM permits breakaway walls to enclose the space below the lowest elevated floor and provides the design loading for the breakaway walls. FEMA 55 also provides commentary type language, breakaway wall designs, details, and design process for breakaway walls (screening, lattice, wood stud walls, metal stud walls and masonry walls.)

Recommendation: None although FEMA 55 provides commentary type language the requirements in FEMA 55 and SFM are compatible.

FEMA 55	SFM	Analysis
4.3.6 Utilities (Pages 4-50 to 4-52)	602.5	Both FEMA 55 and SFM require the utilities to be designed and located so as to be protected from inundation and to minimize the chance of impairment during flooding. FEMA 55 requires protection of utilities from the potential damage from wave impact.

Recommendation: FEMA 55 should address the potential damage from high winds in coastal areas.

FEMA 55	SFM	Analysis
4.3.7 Wind and Storm Protection of Interior 4.3.7.1 Window Selection 4.3.7.2 Operable Shutters (Pages 4-52 to 4-54)	N/A	FEMA 55 provides commentary type language on the need to protect the building from glass breakage to prevent water damage, the importance of window selection to reduce water infiltration, and the need for shutters to protect against wave and wind action. SFM does not address protection of openings.

Recommendation: None.

FEMA 55	SFM	Analysis
4.3.7.3 Gable and Eave Vents (Page 4-54)	801.3	FEMA 55 addresses the vulnerability of vents to wind and wind-driven rain and emphasizes the importance for the careful selection of attic ventilators in order to assure that they will withstand the wind loads. SFM does require all components to be securely fastened and interconnected to resist the loads anticipated during flooding.

Recommendation: None.

FEMA 55	SFM	Analysis
4.3.7.4 Roofing Materials (Page 4-54)	801.3	FEMA 55 emphasizes the need to use self-sealing, heavyweight shingles to avoid the possible loss of roofing materials in high winds. SFM requires all components including roofs and sheathing to be securely fastened and adequately interconnected to resist the loads anticipated during flooding.

Recommendation: None.

FEMA 55	SFM	Analysis
4.3.8 Maintenance (Pages 4-54, 4-55)	N/A	FEMA 55 emphasizes the need for maintenance of all parts of buildings exposed to coastal environment because of the accelerated deterioration. SFM does not address maintenance of building components.

Recommendation: None.

FEMA 55	SFM	Analysis
5.1 General Design Considerations (Pages 5-1, 5-2)	801	FEMA 55 prohibits enclosure for habitation at grade beneath mid-rise and high-rise structures. Nonessential enclosures such as entrances, lobbies, parking areas, and storage areas must have breakaway walls. SFM requires the space below the lowest floor either free of obstruction or constructed with breakaway walls. FEMA 55 requires thicker concrete cover over reinforcing steel to provide added corrosion protection of the reinforcing steel. SFM does not address corrosion protection. FEMA 55 addresses the need to design for wind and water forces. SFM requires the building to be anchored to resist flotation, collapse, and lateral movement due to the effects and water loading.

Recommendation: FEMA 55 should address snow and seismic loads.

FEMA 55	SFM	Analysis
5.2 Foundations (Page 5-2)	801.1	FEMA 55 emphasizes the need for pile foundations that are embedded deeply to provide a safety margin against scour. SFM refers to Chapter 13 of the Standard Building Code for pile system design and installation with emphasis on embedment depth to take into account reduced capacity caused by scour. SFM prohibits the use of mat or raft foundations where soil materials are subject to scour and erosion from wave velocity conditions. FEMA 55 permits strip footings and mat foundations in zones of reduced velocity and wave action. FEMA 55 lists common types of piles and shows typical pile/pile cap/column/grade beam details.

Recommendation: None.

FEMA 55	SFM	Analysis
5.3 Slabs at Grade (Pages 5-3, 5-4)	801.1	FEMA 55 requires the slab supported on the soil to be a minimum of 4 inches thick with minimal reinforcing in the form of welded wire fabric. SFM does not address minimum thickness of slabs at grade. FEMA 55 addresses the use of designed slabs and grade beams to laterally support the pile foundation system. SFM refers to Chapter 13 of the Standard Building Code for pile system design and installation.

Recommendation: None.

FEMA 55	SFM	Analysis
5.4 Superstructure 5.5 Elevated Floors (Pages 5-4 to 5-8)	N/A	FEMA 55 provides commentary type language and typical details of the superstructure of a building which includes columns, beams, slabs, and shear walls. FEMA 55 provides commentary type language for elevated concrete floors. SFM is a performance standard and not a commentary.

Recommendation: None.

FEMA 55	SFM	Analysis
5.6 Exterior Wall Systems (Pages 5-8, 5-9)	801.3	FEMA 55 provides commentary type language on exterior wall systems of masonry or metal studs and the fastening method of the walls. FEMA 55 requires the walls to be designed to resist the lateral forces encountered. SFM requires all components of the building to be securely fastened and adequately interconnected to resist the loads anticipated during flooding.

Recommendation: None since both require the walls to be designed for the lateral forces encountered, however FEMA 55 should address seismic loads.

FEMA 55	SFM	Analysis
5.7 Recommendations (Page 5-9)	401.3	FEMA 55 requires mid-rise and high-rise structures to be designed by a "design professional". SFM requires buildings in coastal high hazard areas to be certified that it is designed to withstand velocity waters, wave action, and wind loadings.

Recommendation: None since both require a design professional.

FEMA 55	SFM	Analysis
Appendix A Design Tables	401.3	FEMA 55 provides design tables. SFM is a performance standard and not a specification code.
Figure A-1 number of piles required	801	
Table A-1 downward loads per pile		
Table A-2 horizontal wind loads per pile in 80 mph winds		
Table A-3 minimum embedment depth of piles		
Table A-4 maximum unbraced height of piles in 80 mph winds and flood forces		
Table A-4.1 maximum unbraced height of piles supporting breakaway walls		
Table A-5 uplift loads per foot of wall in 80 mph winds		
Table A-6 uplift loads per pile in 80 mph winds		
Table A-7 capacity per bolt of floor beam connections		
Table A-8 concrete masonry unit piers		
Table A-9 concrete piers		
Figure A-2 concrete pier cross section		
Figure A-3 grade beams and slabs		
Table A-10 fastener capacities in shear		
Table A-11 fastener schedule for breakaway walls		
(Pages A-1 to A-47)		

Recommendation: None.

FEMA 55	SFM	Analysis
Appendix B - Bracing	401.3	FEMA 55 provides various recommendations and details for bracing methods. SFM is a performance standard and not a specification type code.
B.1 knee bracing	801	
B.2 truss bracing		
B.2.1 diagonals		
B.2.1.1 lumber diagonals		
B.2.1.2 threadbar diagonals		
B.2.2 struts		
B.3 grade beams		
Table B-1 horizontal water loads per pile in 80 mph winds		
Table B-2 loads of transverse truss members		
Table B-3 allowable loads for single 2x8 diagonals		
Table B-4 allowable loads for single 3x8 diagonals		
(Pages B-1 to B-15)		

Recommendation: None.

FEMA 55	SFM	Analysis
Appendix D - Design Equations and Procedures D.1 Procedure A-1: downward loads per pile D.2 Procedure A-2: horizontal wind loads per pile D.3 Procedure A-3: minimum embedment depth of piles D.4 Procedure A-4: maximum unbraced height of piles D.5 Procedure A-4.1: maximum unbraced height of piles supporting breakaway walls D.6 Procedure A-5: uplift loads per foot of walls D.7 Procedure A-6: uplift loads per pile D.8 Procedure B-1: horizontal water loads per pile D.9 Procedure B-2: loads transferred to foundation truss members (Pages D-1 to D-32)	N/A	FEMA 55 contains design equations and procedures which are needed to evaluate individual designs. SFM is a performance standard with design being based on good engineering practice.

Recommendation: None.

FEMA 55	SFM	Analysis
G-2 Purpose (Page G-1)	100.1	The purpose of both FEMA 55 and SFM is to minimize losses due to flood conditions in specific areas through the establishment of comprehensive regulations for floodplain management.

Recommendation: None.

FEMA 55	SFM	Analysis
G-3 Scope (Page G-2)	100.1 102.1	Both FEMA 55 and SFM apply to new construction and additions to existing structures.

Recommendation: None.

FEMA 55	SFM	Analysis
G-4 Definitions (Pages G-2, G-3)	202	The definition of base flood elevation, breakaway wall, and coastal high hazard area appear in both FEMA 55 and SFM. FEMA 55 contains design type definitions (dead load, live load, pile cluster, piling foundation, and uplift pressure.) SFM contains floodplain management type definitions (area of shallowing flooding, flood, flood hazard boundary map, flood insurance rate map, floodproofing, lowest floor, storm water detention, etc.)

Recommendation: None.

FEMA 55	SFM	Analysis
G-5 Elevation Standards (Page G-3)	600.1 602.1.1 800.2 801.1 801.6	FEMA 55 prohibits new construction or substantial improvements from being seaward of an established setback line and requires it to be elevated above the BFE. SFM requires the lowest portion of the horizontal members of the lowest floor to be elevated above the BFE and new construction be located landward of the reach of the mean high tide.

Recommendation: None.

FEMA 55	SFM	Analysis
G-6 Determination of Loading Forces G-6.1 Water Loads G-6.2 Wind Loads (Page G-3)	401.3 801.1	Both BEMA 55 and SFM require the structure to be designed to withstand velocity waters, wave action, and wind loadings. FEMA 55 references ANSI A58.1-1982 for the wind load provisions. SFM references 1205 of the Standard Building Code which contains a basic wind speed map, use factors, velocity pressures, and coefficients for wind design in addition to referencing ASCE 7-88.

Recommendation: FEMA 55 should update its reference ASCE 7-88.

FEMA 55	SFM	Analysis
G-7 Foundation Standards G-7.1 Pile Foundation Design G-7.2 Column Foundation Design (Pages G-4, G-5)	401.3 801.1	Both FEMA 55 and SFM require the foundations to be designed to resist the combined wave and wind loads which they are likely to be subjected during a flood. FEMA 55 contains minimum and maximum pile spacing, minimum embedment length, dimensional requirements for wood piles, minimum compressive strength for concrete piles, and methods of bracing piles. SFM refers to Chapter 13 for pile system design and installation.

Recommendation: None.

FEMA 55	SFM	Analysis
G-8 Anchoring Standards G-8.1 Connector and Fasteners G-8.2 Beam to Pile Connections G-8.3 Floor to Deck Connections G-8.4 Exterior Wall Connections G-8.5 Ceiling Joist/Rafter Connections G-8.6 Projecting Members (Pages G-5, G-6)	601.1 801.1 801.3	Both FEMA 55 and SFM all components to be securely fastened and adequately interconnected to resist the loads anticipated during flooding. FEMA 55 requires corrosion protection for connectors in exposed locations. SFM does not address corrosion protection.

Recommendation: SFM should address corrosion protection of metal connectors.

FEMA 55	SFM	Analysis
G-9 Roof Sheathing (Pages G-6, G-7)	801.3	FEMA 55 provides the minimum thickness of roof sheathing, requires corrosion resistant fasteners, requires the application of waterproof industrial adhesive to all bearing surfaces of plywood used in the sheathing of corners, gable end, or roof overhang, and provides commentary language addressing roof slopes. SFM requires all components including roofs and sheathing to be securely fastened and adequately interconnected to resist the loads anticipated during flooding.

Recommendation: None.

FEMA 55	SFM	Analysis
G-10 Protection of Openings (Page G-7)	801.1	FEMA 55 requires openings to be constructed to withstand loads due to the design windspeed. SFM does not address protection of openings. SFM refers to 1205 of the Standard Building Code which requires the openings to be designed as components and cladding.

Recommendation: None.

FEMA 55		SFM	Analysis
G-11	Use of Space Below the Lowest Elevated Floor	801.4	Both FEMA 55 and SFM permits breakaway walls to enclose the space below the lowest elevated floor and provides the design loading for the breakaway walls.
G-11.1	Breakaway Wall Design Standards		
G-11.2	Certification of Breakaway Walls		
(Pages G-7, G-8)			

Recommendation: None.

FEMA 55	SFM	Analysis
G-12 Utilities (Page G-8)	602.5	FEMA 55 requires the utilities to be elevated above the BFE and backflow valves for combined sanitary sewer and storm drainage systems which have openings below the BFE. SFM requires the utilities to be designed and located so as to be protected from flooding and to minimize the chance of impairment during flooding.

Recommendation: **None.**

FEMA 55	SFM	Analysis
G-13 Certification of Requirements (Page G-8)	401.3 801.7	FEMA 55 requires new and substantial improvements which do not comply with sections 7 and 8 of this Coastal Code to be designed by a registered professional engineer or architect. SFM requires certification from a registered professional engineer or architect that the building is designed to withstand velocity waters, wave action, and wind loadings.

Recommendation: FEMA 55 should provide parameters for which sections 7 and 8 are appropriate (wind load, height above grade, etc.)

FEMA 55	SFM	Analysis
G-14 Reference Documents (Page G-8)	Chapter 11	FEMA 55 references ANSI A58.1-1982 and Shore Protection Manual by the Department of the Army. SFM references FEMA 15, FEMA 54, FEMA 55, FEMA 85, FEMA 104, and EP 1165 2 314.

Recommendation: FEMA 55 should update reference to ASCE 7-88.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Manufactured Home Installation In Flood Hazard Areas (FEMA 85)

Chapter III Elevation and Anchoring Techniques

FEMA 85	SFM	Analysis
Elevation and Anchoring Techniques (Page 19)	600, 601, 603, 604	FEMA 85 provides general techniques which are used to elevate a manufactured home in riverine or coastal flooding areas. SFM requires the manufactured home to be elevated and anchored to resist flotation, collapse or lateral movement.

Recommendation: None since FEMA 85 contains prescriptive type requirements and SFM is a performance type standard.

FEMA 85	SFM	Analysis
Elevation on Fill (Pages 19-20)	600, 601, 603 801.5	FEMA 85 provides commentary and prescriptive type language on the use of earth fill to elevate a manufactured home. FEMA 85 prohibits the use of fill material in areas subject to floodwaters having a velocity greater than 10 fps and where it will constrict the flow of floodwaters and cause increased flood elevations or velocity. SFM requires the manufactured home to be elevated and anchored to resist flotation, collapse or lateral movement. SFM does not permit the placement of manufactured homes in designated floodway or coastal high hazard areas. SFM prohibits the use of fill material for structural support in coastal high hazard areas.

Recommendation: None since FEMA 85 contains prescriptive type requirements and SFM is a performance type standard.

FEMA 85	SFM	Analysis
Elevated Foundations (Pages 21-28)	600, 601, 603	FEMA 85 addresses structural techniques, such as piers, posts, piles, and similar structural arrangements to elevate a manufactured home above the flood level. FEMA 85 provides prescriptive requirements for these structural techniques. SFM requires the manufactured home to be elevated and anchored to resist flotation, collapse, or lateral movement.

Recommendation: None since FEMA 85 contains prescriptive requirements and SFM is a performance type standard.

FEMA 85	SFM	Analysis
Anchoring (Pages 29-31)	601, 603.1	Both FEMA 85 and SFM require the manufactured home to be anchored to resist flotation, collapse, or lateral movement. FEMA 85 provides commentary type language and descriptive details. The anchoring requirements of the SFM are in addition to the anchoring requirements provided in Appendix H of the Standard Building Code.

Recommendation: None since FEMA contains prescriptive type requirements and SFM is a performance type standard.

FEMA 85	SFM	Analysis
Chapter IV Design of Elevated Foundations (Pages 33-70)	601, 602.5, 603, 801.1	FEMA 85 presents an overview of flood-induced loads, tables of calculated forces, governing design equations, and specific technical information which can be used to determine an appropriate elevated design for a manufactured home with the manufactured home complying with HUD's MHCSS. FEMA 85 provides design procedures, tables, and details needed to design bracing and connections. SFM requires the manufactured home to be elevated and anchored to resist flotation, collapse or lateral movement. SFM references 1205 of the Standard Building Code for the design wind load values. FEMA 85 addresses the set-up (jacking), utility service, mechanical systems, and access/egress during flooding around the manufactured home. SFM requires the utilities to be designed and located so as to prevent water from entering the components to minimize the chance of impairment during flooding.

Recommendation: FEMA 85 and HUD's MHCSS should update its reference to wind and snow loads for ASCE 7-88.

FEMA 85	SFM	Analysis
Appendix D - Calculational Procedures for Elevated Foundations Design (Pages 89-97)	N/A	FEMA 85 contains actual design procedures and formulas which were used as a basis of the manual. SFM is a performance type standard and does not contain engineering analysis procedures.

Recommendation: None.

FEMA 85	SFM	Analysis
Appendix E - Buoyancy and Drag Forces (Pages 99-101)	603.1	FEMA 85 addresses the forces from buoyancy and drag caused by the flood waters. FEMA 85 contains design tables for vertical tie forces based on home width and water depth. SFM requires the home to be anchored to resist flotation, collapse, or lateral movement.

Recommendation: None since FEMA 85 contains prescriptive type requirements and SFM is a performance type standard.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Floodproofing Non-Residential Structure (FEMA 102)

FEMA 102	SFM	Analysis
Chapter I Introduction I.E. Contingent Floodproofing Measures I.F.1. Flood Shields I.F.2. Watertight Doors I.F.3. Moveable Floodwalls (Pages 8-13)	Chapter 9	FEMA 102 addresses the use of contingent floodproofing measures that require some type of installation, activation, or other preparation immediately prior to the occurrence of a flood. These measures include flood shields, watertight doors, and moveable floodwalls. SFM does not specifically address contingent floodproofing measures but addresses floodproofing measures in general (watertight doors, bulkheads, shutters, reinforcement of walls to resist water pressures, etc.)

Recommendation: None.

Chapter III Floodproofing Design Permanent and Contingent Measures

FEMA 102	SFM	Analysis
III.B. Elevation on Fill (Pages 37-38)	602 801	FEMA 102 addresses the use of fill material to elevate the building to protect it from flood damages. FEMA 102 contains commentary type language on the design and maintenance of the fill material. SFM requires buildings within the special flood hazard area to be elevated so that the lowest horizontal structural member is elevated above the base flood elevation, but does not address the method. SFM requires buildings within the coastal high hazard area to be elevated on piles and prohibits the building from being elevated on fill material so that the lowest horizontal structural member is elevated above the base flood elevation.

Recommendation: None since FEMA 102 and SFM require the building to be elevated.

FEMA 102	SFM	Analysis
III.C. Elevation on Posts, Piles, Piers, or Walls III.C.2. Posts III.C.3. Piles III.C.4. Piers and Walls Table III-1 Minimum Requirements for Reinforced Piers III.C.6. Maintenance (Pages 39-47)	801.1	FEMA 102 addresses the elevation of buildings on "post" foundations by showing details and design charts. FEMA 102 addresses the elevation of buildings on piles by describing the general length, maximum design load, application, advantages, disadvantages, typical elevation, and typical cross section. FEMA 102 provides details of piers (brick, reinforced concrete, reinforced masonry). FEMA 102 addresses the need to perform maintenance on posts, piles, piers, or walls based on the frequency of flooding. SFM requires buildings to be elevated on pilings or columns so that the lowest horizontal structural member is elevated above the base flood elevation. SFM references Chapter 13 of the Standard Building Code for pile system design and installation. SFM does not provide details. SFM does not address maintenance of the foundation system.

Recommendation: None since FEMA 102 contains prescriptive type requirements and SFM contains performance type requirements.

FEMA 102	SFM	Analysis
III.D. Waterproof Construction III.D.1 Introduction III.D.2 Wall Strength III.D.3 Floor Strength and Structural Stability III.D.4 Counteracting of Hydrostatic Forces III.D.5 Waterproofing III.D.6 Watertight Cores III.D.7 Closures and Flood Shields (Pages 48-72)	900.3 900.4	FEMA 102 addresses floodproofing of the building to prevent floodwaters from reaching the interior; the use of a concrete slab or impervious cutoffs, or subsurface drainage to resist the hydrostatic uplift pressures, the use of impermeable membranes, the use of "watertight cores" around expensive items which are located together and the use of closures and flood shields to protect against floodwater intrusion. SFM addresses the same techniques of floodproofing.

Recommendation: None.

FEMA 102	SFM	Analysis
III.E. Floodwalls and Levees III.E.5 Floodwall Design III.E.7 Floodwall Maintenance (Pages 80-85, 88)	900.4	FEMA 102 provides commentary type language on different types of floodwalls (permanent floodwalls, gravity walls, cantilever walls, and moveable walls) and annual inspection of the floodwalls. SFM permits the use of bulkheads as a form of floodproofing but does not address different types of bulkheads or annual inspection.

Recommendation: None since both FEMA 102 and SFM address floodwalls (bulkheads).

FEMA 102	SFM	Analysis
IV. Other Floodproofing Measures IV.C. Floodproofing Utilities (Pages 99-104)	602.5	Both FEMA 102 and SFM require utilities to be designed and located so as to prevent water from entering or accumulating within the components and to minimize the chance of impairment during flooding.

Recommendation: None.

FEMA 102	SFM	Analysis
Appendix B Glossary (Pages 161-166)	202	Both FEMA 102 and SFM contain some of the same definitions and some different definitions. The definitions are appropriate for each document.

Recommendation: None.

FEMA 102	SFM	Analysis
Appendix D Floodproofing Performance Criteria Appendix D.B Design Loads Appendix D.C Performance Criteria (Pages 182-193)	900.4	FEMA 102 provides a list of the types of loads (dead load, wind loads, floodwater loads, flood impact loads, soil loads, etc.). FEMA 102 contains performance criteria which represents the objectives that should be achieved in the design of floodproofed nonresidential structures and service systems. SFM requires the floodproofing measures to be designed consistent with the flood protection elevation for the particular area, flood velocities, durations, rate of rise, hydrostatic and hydrodynamic forces, and other factors associated with the base flood.

Recommendation: None since the final results are the same.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Retrofitting Flood-Prone Residential Structures (FEMA 114)

FEMA 114	SFM	Analysis
3.5 Elevation Onto Extended Foundation Walls (Pages 46-49)	602.1 801.1	FEMA 114 addresses the method of elevating the structure by increasing the foundation wall height. SFM requires the elevation of the lowest structural member of the lowest floor to be above the base flood level but does not specifically address "extended foundation walls."

Recommendation: None since both FEMA 114 and SFM address the need to have the lowest structural member of the lowest floor above the base flood level.

FEMA 114	SFM	Analysis
3.12 Technical Design Criteria Extended Wall Foundation (Pages 61-63)	601.1 801.1 801.3	FEMA 114 requires the foundation system with the increased foundation wall height to be of sufficient strength to support the loads and forces encountered. SFM does not specifically address "extended foundation walls" but does require the foundations to be adequate to resist the combined wave and wind loads to which they are likely to be subjected during a flood.

Recommendation: None.

FEMA 114	SFM	Analysis
3.13 Technical Design Criteria Anchorage of Superstructure to Foundation (Pages 63-67)	401.3 601.1 801.3	FEMA 114 provides design details for the anchorage of the superstructure to the foundation system. SFM requires the structural system to be designed, connected and anchored to prevent flotation, collapse and permanent lateral movement due to flooding.

Recommendation: None since FEMA 114 contains prescriptive type requirements and SFM contains performance type requirements.

FEMA 114	SFM	Analysis
3.14 Technical Design Criteria Open Foundations (Pages 67, 68)	801.1	FEMA 114 describes three types of open foundations (piers, columns, or piles) and requires them to be designed for the loads encountered. SFM requires the foundations to be adequate to resist the combined wave and wind loads to which they are likely to be subjected during a flood. SFM refers to Chapter 13 of the Standard Building Code for pile system design and installation.

Recommendation: FEMA 114 should address seismic loads.

FEMA 114	SFM	Analysis
Chapter 6 Floodwalls 6.2 Considerations 6.3 Construction Techniques and Materials 6.5 Technical Design Criteria (Pages 111-119, 121-129)	900.4	FEMA 114 addresses the use of floodwalls to protect structures from flooding and emphasizes that tremendous forces are created by high water levels and velocities, techniques and types of materials for the construction of floodwalls, and design criteria. SFM does not address construction materials or design criteria for floodwalls, but does require the floodproofing measures to be designed for the flood velocities, hydrostatic and hydrodynamic forces, and other factors associated with the base flood.

Recommendation: None.

FEMA 114	SFM	Analysis
Chapter 7 Closures 7.2 Considerations 7.3 Low Profile Permanent Closures 7.4 Closure Materials and Construction 7.6 Technical Design Criteria (Pages 133-142)	900.4	FEMA 114 addresses the use of closures (covering openings such as doors, windows, driveways, etc.) to act as shields to prevent water away from or entering residence. SFM addresses the use of watertight doors, bulkheads, and shutters, or similar methods of construction.

Recommendation: None.

FEMA 114	SFM	Analysis
Chapter 8 Sealants 8.2 Considerations 8.3 Sealing Techniques 8.4 Closures 8.5 Design Details 8.7 Technical Design Criteria (Pages 145-156)	900.3 900.4	FEMA 114 addresses the sealing, making watertight, or dry floodproofing of the structure to prevent the entry of water during low level flooding. SFM permits buildings, except residential, to be floodproofed with walls which are impermeable to the passage of water below the base flood level. SFM requires the floodproofing measures to be designed consistent with the flood protection elevation for the particular area, flood velocities, durations, rate of rise, hydrostatic and hydrodynamic forces and other factors associated with the base flood.

Recommendation: None, since floodproofing of basements is allowed only in communities that have been granted an exception by FEMA.

FEMA 114	SFM	Analysis
Chapter 9 Protection of Utilities 9.4 Permanent Protective Measures 9.5 Utility Relocations to Existing Space 9.6 Utility Relocations to New Space (Pages 160-165)	602.4 602.5	FEMA 114 addresses permanent protection of utilities by shielding or elevating the utility. SFM requires the utilities to be designed to prevent water from entering or accumulating with the components and to minimize the chance of impairment during flooding.

Recommendation: None.

FEMA 114	SFM	Analysis
9.8 Storage Tank Storage (Page 166)	N/A	FEMA 114 addresses the need for proper anchorage of tanks to prevent their flotation from the buoyancy forces. SFM does not address anchorage of storage tanks.

Recommendation: SFM should address anchorage of storage tanks.

FEMA 114	SFM	Analysis
10.4 Floating Structures (Pages 176-177)	N/A	FEMA 114 permits "floating structures" as a method of floodproofing. SFM does not address "floating structures."

Recommendation: None.

FEMA 114	SFM	Analysis
Appendix C - Forces (Pages 197-207)	401.3, 601.1, 801	FEMA 114 addresses hydrostatic loads, hydrodynamic loads, impact loads, and wind loads. FEMA 114 also provides definitions, application and methodology for design. SFM requires the design to be designed, connected and anchored to present flotation, collapse and permanent lateral movement due to the effects of wind and water forces. SFM refers to 1205 of the Standard Building Code for the design wind loading.

Recommendation: FEMA 114 should update the wind speed maps to the latest edition and address snow and seismic loads.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Alluvial Fans: Hazards and Management (FEMA 165)

FEMA 165	SFM	Analysis
Window and Doors (Page 10)	N/A	FEMA 165 prohibits openings on the uphill side of the structure to prevent debris and flood water from entering the building. SFM does not address the location of openings; however, it does address the installation of watertight doors, bulkheads, and shutters on similar methods of construction to floodproof the building.

Recommendation: None.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Manual for the Construction of Residential Basements in Non-Coastal Flood Environs (MCRB)

Chapter III Basement Construction

MCRB	SFM	Analysis
III.A. Construction Types-Walls (Pages 13-19)	N/A	MCRB provides commentary and prescriptive type language for minimum thickness, reinforcing, and resistance to lateral loads of masonry and concrete walls. MCRB also addresses stone and wood foundations, excavation and backfilling, and concrete formwork. SFM does not address types of wall construction. This is addressed in Chapters 13, 14, and 16 of the SBCCI Standard Building Code.

Recommendation: None.

B. Other Construction Features

MCRB	SFM	Analysis
III.B.1 Basement Slab III.B.2 Structural Basement Slab III.B.3 Footing (Foundation) III.B.4 Underdrain System - Sumps and Pumps III.B.5.a Ground Surface Slope - Site Investigation III.B.5.b Ground Surface Slope - Grading and Surface Drainage III.B.6 Seepage Quantities III.B.7.a Penetrations, Cracks, Joints, and "Waterproofing" - Utility III.B.7.b Penetrations, Cracks, Joints, and "Waterproofing" - Techniques that Lessen Cracking in Concrete (Pages 19-34)	N/A	MCRB contains commentary and prescriptive type language for basement slabs (minimum thickness and reinforcing), footing size, sumps and pumps, soils investigation, grading of lot, flow net analysis, penetrations through waterproofed walls, and crack control of concrete. This is addressed in Chapter 13 and 16 of the SBCCI Standard Building Code.

Recommendation: None.

MCRB	SFM	Analysis
III.B.7.c Penetrations, Cracks, Joints, and "Waterproofing" - "Waterproofing" Basements (Pages 34, 35)	Chapter 9	Both MCRB and SFM address "Waterproofing" as a method of protecting the basement of residential structures. SFM does not permit floodproofing of the basement of residential structures. Methods of waterproofing are addressed in 1312 of the SBCCI Standard Building Code.

Recommendation: None, since floodproofing of basements is allowed only in communities that have been granted an exception by FEMA.

MCRB	SFM	Analysis
III.B.8 Plumbing Subsystems (Pages 35, 36)	602.5 602.6 602.7	MCRB requires gate valves on the sanitary sewer outlets from the house and the potable water supply system to be designed in such a manner to prevent contamination from flood waters. SFM requires the plumbing systems to be designed and located to minimize the chance of impairment during flooding. SFM requires water supply systems to be designed to minimize infiltration of flood waters into the system and the sewage system to be designed to minimize discharge from the system into flood waters.

Recommendation: None.

MCRB	SFM	Analysis
III.B.9 Anchorage (Pages 36, 37)	601.1	MCRB provides calculations to determine the anchorage requirements. MCRB requires a minimum of 1/2 inch anchor bolts spaced a maximum of 8 ft anchored into 2 block courses or 16 inches with a minimum of 2 bolts per plate. SFM simply requires the structural systems to be designed, connected and anchored to prevent flotation, collapse, and permanent lateral movement due to flooding.

Recommendation: None.

MCRB	SFM	Analysis
III.B.10 Some Concrete Construction Practices III.B.11 Some Block Construction Practices III.C. Loads III.C.1 Soil III.C.2 Water Table (Pages 37-63)	N/A	MCRB contains commentary type language for handling and depositing concrete, consolidating concrete, cold weather considerations, additives, placing reinforcement, etc.; for improving the waterproofing quality of concrete masonry walls; for determination of soil types; for erosion control; for lateral pressures exerted from backfill material; and for the water table. SFM does not address construction practices, erosion control, soil types, or water table.

Recommendation: None.

MCRB	SFM	Analysis
III.C. Loads III.C.3 Superstructure Loads and Buoyancy III.C.4.d Flood Waters - Velocity III.C.4.e Flood Waters - Sediment III.C.4.f Flood Waters - Rate of Rise III.C.4.g Flood Waters - Hydraulic/ Hydrologic Relations (Pages 63-75)	601.1 900.3	MCRB contains sample calculations to determine the superstructure loads imposed by buoyancy. MCRB provides commentary type language addressing increased structural damage which may result from the high velocity of flood waters, floodwater deposited sediment, and the rate of rise of flood water causing unequal loading on basement walls. MCRB references a separate Hydraulic/Hydrologic manual which could be used to evaluate a site. SFM requires the structural systems to be designed, connected and anchored to prevent flotation, collapse and permanent lateral movement due to flooding. SFM requires the floodproofing measures to be designed consistent with the flood protection elevation for the particular area, flood velocities, durations, rate of rise, hydrostatic and hydrodynamic forces, and other factors associated with the base flood.

Recommendation: None.

MCRB	SFM	Analysis
III.C. Loads III.C.5 Debris, Wind Impact, Snow, Ice, and Other Live Loads. (Page 75)	601.1	MCRB states that other than debris and impact loads; wind, snow, and ice are not considered to alter the designs in the MCRB. SFM requires the structural system to be designed, connected and anchored to prevent flotation, collapse and permanent lateral movement due to flooding.

Recommendation: MCRB should include wind, snow, and seismic loads.

Chapter V Basements in Floods

MCRB	SFM	Analysis
A. Structural Design/Analysis A.2 Designs, Methods, and Tables A.2.a Building Model, Dimensions, and Loading A.2.b Structural Analysis Model (Wall) A.2.c Structural Plain Concrete A.2.d Reinforced Concrete A.2.e Plain Masonry Block A.2.f Reinforced Masonry Block A.2.g Flood Waters Above Grade A.2.h Slab Thickness (Based on Bending) A.2.i Structural Slab Design (Ultimate Strength Design) (Pages 88-114)	N/A	MCRB contains sample structural calculations. MCRB refers to the UBC in V.A.2.e and V.A.2.f. SFM does not provide sample calculations.

Recommendation: MCRB should not reference a single model code. MCRB should reference only national consensus documents.

MCRB	SFM	Analysis
B. Soil/Water Load Philosophy B.1 Weir Level Load B.2 Buoyancy B.3 Slab Bending B.4 Wall Loads B.5 Clay vs. Sand or Drain and Sump vs. Sealed "Barge" B.5.a Drained or Sump System B.5.b Undrained or Barge System (Pages 114-126)	N/A	MCRB contains commentary type language addressing the design philosophy of the lateral pressures exerted by soil and/or water loadings. SFM is not a commentary and does not address philosophy.

Recommendation: None.

VII. Appendices

MCRB	SFM	Analysis
Appendix A - Soils Data Allowable Bearing Pressures Allowable Soil Pressures Beneath Footings (Pages 164, 166)	N/A	MCRB contains allowable bearing pressures for various soil types. SFM is a performance code.

Recommendation: None.

MCRB	SFM	Analysis
VIII Builder's Guide A. Introduction A.2.a Soil and Water Loading on Wall Cross-Section (Page 198) A.2.c "Waterproofing" System (Page 206) A.2.d Wall Design (Page 209) A.2.e Slab Design (Page 211) B. Acceptable Wall Designs B.1 Structural Plain Concrete (Unreinforced) B.2 Reinforced Concrete B.3 Unreinforced Masonry Block B.4 Reinforced Masonry Block B.5 Buoyancy Wall (Pages 212-239) C. Acceptable Slab Designs (Pages 240-246) D. Acceptable Control Joint Design, Underdrain, and "Waterproofing" and Seals D.1 Overview and Control Joints D.2 Sump, Pump, and Underdrain (for Drained System) D.3 "Waterproofing" and Seals D.3.a Undrained Slab and Wall System D.3.b Drained Slab and Wall System D.3.c Slab/Wall/Footing Juncture (Pages 247-262)	N/A	MCRB contains details and design charts for wall design, slab design, control joints, sumps, and/or waterproofing. SFM is a performance code and does not contain details or design charts.

Recommendation: None.

MCRB	SFM
Hydraulic/Hydrologic Manual	601.1
I. Introduction	900.3
I.B. Flood Waters	
I.B.4 Velocity	
I.B.5 Sediment	
(Pages 7-9)	

Analysis

MCRB contains commentary type language addressing increased structural damage which may result from the high velocity of floodwaters and floodwater deposited sediment. SFM is a performance code and does not contain commentary. SFM requires the structural systems to be designed, connected and anchored to prevent flotation, collapse and permanent lateral movement due to flooding. SFM requires the floodproofing measures to be designed consistent with the flood protection elevation for the particular area, flood velocities, durations, rate of rise, hydrostatic and hydrodynamic forces, and other factors associated with the base flood.

Recommendation: None.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Technical Standard Bulletin: Wet Floodproofing, No. 85-1

No. 85-1	SFM	Analysis
I. Definition (Page 1)	602.2	No. 85-1 provides a definition of wet floodproofing and explains the justification for this type of floodproofing. SFM does not address wet floodproofing but does address foundation wall openings to allow for the entry and exit of floodwaters to automatically equalize hydrostatic flood forces on exterior walls; however, only breakaway walls are permitted in coastal high hazard areas.

Recommendation: None.

No. 85-1	SFM	Analysis
II. Protection Goals (Page 2)	N/A	No. 85-1 explains that wet floodproofing consists of protection of the structure, protection of interior finishes, protection of mechanical and electrical systems, protection of major equipment and machinery, and protection of contents. SFM does not address wet floodproofing as a method of floodproofing.

Recommendation: None.

No. 85-1	SFM	Analysis
III.B. Structural Features (Pages 4, 5)	900.4	No. 85-1 addresses the superstructure materials as far as their durability, resistance to flood forces, resistance to the deterioration caused by floodwaters, and water resistance. SFM does not address building materials.

Recommendation: None.

No. 85-1	SFM	Analysis
III.C. Building Activity and Use (Page 5-6)	900.3	No. 85-1 addresses the need to determine the feasibility of wet floodproofing based on activity and use. SFM does not address wet floodproofing. SFM addresses the building when floodproofing walls below the base flood level is used.

Recommendation: None.

No. 85-1	SFM	Analysis
IV.A.1 Foundations (Page 6)	801.1 900.4	No. 85-1 emphasizes the importance of the need to investigate the influence of hydrologic and hydraulic conditions on the foundation design when wet floodproofing is used. SFM requires the floodproofing measures to be designed for the flood velocities, durations, rate of rise, hydrostatic and hydrodynamic forces, and other factors associated with the base flood.

Recommendation: None.

No. 85-1	SFM	Analysis
III.A.2 Cavity Wall Construction (Pages 6-7)	N/A	No. 85-1 addresses the need to drain the cavity space at a rate approximately equal to the flood rate. SFM does not address any specific type of construction.

Recommendation: None.

No. 85-1	SFM	Analysis
IV.A.3 Solid Wall Construction (Pages 7-8)	900.3	No. 85-1 addresses the need for the interior and exterior wall cladding to be relatively impervious to prevent the intrusion of the floodwaters into the wall. SFM requires walls below the base flood level to be substantially impermeable.

Recommendation: None.

No. 85-1	SFM	Analysis
IV.A.4 Interior Walls (Page 8)	N/A	No. 85-1 emphasizes that the criteria for cavity wall and solid wall construction applies to interior walls. See analysis for IV.A.2 and IV.A.3.

Recommendation: None.

No. 85-1	SFM	Analysis
IV.A.5 Interior Wall Finishes (Page 8)	N/A	No. 85-1 addresses the need for the interior finishes to be able to withstand inundation for a minimum of 160 hours without damage, not be subject to deterioration from chemicals in the floodwaters, and capable of being easily cleaned. SFM does not address wall finishes.

Recommendation: None.

No. 85-1	SFM	Analysis
IV.A.6 Floors (Pages 8-9)	900.4	No. 85-1 addresses the need for floor systems to be capable of withstanding the hydrostatic pressure generated by a water level differential of two feet between the exterior and interior of the structure. SFM requires the floodproofing measures to be designed for the flood velocities, durations, rate of rise, hydrostatic and hydrodynamic forces, and other factors associated with the base flood.

Recommendation: None.

No. 85-1	SFM	Analysis
IV.A.7 Ceiling and Roofs (Page 9)	N/A	No. 85-1 addresses the need for ceiling materials to be of a type to withstand prolonged exposure to moisture and humidity. SFM does not address exposure to moisture and humidity.

Recommendation: None.

No. 85-1	SFM	Analysis
IV.A.8 Building Envelope Penetrations (Page 10)	900.4	No. 85-1 addresses the need for building penetrations (doors, louvers, vents, skylights, etc.) to be capable of resisting damage for a minimum of 160 hours of inundation, be essentially nonporous, and be conducive to easy cleaning. SFM addresses the installation of watertight doors, bulkheads, and shutters or similar methods of construction. SFM does not address nonporous or easy cleaning material.

Recommendation: None.

No. 85-1	SFM	Analysis
IV.A.9 Electrical System IV.A.10 HVAC (Pages 10-12)	602.5 900.4	No. 85-1 addresses the need to prevent vulnerable electrical components from coming in contact with the floodwaters. No. 85-1 emphasizes that the key protective measures for HVAC equipment is elevation and enclosure. SFM requires all utilities to be designed and located so as to prevent water from entering or accumulating within the components and to minimize the chance of impairment during flooding.

Recommendation: None.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Technical Standards Bulletin: Foundation Wall Openings, No. 85-2

No. 85-2	SFM	Analysis
Flood Forces (Page 1-3)	401.3 801.1 900.3	No. 85-2 provides commentary type language on flood forces, (hydrostatic and hydrodynamic pressure) and formulas to determine these pressures. SFM requires the walls to be designed for the flood velocities, durations, rate of rise, hydrostatic and hydrodynamic forces and other factors associated with the base flood.

Recommendation: None.

No. 85-2	SFM	Analysis
Openings Design Criteria (Pages 4-6)	602.2	No. 85-2 provides design criteria to size the openings (1 sq inch of opening for 1 sq ft of floor area) needed to allow floodwaters in an enclosure for the purpose of equalizing hydrostatic pressures. SFM requires a minimum of two openings having a total net area of no less than 1 sq inch of opening for 1 sq ft of floor area.

Recommendation: None.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Technical Standards Bulletin: Breakaway Walls, No. 85-3

No. 85-3	SFM	Analysis
II. Wind and Water Forces (Pages 2-3)	401.3 801.1 801.3	No. 85-3 addresses wind loads and flood water loads. No. 85-3 references the building codes or ANSI A58.1-1982 for information on wind loads. SFM requires the building to be designed for the wave and wind loads. SFM refers to 1205 of the Standard Building Code for the design wind loads.

Recommendation: No. 85-3 should update reference to ASCE 7-88 and address snow and seismic loads.

No. 85-3	SFM	Analysis
III. Design Approach (Page 4)	801.4	Both No. 85-3 and SFM require the breakaway wall to be designed to withstand at least 10 psf but no more than 20 psf.

Recommendation: None.

No. 85-3	SFM	Analysis
IV. Design Considerations (Pages 4-10)	N/A	No. 85-3 provides commentary type language and details for various types of breakaway walls. SFM does not provide details.

Recommendation: None since No. 85-3 contains specification type requirements and SFM contains performance type requirements.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Technical Standards Bulletin: Wind Design Standards and the NFIP, No. 88-1

No. 88-1	SFM	Analysis
Pages 1-5	801.1	Both No. 88-1 and SFM address wind loads. No. 88-1 contains a reference to ANSI A58.1-1982. SFM references 1205 of the Standard Building Code which contains basic wind speed map, velocity pressure, and coefficients in addition to referencing ASCE 7-88.

Recommendation: No. 88-1 should update reference to ASCE 7-88 and address snow and seismic loads. Section 801.1 of the Standard for Floodplain Management should reference Chapter 12 instead of only 1205 (Wind) to include 1204 (Snow) and 1206 (Seismic).

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Technical Standards Bulletin: Flood Resistant Materials, No. 88-2

No. 88-2	SFM	Analysis
Pages 1-7	N/A	No. 88-2 provides data and guidance to determine "materials resistant to flood damage" and how the material should be used to improve the structure's ability to withstand flooding. SFM does not address "flood resistant" materials.

Recommendation: None.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Technical Standards Bulletin: Free of Obstruction Requirements in Coastal High Hazard Areas, No. 88-3

No. 88-3	SFM	Analysis
Lower Area Obstruction (Pages 2-4)	801.4	Both No. 88-3 and SFM prohibits the construction of anything, except breakaway walls, open wood latticework, or insect screening, beneath the lowest horizontal structural member.

Recommendation: None.

No. 88-3	SFM	Analysis
Obstructions Outside the Perimeter of the Coastal Building (Pages 4-6)	401.3 801.1 801.3	No. 88-3 requires structures outside the perimeter of the coastal building to be anchored to resist flotation, collapse, and lateral movement due to the combined effects of wind and water. SFM requires "all structures" in the coastal high hazard area to be anchored to resist flotation, collapse, and permanent lateral movement due to the effects of wind and water loading.

Recommendation: None.

No. 88-3	SFM	Analysis
Obstructions Attached to But Outside the Building Perimeter (Page 6)	401.3 801.1 801.3	No. 88-3 explains that anything attached to the building is considered part of the building and has to meet the same requirements as the building. SFM requires all structures in the coastal high hazard area to be anchored to resist flotation, collapse, permanent lateral movement due to the effects of wind and water loading.

Recommendation: None.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Technical Standards Bulletin: Protection of Elevator Equipment in Flood Hazard Areas, No. 88-4

No. 88-4	SFM	Analysis
Recommendations (Page 3)	602.5 900.4	No. 88-4 recommends that the elevator-related hydraulic equipment and elevator-related electrical equipment be located above the BFE. No. 88-4 recommends that electrical equipment that cannot be placed above the BFE to be of water resistant models. No. 88-4 recommends that the elevator cab automatically stay above flood waters by interlocking the controls with "float" switches in the elevator shaft. SFM does not specifically address elevators but does require all utilities to be designed and located so as to prevent water from entering or accumulating within the components and to minimize the chance of impairment during flooding.

Recommendation: None.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Technical Standards Bulletin: NFIP Requirements for Below Grade Parking Garages in Flood Hazard Areas, No. 90-2.

No. 90-2	SFM	Analysis
Pages 1-4	602.3	No. 90-2 provides a summary of the National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard identification) requirements for below grade parking garages in flood hazard areas. Both No. 90-2 and SFM require the enclosed area below an elevated building to be used solely for parking of vehicles, limited storage of maintenance equipment used in connection with the premises, and access to the elevated living area.

Recommendation: None.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Technical Standards Bulletin: Non-Residential Floodproofing Certification Requirements of the National Flood Insurance Program, No. 90-3.

No. 90-3	SFM	Analysis
Pages 1-6	401.2	No. 90-3 provides a summary of the National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification) requirements to obtain certification by floodproofing the non-residential structure. No. 90-3 also provides the forces that the structure would be subjected to when the structure is subjected to the base flood. SFM requires certification from a registered professional engineer or architect that the floodproofing is in accordance with the SFM when floodproofing is utilized on a non-residential building as specified in Chapter 9.

Recommendation: None.

STANDARD FOR FLOODPLAIN MANAGEMENT (SFM) COMPARISON

The Standard for Floodplain Management contains provisions which are unique to floodplain management and does not contain provisions for conventional construction contained in the Standard Codes.

Technical Standards Bulletin: Installation of Manufactured Homes in Special Flood Hazard Areas, No. 90-4.

No. 90-4	SFM	Analysis
Pages 3-19	603	No. 90-4 provides a summary of the National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification) requirements which affect the placement of manufactured homes in flood hazard areas. SFM requires all manufactured homes located in a special flood hazard area to be elevated above the base flood elevation and anchored to resist flotation, collapse, or lateral movement in addition to the anchoring requirements provided in Appendix H of the Standard Building Code.

Recommendation: None.

Code Compatibility Report

Appendices C, D, E, and F

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APPENDIX C

COMPARISON BETWEEN THE ICBO UNIFORM CODES AND THE NFIP STANDARDS AND TECHNICAL GUIDELINES

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NFIP Flood-Resistant Design Standards (44 CFR 59.1, 60.3 and 60.6)

CFR 59.1	U.B.C.	Analysis
Appurtenant Structure	None.	CFR 59.1 has a definition of a structure that is accessory to the insured structure on the same parcel of land. The U.B.C. has no such definition and does not make a distinction between one structure and another on a parcel of land.
Recommendation:	None.	

CFR 59.1	U.B.C.	Analysis
Base Flood	Appendix Chapter 23, Division IV.	CFR 59.1 has a definition of the flood to be used in the design of structures within areas under the authority of the National Flood Insurance Program (NFIP). The U.B.C. has a definition for the elevation that a base flood may reach and is in fact the same design flood.
Recommendation:	None.	

CFR 59.1	U.B.C.	Analysis
Basement	Sec. 403.	CFR 59.1 has a definition of basement stating that the floor of a building below ground level on all sides is a basement. The U.B.C. defines a basement as a floor level below the first story of a building except that a building having only one floor level shall be classified as a basement unless that floor level qualifies as a first story.
Recommendation:	None.	

CFR 59.1	U.B.C.	Analysis
Breakaway Wall	Appendix Chapter 23, Division IV.	CFR 59.1 defines a breakaway wall as a wall, not a part of the structural support of the building and intended to collapse under specific lateral load forces. The Uniform Building Code indirectly defines a breakaway wall as one being below the base flood elevation and designed to breakaway under high tides or wave action without causing damage to the structural system, given specific design criteria.
Recommendation:	None.	

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

NFIP Flood-Resistant Design Standards (44 CFR 59.1, 60.3 and 60.6)

CFR 59.1	U.B.C.	Analysis
Building (See Structure)	Sec. 403 Sec. 420.	See analysis of "structure."
Recommendation:	See the recommendation of "structure."	

CFR 59.1	U.B.C.	Analysis
Critical Feature	None.	CFR 59.1 defines a critical feature as one that is integral and readily identifiable part of a flood protection system without which the flood protection would be compromised. The U.B.C. considers all elements of a building to be important.
Recommendation:	None.	

CFR 59.1	U.B.C.	Analysis
Development	Sec. 402 Appendix Chapter 70.	CFR 59.1 defines development as any change to improved or unimproved property which includes, but is not limited to building structures, grading, mining, etc. The Uniform Building Code has a definition of alteration, which is any change, addition or modification in construction or occupancy. The U.B.C. also regulates grading on a site, but does not include mining or other such exploratory or other drilling.
Recommendation:	The U.B.C. is not intended to regulate mining, dredging, drilling operations or the storage of equipment or materials whereas CFR 59.1 is intended to do so. Therefore, no change is recommended.	

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

NFIP Flood-Resistant Design Standards (44 CFR 59.1, 60.3 and 60.6)

CFR 59.1	U.B.C.	Analysis
Elevated Building	Appendix Chapter 23, Division IV.	CFR 59.1 defines elevated building differently in different zones. In Zones A-130 through D, the top of the elevated floor must be above the BFE. In Zones V-130, VE or V, the bottom of the lowest horizontal structure member must be elevated above the BFE. CFR 59.1 also goes as far as to say that fill or solid foundation perimeter walls may be used to elevate the building above the BFE provided that it facilitates the unimpeded movement of flood waters in or around the building in A Zones. The U.B.C. requires that a building located within flood-hazard Zone A shall have its lowest floor at or above the BFE. Any means of elevating the building within the A Zone is acceptable provided unimpeded flood water flow around the building or through the building is allowed. In V Zones, these buildings must be elevated on piles or columns.

Recommendation: None.

CFR 59.1	U.B.C.	Analysis
Existing Construction	Sec. 403.	CFR 59.1 defines existing construction as those structures which started construction prior to the effective date of the FIRM or before January 1, 1975. The U.B.C. defines an existing building as one that was erected or completed prior to the adoption of the Uniform Building Code or for one which a legal building permit was issued.

Recommendation: The definition in CFR 59.1 and the U.B.C.'s definition are for two totally different purposes and both are valid. Therefore, no recommendation.

CFR 59.1	U.B.C.	Analysis
Existing Structures	Sec. 403.	See analysis of "Existing Construction."

Recommendation: See recommendation of "Existing Construction."

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

NFIP Flood-Resistant Design Standards (44 CFR 59.1, 60.3 and 60.6)

CFR 59.1	U.B.C.	Analysis
Flood	Appendix Chapter 23, Division IV.	The definition found in CFR 59.1 not only includes complete or partial inundation of normally dry land by inland or title waters, but also mud slides and the erosion of land along a coast or shoreline. The U.B.C. refers to a flood-plain management ordinance that is a separate document.

Recommendation: None.

CFR 59.1	U.B.C.	Analysis
Flood Plain or Flood Prone Area	Appendix Chapter 23, Division IV.	CFR 59.1 defines flood-plain or flood-prone area as any land susceptible to a flooding event. The Uniform Building Code refers to the flood-hazard map as published by an approved agency and adopted by the jurisdiction.

Recommendation: None.

CFR 59.1	U.B.C.	Analysis
Lowest Floor	Appendix Chapter 23, Division IV.	CFR 59.1's definition is the lowest floor of an enclosed area, including basement, with the exception of unfinished flood-resistant parking, building access or storage areas that are not in violation of applicable non-elevation design requirements. The U.B.C. makes reference to the lowest floor in any building, including basements, with the exception of enclosures used for building access, exits, foyers, storage and parking garages, provided they meet the enclosure requirements found in Appendix Chapter 23.

Recommendation: None.

CFR 59.1	U.B.C.	Analysis
Manufactured Home	None.	CFR 59.1 defines a manufactured home as a transportable structure when it is attached to the required utilities, but not including a recreational vehicle. The U.B.C. has no such definition.

Recommendation: The U.B.C. relies on the discretion of the building official in approving such structures. However, a reference to an approved national standard or other such document could make the approval much easier.

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

NFIP Flood-Resistant Design Standards (44 CFR 59.1, 60.3 and 60.6)

CFR 59.1	U.B.C.	Analysis
One-Hundred-Year Flood	Appendix Chapter 23, Division IV.	See analysis of "Base Flood."

Recommendation: See recommendation of "Base Flood."

CFR 59.1	U.B.C.	Analysis
Storm Cellar	None.	CFR 59.1 defines a storm cellar as a space used to temporarily accommodate occupants of a structure above in an emergency due to severe wind activity. The U.B.C. has no such definition.

Recommendation: The U.B.C. does not intend to require a storm cellar for every building in areas subject to severe winds. Therefore, no recommendation.

CFR 59.1	U.B.C.	Analysis
Structure	Sec. 403 Sec. 420.	CFR 59.1 defines a structure as a walled and roofed building and includes tanks for flood plain management purposes, but not for insurance coverage purposes. The U.B.C. has two related definitions, one for building and the other for structure. A building, according to the U.B.C., is any structure used or intended for supporting or sheltering any use or occupancy. A structure is any artificially built-up piece of work, built or constructed, in some definite manner.

Recommendation: Since the U.B.C. and CFR 59.1 have different purposes, no recommendation is required.

CFR 59.1	U.B.C.	Analysis
Substantial Improvement	Chapter 1 Sec. 402.	CFR 59.1 defines substantial improvement as an improvement whose cost equals or exceeds fifty percent of the market value of the structure with exception given to work repairing health, sanitary or safety code violations or alterations to historic structures. The Uniform Building Code considers a substantial improvements as any work requiring a permit as defined in the code.

Recommendation: Both of these definitions serve different purposes. Therefore, no recommendation is required.

NFIP Flood-Resistant Design Standards (44 CFR 59.1, 60.3 and 60.6)

CFR 60.3	U.B.C.	Analysis
(b) (8) Manufactured Home Installation	Appendix Chapter 23, Division IV.	CFR 60.3 requires that all manufactured homes installed in A Zones be placed in such a way as to minimize flood damage and that they must be elevated and anchored to resist flotation, collapse or lateral movement. The Uniform Building Code requires that these structures, if they are located in any flood zone, shall meet the applicable elevation requirements and anchorage and tie-down requirements as stated in this appendix chapter.
Recommendation:	None.	

CFR 60.3	U.B.C.	Analysis
(c) (2) Elevation for Residential Structures	Appendix Chapter 23, Division IV.	CFR 60.3 requires that all new residential structures and substantial improvements within A Zones have their lowest floor elevated to or above the base flood elevation. The Uniform Building Code requires that all buildings erected within an A Zone have their lowest floor, including basement floors, located at or above the base flood elevation.
Recommendation:	None.	

CFR 60.3	U.B.C.	Analysis
(c) (3) Elevation of Non-Residential Structures	Appendix Chapter 23, Division IV.	CFR 60.3 requires that all new non-residential structures and substantial improvements of same within A Zones have their lowest floor elevated to or above the base flood elevation or be designed with hydrostatic and hydrodynamic loads and buoyancy forces under consideration. The Uniform Building Code requires that all buildings within an A Zone have their lowest floor, including basement floors, located at or above the base flood elevation. Any approved enclosed space below the base flood elevation would have to be designed to automatically equalize the pressure of the waters acting upon any exterior wall surface.
Recommendation:	None.	

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

NFIP Flood-Resistant Design Standards (44 CFR 59.1, 60.3 and 60.6)

CFR 60.3	U.B.C.	Analysis
(c) (5) Flood Openings	Appendix Chapter 23, Division IV.	CFR 60.3 requires that all new construction or substantial improvements that have approved, fully enclosed areas below the base flood elevation be designed in such a manner as to automatically equalize hydrostatic flood forces on the exterior walls with some specific design criteria. The U.B.C. requires that any approved enclosed spaces below the base flood elevation shall be designed in such a manner as to automatically equalize the lateral pressure of waters acting on any exterior wall surfaces with specific design criteria.

Recommendation: None.

CFR 60.3	U.B.C.	Analysis
(c) (4) Piling Certification	Appendix Chapter 23, Division IV.	CFR 60.3 requires that any new construction or substantial improvement in V Zones be elevated on pilings and columns so that the bottom of the lowest horizontal structural member of the lowest floor is elevated to or above the base flood level with specific design criteria and requires certification of the design by a professional engineer or architect. The Uniform Building Code requires that any new structure or addition in V Zones be elevated on pilings or columns so that the bottom of the lowest horizontal structural member of the lowest floor is elevated at or above the base flood elevation with specific design criteria and requires that the design be by a professional engineer or architect.

Recommendation: None.

CFR 60.3	U.B.C.	Analysis
(c) (5) Breakaway Walls	Appendix Chapter 23, Division IV.	CFR 60.3 requires that any approved enclosed space below the lowest floor in V Zones be enclosed with nonsupporting breakaway walls that are designed given the specific design criteria found within. The Uniform Building Code requires that any walls or partitions used to enclose any approved space below the base flood elevation be enclosed by breakaway walls designed to specific criteria.

Recommendation: None.

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

NFIP Flood-Resistant Design Standards (44 CFR 59.1, 60.3 and 60.6)

CFR 60.3	U.B.C.	Analysis
(e) (6) Fill	Appendix Chapter 23, Division IV.	CFR 60.3 prohibits the use of fill for structural support of any buildings within V Zones. The Uniform Building Code only allows fill in A Zones and not in any V Zones.

Recommendation: None.

CFR 60.6	U.B.C.	Analysis
(c) (2) (i) Flood-proof Walls	Appendix Chapter 23, Division IV	CFR 60.3 requires that any residential basement in an addition or substantial improvement that is located in an A1-30, AH, AO or AE zone be watertight and designed to resist hydrostatic and hydrodynamic loads and buoyancy effects. The U.B.C. requires that basements in other than residential uses below the BFE be impermeable to the passage of water and designed to resist hydrostatic and hydrodynamic loads.

Recommendation: None, since floodproofing of basements is allowed only in communities that have been granted an exception by FEMA.

CFR 60.6	U.B.C.	Analysis
(c) (2) (ii) Basement Top Floor Elevation	Appendix Chapter 23 Division IV	CFR 60.3 requires that the top floor of any residential basement be located no lower than 5 feet below the BFE. The U.B.C. allows basements in other than residential buildings to be located at any depth below the BFE provided they are designed to be impermeable to water and resistant to hydrostatic and hydrodynamic loads.

Recommendation: See recommendation of CFR 60.6 (c) (2) (i).

CFR 60.6	U.B.C.	Analysis
(c) (2) (iii) Fill	None	CFR 60.6 requires that the area surrounding exterior walls below the BFE be protected with sloped fill to or above the BFE. The U.B.C. has no such provision.

Recommendation: If the basement is designed to be impermeable to water and to resist hydrostatic and hydrodynamic loads, then additional protection is not necessary. Therefore, no recommendation.

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

NFIP Flood-Resistant Design Standards (44 CFR 59.1, 60.3 and 60.6)

CFR 60.6	U.B.C.	Analysis
(c) (2) (iv) Use of a Registered Professional	Sec. 302 (b) Appendix Chapter 23, Division IV	Both CFR 60.6 and the U.B.C. require the use of a registered professional for the design of such basements.

Recommendation: None.

CFR 60.6	U.B.C.	Analysis
(c) (2) (v) Building Inspection	Sec. 305.	Both CFR 60.6 and the U.B.C. require the inspection of the construction of such basements to verify they are constructed to the approved plans.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
4.1- Environ-mental Forces	Sec. 2308 (e) Sec. 2390 Sec. 2393 (a).	FEMA-55 recommends a flood-risk analysis for the design of a structure in coastal areas. The provisions found in the U.B.C. require that the design of a structure subject to a flooding risk reduces the risk of damage due to such a hazard prior to receiving a building permit.

Recommendation: None.

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
4.1.1- Wind	Sec. 2311-2321 Figure No. 23-1 Tables Nos. 23-F G, and H, Appendix Chapters 24 and 25.	FEMA-55 refers to recommendations found in the Minimum Design Loads for Buildings and Other Structures (ANSI 58-1-1982) document and other model codes for the basic wind design of structures. Figure 4-1, the basic wind speed map, is identical to U.B.C. Figure No. 23-1 as both are based upon the ANSI document. The U.B.C. prescribes specific wind design procedures that are dependent upon the building site as well as the design of the structure. The U.B.C. also includes prescriptive design requirements and construction details for masonry and light-frame construction in areas subject to a basic wind speed of 80 to 110 miles per hour.

Recommendation: FEMA-55 should reference the latest edition of the Minimum Design Loads for Buildings and other structures published by the American Society of Civil Engineers (ASCE 7-88, formerly ANSI 58.1) as this document contains the most recent developments and is being used as evidence for recent code changes.

FEMA-55	U.B.C.	Analysis
4.1.2- Corrosion Protection	Sec. 1708 Sec. 2510 Sec. 2516 (g) and (j) Sec. 2604 (c) and (d) Sec. 2908 (i) Sec. 2909 (a) Sec. 3003 Sec. 3202 Sec. 3208 Chapter 32 Tables Sec. 4706 Appendix Chapters 27 and 25. U.P.C.: Sec. 315.	FEMA-55 recommends that the elements of a buildings be protected from the corrosive environment associated with coastal construction. It also recommends that a potential waterway path into a structure be identified and sealed. The U.B.C. has specific provisions for the protection of exterior assemblies and materials used that are exposed to such an environment. The Uniform Plumbing Code requires that all piping exposed to a corrosive environment be protected in an approved manner.

Recommendation: It is recommended that FEMA-55 address roofing and other exterior assemblies in more detail.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
4.1.3- Water Force Data	Appendix Chapter 23 Sec. 2390 Sec. 2396.	FEMA-55 recommends that structures located in coastal environments be designed with the forces of water, waves and debris considered. This document sets a specific impact loading criteria and a design load based upon an accumulation of debris. The Uniform Building Code requires the same type of structural analysis which is based upon well-established engineering principles for these environments.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
4.1.4- Higher Structures	Appendix Chapter 23 Sec. 2390 Sec. 2396.	FEMA-55 discusses the forces on tall or large structures, requiring an appropriate structural analysis considering wind and water action. The Uniform Building Code does not make a distinction between tall or large structures and all others.

Recommendation: Both are compatible, as they are based upon sound, well-established engineering principles.

FEMA-55	U.B.C.	Analysis
4.2- Materials	Chapters 24, 25, 26, 27 and 28.	FEMA-55 discusses the use of wood, steel and concrete and makes general recommendations as to their protection in a corrosive environment. The Uniform Building requires that any material used be adequately protected against corrosion.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
4.2.1.1- Wood Pilings	Sec. 2501 (a), 4 Sec. 2504 (b) Sec. 2516 (c) 1 Table No. 25-E Sec. 2909 (a).	FEMA-55 briefly discusses the use of wood pilings as foundation system. The Uniform Building Code requires wood pilings to meet specific design criteria and has established standards for the preparation of wood piles.

Recommendation: None.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
4.2.1.2- Wood Beams	Sec. 2303 (a) Sec. 2516 (c) 8 and 11 Appendix Chapter 23 Sec. 2393 (d).	FEMA-55 discusses, in general terms, the use of wood beams and their protection from a corrosive environment. The Uniform Building Code allows the use of any structurally adequate beam and requires adequate protection from the same environment.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
4.2.1.3- Other Wood Members	Sec. 2516 (c) 3, 4, 5, 8, 9, and 11 Appendix Chapter 23 Sec. 2393 (d).	FEMA-55 states that other wood structural members are not required to be preservative treated. The Uniform Building Code requires that such members which are exposed to weather or corrosive conditions be preservative treated.

Recommendation: FEMA-55 and the Uniform Building Code are in direct conflict, with the Uniform Building Code requiring protection of all exposed members and FEMA-55 allowing unprotected members. It is recommended that FEMA-55 include the protection of all members that are exposed to these conditions.

FEMA-55	U.B.C.	Analysis:
4.2.1.4- Preservatives	Sec. 2501 (a) Sec. 2516 (c).	FEMA-55 discusses, in general terms, the use of wood preservatives in corrosive environments. The U.B.C. has specific requirements for the use of wood preservatives and has standards for the preservatives to meet.

Recommendation: FEMA-55 should recommend that the wood preservatives meet the approved standards within the jurisdiction where the project is located.

FEMA-55	U.B.C.	Analysis
4.2.2- Masonry	Chapters 23 and 26 Appendix Chapter 23, Division IV.	FEMA-55 has a brief paragraph on the use of masonry and concrete in corrosive environments. The U.B.C. has specific design requirements for concrete on corrosive environments but does not address masonry in similar situations.

Recommendation: The U.B.C. should discuss the use of masonry in corrosive environments.

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
4.2.3.1- Aluminum	Chapter 28 Appendix Chapter 23.	FEMA-55 discusses the protection of aluminum trim, windows, etc. in corrosive environments. The U.B.C. does not address the use of these types of aluminum products in corrosive situations.

Recommendation: The U.B.C. should address the protection of all materials exposed to corrosive environments in Appendix Chapter 23.

FEMA-55	U.B.C.	Analysis
4.2.3.2- Steel	Chapter 27 Sec. 2510.	FEMA-55 discusses the protection of exposed steel in corrosive environments and recommends regular inspection and maintenance of same. The U.B.C. does not discuss the protection of steel members.

Recommendation: See recommendation for Section 4.2.3.1.

FEMA-55	U.B.C.	Analysis
4.2.3.3- Dissimilar Materials	Sec. 2804 (c).	FEMA-55 discusses dissimilar materials in general terms and recommends against their use, unless their safety has been verified. The U.B.C. requires that such materials be separated from each other and provides a standard for the separation.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
4.3.1- Foundations	Sec. 2908-2910 Appendix Chapter 23, Division IV.	FEMA-55 briefly discusses different foundation systems. The U.B.C. provides specific design requirements for different foundation systems and requires the use of piles or columns in V zones.

Recommendation: FEMA-55 should recommend the use of only piles or columns in Coastal High Hazard Zones.

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
4.3.1.1- Soil Conditions	Sec. 2904-2906 Table No. 29-B.	FEMA-55 discusses, in general terms, soils conditions at the site and gives some general rules of thumb for the identification. The U.B.C. has specific requirements for the classification of soil.

Recommendation: FEMA-55 should recommend the use of a licensed engineer for the classification of the soil.

FEMA-55	U.B.C.	Analysis
4.3.1.2- Piles	Sec. 2908-2910 Appendix Chapter 23, Division IV.	FEMA-55 discusses the use of piles as the foundation and gives some minimum design recommendations. The U.B.C. requires the use of piles or columns in V zones but requires their design to be justified by structural calculations.

Recommendation: FEMA-55 should recommend that the sizing of the piles is done by a licensed engineer or architect or provide a reference to a document that does require such certification.

FEMA-55	U.B.C.	Analysis
4.3.1.3- Wood Posts	Appendix Chapter 23, Division IV.	FEMA-55 does not recommend the use of wood posts in either flood hazard zone. The U.B.C. requires that in V zones only piles or columns shall be used, all other zones may have any type of designed foundation system.

Recommendation: FEMA-55 should allow the use of wood posts in A zones provided the foundation system is designed by a licensed engineer or architect.

FEMA-55	U.B.C.	Analysis
4.3.1.4- Masonry Piers	Sec. 2907 and 2910 Appendix Chapter, Division IV.	FEMA-55 discusses the use of piers as a foundation system and provides some design criteria. The U.B.C. provides design criteria that is to be used by a licensed engineer or architect.

Recommendation: FEMA-55 should recommend that a licensed engineer or architect design the pier foundation or provide a reference to a document that requires such certification.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
4.3.2.1- Framing	Chapter 23 Chapter 25 Appendix Chapter 23, Division IV.	FEMA-55 discusses the use platform framing in flood-prone environments. The U.B.C. does not address this specific type of framing but instead requires any such design to be based on well-established engineering principles.

Recommendation: FEMA-55 should recommend that the design of this type of framing system be done by a licensed engineer or architect or provide a reference to a document that requires such certification, since these areas may also be subject to other lateral forces.

FEMA-55	U.B.C.	Analysis
4.3.2.2- Floor Beams	Chapter 23 Chapter 25 Appendix Chapter 23, Division IV.	FEMA-55 discusses the orientation and sizing of floor beams that are exposed. The U.B.C. requires that floor beams be designed by a licensed engineer or architect taking under consideration all loads that it may support.

Recommendation: See the recommendation for 4.3.2.1.

FEMA-55	U.B.C.	Analysis
4.3.2.3- Joists and Rafters	Chapter 23 Chapter 25 Appendix Chapter 23, Division IV.	FEMA-55 discusses types of joists and rafters. The U.B.C. has specific design criteria for such members.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
4.3.2.4- Subflooring	Chapter 23 Chapter 24 Appendix Chapter 23, Division IV.	FEMA-55 discusses subflooring in flood-prone areas. The U.B.C. has specific design criteria for subflooring.

Recommendation: None.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
4.3.2.5- Studs	Chapter 23 Chapter 25 Appendix Chapter 23, Division IV.	FEMA-55 briefly discusses the types of studs used. The U.B.C. has specific design criteria for stud walls.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
4.3.2.6- Wall Sheathing	Chapter 23 Chapter 25 Appendix Chapter 23, Division IV.	FEMA-55 discusses wall sheathing and gives some design criteria. The U.B.C. has specific deign criteria for wall sheathing.

Recommendation: FEMA-55 should recommend that an licensed engineer or architect design the wall sheathing as other lateral loads may govern.

FEMA-55	U.B.C.	Analysis
4.3.2.7- Wall Bracing	Chapter 23 Chapter 25 Appendix Chapter 23, Division IV.	FEMA-55 discusses different types of wall bracing. The U.B.C. has specific design criteria for wall bracing.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
4.3.2.8- Roof	Chapter 23 Chapter 25 Appendix Chapter 23, Division IV.	FEMA-55 discusses different types of roof construction. The U.B.C. has specific design criteria for any type of roof.

Recommendation: None.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
4.3.3- Foundation Bracing	Sec. 2908 and 2910 Appendix Chapter 23, Division IV.	FEMA-55 discusses the use of foundation braces as an effective lateral force resisting system. The U.B.C.requires interconnection for all types of piles, unless proven that another system is adequate.

Recommendation: FEMA-55 should recommend that a licensed engineer or architect design these braces and the rest of the foundation system.

FEMA-55	U.B.C.	Analysis
4.3.3.1- Knee Bracing	Sec. 2908 and 2910 Appendix Chapter 23, Division IV.	FEMA-55 discusses the use of knee bracing and gives some design criteria. The U.B.C. requires that pile foundations be designed for lateral forces.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
4.3.3.2- Grade Beams	Sec. 2908 and 2910 Appendix Chapter 23, Division IV.	FEMA-55 recommends the use of grade beams to restrain a pile foundation. The U.B.C. requires interconnection of all pile foundation systems or another equivalent form of restraint.

Recommendation: FEMA-55 should recognize other methods of foundation restraint.

FEMA-55	U.B.C.	Analysis
4.3.3.3- Truss Bracing	Sec. 2908 and 2910 Appendix Chapter 23, Division IV Appendix Chapter 24 Appendix Chapter 25.	FEMA-55 recommends a more substantial pile bracing system when the structure is 10 feet or more above grade or is subject to hurricane force winds. The U.B.C. requires that all foundation systems be designed with all lateral loads considered and provides specific connection details for structures in areas subject to high winds.

Recommendation: None.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
4.3.3.4- Shear Walls	Chapter 24 Chapter 26 Chapter 26 Appendix Chapter 23, Division IV Appendix Chapter 24 Appendix Chapter 25.	FEMA-55 discusses the use of shear walls to resist wind forces. The U.B.C. requires that the lateral resisting system of a structure be designed with all lateral loads under consideration.

Recommendation: FEMA-55 seems to recommend the use of reinforced concrete and reinforced masonry as the only acceptable means of resisting wind loads. FEMA-55 should also consider the use of wood shear walls as an acceptable method of resisting wind and water loads.

FEMA-55	U.B.C.	Analysis
4.3.4- Connections	Chapter 23 Sec. 2510 Sec. 2516-17, Appendix Chapter 23, Division IV Appendix Chapter 24 Appendix Chapter 25.	FEMA-55 recommends that extra care is given to the design and detailing of all connections in a structure. The U.B.C. requires that all connections be designed for the loads incurred by the structure.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
4.3.4.1- Roof to Wall	Chapter 23 Sec. 2510 Sec. 2516 and 2517 Appendix Chapter 23, Division IV Appendix Chapter 24 Appendix Chapter 25.	See analysis of 4.3.4.

Recommendation: None.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
4.3.4.2- Wall to Floor	Chapter 23 Sec. 2510 Sec. 2516 and 2517 Appendix Chapter 23, Division IV Appendix Chapter 24 Appendix Chapter 25.	See analysis of 4.3.4.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
4.3.4.3- Floor Joist to Beam	Chapter 23 Sec. 2510 Sec. 2516 and 2517 Appendix Chapter 23, Division IV Appendix Chapter 24 Appendix Chapter 25.	See analysis of 4.3.4.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
4.3.4.4- Floor Beam to Pile	Chapter 23 Sec. 2510 Sec. 2516 and 2517 Appendix Chapter 23, Division IV Appendix Chapter 24 Appendix Chapter 25.	See analysis of 4.3.4

Recommendation: None.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
4.3.5- Breakaway Walls	Appendix Chapter 23, Division IV.	FEMA-55 recommends that any sheltered space beneath an elevated structure be enclosed by breakaway walls and gives examples of same. The U.B.C. requires that any enclosing walls beneath an elevated structure be designed and constructed as a breakaway wall.
Recommendation:	None.	

FEMA-55	U.B.C.	Analysis
4.3.5.1- Types of Walls	Appendix Chapter 23, Division IV.	FEMA-55 discusses different types of breakaway walls. The U.B.C. requires that any breakaway wall be designed for specific loads.
Recommendation:	None.	

FEMA-55	U.B.C.	Analysis
4.3.5.2- Design of Breakaway Walls	Appendix Chapter 23, Division IV.	FEMA-55 discusses the design of breakaway walls. The U.B.C. requires that any breakaway wall be designed for specific loads.
Recommendation:	None.	

FEMA-55	U.B.C.	Analysis
4.3.6- Utilities	Appendix Chapter 23, Division IV U.P.C.: Sec. 315 (e).	FEMA-55 discusses the protection of utilities in the "Coastal High Hazard" zone. The U.B.C. requires that utilities be protected in both the flood hazard zones.
Recommendation:	FEMA-55 should also include the protection of utilities in the "A" flood hazard zone as they subject to similar forces as found on the Coastal High Hazard zone.	

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
4.3.7- 4.3.7.1 4.3.7.2 4.3.7.3 4.3.7.4- Protection of the Interior	Sec. 1708 Sec. 2516 Sec. 3201 Sec. 3205 Sec. 4205 Appendix Chapter 23, Division IV.	FEMA-55 discusses the protection of the interior of a structure from wind and water action. The U.B.C. requires that openings below the base flood elevation (BFE) be protected and that exterior assemblies provide a weather-resistive barrier.

Recommendation: The U.B.C. should also address the protection of openings above the BFE from wind and water action.

FEMA-55	U.B.C.	Analysis
4.3.8- Maintenance	Sec. 104 (d).	FEMA-55 recommends regular inspection and maintenance of pilings, exposed connections, exposed protective devices and utilities. The U.B.C. requires that the owner or owner's designate maintain the structure and all devices and safeguards required by code in a safe and sanitary condition.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
5.1- General Design	Sec. 2311 and 2321 Appendix Chapter 23.	FEMA-55 discusses the lateral design criteria for larger structures. The U.B.C. requires a lateral analysis of all buildings with no distinction in the size of the building.

Recommendation: FEMA-55 recognizes that wind loads may govern in large structures, but should recommend that all lateral loads be considered in the design of all structures.

FEMA-55	U.B.C.	Analysis
5.2- Foundations	Sec. 2907 and 2910 Appendix Chapter 23, Division IV.	FEMA-55 discusses the types of foundations used on larger structures. The U.B.C. requires that all foundations be designed for the loads they support.

Recommendation: None.

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Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
5.3- Slabs-on-grade	Sec. 2623 Sec. 2908 (b).	FEMA-55 briefly discusses the different uses of slabs-on-grade. The U.B.C. prescribes specific design criteria for the different uses of slabs-on-grades.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
5.4- Superstructure	Chapter 23 Chapter 24 Chapter 26 Chapter 27.	FEMA-55 discusses some types of structural systems found in larger buildings. The U.B.C. requires that the structural system used be designed according to specific criteria.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
5.5- Elevated Floors	Chapter 26 Chapter 27.	FEMA-55 briefly discusses the use of reinforced concrete floors in larger structures. The U.B.C. requires that any floors used in larger structures be designed to meet specific criteria.

Recommendation: FEMA-55 should also discuss composite floor systems as these are prevalent in high-rise construction.

FEMA-55	U.B.C.	Analysis
5.6- Exterior Walls	Sec. 2309 and 2321 Appendix Chapter 24 Appendix Chapter 25.	FEMA-55 briefly discusses the types of exterior wall systems and their connections. The U.B.C. require that any exterior wall system used meet specific design criteria.

Recommendation: None.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
5.7- Professionals	Sec. 302 (b) Appendix Chapter 23, Division IV.	FEMA-55 recommends the use of design professionals in the design and construction of larger structures in areas subject to wind and water action. The U.B.C. requires a licensed engineer or architect for the design of such buildings.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
Figure No. A-1 Number of Piles	Sec. 302 (b) Chapter 23 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-55 recommends a certain number of piles which is dependent upon the dimensions of the supported structure. The U.B.C. requires that an engineer or architect design the piling system based on the applied loads and soil conditions.

Recommendation: FEMA-55 should recommend that a licensed engineer or architect design the piling system or provide a reference to a document that does require such certification rather than provide specific design criteria for all situations. Also, FEMA-55 should consider the soil conditions at the site when making design recommendations.

FEMA-55	U.B.C.	Analysis
Table No. A-1 Vertical Loads on Piles	Sec. 302 (b) Chapter 23 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-55 provides design loads for typical one- and two-story houses which leads to a recommended pile embedment depth. The U.B.C. requires that an engineer or architect design the piling system based on the applied loads and soil conditions.

Recommendation: See the recommendation for Figure No. A-1.

FEMA-55	U.B.C.	Analysis
Table No. A-2 Horizontal Wind Load per Pile	Sec. 302 (b) Chapter 23 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-55 provides wind design loads for typical one- and two-story houses which leads to the design of the bracing of the piles. The U.B.C. requires that an engineer or architect design the piling system based on the applied loads and soil conditions.

Recommendation: See the recommendation for Figure No. A-1.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
Table No. A-3 Minimum Pile Embedment	Sec. 302 (b) Chapter 23 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-55 provides the minimum embedment length of piles based on the loads provided. The U.B.C. requires that an engineer or architect design the piling system based on the applied loads and soil conditions.

Recommendation: See the recommendation for Figure No. A-1.

FEMA-55	U.B.C.	Analysis
Table No. A-4 Maximum Unbraced Pile Height	Sec. 302 (b) Chapter 23 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-55 provides a table of the maximum unbraced pile heights. The U.B.C. requires that an engineer or architect design the piling system based on the applied loads and soil conditions.

Recommendation: See the recommendation for Figure No. A-1.

FEMA-55	U.B.C.	Analysis
Table No. A-4.1 Maximum Unbraced Pile Heights Supporting Breakaway Walls	Sec. 302 (b) Chapter 23 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-55 provides a table of the maximum unbraced pile heights that support breakaway walls. The U.B.C. requires that an engineer or architect design the piling system based on the applied loads and soil conditions.

Recommendation: See the recommendation for Figure No. A-1.

FEMA-55	U.B.C.	Analysis
Table No. A-5 Uplift Loads per Foot of Wall	Sec. 302 (b) Chapter 23 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-55 provides wind loads that are to be used in the design of the connections between floors. The Uniform Building Code requires that an engineer or architect design the lateral resisting system based on the applied loads.

Recommendation: See the recommendation for Figure No. A-1.

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Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
Table No. A-6 Uplift Loads per Pile	Sec. 302 (b) Chapter 23 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-55 provides a table of loads to be used in the design of the connection of the floor beams to the piles. The Uniform Building Code requires that an engineer or architect design the lateral resisting system based on the applied loads.

Recommendation: See the recommendation for Figure No. A-1.

FEMA-55	U.B.C.	Analysis
Table No. A-7 Bolt Capacity of Floor Beam Connections	Table No. 26-E Sec. 2510 Table No. 25-F.	FEMA-55 provides bolt capacities based on the type of connection. The U.B.C. provides design loads based on the material in which the bolts are used.

Recommendation: FEMA-55 should also base their design tables on the materials used along with the connection requirements.

FEMA-55	U.B.C.	Analysis
Table No. A-8 Concrete Masonry Piers	Sec. 2303 Chapter 24 Appendix Chapter 24.	FEMA-55 provides recommended reinforcing requirements for areas subject to high winds. The Uniform Building Code requires that an engineer or architect design these concrete masonry piers for any horizontal loads that it may be subjected to.

Recommendation: FEMA-55 should require that an engineer or architect design all concrete masonry piers or provide a reference to a document that does require such certification rather than providing prescriptive reinforcing requirements.

FEMA-55	U.B.C.	Analysis
Table No. A-9 Concrete Piers	Sec. 2303 Chapter 26	FEMA-55 provides prescriptive reinforcing requirements for structures that are subject to high winds. The Uniform Building Code requires that an engineer or architect design such structures with all loads taken into account.

Recommendation: FEMA-55 should require that an engineer or architect design all concrete piers based on the loads generated by such winds rather that provide prescriptive reinforcing requirements or provide a reference to a document that does require such certification.

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Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
Figure No. A-2 Concrete Pier Cross Section	Sec. 2303 Chapter 26	FEMA-55 provides two diagrams of recommended locations for the reinforcing steel. Also, FEMA-55 recommends the use of No. 3 ties at 16 inches on center as the shear reinforcement for the concrete pier. The U.B.C. requires that all concrete piers be designed for both flexure and shear stresses.

Recommendation: FEMA-55 should recommend that a licensed engineer or architect design the concrete pier rather than provide specific design recommendations for all situations or provide a reference to a document that does require such certification.

FEMA-55	U.B.C.	Analysis
Figure No. A-3 Grade Beams and Slabs	Sec. 2303 Chapter 26	FEMA-55 provides a diagram for the recommended location of the steel reinforcing in grade beams and other specific design criteria. Also, this figure contains specific reinforcing requirements for slabs located in areas subject to these conditions. The Uniform Building Code requires such structural members be designed by a licensed engineer or architect based on the applied loads and conditions of the site.

Recommendation: FEMA-55 should recommend that a licensed engineer or architect should design such members based on the applied loads and site conditions.

FEMA-55	U.B.C.	Analysis
Table No. A-10 Fastener Capacities in Shear	Sec. 2303 Tables Nos. 24-D-1 and 24-D-2 Table No. 24-E Tables Nos. 25-F, G, H, J, K, O, Q.	FEMA-55 provides specific shear capacities for nails, screws and dowel pins. The Uniform Building Code provides specific criteria for the design of all fasteners.

Recommendation: FEMA-55 should recommend the use of the shear capacity requirements in the building code of that project's jurisdiction.

FEMA-55	U.B.C.	Analysis
Table No. 11-A Fasteners for Breakaway Walls	Sec. 2303 Appendix Chapter 23, Division IV.	FEMA-55 provides specific design criteria for the fasteners for breakaway walls. The Uniform Building Code requires that these breakaway walls be designed in accordance with specific loading criteria.

Recommendation: None.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
Appendix B Bracing	Sec. 2303 Sec. 2908 and 2910 Appendix Chapter 23, Division IV.	FEMA-55 discusses the use of pile bracing. The U.B.C. requires that a lateral resisting pile system be designed with wind loads, water and wave action under consideration.

Recommendation: FEMA-55 should recommend the use of an engineer or architect in the design of such a foundation system or provide a reference to a document that does require such certification.

FEMA-55	U.B.C.	Analysis
B.1 Knee Bracing	Sec. 2303 Sec. 2908 and 2910 Appendix Chapter 23, Division IV.	FEMA-55 discusses the use of knee braces and the detailing of same. The Uniform Building Code requires that such connections and braces be designed by a licensed engineer or architect with wind, water and wave action under consideration.

Recommendation: FEMA-55 should recognize the use of other forms of bracing as well as requiring the use of a licensed engineer or architect in the design of such a system or provide a reference to a document that does require such certification.

FEMA-55	U.B.C.	Analysis
B.2 Truss Bracing	Sec. 2303 Sec. 2908 and 2910 Appendix Chapter 23, Division IV.	FEMA-55 recommends that truss bracing be designed per the following sections. The U.B.C. requires that such a bracing system be designed by a licensed engineer or architect.

Recommendation: FEMA-55 should require the use of a licensed engineer or architect to design such a bracing system or provide a reference to a document that does require such certification.

FEMA-55	U.B.C.	Analysis
B.2.1 Diagonals	Sec. 2303 Sec. 2908 and 2910 Appendix Chapter 23, Division IV.	FEMA-55 discusses, in general terms, the use of diagonals as a bracing element and gives some specific design examples. The U.B.C., on the other hand, relies on a design by a licensed engineer or architect rather than specific design criteria.

Recommendation: FEMA-55 should rely on the design of a licensed engineer or architect or provide a reference to a document that does require such certification rather than providing specific design criteria.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
B.2.1.1 Lumber Diagonals	Sec. 2303 Chapter 25 Sec. 2908 and 2910 Appendix Chapter 23, Division IV.	FEMA-55 gives specific design criteria and examples for all conditions. The U.B.C. requires a design by a licensed engineer or architect given the site conditions.

Recommendation: FEMA-55 should rely more on the design of a licensed engineer or architect rather than give specific design criteria.

FEMA-55	U.B.C.	Analysis
B.2.1.2 Thread Bar Diagonals	Sec. 2303 Chapter 27 Sec. 2908 and 2910 Appendix Chapter 23, Division IV.	FEMA-55 gives recommendations for specific manufactured product as the use of a thread bar diagonal. The Uniform Building Code requires that these diagonals be designed by a licensed engineer or architect based on the applied loads and site conditions.

Recommendation: FEMA-55 should not recommend a specific manufacturer and should rely on the design of a licensed engineer or architect or provide a reference to a document that does require such certification.

FEMA-55	U.B.C.	Analysis
B.2.2 Struts	Sec. 2303 Chapter 25 Sec. 2908 and 2910 Appendix Chapter 23, Division IV.	FEMA-55 provides specific design criteria for struts and makes specific manufacturer recommendations. The U.B.C. relies on a design by a licensed engineer or architect based on the implied loads and site conditions.

Recommendation: See recommendation of B.2.1.2.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
B.3 Grade Beams	Sec. 2303 Chapter 26 Sec. 2908 and 2910 Appendix Chapter 23, Division IV.	FEMA-55 discusses the at-grade supports of a piling system by certain materials. The U.B.C. requires such a design to be by a licensed engineer or architect based on the applied loads and site conditions.

Recommendation: FEMA-55 should rely upon the design of a licensed engineer or architect or provide a reference to a document that does require such certification.

FEMA-55	U.B.C.	Analysis
D.1 Procedure A-1 Downward Loads per Pile	Chapter 23 Sec. 2908-2910.	FEMA-55 provides a simplistic approach to calculating the downward loads per pile. It also assumes certain dead and live loads without providing justification for the figures. The U.B.C. requires that the engineer or architect base the design dead and live loads on the use of the structure. Also, the load per pile is based on the tributary area supported by the pile and a reduction is given for any group action that may be used in the system.

Recommendation: FEMA-55 should indicate that this is a design example only and not a procedure to be used for every situation that may arise.

FEMA-55	U.B.C.	Analysis
D.2 Procedure A-2 Wind Loads per Pile	Chapter 23 Sec. 2908-2910.	FEMA-55 provides a simplistic procedure for the calculation of the wind loads per pile given a specific design situation. The U.B.C. provides two methods, normal force method and projected area method for calculating the wind loads on any given building. It also provides the means for calculating loads generated at roof eaves, ridges, overhangs and also on miscellaneous structures and provides criteria for calculating the loads on leeward elements.

Recommendation: See the recommendation for D.1, Procedure A-1.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
D.3 Procedure A-3 Minimum Embedment of Piles	Sec. 2908-2910.	FEMA-55 gives the design procedure for two types of piles in two different types of soil. These procedures come up with an embedment length for two different diameters of these piles based on the soils equations provided therein. The Uniform Building Code relies on the investigation of a soils engineer and subsequent recommendations for the minimum embedment depth of piles.

Recommendation: FEMA-55 should recommend that a soils engineer by consulted and a soils report be undertaken for each specific site as the soil conditions vary from site to site.

FEMA-55	U.B.C.	Analysis
D.4 Procedure A-4 Maximum Unbraced Pile Height	Sec. 2908-2910 Appendix Chapter 23, Division IV.	FEMA-55 provides design equations for the calculation of moments due to wave, current, debris impact and wind forces which ultimately leads to the allowable bending moment of piles and then to the maximum unbraced pile height. The Uniform Building Code requires that the structural system be designed in accordance with well established engineering principles with hydrodynamic and hydrostatic loads being considered and requires that the required loading be established by an investigation of the conditions at the site.

Recommendation: FEMA-55 should indicate the source of the equations used for the forces calculated.

FEMA-55	U.B.C.	Analysis
D.5 Procedure A-4.1 Maximum Unbraced Height for Piles Supporting Breakaway Walls	Sec. 2908-2910 Appendix Chapter 23, Division IV.	FEMA-55 provides a means of calculating the unbraced height for piles that support breakaway walls. The Uniform Building Code requires that the structural system be designed in accordance with well established engineering principles with hydrodynamic and hydrostatic loads being considered. The required loading should be established by an investigation of the conditions at the job site or by approved national standards.

Recommendation: See the recommendation for D.4, Procedure A-4.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
D.6 Procedure A-5 Wall Uplift Loads	Chapter 23.	FEMA-55 provides an example of a method of calculating wind generated uplift loads in the walls of a building given specific design criteria. The U.B.C. requires that a licensed engineer or architect consider all of the loads generated by wind forces, including uplift forces, in the design of the structure.

Recommendation: FEMA-55 should recommend the use of a licensed engineer or architect in the design of such structures and should indicate that this is a design example that may not be appropriate for all situations.

FEMA-55	U.B.C.	Analysis
D.7 Procedure A-6 Pile Uplift Loads	Chapter 23.	FEMA-55 provides an example of a method of calculating the uplift loads generated by wind forces per pile. The U.B.C. requires that a licensed engineer or architect design the piling system for wind generated uplift loads depending on the design of the structure and the site conditions.

Recommendation: FEMA-55 should require that a licensed engineer or architect design the structure with all loads under consideration or provide a reference to a document that does require such certification. It should also indicate that this is a design example which may not be appropriate for all situations.

FEMA-55	U.B.C.	Analysis
D.8 Procedure B-1 Horizontal Water Loads per Pile	Appendix Chapter 23, Division IV.	FEMA-55 provides a method of calculating lateral loads due to wave, current drag, debris impact forces on each pile. The Uniform Building Code requires that the piling be designed in accordance with well established engineering principles and with hydrodynamic and hydrostatic loads under consideration. The required loading should be established by an investigation of the site conditions or approved national standards.

Recommendation: FEMA-55 should require that a licensed engineer or architect consider these forces in the design of the building or provide a reference to a document that does require such certification.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
D.9 Procedure B-2 Loads Transferred to the Foundation Truss Members	Chapter 23 Appendix Chapter 23, Division IV.	FEMA-55 has a brief description of a procedure to evaluate any loads resulting from lateral forces which may be transferred to horizontal or diagonal bracing members. The U.B.C. requires that a complete load path be identified and designed for both lateral and vertical loads.

Recommendation: See the recommendation for D.8.

FEMA-55	U.B.C.	Analysis
Appendix G.2 Purpose	Sec. 102.	FEMA-55 recommends that this sample Coastal Construction Code supplement the local building code with the more restrictive requirements governing. The purpose of the U.B.C. is to provide minimum standards for the protection of property and public welfare for all buildings within the local jurisdiction.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
Appendix G.3 Scope	Sec. 103.	Scope of FEMA-55 includes only residential structures, both large and small and the additions thereto, even though Chapter 5 in the Coastal Construction Manual addresses larger structures which seems to include both commercial and industrial buildings. The scope of the U.B.C., on the other hand, includes all buildings and miscellaneous structures within the authority of the local building official.

Recommendation: FEMA-55 should include, within the sample Coastal Construction Code, any other uses which may be subjected to these kinds of conditions.

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
Appendix G.4 Definitions	Chapter 4 Chapter 23 Appendix Chapter 23, Division IV.	The definitions found in the sample Coastal Construction Code in FEMA-55 are strictly related to the design of structures subject to flood, wave and wind actions. Half of the definitions in FEMA-55 are located in the U.B.C. and most of those are compatible with the Uniform Building Code. However, the definition of "grade" is in conflict with U.B.C. The other definitions located in FEMA-55 are indirectly referenced in the U.B.C. by way of a reference to approved national standards.

Recommendation: FEMA-55 should develop language that correlates the definition of "grade" with the U.B.C., such as replacing the term "adjoining" with a specific distance at which point the measurement is taken.

FEMA-55	U.B.C.	Analysis
Appendix G.5 Elevation Standards	Appendix Chapter 23, Division IV.	FEMA-55 has a provision in this section where a setback can be established, where within same, no new construction or substantial improvements are allowed. Also, all new construction or substantial improvements in this provision must have their lowest horizontal structural member supporting the elevated floor at or above the base flood elevation. The U.B.C. does not establish a setback where construction is not allowed. It requires that all new construction or improvements have the lowest horizontal structural member at or above base flood elevation.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
Appendix G.6 Loading Forces	Chapter 23 Appendix Chapter 23, Division IV.	FEMA-55 recommends that the structural design in coastal high-hazard areas consider the effects the wind and water loads acting simultaneous during a base flood on all building components. The U.B.C. states that the structural system shall be designed in accordance with well established engineering principles with hydrodynamic and hydrostatic loads under consideration and that the required loading shall be established by an investigation of the conditions at the site or approved national standards.

Recommendation: None.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
Appendix G.6.1 Water Loads	Appendix Chapter 23, Division IV.	FEMA-55 states that the structural design shall take horizontal water loads under consideration and shall consider specific forces of waves and other forces in the analysis. The U.B.C. requires that the structural system shall be designed in accordance with well established engineering principles and with hydrodynamic and hydrostatic loads under consideration and that the loading shall be established by an investigation of the site conditions or approved national standards.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
Appendix G.6.2 Wind Loads	Chapter 23 Appendix Chapters 24 and 25.	FEMA-55 recommends that all buildings be designed to resist wind load pressures based on ANSI Standard A 58.1-1982. The Uniform Building Code requires that all buildings be designed and detailed to resist the forces due to wind pressures and includes a number of the provisions from the ANSI Standard.

Recommendation: FEMA-55 should include the latest edition of ANSI Standard A 58.1 which is now ASCE 7-88.

FEMA-55	U.B.C.	Analysis
Appendix G.7 Foundation Standards	Chapter 29 Appendix Chapter 23, Division IV.	FEMA-55 requires that all structures built in the coastal high-hazard area be designed and detailed to resist lateral forces due to wind and water pressures. The U.B.C. requires that all loads that the building might be subject to be taken into consideration in the structural calculations and designed appropriately.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
Appendix G.7.1 Pile Foundation Design	Sec. 2908-2910 Appendix Chapter 23, Division IV.	FEMA-55 has some specific design criteria for pile foundations. The U.B.C. requires that the structural system, in this case the pile foundation, be designed in accordance with well established engineering principles and take into consideration hydrodynamic and hydrostatic loads. Also, the required loading and design shall be established by an investigation of the site conditions or approved national standards.

Recommendation: FEMA-55 should include a provision for soil investigations to determine the site soil conditions.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
Appendix G.7.2 Column Foundations	Chapters 24, 26 Appendix Chapter 23, Division IV.	FEMA-55 briefly discusses the use of masonry piers and poured-in-place concrete piers and requires that they be reinforced to resist both vertical and lateral loads and be interconnected. The Uniform Building Code has specific design criteria for such piers and also requires that they be interconnected.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
Appendix G.8 Anchoring Standards	Appendix Chapter 23, Division IV Appendix Chapters 24 and 25.	FEMA-55 requires that the entire structural system be tied together to prevent flotation collapse or a permanent lateral movement due to a base flood event concurrent with the one-hundred-year design wind velocity. The U.B.C. requires that the structural system of a building or structure shall be tied together to resist the flotation, collapse, or permanent lateral movement due to loads to flooding equal to the base flood elevation. Another provision requires that the structure be designed and tied together to resist basic wind speeds from 80 to 110 miles per hour.

Recommendation: The U.B.C. should consider one-hundred-year design wind velocities concurrently with the base floor elevation forces.

FEMA-55	U.B.C.	Analysis
Appendix G.8.1 Connectors and Fasteners	Sec. 2510 Appendix Chapters 24 and 25.	FEMA-55 requires that these connections be adequate for the loads applied and also, if exposed, shall be protected against corrosion. The U.B.C. also requires that connections be adequate for the applied loads and also be corrosion resistant if exposed to a corrosive environment.

Recommendation: None.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
Appendix G.8.2 Beam to Pile Connections	Sec. 2510 Appendix Chapter 23, Division IV.	FEMA-55 has design requirements for specific beam to pile connections with no consideration for other possibly structural adequate connectors. The Uniform Building Code requires that these connections be designed by a licensed engineer or architect based on the applied loads, but does require that any connectors that are exposed to corrosive environments be protected.

Recommendation: FEMA-55 should allow for other structurally adequate connections.

FEMA-55	U.B.C.	Analysis
Appendix G.8.3 Floor and Deck Connections	Chapter 25.	FEMA-55 has specific design criteria for floor and deck connections in coastal high-hazard areas. The U.B.C. requires that a licensed engineer or architect design these connections for the applied loads and site conditions.

Recommendation: FEMA-55 should consider other structurally adequate materials than what is prescribed within their provisions provided a licensed engineer or architect verifies the adequacy.

FEMA-55	U.B.C.	Analysis
Appendix G.8.4 Exterior Wall Connections	Chapter 25.	FEMA-55 contains specific design criteria for exterior wall connections. The U.B.C. requires that exterior wall connections be designed and detailed by a licensed engineer or architect to support the applied loads.

Recommendation: FEMA-55 should recommend other types of designed exterior wall connections.

FEMA-55	U.B.C.	Analysis
Appendix G.8.5 Ceiling Joist and Rafter Connections	Sec. 2303 Sec. 2510 Appendix Chapter 23, Division IV.	FEMA-55 requires that the roof framing and ceiling be designed in such a manner as to provide a continuous tie across the rafters and that an adequate connection to the exterior walls be provided. The Uniform Building Code requires that these connections be designed by a licensed engineer or architect for the applied loads.

Recommendation: FEMA-55 should recognize other types of systems which may provide this continuous tie.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
Appendix G.8.6 Projecting Members	Chapter 23 Sec. 2510 Appendix Chapter 23, Division IV.	FEMA-55 gives design provisions for small overhangs and projecting members and requires that larger projecting members be designed by a licensed engineer or architect. The Uniform Building Code requires that all such projecting members be designed and detailed given the applied loads by a licensed engineer or architect.

Recommendation: FEMA-55 should require that all projecting members be designed by a licensed engineer or architect.

FEMA-55	U.B.C.	Analysis
Appendix G.8.9 Roof Sheathing	Chapter 23 Chapter 25 Chapter 32 Appendix Chapter 23, Division IV.	FEMA-55 has specific design criteria for roof sheathing on buildings in the coastal high-hazard areas and also for the design of roofs in these areas. The Uniform Building Code requires that roof sheathing be detailed in a manner that allows any design of roof if high winds and water forces are considered.

Recommendation: FEMA-55 should recognize other types of roofs if they are designed by a licensed engineer or architect.

FEMA-55	U.B.C.	Analysis
Appendix G.10 Protection of Openings	None.	FEMA-55 requires that exterior openings be designed and detailed to withstand high wind speeds and recommends additional protection such as storm shutters. The Uniform Building Code has no such provision.

Recommendation: The Uniform Building Code should address the protection of exterior openings from wind and water action that are above the base flood elevation.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
Appendix G.11 Use of Space Below the Lowest Elevated Floor	Appendix Chapter 23, Division IV.	FEMA-55 requires that all new construction and substantial improvements within the coastal high-hazard zone must have the space below the base flood elevation free of obstruction or constructed with breakaway walls. Enclosed space, may be used only for vehicular parking or access to the building. The U.B.C. requires that the space below the base flood elevation in coastal high-hazard zones be free of obstruction except that it allows the storage of portable or mobile items that can be moved in the event of a storm to be located below the lowest floor as well as stairs and entrances required to access the building.

Recommendation: FEMA-55 should not allow enclosed space for vehicular parking unless it is provided by breakaway walls and should recognize that portable or temporary storage of items can be located there.

FEMA-55	U.B.C.	Analysis
Appendix G.11.1 Breakaway Wall Design	Appendix Chapter 23, Division IV.	FEMA-55 requires that breakaway walls be designed for loads as designated by the jurisdiction and gives some design recommendations for the design of the piles that support the breakaway walls. The Uniform Building Code requires that breakaway walls be designed for specific criteria and includes these loads in the design of the pile system.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
Appendix G.11.2 Certification of Breakaway Walls	Appendix Chapter 23, Division IV.	FEMA-55 allows the use of breakaway walls designed for greater loads than twenty pounds per square foot if designed by a licensed architect or engineer. The Uniform Building Code does not allow the use of breakaway walls that are designed above twenty pounds per square foot.

Recommendation: The Uniform Building Code should recognize that the design of breakaway walls with a higher loads considered may be appropriate under certain circumstances.

Coastal Construction Manual (FEMA-55)

FEMA-55	U.B.C.	Analysis
Appendix G.12 Utilities	Appendix Chapter 23, Division IV.	FEMA-55 requires that all machinery servicing the building be elevated at or above the base flood elevation (BFE) or that any system below the BFE be provided with protection from water penetration. The U.B.C. requires that new or replacement utilities that service the building be placed above the base flood elevation or protected against water penetration.

Recommendation: None.

FEMA-55	U.B.C.	Analysis
Appendix G.13 Certification	Sec. 2303 Appendix Chapter 23, Division IV.	FEMA-55 requires that all new or substantial improvements to residential buildings in coastal high-hazard zones either be designed by a licensed engineer or architect or certified as meeting standard accepted practices. The Uniform Building Code requires that all such structures be designed and detailed by a licensed engineer or architect.

Recommendation: FEMA-55 should require a design by a licensed engineer or architect or provide a reference to a document that does require such certification.

FEMA-55	U.B.C.	Analysis
Appendix G.14 Reference Documents	Chapter 23 Appendix Chapter 23, Division IV Appendix Chapters 24 and 25.	FEMA-55 lists the documents used in determining the design wind and water forces on structures and provides a reference to the Coastal Construction Manual. The U.B.C. provides specific criteria for wind and high-wind design or requires that such design of the structures meet approved national standards.

Recommendation: None.

Elevated Residential Structures (FEMA-54)

FEMA-54	U.B.C.	Analysis
Posts	Sec. 2908-2910 Appendix Chapter 23, Division IV.	FEMA-54 discusses, generally, the use and design of post foundations. The Uniform Building Code gives specific design criteria for such foundations.

Recommendation: None.

FEMA-54	U.B.C.	Analysis
Post Embedment	Sec. 2507 Sec. 2516 Sec. 2908-2910 Appendix Chapter 23, Division IV.	FEMA-54 discusses some general construction practices for post foundations. The Uniform Building Code requires a design by a licensed engineer or architect and provides specific design criteria for these foundations.

Recommendation: FEMA-54 should recommend the use of a soils investigation report by a licensed soil engineer in the design of the foundation system.

FEMA-54	U.B.C.	Analysis
Post Anchorage	Sec. 2510 Sec. 2910 Appendix Chapter 23, Division IV Appendix Chapter 25.	FEMA-54 recommends the anchorage of posts to the foundation. The U.B.C. requires that such connections be designed by a licensed engineer or architect with all applied loads considered.

Recommendation: None.

FEMA-54	U.B.C.	Analysis
Piers	Sec. 2403-2409 Sec. 2907 Appendix Chapter 23, Division IV.	FEMA-54 discusses, in general terms, pier foundations in areas subject to flood events. The Uniform Building Code has specific design criteria for pier foundations in these same areas.

Recommendation: None.

Elevated Residential Structures (FEMA-54)

FEMA-54	U.B.C.	Analysis
Brick in Concrete Masonry Piers	Sec. 2403-2409 Sec. 2907 Appendix Chapter 23, Division IV.	FEMA-54 discusses, in general terms, the design of brick in concrete masonry piers and recommends that the long dimension of the pier be placed parallel to any anticipated flood flow. The Uniform Building Code has specific design criteria for the use these masonry pier foundations of brick in concrete in A Zones, but has no requirement for the placement of these piers parallel to any anticipated flood flow.

Recommendation: None.

FEMA-54	U.B.C.	Analysis
Concrete Piers	Chapter 26 Sec. 2907 Appendix Chapter 23, Division IV.	FEMA-54 discusses, in general terms, piers as a foundation system and gives recommendations as to their use. The Uniform Building Code has specific design criteria for concrete pier foundations given the applied loads and soil conditions.

Recommendation: FEMA-54 should recommend the use of a soils engineer and soils investigation report in determining the best type of foundation.

FEMA-54	U.B.C.	Analysis
Pier Footings	Chapter 29 Appendix Chapter 23, Division IV.	FEMA-54 discusses, in general terms, the sizing of pier footings in the foundation system and gives a recommendation that a soils engineer be consulted prior to the design of such a footing. The Uniform Building Code has specific design criteria for the design of the footings and embedment and requires a soils investigation.

Recommendation: None.

FEMA-54	U.B.C.	Analysis
Shear Walls and Diaphragms	Chapter 23 Chapter 24 Chapter 26 Appendix Chapter 23, Division IV Appendix Chapters 24 and 25.	FEMA-54 discusses, in general terms, the use of wood shear walls and wood floor diaphragms to transfer any horizontal forces to the foundation system. It does not recommend their use in coastal V Zones. The U.B.C. has specific design criteria for the use of shear walls as a bracing system and does not exclude the use of other materials such as masonry or concrete shear walls.

Recommendation: None.

Elevated Residential Structures (FEMA-54)

FEMA-54	U.B.C.	Analysis
Pier Foundation Connections	Sec. 2303 Sec. 2615 Sec. 2907.	FEMA-54 recommends certain pier foundation connections and gives some specific design criteria. The U.B.C. requires that these connections be designed by a licensed engineer or architect for the applied loads.

Recommendation: As these are very important connections, it is recommended that FEMA-54 recommend the use of a licensed engineer or architect in the design of these connections and that it should recognize that other connections may be more adequate for the same purpose.

FEMA-54	U.B.C.	Analysis
Floor Beams	Chapter 25.	FEMA-54 discusses, in general terms, the different sizes and types of floor beams used in construction of residential structures and gives some general design recommendations. The Uniform Building Code requires that floor beams be designed for the applied loads by a licensed engineer or architect and that they meet specific design criteria.

Recommendation: FEMA-54 should recommend that these members and any splices of some be designed by a licensed engineer or architect.

FEMA-54	U.B.C.	Analysis
Cantilevers	Chapter 25 Chapter 29.	FEMA-54 discusses, in general terms, the use of a cantilevered floor area to reduce the number of piles in the foundation system. The U.B.C. requires that a pile foundation system be design by a licensed engineer or architect for the applied loads.

Recommendation: None.

FEMA-54	U.B.C.	Analysis
Floor Joist/Floor Beam Connections	Chapter 25 Appendix Chapters 23, 24 and 25.	FEMA-54 recommends that a positive connection be developed between the first floor joists and the floor beams supporting them and discusses, in general terms, the usage of straps as the connection. The U.B.C. requires that approved anchors be installed to provide a continuous tie from the roof to the foundation system and that these connections be designed by a licensed engineer or architect.

Recommendation: FEMA-54 should recommend the use of a licensed engineer or architect in the design of a substantial connection.

Elevated Residential Structures (FEMA-54)

FEMA-54	U.B.C.	Analysis
Figure No. 4.48 Protected Utility Shaft	Appendix Chapter 23, Division IV. U.P.C.: Sec. 315 (e).	FEMA-54 provides a diagram of a recommended protective utility shaft. The Uniform Building Code requires that mechanical and electrical systems be either placed above the base flood elevation or protected to prevent any water from entering the system's components during a flood event.

Recommendation: None.

FEMA-54	U.B.C.	Analysis
Mechanical Equipment	Appendix Chapter 23, Division IV. U.P.C.: Sec. 315 (e).	FEMA-54 discusses the elevating of all mechanical equipment above the base flood elevation and the protection of same due to a flood event. The Uniform Building Code requires that all mechanical equipment either be placed above the base floor elevation or protected against a flood event.

Recommendation: None.

FEMA-54	U.B.C.	Analysis
Septic Tanks	Appendix Chapter 23, Division IV. U.P.C.: Sec. 315 (e).	FEMA-54 discusses the protection of septic tanks during a flood event. The Uniform Building Code requires that such equipment be protected to prevent water from entering or accumulating within the tank.

Recommendation: None.

FEMA-54	U.B.C.	Analysis
Building Materials	Chapters 24, 25, 26 Appendix Chapter 23, Division IV.	FEMA-54 discusses, in general terms, the protection of different types of building materials from a corrosive environment. The Uniform Building Code requires that materials in corrosive environments be protected in an approved manner.

Recommendation: FEMA-54 should not recommend that the designer use specific manufacturers or industrial groups for the protection of their products. The wording should be in general terms.

Elevated Residential Structures (FEMA-54)

FEMA-54	U.B.C.	Analysis
Wood	Chapter 25 Appendix Chapter 23, Division IV.	FEMA-54 discusses, in general terms, the treatment of wood to protect it against a corrosive environment. The Uniform Building Code requires that wood exposed to such environments be protected with an approved preservative treatment.

Recommendation: FEMA-54 should not recommend that a designer seek the guidance of a specific manufacturer of preservative in the guidelines. The terms should be more general.

FEMA-54	U.B.C.	Analysis
Steel	Chapter 1 Chapter 27 Appendix Chapter 23, Division IV.	FEMA-54 discusses the protection of steel structural members that are exposed to a corrosive environment. The U.B.C. does not have a specific requirement for the protection of steel. Rather, it requires that a structure be maintained in a safe condition which also has been interpreted as being protected from corrosive environments.

Recommendation: The U.B.C. should address the protection of steel structural elements specifically in Appendix Chapter 23, Division IV.

FEMA-54	U.B.C.	Analysis
Concrete and Masonry	Chapter 24 Chapter 26 Appendix Chapter 23, Division IV.	FEMA-54 discusses, in general terms, the use of chemical admixtures in surface treatments in the protection and strengthening of reinforced concrete and masonry block in corrosive environments. The Uniform Building Code has specific design criteria for the use of chemical admixtures in reinforced concrete and masonry construction.

Recommendation: FEMA-54 should not recommend a specific manufacturer for these products.

FEMA-54	U.B.C.	Analysis
Insulation	Sec. 1714 Appendix Chapter 23, Division IV.	FEMA-54 discusses, in general terms, the insulating of buildings. The Uniform Building Code requires that buildings are insulated per the requirements of the *Model Energy Code* and that such insulation meets specific design criteria.

Recommendation: None.

Elevated Residential Structures (FEMA-54)

FEMA-54	U.B.C.	Analysis
Glossary	Chapter 4 Appendix Chapter 23, Division IV.	FEMA-54 goes into much greater detail in defining the terms used in flood-resistant construction. The Uniform Building Code goes into much less detail in these definitions and only classifies the hazard zones into two zones, A Zones and V Zones.

Recommendation: None.

FEMA-54	U.B.C.	Analysis
Performance Criteria	Chapter 1 Chapter 4 Chapter 23 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-54 identifies and defines loads which buildings may be subject to during a flood event and then provides three standards to which a building may be designed to. The U.B.C. has these different load definitions, however, the specific water loads and soil loads are left to the design of the engineer. Also, the U.B.C. has only one standard which the building can be designed to and that is the prescribed code requirements in this document.

Recommendation: None. Both documents serve different purposes.

Retrofitting Flood-Prone Residential Structures (FEMA-114)

FEMA-114	U.B.C.	Analysis
3.5 Foundation Walls	Chapter 23 Chapter 24 Chapter 26 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-114 discusses the protection of a structure by elevating it above its original foundation and the various methods of achieving that. The Uniform Building Code provides design criteria for the design of such elevated structures. However, it is only required that these buildings be elevated above the BFE.

Recommendation: None.

FEMA-114	U.B.C.	Analysis
3.12 Extended Wall Foundations	Chapter 23 Chapter 24 Chapter 26 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-114 discusses, in general terms, the design of extended reinforced concrete masonry and reinforced concrete extended wall foundations and provides some recommended construction practices as well as reference to Appendix C which provides a method for calculating the different loads that the building may be subject to. The Uniform Building Code provides specific design criteria for these types of foundations as well as standards of quality of the construction materials.

Recommendation: FEMA-114 should recognize that seismic forces may govern over wind loads in certain areas of the country and should recommend the use of a licensed engineer or architect in the design of such structures. FEMA-114 should also recognize the latest edition of all referenced standards within that portion of text.

FEMA-114	U.B.C.	Analysis
3.13 Anchorage of Super-Structured Foundation	Chapter 23 Sec. 2510 Chapter 29 Appendix Chapter 23, Division IV Appendix Chapters 24 and 25.	FEMA-114 provides a good discussion on the anchorage of exterior walls and floor diaphragms to the foundation system. Also, a number of details are provided to assist in the construction of such an anchor. The Uniform Building Code requires that these connections be provided and that a licensed engineer or architect design such connections given the applied loads on the building.

Recommendation: FEMA-114 should reference the latest edition of the ACI Standard 318.

Retrofitting Flood-Prone Residential Structures (FEMA-114)

FEMA-114	U.B.C.	Analysis
3.14 Open Foundations	Chapter 23 Chapter 24 Chapter 25 Chapter 26 Chapter 29 Appendix Chapter 23, Division IV Appendix Chapters 24 and 25.	FEMA-114 discusses, in general terms, the use of piers, columns and piles as a foundation system in flood-prone areas. The Uniform Building Code requires that piles or columns be used in V Zones only and gives specific design criteria for the use of same.

Recommendation: FEMA-114 should discuss the use of a soils engineer and soils report in determining the embedment length of piles and the soil-bearing pressure in flood-prone areas.

FEMA-114	U.B.C.	Analysis
6.2 Flood Wall Considerations	None.	FEMA-114 discusses the use of flood walls in the protection of residential structures. The U.B.C. requires that such buildings are elevated above the base flood elevation and has no provisions for such retrofitting of existing residential structures.

Recommendation: It is recommended that the U.B.C. develop some provisions for the retrofitting of existing buildings or at least refer to approved national standards.

FEMA-114	U.B.C.	Analysis
6.3 Techniques and Materials	Chapter 23 Chapter 24 Chapter 26.	FEMA-114 discusses the different types of flood walls and the materials used in their construction. The U.B.C. provides specific design criteria for the materials used in walls.

Recommendation: None.

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Retrofitting Flood-Prone Residential Structures (FEMA-114)

FEMA-114	U.B.C.	Analysis
6.5 Technical Design Criteria	Chapter 23 Chapter 24 Chapter 26 Chapter 29.	FEMA-114 discusses specific design criteria for the materials used in flood walls and provides specific references to ACI Standards. It also provides a good discussion of the adequacy of the soil at the site to bear the applied loads. The U.B.C. provides specific design criteria for the design of walls, and also, requires that a soils investigation be done under specific conditions.

Recommendation: FEMA-114 should recognize the authority of the local building codes, rather than recommend the use of standards which may not be recognized by the jurisdiction.

FEMA-114	U.B.C.	Analysis
7.2 Closure Considerations	Appendix Chapter 23, Division IV.	FEMA-114 discusses the closure of any openings in either flood walls or exterior walls of a building and recommends that a professional engineer be consulted for the design of such closures. The U.B.C. requires that openings below the base flood elevation shall be provided with water-tight closures designed to withstand the applied loads.

Recommendation: None.

FEMA-114	U.B.C.	Analysis
7.3 Low Profile Closures	Appendix Chapter 23, Division IV.	FEMA-114 discusses the use of low profile, permanent closures around openings which may be below grade. The U.B.C. requires that openings below the base flood elevation shall be provided with water-tight closures designed to withstand the applied loads.

Recommendation: None.

FEMA-114	U.B.C.	Analysis
7.4 Closure Materials and Construction	Chapter 23 Chapter 25 Chapter 27 Chapter 28 Appendix Chapter 23, Division IV.	FEMA-114 discusses the types of materials used in construction of the closures at openings in flood walls. The U.B.C. provides specific design criteria for the use of such materials under the applied loads.

Recommendation: None.

Retrofitting Flood-Prone Residential Structures (FEMA-114)

FEMA-114	U.B.C.	Analysis
7.6 Technical Design Criteria for Closures	Chapter 23 Chapter 25 Chapter 27 Chapter 28 Appendix Chapter 23, Division IV.	FEMA-114 provides a method for calculating potential flood forces. The U.B.C. recommends the use of well-established engineering principles and/or approved national standards and provides the allowable stresses for such materials used.

Recommendation: FEMA-114 should recognize the authority of the local building codes in determining the allowable stresses for such materials.

FEMA-114	U.B.C.	Analysis
8.2 Sealant Considerations	Sec. 1708 Appendix Chapter 23, Division IV.	FEMA-114 discusses the problem of sealing different types of walls from water penetration. The U.B.C. requires that such walls be designed to withstand hydrostatic and hydrodynamic loads during the occurrence of flooding, but not necessarily to resist the penetration of the water due to the flood event. It does, however, address the sealing of openings in walls below the base flood elevation.

Recommendation: Both the U.B.C. and FEMA-114 should develop some language to address acceptable water penetration.

FEMA-114	U.B.C.	Analysis
8.3 Sealing Techniques	Sec. 1708 Appendix Chapter 23, Division IV.	FEMA-114 discusses several techniques of sealing exterior walls that are exposed to waters due to a flood event. The U.B.C. has no such provision. The U.B.C. requires that the exterior walls be weatherproofed to protect the interior finish of the wall.

Recommendation: None.

FEMA-114	U.B.C.	Analysis
8.4 Closures	Appendix Chapter 23, Division IV.	FEMA-114 discusses a few sealing techniques for larger openings such as windows and doors. The U.B.C. requires that openings below the base flood elevation shall be provided with water-tight closures designed to withstand the applied loads.

Recommendation: None.

Retrofitting Flood-Prone Residential Structures (FEMA-114)

FEMA-114	U.B.C.	Analysis
8.5 Design Details	Appendix Chapter 23, Division IV.	FEMA-114 recommends that all walls subject to flood waters be designed for hydrodynamic, hydrostatic and impact loads due to the flood event. The U.B.C. also requires that such walls be designed to withstand the same applied loads.

Recommendation: None.

FEMA-114	U.B.C.	Analysis
8.7 Technical Design Criteria	Chapter 23 Chapter 24 Chapter 26 Chapter 27 Chapter 28 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-114 discusses the use of the materials in the structural analysis of walls that are subject to hydrodynamic, hydrostatic and impact loads. The U.B.C. has specific design criteria for the use of such materials and requires that they are also designed for these same applied loads.

Recommendation: FEMA-114 should recognize the authority of the local building codes in the design of such walls and should only reference the latest edition of the ACI Standards as guidelines.

FEMA-114	U.B.C.	Analysis
9.4 Permanent Protective Measures of Utilities	Appendix Chapter 23, Division IV. U.P.C.: Sec. 315 (e).	FEMA-114 discusses a number of techniques of protecting utilities that may be subject to flood waters due to a flood event. The Uniform Building Code requires that electrical and mechanical equipment either be placed above the base flood elevation or protected to prevent water from entering or accumulating in the system due to a flood event.

Recommendation: None.

FEMA-114	U.B.C.	Analysis
9.5 Utility Relocations to Existing Space	Appendix Chapter 23, Division IV. U.P.C.: Sec. 315 (e).	FEMA-114 discusses methods of protecting different utilities from flood events using existing space within the structure. The U.B.C. just requires that new or replacement electrical and mechanical equipment be either placed above the base flood elevation or protected to prevent water from entering the system.

Recommendation: None.

Retrofitting Flood-Prone Residential Structures (FEMA-114)

FEMA-114	U.B.C.	Analysis
9.6 Utility Relocations to New Space	Appendix Chapter 23, Division IV. U.P.C.: Sec. 315 (e).	FEMA-114 discusses the protection of utilities by relocating them to new additions that are above or protected from the base flood event. The Uniform Building Code just requires that new or replacement electrical and mechanical equipment be either placed above the base flood elevation or protected to prevent water from entering the system.
Recommendation:	None.	

FEMA-114	U.B.C.	Analysis
9.8 Storage Tank Anchorage	None.	FEMA-114 discusses methods of anchoring fuel tanks in the event that the buoyant force may lift the tank during a flood event. The Uniform Building Code does not regulate such structures.
Recommendation:	None.	

FEMA-114	U.B.C.	Analysis
10.4 Floating Structures	None.	FEMA-114 discusses an unusual method of flood-proofing a structure by allowing it to rise or fall with the flood waters. The Uniform Building Code does not allow such a situation.
Recommendation:	None.	

FEMA-114	U.B.C.	Analysis
Appendix C Forces	Chapter 23 Appendix Chapter 23, Division IV.	FEMA-114 discusses the methods for calculating hydrostatic, hydrodynamic and impact loads as well as wind loads on the structures that may be subject to flood events. The Uniform Building Code makes reference to approved national standards and site conditions for hydrostatic, hydrodynamic and impact loads, but has a specific methodology for calculating wind loads.
Recommendation:	None.	

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FEMA-102	U.B.C.	Analysis
E Contingent Flood Proofing Measures	Appendix Chapter 23, Division IV.	FEMA-102 discusses the different types of flood proofing measures and their advantages and disadvantages in this section. The Uniform Building Code only requires that openings below the base flood elevation be provided with watertight enclosures.
Recommendation:	None.	

FEMA-102	U.B.C.	Analysis
F.1 Flood Shields	Appendix Chapter 23, Division IV.	FEMA-102 discusses the advantages and disadvantages of using flood shields as a flood proofing method. The Uniform Building Code only requires that openings below the base flood elevation be provided with watertight closures.
Recommendation:	None.	

FEMA-102	U.B.C.	Analysis
F.2 Watertight Doors	Appendix Chapter 23, Division IV.	FEMA-102 discusses the advantages and disadvantages of using watertight doors as a method of flood proofing the openings in the structure. The Uniform Building Code only requires that openings below the base flood elevation be provided with watertight enclosures.
Recommendation:	None.	

FEMA-102	U.B.C.	Analysis
F.3 Moveable Flood Walls	Appendix Chapter 23, Division IV.	FEMA-102 discusses the advantages and disadvantages of using moveable flood walls as a method of flood proofing a structure. The Uniform Building Code only requires that openings below the base flood elevation be provided with watertight closures.
Recommendation:	None.	

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FEMA-102	U.B.C.	Analysis
B Elevation Non-Fill	Chapter 29 Appendix Chapter 23, Division IV.	FEMA-102 discusses the use of fill material to elevate a structure above the base flood elevation and provides some design recommendations. The U.B.C. requires that fill can only be used as an elevation technique in the "A" Zones.

Recommendation: None.

FEMA-102	U.B.C.	Analysis
C.2 Posts	Appendix Chapter 23, Division IV.	FEMA-102 discusses the use of posts to elevate a structure above the base flood elevation. The U.B.C. requires that a building be elevated above the base flood elevation.

Recommendation: None.

FEMA-102	U.B.C.	Analysis
Figure No. III-7 Pile Characteristics and Pier Walls	Chapter 24 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-102 discusses the general characteristics of piles and pier walls and their advantages and disadvantages. The Uniform Building Code provides specific design criteria for the design of piers and pier walls, but relies on the design of a licensed engineer or architect.

Recommendation: FEMA-102 should recommend that a licensed engineer or architect design the structure.

FEMA-102	U.B.C.	Analysis
Table No. III-1 Requirements for Reinforced Piers	Chapter 24 Chapter 26 Chapter 29 Appendix Chapter 23, Division IV.	Table No. III-1 of FEMA-102 gives some minimum design requirements for the construction of reinforced piers. The U.B.C. has specific design criteria for the use of reinforced piers and relies on the design of a licensed engineer or architect.

Recommendation: FEMA-102 should rely on the design of a licensed engineer or architect for the use of reinforced piers.

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FEMA-102	U.B.C.	Analysis
C.6 Maintenance	Chapter 1.	FEMA-102 recommends the regular maintenance of those structural elements that are exposed to flood events. The Uniform Building Code requires that all buildings and structures be maintained in a safe and sanitary condition.

Recommendation: None.

FEMA-102	U.B.C.	Analysis
E.1 and E.2 Waterproof Walls	Chapter 24 Chapter 26 Appendix Chapter 23, Division IV.	FEMA-102 discusses the use of different building materials in the construction of waterproof walls and gives some simple design recommendations. The Uniform Building Code has specific design criteria for the use of these construction materials.

Recommendation: FEMA-102 should recognize that the local building code has authority for the design of such structural elements and it should also provide, as a recommendation only, the latest edition of the referenced documents listed within this section.

FEMA-102	U.B.C.	Analysis
D.3 and D.4 Concrete Slabs	Chapter 26 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-102 discusses, in general terms, two methods of resisting uplift forces in concrete slabs due to a flood event and provides design recommendations as to the relief of such uplift forces. The Uniform Building Code provides specific criteria for the design of such slabs as well as requiring that they resist uplift and buoyancy type forces.

Recommendation: FEMA-102 should recognize the authority of the local building code in the design of such structural elements.

FEMA-102	U.B.C.	Analysis
D.5 Waterproofing	Sec. 1714 Chapter 24 Chapter 26 Appendix Chapter 23, Division IV.	FEMA-102 discusses three methods of waterproofing exterior walls. The Uniform Building Code requires that walls and floors that are impermeable to the passage of water.

Recommendation: None.

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FEMA-102	U.B.C.	Analysis
D.6 Watertight Cores	None.	FEMA-102 discusses the waterproofing of interior walls when such waterproofing of exterior walls is not feasible. The U.B.C. has no provisions for this.

Recommendation: None.

FEMA-102	U.B.C.	Analysis
D.7 Closures and Flood Shields	Appendix Chapter 23, Division IV.	FEMA-102 discusses the use of closures and flood shields as a means of protecting openings below the base flood elevation and provides several details for different types of openings. The Uniform Building Code requires that openings below the base flood elevation be provided with a watertight closure.

Recommendation: None.

FEMA-102	U.B.C.	Analysis
E.5 Flood Walls	Chapter 24 Chapter 26 Chapter 29 Appendix Chapter 23, Division IV.	FEMA-102 discusses the different types of flood walls that can be used to protect structures from flood events and gives some general design recommendations. The U.B.C. provides design criteria for the design of flood walls, given the applied loads.

Recommendation: FEMA-102 should recommend the use of a soils engineer in the design of such walls and levees.

FEMA-102	U.B.C.	Analysis
E.7 Flood Wall Maintenance	Chapter 1.	FEMA-102 recommends regular inspection and maintenance of flood walls and levees to maintain their structural integrity. The Uniform Building Code requires that all buildings and structures be maintained in a safe and sanitary condition.

Recommendation: None.

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FEMA-102	U.B.C.	Analysis
C Utilities	Appendix Chapter 23, Division IV. U.P.C.: Sec. 315 (e).	FEMA-102 discusses a number of the techniques for the flood proofing of utilities associated with nonresidential structures. The Uniform Building Code requires that such utilities be either placed above the base flood elevation or protected to prevent water from entering within the system.

Recommendation: None.

FEMA-102	U.B.C.	Analysis
Appendix B Glossary	Chapter 4 Appendix Chapter 23, Division IV.	All of the terms found in the glossary of FEMA-102 are related to flood proofing of structures or flood plain management. The Uniform Building Code's definitions are much more general in nature and terms that are not found within are referenced to the definitions found in *Webster's Third New International Dictionary of the English Language Unabridged*, Copyright 1986.

Recommendation: None.

FEMA-102	U.B.C.	Analysis
B Design Loads	Chapter 23 Appendix Chapter 23, Division IV.	FEMA-102 provides a general definition of the design loads that may occur on a structure located in a flood plain. The Uniform Building Code provides specific criteria for the determination of these loads with the exception of hydrostatic, hydrodynamic and impact loads generated by flood events. Those are referenced to either well-established engineering principles or approved national standards.

Recommendation: None.

FEMA-102	U.B.C.	Analysis
C Performance Criteria	Chapter 23 Appendix Chapter 23, Division IV.	FEMA-102 recommends specific design criteria for the structural analysis of elements that are exposed to waters generated by a design flood event. The Uniform Building Code has specific design criteria for all structures, however, for the loads generated by a design flood event, it references well-established engineering principles in approved national standards for the design of such structures.

Recommendation: FEMA-102 should recognize the authority of the local building code in this section and include that in the recommended design of these elements.

Manufactured Home Installation in Flood Hazard Areas (FEMA-85)

FEMA-85	U.B.C.	Analysis
Chapter III Elevation and Anchoring Techniques	Chapter 23 Chapter 24 Chapter 25 Chapter 26 Chapter 27 Chapter 29 Appendix Chapter 23, Division IV Appendix Chapters 24 and 25.	FEMA-85 discusses a number of techniques of elevating and anchoring manufactured homes in areas that are subject to flood events. The Uniform Building Code has specific design criteria for the design of most of these methods of elevating or anchoring a manufactured home. However, some of the methods would have to rely on the discretion of the building official.

Recommendation: FEMA-85 should discuss the authority of the local building code in the design and construction of such elevation and anchoring techniques.

FEMA-85	U.B.C.	Analysis
Chapter IV Design of Elevated Foundations	Chapter 23 Chapter 24 Chapter 25 Chapter 26 Chapter 27 Chapter 29 Appendix Chapter 23, Division IV Appendix Chapters 24 and 25.	FEMA-85 provides methods for calculating the hydrostatic and hydrodynamic loads generated by floods as well as certain conditions that may occur that could effect manufactured homes in the event of a flood. FEMA-85 also provides specific design criteria for the sizing of the structural members that elevate manufactured homes, as well as methods of protecting utilities that serve the manufactured homes. The Uniform Building Code provides specific design criteria for the structural design of the supports of manufactured homes, but defers to well-established engineering principles or approved national standards for the calculation of hydrodynamic or hydrostatic loads by licensed engineer or architect.

Recommendation: FEMA-85 should recognize the authority of the local building code in the design and sizing of the structural elements supporting manufactured homes and should recommend that a licensed engineer or architect be utilized in such design.

FEMA-85	U.B.C.	Analysis
Appendix D Calculation Procedure	Chapter 23 Chapter 25 Chapter 26 Appendix Chapter 23, Division IV.	FEMA-85 provides recommended procedures for the design of specific structural elements supporting the manufactured home. The Uniform Building Code provides specific criteria for the design of such members.

Recommendation: FEMA-85 should consider the authority of the local building code in the recommendations of this section.

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Manufactured Home Installation in Flood Hazard Areas (FEMA-85)

FEMA-85	U.B.C.	Analysis
Appendix E Buoyancy and Drag Forces	Appendix Chapter 23, Division IV.	FEMA-85 provides criteria for the design of ground anchors to counteract any buoyancy or drag forces that may be generated by a flood event. The Uniform Building Code requires that all buildings or structures erected in the flood zone be designed and constructed to resist flotation, collapse or permanent lateral movement due to loads from a flood event.

Recommendation: FEMA-85 should consider that other types of hold-downs may be adequate to resist these generated forces.

Alluvial Fans: Hazards and Management (FEMA-165)

FEMA-165	U.B.C.	Analysis -
Windows and Doors	Appendix Chapter 23, Division IV.	FEMA-165 recommends that the designer avoid the placement of openings on the uphill side of the structure on alluvial fans to prevent debris and flood water from entering a building. The Uniform Building Code just requires that openings below the base flood elevation be provided with watertight closures adequate to support any generated loads. If such openings are used, then they should be designed to withstand any forces generated by a flood on the alluvial fan.

Recommendation: None.

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Manual for the Construction of Residential Basements in Non-Coastal Flood Environments (MCRB)

MCRB	U.B.C.	Analysis
III A.1 Unreinforced Block	Sec. 2407 (i) Appendix Chapter 23, Division IV.	The MCRB briefly discusses the use of unreinforced block in non-coastal flood areas. The U.B.C. has specific design criteria for the use of unreinforced block but does not allow residential basements to be located below the BFE.

Recommendation: None, since floodproofing of basements is allowed only in communities that have been granted an exception by FEMA.

MCRB	U.B.C.	Analysis
III A.2 Reinforced and Grouted Block	Chapter 24 Appendix Chapter 23, Division IV	The MCRB briefly discusses the use of reinforced and grouted block in non-coastal flood areas. The U.B.C. has specific criteria for the use of reinforced and grouted block, but does not allow residential basements below the BFE.

Recommendation: See recommendation for MCRB III A.1.

MCRB	U.B.C.	Analysis
III A.3 Unreinforced Concrete	Sec. 2622.	The MCRB briefly discusses the use of unreinforced concrete in residential basement walls in non-coastal flood areas. The U.B.C. has specific provisions for the use of plain (unreinforced) concrete, but does not allow residential basements below the BFE.

Recommendation: See the recommendation for MCRB III A.1.

MCRB	U.B.C.	Analysis
III A.4 Reinforced Concrete	Chapter 26	The MCRB briefly discusses the use of reinforced concrete in residential basement walls in non-coastal flood areas. The U.B.C. has specific provisions for the use of reinforced concrete, but does not allow residential basements below the BFE.

Recommendation: See the recommendation for MCRB III A.1.

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MCRB	U.B.C.	Analysis
III A.5 Stone, Cribbing and Planking	None.	The MCRB briefly discusses the use of cut stone rubble stone and even cribbing and planking in older residential homes and does not recommend its use as a construction material below the BFE. The U.B.C. does not have such provisions.

Recommendation: None.

MCRB	U.B.C.	Analysis
III A.6 Treated Wood Foundations	Sec. 2907.	The MCRB did not have enough information to discuss the use of treated wood foundations. The U.B.C. has specific provisions for the use of treated wood foundations, but does not allow residential basements below the BFE.

Recommendation: None.

MCRB	U.B.C.	Analysis
III A.7 Variations of Foundations	Chapter 24 Chapter 26 Chapter 29	The MCRB briefly discusses variations in the design of foundations used in residential basements below the BFE. The U.B.C. has specific provisions for the design of foundations, but does not allow residential basements below the BFE.

Recommendation: None.

MCRB	U.B.C.	Analysis
III A.8	Sec. 2903 Appendix Chapter 70	The MCRB discusses specific requirements for excavation, grading and backfilling residential basement walls. The U.B.C. has specific provisions for excavation, grading and backfilling basement walls, but does not allow residential basements below the BFE.

Recommendation: See the recommendation for MCRB III A.1.

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MCRB	U.B.C.	Analysis
III A.9	Sec. 2606	The MCRB discusses the design and construction of formwork for concrete basement walls. The U.B.C. has similar design criteria for formwork for all types of concrete work.

Recommendation: None.

MCRB	U.B.C.	Analysis
III B.1 Basement Slab	Sec. 2623 Sec. 2904	The MCRB discusses the types of slabs used in basement floors below the BFE. The U.B.C. has specific criteria for slabs-on-grade, but does not allow residential basements below the BFE.

Recommendation: See the recommendation for MCRB III A.1.

MCRB	U.B.C.	Analysis
III B.2 Structural Basement Slab	Chapter 26	The MCRB discusses the thickness of slabs used to resist water pressure heads. The U.B.C. has specific provisions for the design of such slabs subject to applied loads, but does not allow residential basements below the BFE.

Recommendation: See the recommendation for MCRB III A.1.

MCRB	U.B.C.	Analysis
III B.3 Footing	Sec. 2907	The MCRB briefly discusses footing construction in residential basement wall foundations below the BFE. The U.B.C. has specific criteria for the design of footing, but does not allow residential basements below the BFE.

Recommendation: See the recommendation for MCRB III A.1.

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MCRB	U.B.C.	Analysis
III B.4 Underdrain System and Sumps and Pumps	Sec. 2905	The MCRB discusses the use of an underdrain system in sumps and pumps as a method of relieving the build-up of hydrostatic head on the walls and slabs of a basement. The U.B.C. requires that the classification of the soil at each building site shall be determined by the building official who may require that this determination be made by an engineer or architect. The U.B.C., however, does not provide specific provisions for underdrain systems.
Recommendation:	None.	

MCRB	U.B.C.	Analysis
III B.5A Ground Surface Slope	Sec. 2905	The MCRB discusses some techniques of site investigation and some possible findings of the same. The U.B.C. requires that the classification of the soil at each building site shall be determined by the building official who may require that this determination be made by an engineer or architect.
Recommendation:	None.	

MCRB	U.B.C.	Analysis
III B.5B Grading and Surface Drainage	Sec. 2905 and Appendix Chapter 70	The MCRB discusses grading and surface drainage provisions and gives some minimum slopes for proper drainage. The U.B.C. just requires that provisions be made for the control and drainage of surface water around the building.
Recommendation:	None.	

MCRB	U.B.C.	Analysis
III B.6 Seepage Quantities	Sec. 2303	The MCRB discusses a method of determining the size of a drain system using Darcy's law. The U.B.C. relies on approved national standards.
Recommendation:	None.	

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Manual for the Construction of Residential Basements in Non-Coastal Flood Environments (MCRB)

MCRB	U.B.C.	Analysis
III B.7A Penetrations	Appendix Chapter 23, Division IV.	The MCRB discusses the means of ceiling penetrations through basement walls or slabs. The U.B.C. requires that all floor and wall penetrations be made water tight to prevent flood water seepage.

Recommendation: None.

MCRB	U.B.C.	Analysis
III B.7B Cracks and Joints	Appendix Chapter 23, Division IV.	The MCRB gives a fairly detailed description of techniques to lessen cracking in concrete. The U.B.C. just requires that exterior walls and floors be impermeable to the passage of water with no specific design provision, but does not allow residential basements below the BFE.

Recommendation: See the recommendation for MCRB III A.1.

MCRB	U.B.C	Analysis
III B.7C Waterproofing	Appendix Chapter 29	The MCRB briefly discusses the limitations of waterproofing basements below the BFE. The U.B.C. has design provisions for the waterproofing of foundations and basement walls, but does not allow residential basements below the BFE.

Recommendation: See the recommendation for MCRB III A.1.

MCRB	U.B.C.	Analysis
III B.8 Plumbing Subsystems	None.	The MCRB discusses the materials and considerations in the design of drainage subsystems. The uniform codes have no such provisions.

Recommendation: See the recommendation for MCRB III A.1.

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MCRB	U.B.C.	Analysis
III B.9 Anchorage	Sec. 2303	The MCRB provides a means of calculating the lateral force due to flood water pressures. The Uniform Building Code has a very general statement that the entire system must be designed to resist all applied loads which would include a hydrostatic load, but does not allow residential basements below the BFE.

Recommendation: See the recommendation for MCRB III A.1.

MCRB	U.B.C.	Analysis
III B.10 Concrete Construction Practices	Chapter 26	The MCRB goes through a number of typical handling and construction techniques for concrete walls and slabs. U.B.C. has specific provisions for the handling, depositing and considerations for concrete construction.

Recommendation: None.

MCRB	U.B.C.	Analysis
III B.11 Block Construction Practices	Chapter 24	The MCRB recommends a number of construction practices for the design and installation of concrete block walls. The U.B.C. has specific provisions for the construction of concrete block walls, but does not allow residential basements below the BFE.

Recommendation: See the recommendation for MCRB III A.

MCRB	U.B.C.	Analysis
III C.1.A-D Soil Loads	Secs. 2904 and 2905	The MCRB has specific provisions for the classification of the soil that may be found at the site. The U.B.C. relies on an engineer or architect licensed by the state to conduct a thorough site investigation for these particular items and to provide a report with the findings.

Recommendation: None.

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MCRB	U.B.C.	Analysis
III C.1E Soil Erosion	Appendix Chapter 70.	The MCRB provides a brief discussion as to the effects of soil erosion on basement construction. The U.B.C. requires that measures be undertaken by the soil engineer to limit the amount of erosion around the building site.

Recommendation: None.

MCRB	U.B.C.	Analysis
III C.1.F Backfill	Chapter 29 and Appendix Chapter 70	The MCRB provides a discussion as to the means of calculating the lateral pressure due to soil and the backfill behind basement walls. The U.B.C. relies on the judgement of an engineer or architect licensed by the state to practice soil engineering for the determination of the lateral pressure due to the soil and backfill.

Recommendation: None.

MCRB	U.B.C.	Analysis
III C.2 Water Table	Section 2905	The MCRB has a short description of how the water table affects stresses in the soil. The U.B.C. relies on the judgement of the engineer or architect licensed to practice soil engineering for this determination.

Recommendation: None.

MCRB	U.B.C.	Analysis
III C.3 Super Structure Loads and Buoyancy	Chapter 23	The MCRB provides examples of calculating super imposed loads on the basement foundation walls and footings. The U.B.C. does not allow residential basements below the BFE, therefore, there are no such provisions.

Recommendation: See the recommendation for MCRB III A.1.

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MCRB	U.C.B.	Analysis
III C.4.d Flood Velocity	None.	The MCRB discusses the effect of flood water velocity and it's affect on a structure's structural integrity. The U.B.C. has no such provision.
Recommendation:	None.	

MCRB	U.B.C.	Analysis
III C.4.e Sediment	None.	The MCRB discusses flood water deposited sediment and it's affect on a structure. The U.B.C. has no such provision.
Recommendation:	None.	

MCRB	U.B.C.	Analysis
III C.4.f Rate of Rise	None.	The MCRB discusses the importance of the rate of rise of flood waters as a consideration in the design of a structure's ability to withstand flood water damage. The U.B.C. has no such provision.
Recommendation:	None.	

MCRB	U.B.C.	Analysis
III C.4.g Hydraulic Relations	None.	The MCRB discusses the interdependence of design variables in the analysis of site design. The U.B.C. has no such provisions.
Recommendation:	None.	

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MCRB	U.B.C.	Analysis
III C.5.h Debris, Wind, Impact, Snow, Ice and Other Live Loads	Chapter 23	The MCRB discusses the importance of debris and impact loading in the design of structures near coastal areas. The U.B.C. generally discusses live loads and defers to approved national standards.

Recommendation: None.

MCRB	U.B.C.	Analysis
V A.2.a Building Model Dimensions and Loading	None.	The MCRB provides a cross section of a typical basement wall being loaded by flood water. The U.B.C. has no such sketch or provision.

Recommendation: None.

MCRB	U.B.C.	Analysis
V A.2.b Structural Analysis Model	None.	The MCRB provides an analysis model of a loaded beam and it's applicability in flood water design. The U.B.C. has no such provision.

Recommendation: None.

MCRB	U.B.C.	Analysis
V A.2.c Structural Plain Concrete	None.	The MCRB provides a model for structural plain concrete and derives some design values. The U.B.C. provides specific equations in design criteria, but does not provide any models by which to follow.

Recommendation: None.

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MCRB	U.B.C.	Analysis
V A.2.d Reinforced Concrete	None.	The MCRB provides a model for reinforced concrete using ultimate strength design. The U.B.C. provides specific equations in design criteria, but does not provide any models by which to follow.

Recommendation: None.

MCRB	U.B.C.	Analysis
V A.2.e Plain Masonry Block	None.	The MCRB provides a model for plane masonry block using working stress design. The U.B.C. provides specific equations in design criteria, but does not provide any models by which to follow.

Recommendation: None.

MCRB	U.B.C.	Analysis
V A.2.f Reinforced Masonry Block	None.	The MCRB provides a model for reinforced masonry block. The U.B.C. provides specific equations in design criteria, but does not provide any models by which to follow.

Recommendation: None.

MCRB	U.B.C.	Analysis
V A.2.g Flood Waters Above Grade	None.	The MCRB provides typical wall analyses for flood waters acting above grade level. The U.B.C. has no such model.

Recommendation: None.

MCRB	U.B.C.	Analysis
V A.2.h Slab Thickness	None.	The MCRB calculates the slab thickness in slab span for flood water type loading.

Recommendation: None.

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

Manual for the Construction of Residential Basements in Non-Coastal Flood Environments (MCRB)

MCRB	U.B.C.	Analysis
V A.2.i Structural Slab Design	None.	The MCRB provides the design example for the design of structural slabs given flood water conditions. The U.B.C. has no such analysis.
Recommendation:	None.	

MCRB	U.B.C.	Analysis
V B.1 Weir Load Level		The MCRB gives consideration to weir type effect of windows in the design of structures for flood water conditions. The U.B.C. has no such consideration, but would defer to approved national standards.
Recommendation:	None.	

MCRB	U.B.C.	Analysis
V B.2 Buoyancy	None.	The MCRB has a brief discussion of the affects of buoyancy in residential basements. The U.B.C. has no such provision, but would defer to approved national standards.

MCRB	U.B.C.	Analysis
V B.3 Slab Venting	None.	The MCRB is a very brief discussion as to the treatment of bending in slabs due to flood water conditions. The U.B.C. has no such provision, but would defer to approved national standards.
Recommendation:	None.	

MCRB	U.B.C.	Analysis
V B.4 Wall Loads	None.	The MCRB briefly discusses wall design due to flood water conditions. The U.B.C. has no such provisions, but would defer to approved national standards.
Recommendation:	None.	

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

Manual for the Construction of Residential Basements in Non-Coastal Flood Environments (MCRB)

MCRB	U.B.C.	Analysis
V B.5 Water Infiltration Protection	Appendix Chapter 29	The MCRB discusses the protection of basements from water infiltration and gives some recommendations. The U.B.C. has specific provisions for the protection of foundation walls and would rely upon approved materials for such protection.

Recommendation: None.

MCRB	U.B.C.	Analysis
V B.5.a Drain or Sump System	None.	The MCRB provides a discussion of drain or sump system type protection of basements which assumes some infiltration of water. The U.B.C. has provisions which require the water proofing of foundation walls without allowing any infiltration of water when hydrostatic pressure caused by water table may exist, other than that, damp proofing can be provided.

Recommendation: None.

MCRB	U.B.C.	Analysis
V B.5.b Undrained or Barge System	Appendix Chapter 29	The MCRB discusses undrained or barge system type protection of basement walls and gives some construction details or same. The U.B.C. requires water proofing when hydrostatic pressure may be due to water table they occur on basement walls, other than that, damp proofing may be provided.

Recommendation: None.

MCRB	U.B.C.	Analysis
VIII Appendix A Allowable Bearing Pressures	Chapter 29	The MCRB provides a table of allowable bearing pressures based on consistency of soil as determined by the classification and identification of the soil. The U.B.C. has no such specific provision based on the consistency of soil, but determines the allowable foundation pressure based on the class of the material. Both are acceptable means of determining the allowable bearing pressure.

Recommendation: None.

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

Manual for the Construction of Residential Basements in Non-Coastal Flood Environments (MCRB)

MCRB	U.B.C.	Analysis
VIII Appendix A Allowable Soil Pressures Beneath Footings	Chapter 29	The MCRB provides two charts for determining allowable soil bearing pressure based on the cohesiveness of the soil and the width or depth of the footing. The U.B.C. has no such tables, but would defer to approved national standards.
Recommendation:	None.	

MCRB	U.B.C.	Analysis
VIII A.2.a Soil and Water Loading	Chapter 29	The MCRB provides specific soil and water loading design criteria based on the type of soil in which the structure is located. The U.B.C. does not contain specific soil and water loading design criteria, but would defer to approved national standards.
Recommendation:	None.	

MCRB	U.B.C.	Analysis
VIII A.2.c Water Proofing Systems	Appendix Chapter 29	The MCRB provides two cross sections of basement construction as examples of drained and undrained systems with construction recommendations. The U.B.C. has no specific design criteria for these types of systems, but contains performance criteria which water proofing systems must meet.
Recommendation:	None.	

MCRB	U.B.C.	Analysis
VIII A.2.d Wall Design	Chapter 24 and Appendix Chapter 29.	The MCRB provides an example of designing reinforced masonry basement walls and their water proofing. The U.B.C. has no such example, but has specific design criteria which the system must meet.
Recommendation:	None.	

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

Manual for the Construction of Residential Basements in Non-Coastal Flood Environments (MCRB)

MCRB	U.B.C.	Analysis
VIII A.2.e Slab Design	Chapter 26 and Appendix Chapter 29	The MCRB provides specific example for the design of slabs and their water proofing. The U.B.C. has no such examples, but provides specific design criteria for those systems.

Recommendation: None.

MCRB	U.B.C.	Analysis
VIII B. Acceptable Wall Designs	None.	The MCRB discusses a number of provided structural design curves for basement walls given an equivalent fluid loading condition for different types of construction materials. The U.B.C. has no such design curves, but provides specific design criteria for each construction material.

Recommendation: None.

MCRB	U.B.C.	Analysis
VIII B.1 Structural Plain Concrete Wall	Chapter 26	The MCRB provides specific charts for the design of structural plain concrete walls given an equivalent fluid loading condition. The U.B.C. would rely upon the determination of structural capacity by a licensed engineer or architect and approved national standards.

Recommendation: None.

MCRB	U.B.C.	Analysis
VIII B.2 Reinforced Concrete Wall	Chapter 26	The MCRB provides specific design criteria for reinforced concrete walls given an equivalent fluid loading condition. The U.B.C. has no such provisions, but would rely on the design of a licensed engineer or architect and approved national standard.

Recommendation: None.

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

Manual for the Construction of Residential Basements in Non-Coastal Flood Environments (MCRB)

MCRB	U.B.C.	Analysis
VIII B.3 Unreinforced Masonry Block Wall	Chapter 24	The MCRB provides specific design criteria for unreinforced masonry walls given an equivalent fluid loading condition. The U.B.C. has no such provisions and would rely on the design of a licensed engineer or architect and approved national standards.

Recommendation: None.

MCRB	U.B.C.	Analysis
VIII B.4 Reinforced Masonry Block Wall	Chapter 24	The MCRB provides specific design criteria for reinforced masonry block walls given an equivalent fluid loading condition. The U.B.C. has no such provisions and would rely on the design of a licensed engineer or architect and approved national standards.

Recommendation: None.

MCRB	U.B.C.	Analysis
VIII B.5 Buoyancy Wall	None.	The MCRB gives specific design criteria for the design of buoyancy walls required in undrained systems. The U.B.C. has no such provisions and does not allow residential basements below the BFE.

Recommendation: None.

MCRB	U.B.C.	Analysis
VIII C.6 Reinforced Concrete Slab	Chapter 26	The MCRB provides specific design criteria for the design of basement slabs and undrained systems based on an allowable depth of loading. The U.B.C. has no such provisions.

Recommendation: None.

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

Manual for the Construction of Residential Basements in Non-Coastal Flood Environments (MCRB)

MCRB	U.B.C.	Analysis
VIII D.1 Control Joints	Appendix Chapter 29	The MCRB provides specific water proofing provisions for wall and slab control joints. The U.B.C. does not provide specific provisions, but has performance criteria for the water proofing of slabs and walls requiring water proofing.

Recommendation: None.

MCRB	U.B.C.	Analysis
VIII D.2 Sump, Pump and Underdrain	None.	The MCRB provides specific details for the design of sump pumps and associated underdrain system. The U.B.C. has no such provisions.

Recommendation: None.

MCRB	U.B.C.	Analysis
VIII D.3.a Water Proofed Underdrain Slab and Wall System	Appendix Chapter 29	The MCRB provides specific design criteria for water proofing undrained basements. The U.B.C. has no such provisions.

Recommendation: None.

MCRB	U.B.C.	Analysis
VIII D.3.b Water Proofed Drain, Slab and Wall System	Appendix Chapter 29	The MCRB provides specific design criteria for drain basement type systems. The U.B.C. has no such provision.

Recommendation: None.

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

Manual for the Construction of Residential Basements in Non-Coastal Flood Environments (MCRB)

MCRB	U.B.C.	Analysis
VIII D.3.c Slab Wall Footing Juncture	Appendix Chapter 29	The MCRB provides specific details for the protection of the intersection of a slab wall and footing. The U.B.C. has no such details.

Recommendation: None.

MCRB	U.B.C.	Analysis
I B.4 Flood Velocity	None.	The MCRB discusses the effects of high velocities of flood waters and the increased potential for damage to structures in their path. The U.B.C. has no such discussion and would rely on approved national standards.

Recommendation: None.

MCRB	U.B.C.	Analysis
I B.5 Sediment	None.	The MCRB discusses the effects of sediment deposition on structures due to flood events. The U.B.C. has no such discussion.

Recommendation: None.

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

Technical Standards Bulletin: Wet Flood Proofing, Bulletin No. 85-1

Bulletin No. 85-1	U.B.C.	Analysis
I. Definition	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-1 defines wet flood proofing as the intentional internal flooding of a structure in order to alleviate any pressures due to a flood event. The U.B.C. requires that any approved occupiable space, in other than a residential occupancy, that is below the base flood elevation be constructed with exterior walls and floors that are impermeable to the passage of water and designed to meet any hydrostatic and hydrodynamic loads that may be incurred. Other enclosed spaces such as those for building access exits, foyers, storage and parking garages are required to have openings to allow the equalization of pressure due to a flood event.

Recommendation: FEMA Bulletin No. 85-1 should state that this method of floodproofing is only acceptable for the retrofitting of existing buildings.

Bulletin No. 85-1	U.B.C.	Analysis
II. Protection Goals	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-1 lists a number of the components in the protection of a building and its contents. The Uniform Building Code does not recognize the viability of wet flood proofing in occupiable spaces.

Recommendation: See the recommendation of Item I in Bulletin No. 85-1.

Bulletin No. 85-1	U.B.C.	Analysis
III. B Structural Considerations	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-1 recommends that a structure be designed so that all of its materials, finishes, utilities, etc. be able to withstand any forces generated by flood elements as well as the corrosive nature of water. The U.B.C. does not recognize the viability of wet flood proofing of occupiable spaces, but does recommend that structural members, utilities, etc. that are exposed to such conditions be protected.

Recommendation: See the recommendation of Item I in Bulletin No. 85-1.

Technical Standards Bulletin: Wet Flood Proofing, Bulletin No. 85-1

Bulletin No. 85-1	U.B.C.	Analysis
III. C Building Activity and Use	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-1 discusses how the activities and uses within a building can change the likelihood of a building being damaged during a flood event. The Uniform Building Code does not recognize the viability of wet flood proofing in occupiable spaces.

Recommendation: See the recommendation of Item I in Bulletin No. 85-1.

Bulletin No. 85-1	U.B.C.	Analysis
IV. A.1 Foundations	Chapter 29 Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-1 discusses, in general terms, the loads that a foundation may be subject to during a flood event under a wet flood proofing design. The Uniform Building Code requires a foundation to be designed for all applied loads.

Recommendation: None.

Bulletin No. 85-1	U.B.C.	Analysis
IV. A.2 Cavity Walls	None.	FEMA Bulletin No. 85-1 recommends that if cavity walls are used in the design of a structure, that they must be made so that the cavity space drains at a rate approximately equal to the flood rate and that any material contained within be able to withstand the inundation. The Uniform Building Code has no such provisions.

Recommendation: None.

Bulletin No. 85-1	U.B.C.	Analysis
IV. A.3 Solid Walls	Chapter 24 Chapter 25 Chapter 26 Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-1 discusses the protection of solid walls due to any moisture permeation, especially any spalling due to freeze/thaw conditions. The Uniform Building Code has provisions for the protection of solid walls due to freeze/thaw conditions and also provides specific design criteria to prevent any spalling due to moisture penetration.

Recommendation: None.

Technical Standards Bulletin: Wet Flood Proofing, Bulletin No. 85-1

Bulletin No. 85-1	U.B.C.	Analysis
IV. A.4 Interior Walls	Chapter 24 Chapter 25 Chapter 26 Appendix Chapter 23, Division IV.	FEMA Bulletin 85-1 discusses the protection of interior walls and recommends that the same provisions for cavity walls and solid walls be used for any such interior walls. The Uniform Building Code does not recognize the wet flood proofing of the interior of an occupiable space as a viable option, therefore, there are no provisions.

Recommendation: See the recommendation of Item I in Bulletin No. 85-1.

Bulletin No. 85-1	U.B.C.	Analysis
IV. A.5 Interior Wall Finishes	Chapter 42 Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-1 discusses the protection of interior wall finishes due to direct contact with flood waters. The Uniform Building Code does not recognize the viability of wet flood proofing of occupiable spaces, therefore, there are no provisions.

Recommendation: See the recommendation of Item I in Bulletin No. 85-1.

Bulletin No. 85-1	U.B.C.	Analysis
IV. A.6 Floors	Chapter 25 Chapter 42 Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-1 discusses the protection of floor systems in wet flood proofing situations and recommends that the design of such a floor system be able to withstand a minimum hydrostatic pressure. The Uniform Building Code does not recognize the viability of wet flood proofing occupiable spaces, therefore, there are no provisions.

Recommendation: See the recommendation of Item I in Bulletin No. 85-1.

Bulletin No. 85-1	U.B.C.	Analysis
IV. A.7 Ceilings and Roofs	Chapter 25 Chapter 42 Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-1 discusses the protection of ceilings and roofs and any other related features from any waters due to a flood event. The Uniform Building Code doe not recognize the viability of wet flood proofing occupiable spaces, therefore, there are no provisions.

Recommendation: See the recommendation of Item I in Bulletin No. 85-1.

Technical Standards Bulletin: Wet Flood Proofing, Bulletin No. 85-1

Bulletin No. 85-1	U.B.C.	Analysis
IV. A.8 Building Envelope Penetrations	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-1 discusses the protection of any penetrations or openings in the building's structural envelope and provides some general design criteria. The Uniform Building Code requires that all openings below the base flood elevation shall be provided with watertight closures designed to withstand the applied loads.

Recommendation: See the recommendation of Item I in Bulletin No. 85-1.

Bulletin No. 85-1	U.B.C.	Analysis
IV. A.9 Electrical Systems	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-1 discusses the protection of electrical utilities from any waters generated by a design flood and recommends that standby electrical power be available in case of an emergency. The Uniform Building Code requires that new or replacement electrical equipment be either placed above the base flood elevation or protected to prevent water from entering the system.

Recommendation: None.

Bulletin No. 85-1	U.B.C.	Analysis
IV. A.10 H.V.A.C.	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-1 discusses the protection of heating, ventilating and air conditioning equipment from waters due to a design flood. The Uniform Building Code requires that such equipment be either placed above the base flood elevation or protected to prevent water from entering the system.

Recommendation: None.

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

Technical Standards Bulletin: Foundation Wall Openings, Bulletin No. 85-2

Bulletin No. 85-2	U.B.C.	Analysis
Flood Forces	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-2 discusses the calculation of the hydrostatic pressures generated by a flood on the exterior walls of a structure and defines hydrodynamic forces. The U.B.C. requires that the structural system of the building be designed in accordance with well-established engineering principles with consideration of the hydrodynamic and hydrostatic loads generated by a flood event.
Recommendation:	None.	

Bulletin No. 85-2	U.B.C.	Analysis
Openings Design Criteria	None.	FEMA Bulletin No. 85-2 discusses the use of openings in exterior walls in equalizing the pressure on either side of such walls. The U.B.C. does not recognize wet flood proofing as a viable method of protecting an occupiable space in a structure, but allows openings for other spaces such as those for building access, exits, foyers, storage and parking garages.
Recommendation:	See the recommendation of Item I in Bulletin No. 85-1.	

ICBO UNIFORM BUILDING CODE (U.B.C.) COMPARISON

Technical Standards Bulletin: Breakaway Walls, Bulletin No. 85-3

Bulletin No. 85-3	U.B.C.	Analysis
II. Wind and Water Forces	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-3 discusses the wind and water forces that breakaway walls may be subject to. The Uniform Building Code requires that the structural system including breakaway walls be designed in accordance with well-established engineering principles and gives criteria for the design of the connections.

Recommendation: FEMA Bulletin No. 85-3 should recognize the latest edition of the Minimum Design Loads for Buildings and Other Structures, which is ASCE 7-88.

Bulletin No. 85-3	U.B.C.	Analysis
III. Design Approach	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-3 gives the loads for the design of the connections of the breakaway wall and reasons for same. The Uniform Building Code requires that breakaway walls be designed for two specific loading requirements in accordance with well-established engineering principles.

Recommendation: None.

Bulletin No. 85-3	U.B.C.	Analysis
Design Considerations	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 85-3 discusses the design of the different elements that make up breakaway walls. The Uniform Building Code requires that this system be designed in accordance with well-established engineering principles and with hydrodynamic and hydrostatic loads considered.

Recommendation: None.

Technical Standards Bulletin: Breakaway Walls, Bulletin No. 85-3

Technical Standards Bulletin: Wind Design Standards, NFIP No. 88-1

Bulletin No. 88-1	U.B.C.	Analysis
Pages 1-5	Chapter 23 Appendix Chapter 23, Division IV.	FEMA Bulletin No. 88-1 discusses the potential damage due to high winds on structures in a coastal high-hazard area and provides a general comparison between the three national model codes and the NFIP regulations. The U.B.C. provides specific criteria for the design of structures due to high winds based upon the latest edition of the ANSI document which is now ASCE 7-88.

Recommendation: FEMA Bulletin No. 88-1 should refer to the latest edition of the ANSI document which is now ASCE 7-88.

Technical Standards Bulletin: Flood-Resistant Materials, Bulletin No. 88-2

Bulletin No. 88-2	U.B.C.	Analysis
Pages 1-7	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 88-2 discusses different classes of materials which are resistant to damage due to flood events and provides a table of materials and the related flood-resistant classification. The U.B.C. requires that materials exposed to the weather or to water splash be protected with an appropriate material.

Recommendation: None.

Technical Standards Bulletin: Breakaway Walls, Bulletin No. 85-3

Technical Standards Bulletin: Free of Obstruction Requirement in Coastal High-Hazard Areas, Bulletin No. 88-3

Bulletin No. 88-3	U.B.C.	Analysis
Lower Area Obstructions	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 88-3 discusses the various structural elements that may be found below the lowest floor of a building in a Zone. The U.B.C. discusses the same structural systems and also allows for the storage of portable or mobile items.

Recommendation: None.

Technical Standards Bulletin: Breakaway Walls, Bulletin No. 85-3

Bulletin No. 88-3	U.B.C.	Analysis
Perimeter Obstructions	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 88-3 discusses and defines various obstructions that may be found outside the perimeter of a building in a coastal high-hazard area and how they may affect adjacent structures. The Uniform Building Code does not regulate obstructions which may be outside the perimeter of the building, but does require that the structural system be constructed to prevent collapse or permanent lateral movement due to any loads in the flood which may also be caused by obstructions outside the perimeter of the building.

Recommendation: None.

Technical Standards Bulletin: Free of Obstruction Requirement in Coastal High-Hazard Areas, NFIP No. 88-3

Bulletin No. 88-3	U.B.C.	Analysis
Attached Perimeter Obstructions	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 88-3 generally discusses any obstruction which may be attached to, but located outside, the perimeter of the building. For example, access stairs, and recommends that it be considered as a part of the building. The U.B.C. would consider anything attached to the building as being a part of the building, even if it were outside the perimeter of the structure and would require that the entire structural system of the building be constructed to resist collapse of permanent lateral movement due to any loads from a flood event.

Recommendation: None.

Technical Standards Bulletin: Protection of Elevator Equipment in Flood-Hazard Areas, Bulletin No. 88-4

Bulletin No. 88-4	U.B.C.	Analysis
Page 3	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 88-4 recommends that any equipment used for the service of elevators be either located above the base flood elevation or, if that is not possible, protected to prevent water from damaging the system. The Uniform Building Code requires that such service facilities be either placed above the base flood elevation or protected to prevent water from entering the system.

Recommendation: None.

Technical Standards Bulletin: NFIP Requirements for Below Grade Parking Garages in Flood-Hazard Areas, Bulletin No. 90-2

Bulletin No. 90-2	U.B.C.	Analysis
Pages 1-4	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 90-2 discusses the flood proofing of below grade parking garages and recommends specific code language for the design of same, in both A and Zones. The Uniform Building Code has specific requirements for the design of below grade parking garages provided they meet specific enclosure requirements and flood-resistant construction, for both the A and Zones.

Recommendation: None.

Technical Standards Bulletin: Non-Residential Flood Proofing Certification Requirements of the National Flood Insurance Program, Bulletin No. 90-3

Bulletin No. 90-3	U.B.C.	Analysis
Pages 1-6	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 90-3 discusses, in general terms, the flood proofing of non-residential structures and requires that a certification of the flood proofing design is provided as well as providing a means of calculating hydrostatic and hydrodynamic type forces. The Uniform Building Code has essentially the same type of requirements, but requires that the structural system be designed in accordance with well-established engineering principles with hydrodynamic and hydrostatic loads under consideration.

Recommendation: None.

Technical Standards Bulletin: Installation of Manufactured Homes in Special Flood-Hazard Areas, Bulletin No. 90-4

Bulletin No. 90-4	U.B.C.	Analysis
Pages 3-19	Appendix Chapter 23, Division IV.	FEMA Bulletin No. 90-4 gives specific design recommendations for the installation of manufactured homes in special flood-hazard areas. The U.B.C. requires that all buildings or structures within a flood-hazard zone shall conform to the elevation requirements and flood-resistant construction as found in Appendix Chapter 23, Division IV.

Recommendation: None.

APPENDIX D

COMPARISON BETWEEN THE NFPA STANDARDS AND THE NFIP STANDARDS AND TECHNICAL GUIDELINES

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NATIONAL/FUEL GAS CODE (NFPA 54)	D-1
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NATIONAL FIRE PROTECTION ASSOCIATION CODE COMPARISON
NATIONAL FUEL GAS CODE (NFPA 54)

NFIP Flood Resistant Design Standards (44 CFR)

FEMA-44	NFPA 54	Analysis
Chapter 1, 60.6		The scope of the documents differ. 44 CFR is establishing design standards for structures does not define utility requirements found in the Fuel Gas Code.

Coastal Construction Manual (FEMA-55)

FEMA-55	NFPA 54	Analysis
		The scope of the documents differ. In FEMA 55 structural requirements there are no parallel requirements found in the Fuel Gas Code.

Elevated Residential Structures (FEMA 54)

FEMA-54	NFPA 54	Analysis
		The scope of the documents differ. The guidelines for elevated structures, while including mechanical equipment, does not include specifics for Fuel Gas Code use in the installation.

Manufactured Home Installation in Flood Hazard Areas (FEMA 85)

FEMA-85	NFPA 54	Analysis
		The scope of the documents differ with FEMA 85 limited to structural based requirements.

Floodproofing Non-Residential Structures (FEMA 102)

FEMA-102	NFPA 54	Analysis
		Floodproofing design for structures is outside the scope of the Fuel Gas Code.

Retrofitting Flood-Prone Structures (FEMA-114)

FEMA-114	NFPA 54	Analysis
Chapter 9 Protection of Utilities 9.3 Emergency Protective Measures	4.2.1, 4.2.2	Paragraph 9.3 recommends closing the main gas valve when a flood is imminent. NFPA 54 contains requirements when turning the gas back on in paragraphs 4.2.1, 4.2.2 and appendix D.

Recommendation: Add references to NFPA 54.

Alluvial Fans: Hazards and Management (FEMA-165)

FEMA-165	NFPA 54	Analysis
		The Fuel Gas Code does not evaluate environmental factors covered in FEMA 165.

Technical Standards Bulletin: Wet Floodproofing, No 85-1

FEMA-No. 85-1	NFPA 54	Analysis
		Wet floodproofing is not addressed in the Fuel Gas Code.

Technical Standards Bulletin: Foundation Wall Openings No. 85-2

FEMA-No. 85-2	NFPA 54	Analysis
		The Fuel Gas Code contains no requirements for installations addressed in 85-2.

Technical Standards Bulletin: Breakaway Walls No. 85-3

FEMA-No. 85-3	NFPA 54	Analysis
		Breakaway walls are not addressed as a part of the Fuel Gas Code.

Technical Standards Bulletin: Free of Obstruction Requirements in Coastal High Hazard Areas, No. 88-3

FEMA-No. 85-3	NFPA 54	Analysis
		No common requirements exist between FEMA 88-3 and NFPA 54.

Manual for the Construction of Residential Basements in Non-Coastal Flood Environs

FIA/HUD-No.CR-997	NFPA 54	Analysis
		No common requirements exist between the documents.

NATIONAL FIRE PROTECTION ASSOCIATION CODE COMPARISON
STANDARD FOR THE STORAGE AND HANDLING OF LIQUEFIED PETROLEUM GASES (NFPA 58)

NFIP Flood Resistant Design Standards (44 CFR)

FEMA-44	NFPA 58	Analysis
Chapter 1, 60.6		The scope of the documents differ.

Coastal Construction Manual (FEMA-55)

FEMA-55	NFPA 58	Analysis
		The scope of the documents differ.

Elevated Residential Structures (FEMA 54)

FEMA-54	NFPA 58	Analysis
		The scope of the documents differ. The guidelines for Elevated Structures, while including mechanical equipment, does not include specifics for LPG use or handling.

Manufactured Home Installation in Flood Hazard Areas (FEMA 85)

FEMA-85	NFPA 58	Analysis
		The scope of the documents differ.

Floodproofing Non Residential Structures (FEMA 102)

FEMA-102	NFPA 58	Analysis
		Floodproofing is not addressed as a part of LPG storage and handling in NFPA 58.

Technical Standards Bulletin: Wet Floodproofing, No. 85-1

FEMA-85-1	NFPA 58	Analysis
II Protection Goals	4-4, 4-4.3	In part IV, Guidelines for Implementation, Item 10 Heating, Ventilating and Air Conditioning, recommends that "empty tanks, both above and below ground, should be filled with potable water prior to the arrival of floodwater." This is good guidance for tanks that are open to the atmosphere, such as those used for fuel oil, but should not apply to propane tanks. Propane tanks are never empty, but contain residual propane vapor when "empty". The tank should never be opened to the atmosphere as the flammable vapor will probably escape and create a hazard of fire. In addition, the introduction of water and air into the tank will cause corrosion which can result in loss of the odorant that is added to the gas as a warning.

Recommendation: Revise FEMA 85-1 to include a caution on LP-Gas or liquid transfer consistent with NFPA 58 philosophy and requirements.

Retrofitting Flood-prone Residential Structures (FEMA-114)

FEMA-114	NFPA 58	Analysis
9.4 Permanent Protective Measures II Protection Goals	3-2.2.6(g)	NFPA 58 includes requirements for anchoring of propane tanks flood areas.

Recommendation: Include a reference to NFPA 58 in FEMA 114.

Alluvial Fans: Hazard and Management (FEMA-165)

FEMA-165	NFPA 58	Analysis
	3-2.2.b(g)	NFPA 58 includes requirements for anchoring of propane tanks in flood areas.

Recommendation: Include a reference to NFPA 58 in FEMA-165.

Technical Standards Bulletin: Wet Floodproofing, No. 85-1

FEMA-85-1	NFPA 58	Analysis
II Protection Goals	4-4, 4-4.3	In part IV, Guidelines for Implementation, Item 10 Heating, Ventilating and Air Conditioning, recommends that "empty tanks, both above and below ground, should be filled with potable water prior to the arrival of floodwater." This is good guidance for tanks that are open to the atmosphere, such as those used for fuel oil, but should not apply to propane tanks. Propane tanks are never empty, but contain residual propane vapor when "empty". The tank should never be opened to the atmosphere as the flammable vapor will probably escape and create a hazard of fire. In addition, the introduction of water and air into the tank will cause corrosion which can result in loss of the odorant that is added to the gas as a warning.

Recommendation: Revise FEMA 85-1 to include a caution on LP-Gas or liquid transfer consistent with NFPA 58 philosophy and requirements.

Technical Standards Bulletin: Foundation Wall Openings No. 85-2

FEMA-165	NFPA 58	Analysis
	3-2.2.b(g)	NFPA 58 includes requirements for anchoring of propane tanks in flood areas.

Technical Standards Bulletin: Foundation Wall Openings No. 85-3

FEMA-85-3	NFPA 58	Analysis
		Breakaway walls are not addressed in NFPA 58.

Technical Standards Bulletin: Free of Obstruction Requirements In Coastal High Hazard Areas No. 88-3.

FEMA-85-3	NFPA 58	Analysis
		No Common requirements exist.

Manual for the Construction of Residential Basements in Non-Coastal Flood Environs

FIA/HUD-No.CR-997	NFPA 58	Analysis
		No common requirements exist between the documents.

NATIONAL FIRE PROTECTION ASSOCIATION CODE COMPARISON
NATIONAL ELECTRICAL CODE (NFPA 70)

NFIP Flood Resistant Design Standards (44CFR 59.1 & 60.3)

FEMA-44	NFPA 70	Analysis
59.1 Definitions Recreational vehicle Chapter 1, 60.6	551-1 Definitions	FEMA 44 definition goes into specifics pertaining to design by specifying maximum area built on a single chassis, NFPA 70 goes into more detail as to how the vehicle is used, what it is used for and how it is propelled.

Recommendation: Elliminate the "400 square feet or less when measured at the largest horizontal projection" in Pargraph (c) of FEMA 44.

Elevated Residential Structures (FEMA-54)

FEMA-54	NFPA 70	Analysis
Utility Service P. 92, 93	110-11	FEMA-54 cautions against the results of water damage to utility service. NFPA 70 qualifies electrical service identified for use in the operating environment, no conductors or equipment shall be located in damp or wet locations; where exposed to gases, fumes, vapors, liquids or other agents having a deteriorating effect on the conductors or equipment; nor where exposed to excessive temperatures.

Recommendation: For FEMA-54, electrical supply conduits and cables should be suitable for the environment they are likely to be exposed, especially in locations subject to corrosive environments such as salt water or spray.

FEMA-54	NFPA 70	Analysis
Service Mounting P. 92 P. 93	110-13	Secure mounting of utilities and mechanical equipment are addressed in FEMA-54. NFPA 70 requires electric equipment to be securely fastened to the surface on which it is mounted.

Recommendation: Revise FEMA-54 to clarify that electric equipment shall be securely fastened to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials shall not be used. Underground electric supply conduits or cables should not be fastened to walls, or structures intended to break-away under flood conditions.

Suggested Code revision:
NFPA 70 (110-13(a), 300-5(d)).
Add the following sentence: Buildings designed with breakaway walls shall have electric services secured to the sides of interior piles or within flood proof enclosures attached to interior poles.

FEMA-54	NFPA 70	Analysis
P. 92, 93 Raceways	230-8 230-32 300-5(c), (d)	Electrical service raceways entering from an underground distribution system are recognized in FEMA-54 as vulnerable while NFPA 70 provides more specific guidelines.

Recommendation: For FEMA-54, where electrical conduits supplying the structure are installed underground, the conduit should be sealed. The sealant should be installed at a location in the system so arranged to prevent entrance of water due to flood conditions. Underground electrical conduits or cables should be protected against damage by burying them to a depth which would minimize their shifting under flood conditions.

NATIONAL FIRE PROTECTION ASSOCIATION CODE COMPARISON
NATIONAL ELECTRICAL CODE (NFPA 70)

Elevated Residential Structures (FEMA-54)

FEMA-54	NFPA 70	Analysis
P. 92, 93 Electrical service location	230-53 380-8	FEMA-54, while allowing for the location of electrical service, does not detail design or location similar to NFPA 70.

Recommendation: For FEMA-54, all switches and circuit breakers shall be located so that they can be operated from a readily accessible place. They should be located so that the center of the operating handle is not more than 6 1/2 feet above the floor or platforms. Where necessary, a platform may be installed to provide accessibility where devices are located above the flood plain.

Coastal Construction Manual (FEMA-55)

FEMA-55	NFPA 70	Analysis
4.3.6 Utilities	110-13(a) 300-5(d)	FEMA 55 recommends locating electric utility risers be located on the sides of interior piles or away from the ocean front or located within floodproof enclosures attached to interior piles. Electrical service secured to the structure should be securely fastened in such a way that the building's protective covering will not be damaged where electric wires are pulled away from the structure. NFPA 70 also requires electric equipment to be securely fastened to the surface it is mounted on. NFPA 70 requires enclosures or raceways that may be subject to damage to be rigid metal conduit intermediate metal conduit, Schedule 80 nonmetallic conduit are equivalent.

Recommendation: In the fifth paragraph of Section 4.3.6 of FEMA 55, insert the following as a second sentence: "Since the enclosure or raceway for the electric utilities is subject to physical damage, it should be installed in rigid metal conduit, intermediate metal conduit, or schedule 80 rigid nonmetallic conduit".

Manufactured Home Installation in Flood Hazard Areas (FEMA-85)

FEMA-85	NFPA 70	Analysis
Chapter IV p. 69 Utility service	110-11 110-13	Electrical service locations are required to be above flood levels in FEMA-85 while NFPA 70 more specifically outlines performance and material requirements.

Recommendation: For FEMA-85, Electric equipment shall be securely fastened to the surface on which it is mounted. Wooden plugs driven into holes in masonry, concrete, plaster, or similar materials shall not be used. Underground electric supply conduits or cables should not be fastened to walls, or structures intended to break-away under flood conditions. Electrical supply conduits and cables should be suitable for the environment they are likely to be exposed, especially in locations subject to corrosive environments such as salt water or spray.

Manufactured Home Installation in Flood Hazard Areas (FEMA-85)

FEMA-85	NFPA 70	Analysis
Chapter IV p. 69 Utility Service	230-8 300-5(c),(d) 230-32 230-53	FEMA-85 generally defines electrical mounting while NFPA 70 is more equipment specific.

Recommendation: For FEMA-85, where electrical conduits supplying the structure are installed underground, the conduit should be sealed. The sealant should be installed at a location in the system so arranged to prevent entrance of water due to flood conditions. Underground electrical conduits or cable should be protected against damage by burying them to a depth which would minimize their shifting under flood conditions. Means should be provided to protect electrical supply conduits emerging from underground to the bottom of the structure from floating debris during flood conditions. All switches and circuit breakers should be located so that they can be operated from a readily accessible place. They should be located so that the center of the operating handle is not more than 6 1/2 feet above the floor or platforms. Where necessary, a platform may be installed to provide accessibility where devices are located above the flood plain.

Technical Standards Bulletin: Wet Floodproofing, No. 85-1

FEMA-85-1	NFPA 70	Analysis
IV A.9 Electrical System	110-11 110-17(b)	FEMA 85-1 recommends that electrical supply lines and equipment be elevated above Design Flood Level or be waterproofed where required to be installed below flood level. NFPA 70 requires electrical supply lines and equipment to be suitable for the environment under normal operating environmental conditions. However, if flooding often or anticipated due to location, including 100 year flood levels, the electrical installation must be suitable for the expected event.

Recommendation: In the second paragraph, add the following: "Where electrical supply lines cannot be elevated above flood level, they should be installed to arrange for draining away from panelboards, controllers, switches or other electrical equipment."

Floodproofing Non-Residential Structures (FEMA-102)

FEMA 102	NFPA 70	Analysis
Chapter IV D. Wet Floodproofing Techniques	110-11 110-17(b)	FEMA 102 recommends that electrical supply lines and panels be elevated above the Design Flood Level, whereas NFPA 70 requires electrical installations be suitable for the environment under normal operating. However, if the frequency of flooding is often, the electrical code would require the electrical installation to be suitable for that event.

Recommendation: In the fourth paragraph following the second sentence, insert "where electrical supply lines cannot be elevated above the Design Flood Level, they must be installed to arrange for draining away from panelboards, controllers, switches or other electrical equipment".

Retrofitting Flood-prone Residential Structures (FEMA-114)

FEMA-114	NFPA 70	Analysis
8.7 Technical Design Criteria, p. 156 Drainage System	110-3(a)(1) 110-11 410-57(b)	FEMA 114 requires pump and pump motor combination and its associated control devices to be provided with watertight electrical supply. Three-wire heavy duty U.L. listed power receptacles and wire are required to be installed above possible flood water level. NFPA 70 allows equipment that is to be used in a specific environment to be identified as suitable for that use by testing and listing and labeling by a testing laboratory. NFPA 70 does not require the testing laboratory to be U.L. (Underwriters Laboratories, Inc.).

Recommendation: In the third paragraph of FEMA 114, revise the third sentence as follows: "The power receptacle outlet and associated equipment should be of the grounding type and be labeled and listed by a recognized testing laboratory.

Retrofitting Flood-prone Residential Structures (FEMA-114)

FEMA-114	NFPA 70	Analysis
9.3 Emergency Protective Measures	373-2(a)	FEMA 114 recommends shutting off the main power in the distribution panel and removing any fuses from the panelboard when flooding is imminent and all electrical equipment should be cleaned and dried before restoring power. NFPA 70 requires cabinets such as used for panelboards to be of the weatherproof type where installed in wet locations. Cabinets installed in wet locations are required to have at least 1/4 inch space between the cabinet and the structure it is mounted on. NFPA 70 does not address maintenance or refurbishing electrical equipment after being submerged during floods.

Recommendation: Refer to NFPA 70B "Electrical Equipment Maintenance.

FEMA-114	NFPA 70	Analysis
9.4 Permanent Protective Measures pg. 160 Utility Connections	230-53	FEMA 114 recommends relocating electric power lines above the flood level and install electrical conductors in waterproofed conduits. NFPA 70 does not address clearance heights above flood levels, however, it does require conduits exposed to the weather to be arranged to drain should water enter the conduit system.

Recommendation: Add the following as a fifth sentence in Section 9.4 Utility Connections: "Where electric service conductors are located within flood level range, most type services can be installed to raise the electrical service above flood level range.

Alluvial Fans: Hazards and Management (FEMA-165)

FEMA-165	NFPA 70	Analysis
		FEMA-165 addresses no electrical code concerns.

Technical Standards Bulletin: Foundation Wall Openings No. 85-2.

FEMA-85-2	NFPA 70	Analysis
		The National Electrical Code contains no requirements for installations addressed in No. 85-2.

Technical Standards Bulletin: Breakaway Walls No. 85-3

FEMA-85-3	NFPA 70	Analysis
	110-13(a) 300-5(d)	Breakaway walls do not meet NFPA 70 requirements for secure fastening of electrical equipment.

Recommendation: See FEMA 55 utility requirements.

Technical Standards Bulletin: Free Of Obstruction Requirements in Coastal High Hazard Areas. No. 88-3

FEMA-88-3	NFPA 70	Analysis
		No common requirements exist between FEMA 88-3 and NFPA 70.

Manual for the Construction of Residential Basements in Non-Coastal Flood Environs

FIA/HUD-No.CR-997	NFPA 70	Analysis
		No common requirements exist between the documents.

NFIP Flood Resistant Design Standards (44 CFR)

FEMA-44	NFPA 101	Analysis
Chapter 1, 60.6		The scope of the documents differ.

Coastal Construction Manual (FEMA-55)

FEMA-55	NFPA 101	Analysis
Breakaway walls 4.3.5.1	5-1.3.1	FEMA-55 while defining breakaway walls does not relieve the designer from meeting fire barriers construction requirements.

Recommendation: For FEMA-55, as a part of a required enclosure or separation must maintain hourly rating requirements. This may be accomplished using masonry walls or wood stud walls discussed in 4.3.5.1 of FEMA-55.

Elevated Residential Structures (FEMA 54)

FEMA-54	NFPA 101	Analysis
		The scope of the documents differ.

Manufactured Home Installation In Flood Hazard Areas (FEMA 85)

FEMA-85	NFPA 101	Analysis
		The scope of the documents differ with FEMA 85 lilmited to structerally based requirements.

NATIONAL FIRE PROTECTION ASSOCIATION CODE COMPARISON
LIFE SAFETY CODE (NFPA 101)

Floodproofing Non-Residential Structures (FEMA-102)

FEMA 102	NFPA 101	Analysis
p. 11, 67, 68 Watertight Doors		FEMA 102 in addressing watertight doors promotes their use for daily activities. NFPA 101 in Chapter 5 on egress and in educational and assembly occupancies has door hardware requirements that must be met for latching, and force to open. Key among these are requirements for fire exit hardware.

Recommendation: In FEMA 102, p. 11 should add a paragraph to 2. Watertight Doors. "The force to open doors as a part of means of egress requirements should be maintained for exit doors. Latching requirements for exterior doors may include the use of fire exit hardware in educational or assembly occupancies".

Floodproofing Non-Residential Structures (FEMA-102)

FEMA 102	NFPA 101	Analysis
p. 161		FEMA 102 in Building Code qualifies a Building Code as a collection of regulators while not recognizing companion standards such as the National Electrical Code, the Fuel Gas Code, or the Life Safety Code.

Recommendation: Reword the definition of Building Code to include provisions for standards other than a Model Building Code.

Retrofitting Flood Prone Residential Structures (FEMA 114)

FEMA 114	NFPA 101	Analysis
		There are no common requirements.

Alluvial Fans: Hazards and Management (FEMA-165)

FEMA 165	NFPA 101	Analysis
		The Life Safety Code does not evaluate environmental factors covered in FEMA 165.

NATIONAL FIRE PROTECTION ASSOCIATION CODE COMPARISON
LIFE SAFETY CODE (NFPA 101)

Technical Standards Bulletin: Wet Floodproofing Bulletin, No. 85-1

FEMA-85-1	NFPA 101	Analysis
Protection of Interior Finishes	6-5.1.2, 6-5.1.2.1, 9-3.3, 9-3.3.1, 9-3.3.2,9-3.3.3, 10-3.1, 11-3.3.1, 12-3.3.1, 13-3.3.1, 13-3.3.2, 14-3.3.1, 15-3.3.1, 16-3.3.1, 17-3.3.1, 18-3.3.1, 19-3.3.1, 21-3.2.1, 22-3.3.3, 23-3.3.3, 24-3.3.1, 25-3.3.1, 26-3.3.1, 27-3.3.1, 28-3.3.1, 29-3.3.1, 30-3.3.1	FEMA 85-1 while encouraging water resistant interior finishes, may inadvertently negate the finish requirements outlined in NFPA 101.

Recommendation: Technical bulletin 85-1 should qualify the use of water resistant finishes to as to include the maintenance of interior finish requirements to a particular occupancy as defined by other codes.

Technical Standards Bulletin: Foundation Wall Openings No. 85-2

FEMA No. 85-2	NFPA 101	Analysis
		There are no common requirements.

Technical Standards Bulletin, Berakaway Walls No. 85-3

FEMA No. 85-2	NFPA 101	Analysis
		There are no common requirements.

Technical Standards Bulletin: Free Of Obstruction Requirements In Coastal High Hazard Areas, No. 88-3

FEMA No. 88-3	NFPA 101	Analysis
		There are no common requirements.

Manual for the Construction of Residential Basements in Non-Coastal Flood Environs

FIA/HUD-No.CR-997	NFPA 101	Analysis
		No common requirements exist between the documents.

APPENDIX E

COMPARISON BETWEEN THE MANUFACTURED HOUSING CODES AND STANDARDS THE NFIP STANDARDS AND TECHNICAL GUIDELINES

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National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification) [NFIP]

The following is a comparison between Sections 59.1 and 60.3 of the NFIP, the MHCSS, and selected requirements from FEMA 85. The definitions in Section 59.1 have been compared with the MHCSS and found to be compatible.

NFIP	MHCSS	Analysis
§59.1 §60.3 (in its entirety)	§3280.2 (a)(16)	NFIP provides a definition of a "manufactured home" consistent with the MHCSS. Additionally, §60.3 of the NFIP sets forth requirements for both recreational vehicles and manufactured homes. However, the NFIP does not address other types of factory-built or industrialized housing (i.e., modular). Current language in the NFIP such as "manufactured home," "proposed construction," and "new construction" may not be readily understood to include modular homes.

Recommendation: Revise the NFIP to include a consistent definition for modular housing. Clarify existing regulations by including modular in the applicable code sections.

NFIP	MHCSS	Analysis
§60.3 (a)(3) §60.3 (b)(8)		NFIP differentiates between old parks and new parks. The MHCSS provides no installation requirements, but rather requires that the manufacturer of the home provide instructions for the site installation.

Recommendation: None.

NFIP	MHCSS	Analysis
§60.3 (b)(8)		NFIP §60.3 (b)(8) states in part ". . . Methods of anchoring may include, but are not limited to, use of over-the-top or (emphasis added) frame tie to ground anchors." It is presumed from this section that an acceptable method of anchoring would be the application of over-the-top ties alone. Generally, over-the-top ties alone are insufficient to resist lateral flood forces. Again, the MHCSS provides no installation or anchorage provisions.

Recommendation: It is recommended that the NFIP section be clarified to use similar language to that provided in §60.3 (c)(6)(iv).

NFIP	MHCSS	Analysis
§60.3 (a)(3)(iii)(iv) §60.3 (b)(8) §60.3 (c)(6) §60.3 (c)(12)		The requirements of NFIP §60.3 (a)(3)(iii)(iv) appear to provide the community latitude in reviewing the appropriateness of a proposed permit application when that latitude may not be provided by other more prescriptive sections of the NFIP. For example, under §60.3 (a)(3)(iii)(iv) a community may reject a permit for an elevated double-wide manufactured home because the HVAC air duct crossover connecting the two units is typically suspended below the floor level. The community could conclude that the crossover may become dislodged during flood conditions and permit entry of flood waters into the floor and duct system. However, §60.3 (c)(6)(iv) suggests that only the lowest floor (and not the duct) need be elevated to or above the base flood elevation. Additionally, it appears that §60.3 (a)(3)(iii)(iv) is referenced in sections of the NFIP that contain more prescriptive and in some instances less restrictive requirements. (See for example, §60.3 (b)(2).)

Recommendation: Option 1: Revise §60.3 (a)(3)(iii)(iv) to reflect the elevation of the "lowest floor above the base flood elevation." Option 2: Revise the "lowest floor above the base flood elevation" to more clearly reflect the performance requirements outlined in §60.3 (a)(3)(iii)(iv) and allow for certain unusual construction techniques in manufactured housing. Option 3: Redefine the "lowest floor" to clearly include the depth of the chassis I-beam. This may help elevate many of the "underslung" utilities above "harm's way."

Other Areas for Clarification or Enhancement:

NFIP	MHCSS	Analysis
§60.3 (c)(10) and others		The NFIP currently provides for construction in Zones A1-30 and AE on the communities' FIRM provided that the cumulative effect will not increase the water surface elevation of the base flood by more than one foot. FEMA reference documents such as FEMA 85 "Manufactured Home Installation in Flood Hazard Areas" provide several design tables that when subjected to an additional flood load of 12" become inapplicable.

Recommendation: None.

National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification) [NFIP]

The HUD Permanent Foundations Guide provides design methods and data for site installation of factory-built single family dwelling units that are transportable in one or more sections. These are considered manufactured homes built in accordance with the HUD MHCSS.

NFIP	HUD 4930.3	Analysis
§59.1		The HUD Handbook contains only definitions applicable to the construction of foundation walls and piers. Since HUD 4930.3 is used as a guide for homes built per HUD MHCSS, the definitions therein are relevant. The NFIP definitions are generally compatible with the MHCSS. However, the NFIP does not address other types of factory-built or industrialized housing (i.e., modular). Current language in the NFIP such as "manufactured home," "proposed construction" and "new construction" may not be readily understood to include modular homes.

Recommendation: Revise the NFIP to include a consistent definition for modular housing. Clarify existing regulations by including modular in the applicable code sections.

NFIP	HUD 4930.3	Analysis
§60.3 (in its entirety)	102-2.C 201-2.B	HUD 4930.3 references FEMA 85 for manufactured homes on elevated foundations, and provides that homes on elevated foundations must comply with the requirements of NFIP. Therefore, there is no incompatibility.

Recommendation: None.

NFIP	HUD 4930.3	Analysis
§60.3(b)(8)	402-3.C	NFIP requires methods of anchoring in Zone A that are in addition to applicable state and local requirements for wind loading. HUD 4930.3 states that in hurricane zones or where severe wind pressures occur, special treatment may be required, such as foundations that resist greater uplift, more deeply buried foundations, or strengthened home-to-foundation connection.

Recommendation: None.

1989 CABO Appendix C [CABO App. C]

National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification) [NFIP]

Appendix C of the 1989 CABO One and Two Family Dwelling Code applies to the construction, alteration, and repair of foundation systems and building equipment for manufactured homes installed on privately owned (nonrental) lots.

NFIP	CABO App. C	Analysis
§59.1	C-201	The definitions in NFIP and CABO App. C are compatible.

Recommendation: None.

NFIP	CABO App. C	Analysis
§60.3		CABO App. C does not contain any special provisions for the installation of manufactured homes in flood hazard areas.

Recommendation: CABO Appendix C should be revised to include a reference to the NFIP for manufactured home installation in flood hazard areas.

Suggested Code Change [or addition]: Add to Appendix C Section C-101 - Scope, last §, last sentence: Refer to National Flood Insurance Program for installations in flood hazard areas.

National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification) [NFIP]

The MHI Model Manufactured Home Installation Manual is intended as a guide to manufacturers in the preparation of the specific installation instructions that are required under Federal law to accompany the shipment of the homes. The preface to the manual further states that the manual provides a suggested outline and format for manufacturers' installation manuals rather than specific requirements.

NFIP	MHI-MIM	Analysis
§59.1	Chapter 2	The definitions in NFIP and MHI-MIM are not incompatible.

Recommendation: None

NFIP	MHI-MIM	Analysis
§60.3 (in its entirety)	4.4.1, 4.5.4, 5.4.3.3	The MHI-MIM recommends against siting a manufactured home in riverine or coastal flood-prone areas. It further states that special local regulations or flood insurance provisions may apply, and that special elevation and anchoring are required in flood-prone areas. A registered professional or structural engineer is to be consulted to ensure conformance to applicable federal, state, and local regulations. FEMA 85, "Manufactured Home Installation in Flood Hazard Areas," is also referenced in MHI-MIM. By referencing FEMA 85, MHI-MIM is compatible with NFIP.

Recommendation: None

NFIP	MHI-MIM	Analysis
§60.3(b)(8)	5.4.3.3	NFIP requires that homes placed within Zone A be anchored to resist flotation, collapse, or lateral movement, in addition to state and local requirements for wind loading. The MHI-MIM states that unconventional anchorage and tiedowns may be required in flood-prone areas.

Recommendation: None.

NFPA 501A-1987, Manufactured Home Installations [NFPA 501A]

National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification) [NFIP]

NFPA 501A-1987 covers the firesafety requirements for the installation of manufactured home and home sites. In essence, this standard includes specific requirements for fuel supply piping. The definitions in NFIP Section 59.1 have been compared with those in NFPA 501A and found to be compatible.

NFIP	NFPA 501A	Analysis
§60.3 (in its entirety)	4-2.3	Section 4-2.3 of NFPA 501A requires that manufactured home installations, including the support system and utility and structural connections, be compliant with the manufacturer's instructions or the authority having jurisdiction. Support system design is to consider the climatic and geological conditions present at the home site. There is no incompatibility with NFIP.

Recommendation: None.

National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification) [NFIP]

The ANSI A225.1 Manufactured Home Installations Standard is intended to be adopted by jurisdictions having responsibility for the safety and health of manufactured home users and for establishing regulations applicable to manufactured home communities. These standards are applicable to single family dwelling units that are built in accordance with the HUD Manufactured Home Construction and Safety Standards (MHCSS), which require that the manufacturer of the home provide instructions for site installation using at least one system of support and anchorage that can resist the design dead, live, and wind loads.

NFIP	A225.1	Analysis
§59.1	1-3	The definitions in the NFIP and A225.1 are generally in agreement and therefore compatible.

Recommendation: None.

NFIP	A225.1	Analysis
§60.3(in its entirety)	App. G	Appendix G of A225.1 refers to the National Flood Insurance Program. However, it is stated that Appendix G is not part of the requirements of A225.1 but rather is included only as information.

Recommendation: None.

NFIP	A225.1	Analysis
§60.3(b)(8)	1-2.2	NFIP requires methods of anchoring in Zone A that are in addition to state and local requirements for wind loading. A225.1 states that it does not relieve the installer of a manufactured home of responsibility for compliance with manufacturer's instructions and any state and local ordinances, codes, or regulations. There is no incompatibility.

Recommendation: None.

NFIP	A225.1	Analysis
§60.3(c)(12)(ii)	2-6.1.3	NFIP requires that homes placed in an existing park or subdivision in Zones A1-30, AH, or AE have the lowest floor at or above BFE or supported by piers or other foundation elements at least 36 in. above grade. A225.1 requires that a foundation system that places the bottom of the main frame members more than 3 ft. above ground be designed by registered engineer or architect and be approved by local authority having jurisdiction. No incompatibility exists.

Recommendation: None.

Retrofitting Flood Prone Residential Structures [FEMA 114]

The HUD Manufactured Home Construction and Safety Standards (MHCSS) are performance requirements for the construction of factory-built single family dwelling units that are transportable in one or more sections. This standard requires that the manufacturer of the home provide instructions for the site installation using at least one system of support and anchorage that can resist the design dead, live, and wind loads. The MHCSS does not include provisions for flood loads.

The requirement that the manufacturer provide one installation instruction system is the only installation implication of this standard; it does not cover installation details. Therefore, many of the site retrofit issues of FEMA 114 are topically out of range of the HUD MHCSS, and thus a direct comparison of those provisions is not applicable. After review, the FEMA 114 sections for which comparisons were not made are as follows:

3.3	Foundation Walls	8.2	Sealants considerations
3.14	Open foundations technical design	8.3	Sealing techniques
3.5	Extended foundation walls	8.4	Sealing closures
6.2	Floodwalls considerations	8.5	Sealing design details
6.3	Floodwalls construction techniques	8.7	Sealing technical design
6.5	Floodwalls technical design criteria	9.4	Utilities permanent protection
7.2	Closures considerations	9.8	Utilities tank anchorage
7.3	Closures low profile permanent	C.1	Hydrostatic loads
7.4	Closures materials and construction	C.2	Hydrodynamic loads
7.6	Closures technical design criteria	C.3	Impact Loads

Comparisons and analysis for applicable sections of FEMA 114 are as follows:

FEMA 114		MHCSS	Analysis
3.12	Technical design criteria – Extended wall foundations	§3280.305(c)	Section 3.12 of FEMA 114 refers to Appendix C for design loads, which in turn refers to the three model building codes for determination of wind loading characteristics. The wind design data presented in Appendix C is not necessarily in agreement with the wind design criteria in §3280.305(c) of the MHCSS. While §3280.305(c)(2)(ii) states that HUD may establish more stringent requirements in areas with 125 mph and greater recorded wind velocity, HUD has not been known to establish more stringent requirements than those specified in §3280.305(c) [25 psf lateral, 15 psf uplift].

Recommendation: Further research/study is recommended to determine: a) if the wind design criteria in MHCSS is adequate for areas of high wind velocity; and/or b) if stronger recommendations against siting such homes in flood prone areas are in order. This study should be undertaken by HUD and the manufactured housing industry.

FEMA 114		MHCSS	Analysis
3.13	Technical design criteria – Anchorage of superstructure to foundation	§3280.305(c)	Section 3.13 of FEMA 114 covers the importance of the floor diaphragm in maintaining the stability of the foundation walls and cautions against using connections that pull out if the underside of the floor is subjected to upward hydrostatic forces. Hydrostatic forces are not covered in the HUD MHCSS. However, Zone II (hurricane) homes when designed in accordance with §3280.305(c) are connected to the steel frame - chassis so as to sustain 15 psf uplift. (Caution, this is not sufficient for hydrostatic pressures in excess of 3" water column.)

Recommendation: FEMA research on the effects of hydrostatic pressure on manufactured homes has resulted in the requirement to elevate above BFE. If HUD and the manufactured housing industry were to embark on a program to set construction standards for homes sited in flood prone areas, a method of certification similar to the wind zone map and label used in the present MHCSS needs to be devised to provide notice on the homes that identifies the flood intensity for which the home is constructed.

FEMA 114		MHCSS	Analysis
9.5	Utility relocations to existing space		Not applicable. Water heaters and furnaces are installed on the main floor. Relocation of utilities in a manufactured home is generally not recommended. If undertaken at all, it is at great risk of violating the standards for fuel pipe sizing and testing, air duct sizing, etc., and is generally not economical.

Recommendation: None.

FEMA 114		MHCSS	Analysis
10.4	Floating structures	§3280.306(a)	Section 10.4 of FEMA 114 describes a system of floats and collars that control the buoyant movement of the structure that can be used in areas of low wind and/or water velocity. The HUD MHCSS requires that each home have provisions for support and anchoring to resist overturning and lateral movement as imposed by the respective design loads.

Recommendation: None, since FEMA 114, Section 10.4, does not apply to manufactured homes.

FEMA 114		MHCSS	Analysis
C.4	Wind loads	§3280.305(c)(1) and (2)	MHCSS specifies that the wind design forces for homes designated for Zone I, non-hurricane, shall be 15 psf lateral and 9 psf uplift, and the wind design forces for Zone II, hurricane, shall be 25 psf lateral and 15 psf uplift. In FEMA 114, wind zones are delineated in wind velocities (mph) according to the ANSI A58.1 map for 50-year recurrence. When applying the formulas from ANSI A58.1, the resulting wind pressures in high wind zones may exceed the MHCSS minimum pressures. §3280.305(c)(2)(ii) states that HUD may establish more stringent requirements than those specified in §3280.305(c) for areas with 125 mph and greater wind velocities.

Recommendation: Further research/study is recommended to determine: a) if the wind design criteria in MHCSS is adequate for areas of high wind velocity; and/or b) if stronger recommendations against siting such homes in flood prone areas are in order. This study should be undertaken by HUD and the manufactured housing industry.

Retrofitting Flood-Prone Residential Structures [FEMA 114]

The HUD Permanent Foundations Guide provides design methods and data for site installation of factory-built single family dwelling units that are transportable in one or more sections. These are considered manufactured homes built in accordance with the HUD MHCSS.

Inasmuch as the HUD MHCSS does not provide at all for site retrofit of manufactured homes, and because the emphasis of the handbook, HUD 4930.3, is directed toward windstorm resistance, many of the issues of FEMA 114 are topically out of range of the handbook and thus a direct comparison of the provisions made for those issues is not applicable. After review, the FEMA 114 sections for which comparisons with HUD 4930.3 were not made are as follows:

3.3	Foundation Walls	8.3	Sealing techniques
6.3	Floodwalls construction techniques	8.4	Sealing closures
6.5	Floodwalls technical design criteria	8.5	Sealing design details
7.2	Closures considerations	8.7	Sealing technical design
7.3	Closures low profile permanent	9.8	Utilities tank anchorage
7.4	Closures materials and construction	C.1	Hydrostatic loads
7.6	Closures technical design criteria	C.2	Hydrodynamic loads
8.2	Sealants considerations	C.3	Impact Loads

Comparisons and analysis for applicable sections of FEMA 114 are as follows:

FEMA 114		HUD 4930.3	Analysis
3.5	Extended foundation walls	102-2.C Standards	HUD 4930.3 references FEMA 85 for manufactured homes on elevated foundations.
		201-2.B	HUD 4930.3 provides that homes built on elevated foundations must comply with requirements of the NFIP and to refer to FEMA 85 for Manufactured Home Installation in Flood-Hazard Areas.
		402	Chapter 4 in HUD 4930.3 makes no provision for the application of hydrostatic, hydrodynamic, or impact loads.

Recommendation: Since provision is made for coastal wind forces in Section 402.3 of HUD 4930.3, it is advisable to include in HUD 4930.3 either complete design provisions for flooding, or a notice that additional lateral, hydrostatic, hydrodynamic, and impact loads need to be included for foundation walls subjected to flooding.

Suggested Change [or addition]: (a) Change §201-2.B.2 to read: "Homes built on elevated foundations in communities that are part of the National Flood Insurance Program (NFIP) must comply with the NFIP."

(b) Change §402-3.B to add item #3: If the site is in a floodplain, hydrostatic, hydrodynamic, and impact loads must be considered. Refer to FEMA 85 for guidance.

FEMA 114		HUD 4930.3	Analysis
3.12	Technical design criteria – Extended wall foundations	App. H12	The Wind Speed Map, H-12, in HUD 4930.3 corresponds with the 50-year mean recurrence map in Figure C-5b of FEMA 114.
		App. H1	The Flood Map, H-1, in HUD 4930.3 does not provide any provisions for hydrostatic, hydrodynamic, static loads.

Recommendation: On the flood map in HUD 4930.3, it is necessary to include a notice to design for lateral, hydrostatic, hydrodynamic, and impact loads for foundation walls subjected to flooding. Reference to FEMA 85 will suffice.

Suggested Change [or addition]: Revise the Flood Map on Page H-1 to include the following:

Note: 1. Consult with local Building or Planning Office to determine whether home is in the floodplain.
2. See FEMA 85 for recommended hydrostatic, hydrodynamic, and impact loads to be applied to foundation walls subject to flood.

FEMA 114		HUD 4930.3	Analysis
3.13	Technical design criteria – Anchorage of superstructure to foundation	App. B	The designs in HUD 4930.3 are apparently to resist wind and gravity loads only. No provision has been made for buoyancy. The loads given for vertical uplift in Table B-2 of HUD 4930.3 would be ample for approximately 1.7′ water depth above the top of the foundation.

Recommendation: Include a notice in Appendix B, Table B1 of HUD 4930.3 that additional anchorage may be required in areas subject to flooding in order to resist hydrostatic, hydrodynamic, and impact loads.

Suggested Change [or addition]: Provide a note at the end of the first paragraph in Appendix B:

Note: Additional anchorage may be required to resist hydrostatic, hydrodynamic, and impact loads in areas subject to flooding. Refer to FEMA 85.

FEMA 114		HUD 4930.3	Analysis
3.14	Technical design criteria – Open foundations	203	HUD 4930.2 identifies "unstable clays" as a possible cause for foundation instability, while the FEMA 114 favors clay soils for their resistance to scouring. These provisions are incompatible.

Recommendation: Further research/study is recommended to reconcile the limits for foundations in clay soil. This study should be undertaken in a collaborative effort by HUD, FEMA, and the manufactured housing industry.

FEMA 114		HUD 4930.3	Analysis
6.2	Considerations	301-1	The provision in HUD 4930.3, "provide the best available routing of run-off water to assure that buildings or other important facilities will not be endangered by the path of a major emergency flood run-off which would occur if the site storm drainage is exceeded," does not provide notice that this might require the use of flood walls. FEMA 114 discusses the fact that flood wall design is dependent upon the type of flooding expected.

Recommendation: In HUD 4930.3, Section 301-1, include a statement that adequate flood walls provide one way to accomplish the rerouting of run-off water.

Suggested Change [or addition]: Add a sentence to the end of §301-1:

One way to accomplish rerouting of run-off water in retrofitting is to use flood walls. Refer to FEMA 114 for examples.

Note: Flood walls are not acceptable for new installations.

FEMA 114		HUD 4930.3	Analysis
9.4	Permanent protective measures	Chapter 7	There is no provision in HUD 4930.3 for flood protection of utilities. The overall emphasis of this publication is on structural aspects. The scope of Chapter 7 (Final Check) is limited to foundation design.

Recommendation: In HUD 4930.3, refer to FEMA 85 for home installations in flood-prone areas in order to provide protection of utilities.

Suggested Change [or addition]: Add a Section 7004:

700-4 Flood Protection of Utilities

For homes subject to flooding, verify that provisions have been made in the design to protect utilities. Refer to FEMA 85 for methods.

FEMA 114	HUD 4930.3	Analysis
9.5 Utility relocations to existing space		Not applicable. Water heaters and furnaces are installed on the main floor. Relocation of utilities in a manufactured home is generally not recommended. If undertaken at all, it is at great risk of violating the standards for fuel pipe sizing and testing, air duct sizing, etc., and is generally not economical.

Recommendation: None.

FEMA 114	HUD 4930.3	Analysis
10.4 Floating structures		HUD 4930.3 contains no provisions for floating structures.

Recommendation: None, since FEMA 114, Section 10.4, does not apply to manufactured homes.

FEMA 114	HUD 4930.3	Analysis
C.4 Wind loads	402-3, App. H-12	Provision is made in the design charts of HUD 4930.3 for coastal and inland wind loads. The wind velocity map presented in Appendix H-12 conforms with the 50-year recurrence map published in FEMA 114.

Recommendation: None.

Retrofitting Flood-Prone Residential Structures [FEMA 114]

Appendix C of the 1989 CABO One and Two Family Dwelling Code applies to the construction, alteration and repair of foundation systems and building service equipment for manufactured homes installed on privately-owned (nonrental) lots. It does not apply to the design or construction of manufactured homes themselves. Homes built subsequent to June 14, 1976, are required to conform with Federal Manufactured Home Construction and Safety Standards (MHCSS). Others are required to be labeled certifying compliance with NFPA 501/ANSI 119.1. Modifications to the homes themselves are applicable only if they are otherwise not prohibited.

In its application to existing homes and service equipment, CABO Appendix C provides different directions depending upon whether the retrofit is an addition, or an alteration, or a repair. Retrofits classified as additions are required to conform with one of the following:

- Certification under the National Manufactured Housing Construction and Safety Standards Act of 1974.
- Design and construction per the applicable provisions of the National Manufactured Housing Construction and Safety Standards Act of 1974.
- Design and construction per the codes adopted by the local jurisdiction.

Alterations or repairs may be made to any manufactured home or to its building service equipment without requiring the existing manufactured home or its building service equipment to comply with other provisions in CABO provided the alteration or repair conforms to that required for new construction, and provided that no hazard to life, health, or safety will be created by the additions alterations or repairs. Nonstructural alterations or repairs that do not adversely affect any structural member can be made using material equivalent to the materials used in the manufacture of the home subject to approval of the authority having jurisdiction.

The requirement that the manufacturer provide one installation instruction system is the only installation implication of the HUD MHCSS. This standard does not cover installation details. Therefore, many of the site retrofit issues of FEMA 114 are topically not applicable to HUD MHCSS, and consequently, to the extent that CABO relies directly on the HUD Standard, not applicable to CABO. Thus a direct comparison of those provisions is not applicable. After review, the FEMA 114 sections for which comparisons were not made are as follows:

6.2 Floodwalls considerations	8.3 Sealing techniques
6.3 Floodwalls construction techniques	8.4 Sealing closures
6.5 Floodwalls technical design criteria	8.5 Sealing design details
7.2 Closures considerations	8.7 Sealing technical design
7.3 Closures low profile permanent	9.4 Utilities permanent protection
7.4 Closures materials and construction	C.1 Hydrostatic loads
7.6 Closures technical design criteria	C.2 Hydrodynamic loads
8.2 Sealants considerations	C.3 Impact Loads

Comparisons and analysis for applicable sections of FEMA 114 are as follows:

FEMA 114	CABO App. C	Analysis
3.5 Extended foundation walls	C-503.2	Appendix C itself does not cover foundation walls; however Section C-503.2 refers to other provisions in CABO by stating that retaining walls used as permanent perimeter enclosure must conform to the code provisions for foundation walls. Section R-304, Foundation Walls, prescribes specific designs for masonry, concrete and stone foundation walls. [Reference Tables R-304.3a, 3b.] None of the prescribed designs in the CABO Tables are usable to resist hydrostatic, hydrodynamic, or impact loads specified in FEMA 114. Hydraulic venting of the foundations, as provided in FEMA 114, is not specified in CABO. R-304.5 in CABO prescribes all wood foundation wall designs. The comparisons noted above are applicable.

Recommendation: Clarification is needed for the CABO tables to state that designs subject to flood loads require special consideration for such loads that have not been accommodated in the tabulated designs.

Suggested Code Change [or addition]: Add a sentence to the end of §R-304.4:

R-304.4 Design required: . . . accepted engineering practices. Note that designs subject to flood loads require special consideration. Flood loads have not been accommodated in the designs in Tables R-304.3a and R-304.3b.

FEMA 114	CABO App. C	Analysis
3.12 Technical design criteria – Extended wall foundations		While CABO Appendix C is generally not applicable to foundation design, the wind design data presented in Appendix A of CABO is in general agreement with the wind design criteria in Appendix C of FEMA 114, to which Section 3.12 refers.

Recommendation: None.

FEMA 114	CABO App. C	Analysis
3.13 Technical design criteria – Anchorage of superstructure to foundation	C-605	CABO C-605 requires that "wood floor support systems shall be fixed to perimeter foundations in accordance with this code." CABO Figure R-303 specifies the anchorage of sill plates to concrete foundations using ½"ϕ bolts, 6' o.c. maximum. CABO Table R-402.3a specifies joists secured to sills using 3-8d nails, toe nailed. No provision is made to resist hydrostatic lift-off of the floor.

Recommendation: Clarification is needed in CABO C-605 that additional anchorage may be needed to resist hydrostatic lift in flood-prone areas. Reference to FEMA 85 may suffice.

Suggested Code Change [or addition]: In §C-605, add a sentence that follows the second sentence in the second paragraph:

. . . resist the wind load stated in this code. Note that additional anchorage is needed to resist buoyancy due to flooding in those areas where applicable.

FEMA 114	CABO App. C	Analysis
3.14 Technical design criteria – Open foundations	C-602, C-603, C604, C-605	CABO C-602 (Pier Construction) specifically excludes lateral wind and earthquake loads from consideration in the application of the piers specified in this code. Note that the typical manufactured housing foundation system uses diagonal ties that are secured to ground anchors for lateral load resistance. CABO C-603 (Height of Piers) specifies construction details for three height ranges of pier application. Each of these designs is to be used with the anchors and ties specified in Sections C-604 and C-605 respectively. The reliability of ground anchors in flooded soils has not been demonstrated. It would be prudent at this time to specifically disallow their use in the flood plains.

Recommendation: Clarification is needed in CABO to caution that the ground anchor system specified is generally not rated for flooding or for high open foundations.

Suggested Code Change [or addition]: At the end of §C-604.1, add: The use of ground anchors is permitted in the flood plain when substantiating data are provided that satisfy the authority having jurisdiction.

FEMA 114	CABO App. C	Analysis
9.5 Utility relocations to existing space		Not applicable. Water heaters and furnaces are installed on the main floor of manufactured housing. Relocation of utilities in a manufactured home is generally not recommended. If undertaken at all, it is at risk of violating the Standards for fuel pipe sizing and testing, air duct sizing, etc., and is generally not economical.

Recommendation: None.

FEMA 114	CABO App. C	Analysis
9.8 Storage tank anchorage	M-1914	CABO M-1914 requires that "oil tanks be designed to resist all loads and stresses to which they may be subjected."

Recommendation: None.

FEMA 114	CABO App. C	Analysis
10.4 Floating structures	C-604.1 C-604.2	CABO C-604 requires that the home be anchored to the ground. Utilization of a floating confined, tethered system described in FEMA 114 is a violation of this standard and the HUD MHCSS.

Recommendation: None, since FEMA 114, Section 10.4, does not apply to manufactured homes.

FEMA 114	CABO App. C	Analysis
C.4 Wind loads	C-501.1 Appendix A	CABO C-501 requires that foundations be designed and constructed to sustain loads specified in the CABO code. CABO Appendix A, Wind Probability Map, specifies wind pressures in four zones. No wind velocities and no coefficients are shown. The wind pressures specified in the coastal zone of Florida (Zone IV) is 45 psf lateral load and 32 psf uplift applied normal to the roof surface. Zone III pressures are 34 psf lateral and 32 psf uplift. FEMA 114 refers to the building code requirements that apply within a given jurisdiction. It is assumed that the wind load provisions of these two standards are compatible since FEMA 114 references the three model building codes and the CABO Code is a compilation of data from the three model codes.

Recommendation: None.

Retrofitting Flood-Prone Residential Structures [FEMA 114]

The MHI Model Manufactured Home Installation Manual is intended as a guide to manufacturers in the preparation of the specific installation instructions that are required under Federal law to accompany the shipment of the homes. The Preface to the manual further states that the manual provides a suggested outline and format for manufacturers' installation manuals rather than specific requirements.

Direct comparisons of MHI-MIM with FEMA 114 are not applicable with regard to many of the retrofit provisions because general site work and retrofitting of any kind is outside the scope of MHI-MIM. After review, the FEMA 114 sections for which comparisons were not made are as follows:

- 3.3 Elevation on Foundation Walls
- 6.2 Floodwalls considerations
- 6.3 Floodwalls construction techniques
- 6.5 Floodwalls technical design criteria
- 7.2 Closures considerations
- 7.3 Closures low profile permanent
- 7.4 Closures materials and construction
- 7.6 Closures technical design criteria
- 8.2 Sealants considerations
- 8.3 Sealing techniques
- 8.4 Sealing closures
- 8.5 Sealing design details
- 8.7 Sealing technical design
- 9.4 Utilities permanent protection
- 9.8 Utilities tank anchorage
- C.1 Hydrostatic loads
- C.2 Hydrodynamic loads
- C.3 Impact Loads

Several of the site retrofit provisions of FEMA 114 are technically outside the scope of MHI-MIM due to the exclusionary language of Paragraph 4.4.1 in MHI-MIM which states "XYZ Corporation does not recommend siting your home in river or coastal flood-prone areas. Special local regulations or flood insurance provisions may apply. Special elevation and anchoring techniques are required when locating in a flood-prone area. Consult a registered professional engineer to make sure that home design and construction conform to applicable federal, state and local regulations." Reference is made to FEMA 85, Manufactured Home Installation In Flood Hazard Areas. In the case that some manufacturers may wish to offer manufactured homes that are factory ready for flood hazard retrofit, the applicable comparisons of FEMA and MHI-MIM are as follows:

FEMA 114	MHI-MIM	Analysis
3.5 Extended foundation walls	4.4.1	MHI-MIM recommends that homes not be sited in flood-prone areas, and further cites the possibility that special local regulations or flood insurance provisions might apply, and that special elevation and anchoring techniques are required. MIM also references FEMA 85, Manufactured Home Installation in Flood Hazard Areas, and recommends that the homeowner consult with a professional engineer to assure that a home installed in a flood hazard area conforms with applicable federal, state, and local codes and regulations.

Recommendation: None.

FEMA 114	MHI-MIM	Analysis
3.12 Technical design criteria – Extended wall foundations	4-4.2, Figure 5.3	The wind design data in FEMA 114 is not fully in agreement with the wind design criteria in §3280.305(c) of the HUD MHCSS, to which homes installed per MHI-MIM must comply. The MHCSS forms the basis for the wind resistance tiedowns specified in the MIM. While MHCSS §3280.305(c)(2)(ii) states that HUD may establish more stringent requirements in areas with 125 mph and greater recorded wind velocity, HUD has not been known to establish more stringent requirements than those specified in §3280.305(c) [25 psf lateral, 15 psf vertical uplift]. MIM refers to HUD Handbook 4930.3 (1989). This has the effect of imposing a more severe design load on the foundations and the foundation to home connections than is required for the homes themselves. (110 mph vs. 88 mph wind velocity)

Recommendation: Further research/study is recommended to determine: a) if the wind design criteria in MHCSS is adequate for areas of high wind velocity; and/or b) if stronger recommendations against siting such homes in flood prone areas are in order. This study should be undertaken by HUD and the manufactured housing industry.

FEMA 114	MHI-MIM	Analysis
3.13 Technical design criteria – Anchorage of superstructure to foundation	4.4.1	Generally not applicable. MHI-MIM recommends that homes not be sited in flood-prone areas, and further cites the possibility that special local regulations or flood insurance provisions might apply, and that special elevation and anchoring techniques are required. MIM also references FEMA 85, Manufactured Home Installation in Flood Hazard Areas, and recommends that the homeowner consult with a professional engineer to assure that a home installed in a flood hazard area conforms with applicable federal, state, and local codes and regulations. However, Zone II homes (hurricane) when designed in accordance with MHCSS §3280.305(c) are connected to the steel frame - chassis so as to sustain 15 psf uplift. (Caution, this is not sufficient for hydrostatic pressures in excess of 3" water column.)

Recommendation: Further research/study is recommended to determine: a) if the wind design criteria in MHCSS is adequate for areas of high wind velocity; and/or b) if stronger recommendations against siting such homes in flood prone areas are in order. This study should be undertaken by HUD and the manufactured housing industry.

FEMA 114	MHI-MIM	Analysis
3.14 Technical design criteria – Open foundations	4.4.1	See analysis for "FEMA 14, 3.13" above. Consequently no provisions are made in MHI-MIM for special open foundations.

Recommendation: Further research/study is recommended to determine: a) if the wind design criteria in MHCSS is adequate for areas of high wind velocity; and/or b) if stronger recommendations against siting such homes in flood prone areas are in order. This study should be undertaken by HUD and the manufactured housing industry.

FEMA 114	MHI-MIM	Analysis
9.5 Utility relocations to existing space		Not applicable. Water heaters and furnaces are installed on the main floor. Relocation of utilities in a manufactured home is generally not recommended. If undertaken at all, it is at great risk of violating the standards for fuel pipe sizing and testing, air duct sizing, etc., and is generally not economical.

Recommendation: None.

FEMA 114	MHI-MIM	Analysis
10.4 Floating structures		The MHI-MIM contains no provisions for floating structures.

Recommendation: None, since FEMA 114, Section 10.4, does not apply to manufactured homes.

FEMA 114	MHI-MIM	Analysis
C.4 Wind loads	4.4.2; and ref HUD 4930.3, App. H-13	MIM cautions against installing homes in wind zones more severe than the wind zone indicated on the data plate. It also references HUD Handbook 4930.3, the Wind Speed Map, Appendix H-12, which identifies many Special Wind Regions as well as many coastal areas for which the standard and hurricane wind specifications exceed those found on the Manufactured Home Data plate referred to in the MHI-MIM. §3280.305(c)(2)(ii) of the HUD MHCSS states that HUD may establish more stringent requirements than those specified in §3280.305(c) for areas with 125 mph and greater wind velocities. Presently, HUD has not been known to do so.

Recommendation: Further research is recommended to determine if the Zone II (Hurricane) requirements in MHCSS are adequate or if the ASCE-7 maps should be incorporated. This research should be undertaken by HUD and the manufactured housing industry.

Retrofitting Flood-Prone Residential Structures [FEMA 114]

NFPA 501A-1987 covers the firesafety requirements for the installation of manufactured homes and manufactured home sites. This standard includes only the firesafety portions of the scope previously covered by ANSI A225.1/NFPA 501A. The non-firesafety aspects are published separately as ANSI A225.1. Because NFPA 501A is essentially provisions for fuel supply piping and connections, a direct comparison with the retrofit provisions of FEMA 114 are for the most part not applicable. After review, the FEMA 114 sections for which comparisons were not made are as follows:

3.3 Elevation on Foundation Walls
3.12 Design criteria–wall foundations
3.13 Design criteria–anchorage
3.14 Design criteria–open foundations
6.2 Floodwalls considerations
6.3 Floodwalls construction techniques
6.5 Floodwalls technical design criteria
7.2 Closures considerations
7.3 Closures low profile permanent
7.4 Closures materials and construction
7.6 Closures technical design criteria
8.2 Sealants considerations
8.3 Sealing techniques
8.4 Sealing closures
8.5 Sealing design details
8.7 Sealing technical design
9.4 Utilities permanent protection
9.5 Utility relocations
9.8 Utilities tank anchorage
10.4 Floating structures

Comparisons and analysis of applicable sections of FEMA 114 are as follows:

FEMA 114		NFPA 501A	Analysis
3.5	Extended foundation walls	4-2.3	Section 4-2.3 of NFPA 501A requires that manufactured home installations, including the support system and utility and structural connections, be compliant with the manufacturer's instructions or the authority having jurisdiction. Support system design is to consider the climatic and geological conditions present at the home site. There is no incompatibility with FEMA 114.
C.1	Hydrostatic loads		
C.2	Hydrodynamic loads		
C.3	Impact loads		
C.4	Wind loads		

Recommendation: None.

Retrofitting Flood-Prone Residential Structures [FEMA 114]

The ANSI A225.1 Manufactured Home Installations Standard is intended to be adopted by jurisdictions having responsibility for the safety and health of manufactured home users and for establishing regulations applicable to manufactured home communities. These standards are applicable to single family dwelling units that are built in accordance with the HUD Manufactured Home Construction and Safety Standards (MHCSS), which require that the manufacturer of the home provide instructions for the site installation using at least one system of support and anchorage that can resist the design dead, live, and wind loads.

Some of the site retrofit issues of FEMA 114 are topically out of range of ANSI A225.1. Thus a direct comparison of those provisions is not applicable. After review, the FEMA 114 sections for which comparisons were not made are as follows:

3.3 Foundation Walls
6.2 Floodwalls considerations
6.3 Floodwalls construction techniques
6.5 Floodwalls technical design criteria
7.2 Closures considerations
7.3 Closures low profile permanent
7.4 Closures materials and construction
7.6 Closures technical design criteria
8.2 Sealants considerations
8.3 Sealing techniques
8.4 Sealing closures
8.5 Sealing design details
8.7 Sealing technical design
9.4 Utilities permanent protection
9.5 Utility relocations
9.8 Utilities tank anchorage
C.1 Hydrostatic loads
C.2 Hydrodynamic loads
C.3 Impact Loads

Comparisons and analysis for applicable sections of FEMA 114 are as follows:

FEMA 114	A225.1	Analysis
3.5 Extended foundation walls	2-3.1.2 Appendix G	Criteria are presented for the design and construction of built-up foundation walls in FEMA 114. The foundation walls and floors are required to withstand the added hydrostatic pressures and provision needs to be made for hydrostatic relief by means of vents, 1 si per sf of floor area. Connections from the building to the foundation need to be designed to carry the additional loads. ANSI A225.1, Section 2-3.1.2 (Evaluation), states that "Each site shall be evaluated by the authority having jurisdiction to determine: . . . (c) if such hazards as flood erosion, . . . exist which might impair the use or utility of the property." ANSI A225.1 Appendix G provides information on NFIP. The reader is referred to FEMA for additional information. No reference is made to specific FEMA documents.

Recommendation: None.

FEMA 114	A225.1	Analysis
3.12 Technical design criteria – Extended wall foundations	Appendix B B-4.1	Section 3.12 of FEMA 114 refers to Appendix C therein for design loads. The wind design data presented in Appendix C is not fully in agreement with the wind design criteria in Appendix B of A225.1 since A225.1 applies to homes constructed per the HUD MHCSS. Standard A225.1 provides that the authority having jurisdiction should be consulted to determine whether recurrent wind velocities exceed 90 mph, and that the manufactured homes should be designed for the recurrent wind. Specific data is not provided either for wind or for flooding.

Recommendation: Further research is recommended to determine if the Zone II (Hurricane) requirements in MHCSS are adequate or if the ASCE-7 maps should be incorporated. This research should be undertaken by HUD and the manufactured housing industry.

FEMA 114	A225.1	Analysis
3.13 Technical design criteria – Anchorage of superstructure to foundation		Section 3.13 of FEMA 114 covers the importance of the floor diaphragm in maintaining the stability of the foundation walls and cautions against using connections that pull out if the underside of the floor is subjected to upward hydrostatic forces. This topic is not within the scope of A225.1 since A225.1 does not cover home design and construction. However, Zone II (hurricane) homes when designed in accordance with HUD MHCSS are connected to the steel frame - chassis so as to sustain 15 psf uplift. (Caution, this is not sufficient for hydrostatic pressures in excess of 3" water column.)

Recommendation: Further research/study is recommended to determine: a) if the wind design criteria in MHCSS is adequate for areas of high wind velocity; and/or b) if stronger recommendations against siting such homes in flood prone areas are in order. This study should be undertaken by HUD and the manufactured housing industry.

FEMA 114	A225.1	Analysis
3.14 Technical design criteria - Open foundations	2-5	Section 3.14 of FEMA 114 describes systems of piers, columns, posts, and piles, each of which is required to resist "all facets of loading, including water loads, wind loads, structural dead loads, and design live loads." FEMA's Coastal Construction Manual is referenced for details of pile design. A225.1 does not provide any special foundation designs for flood-prone installations.

Recommendation: ANSI A225.1 needs to be enhanced to reference the NFIP and FEMA 85 within the body of the standard in order to provide guidance for home installations in flood hazard areas.

FEMA 114	A225.1	Analysis
10.4 Floating structures		Section 10.4 of FEMA 114 describes a system of floats and collars that control the buoyant movement of the structure that can be used in areas of low wind and/or water velocity. This method of flood damage abatement is clearly not found in Standard A225.1.

Recommendation: None, since FEMA 114, Section 10.4, does not apply to manufactured homes.

FEMA 114	A225.1	Analysis
C.4 Wind loads	App. B	Appendix C.4 of FEMA 114 presents a general overview of wind design criteria as found in the model building codes published by BOCA, ICBO, and SBCCI. The wind velocity maps for 50 year recurrence and 100 year recurrence are included. Coefficients and methods, however, are not included. Hence, the designer will refer to the building code required by the authority having jurisdiction. The Wind Zone Map in Appendix B of A225.1 is that used in the HUD MHCSS.

Recommendation: Further research is recommended to determine if the Zone II (Hurricane) requirements in MHCSS are adequate or if the ASCE-7 maps should be incorporated. This research should be undertaken by HUD and the manufactured housing industry.

Manufactured Home Installation in Flood Hazard Areas [FEMA 85]

The HUD Manufactured Home Construction and Safety Standards (MHCSS) are performance requirements for the construction of factory-built single family dwelling units that are transportable in one or more sections. This standard requires that the manufacturer of the home provide instructions for the site installation using at least one system of support and anchorage that can resist the design dead, live, and wind loads. The MHCSS does not include provisions for flood loads.

The requirement that the manufacturer provide one installation instruction system is the only installation implication of HUD MHCSS. This standard does not cover installation details, economics, and several other areas addressed in FEMA 85, and thus a direct comparison of those provisions is not applicable. After review, the FEMA 85 provisions for which the comparison was not made are as follows:

pg. 31	Evacuation
Chapter V	Economics
pg. 68	Jacking
Appendix B	Federal and State Contacts
Appendix C	Sources of flood Information

Comparisons and analysis for applicable sections of FEMA 85 are as follows:

FEMA 85		MHCSS	Analysis
pg. 3	Manufactured home characteristics	§3280.2 (a)(16)	FEMA 85 states that manufactured homes can be designed for removal of the steel chassis. Subsequent to the publication of FEMA 85, the Department of Housing and Urban Development has advised manufactured home manufacturers and design approval agencies that the chassis shall not be removed.

Recommendation: Design methodology and construction details in FEMA 85 consider that the chassis remains attached to the home. Therefore, only a revision to clarify that the chassis shall not be removed is appropriate.

FEMA 85		MHCSS	Analysis
pg. 5	Conventional manufactured home installation techniques	§3280.306	FEMA 85 describes typical installation techniques and is consistent with the requirements of the MHCSS.

Recommendation: None.

FEMA 85		MHCSS	Analysis
pg. 8	Effects of flooding	§3280.306	FEMA 85 describes the effects of riverine and coastal flooding on manufactured homes. Flood forces are not currently considered in the MHCSS.

Recommendation: None. Since the MHCSS require that manufacturers supply installation instructions with each home, the issues of elevation and anchoring are outside the scope of the MHCSS.

FEMA 85		MHCSS	Analysis
pg. 11	Regulatory requirements	§3282.11	FEMA 85 describes the NFIP insurance structure and state and local regulations regarding siting manufactured homes in flood hazard areas. The MHCSS do not preempt the authority of states to enact regulations regarding installation of manufactured homes.

Recommendation: None.

FEMA 85		MHCSS	Analysis
pg. 15	Hazards from floods	§3280.2 §3280.306	FEMA 85 defines "hydrostatic," "hydrodynamic," and "debris impact" forces. The section further defines "depth," "velocity," "rate-of-rise," "duration of flooding," "duration of flooding," "frequency of flooding" and "debris load." The MHCSS does not require that the manufactured home or manufactured home foundation resist flood forces. Consequently, MHCSS does not offer any similar definitions.

Recommendation: None. The requirements of the NFIP (and FEMA 85) are not appreciably strengthened by the possible introduction of the aforementioned "flood" definitions into the MHCSS. The current approach of designing the foundation for flood forces and removing the manufactured home structure from "harm's way" appear appropriate. However, the foundation design and structure provided by the manufacturer may perform adequately under no or very low velocity and limited rate-of-rise conditions. Therefore, FEMA 85 could give consideration to clearly defining appropriate parameters and definitions.

FEMA 85		MHCSS	Analysis
pg. 17	Wind hazards	§3280.306 §3280.305 (c)	FEMA 85 and the MHCSS are incompatible. The issue of increased wind pressure at higher elevations is addressed on pg. 46 of FEMA 85.

Recommendation: None.

FEMA 85		MHCSS	Analysis
pg. 19	Elevation on fill	§3280.306	FEMA 85 describes the application of fill, including suggested slopes, minimum distances, etc. to elevate the manufactured home above flood level. The MHCSS does not include any requirements for the foundation design. However, requirements of FEMA 85 are generally consistent with typical specifications provided by the manufacturer in the manufactured home installation manual.

Recommendation: None.

FEMA 85		MHCSS	Analysis
pg. 21	Elevated foundations (piers, posts, horizontal beams)	§3280.306	FEMA 85 provides general and in some instances prescriptive guidelines for the construction of built-up and cast-in-place piers, piles, and bracing. Although not necessarily incompatible with the MHCSS, the MHCSS provides performance criteria for foundations generally without the prescription of construction materials and techniques. Therefore, it is possible for a manufacturer to provide a foundation design that satisfies the MHCSS but may not satisfy FEMA 85.

Recommendation: Prescriptive guidelines in FEMA 85 are generally not incompatible because the typical foundation design provided by the manufacturer does not address flood forces. However, designs provided by the manufacturer may be acceptable for no or very low velocity flood forces but may not satisfy FEMA 85 requirements. Therefore, FEMA 85 should be clarified to describe under what flood conditions the manufacturer's design is acceptable and under what conditions the prescriptive requirements of FEMA 85 should prevail.

FEMA 85		MHCSS	Analysis
pg. 28	Anchoring	§3280.306	FEMA 85 and the MHCSS are not incompatible. The MHCSS sets forth minimum performance requirements for anchor resistance and prescriptive requirements for the strapping material. FEMA 85 describes the typical application of these requirements. However, neither document currently provides a standard to determine the capacity of the anchoring devices. Commonly, the capacity of the anchor is determined in unsaturated soil. It is anticipated that the withdrawal capacity of the anchor will be reduced under flood conditions.

Recommendation: Further research/study is recommended to determine the capacity of anchors and to consider the withdrawal capacity of the anchor under saturated soil conditions. This study should be undertaken in a collaborative effort by HUD, FEMA, and the manufactured housing industry.

FEMA 85		MHCSS	Analysis
pg. 33	Design of elevated foundations	§3280.305 §3280.306	FEMA 85 reiterates the design parameters of the MHCSS. The sections are currently compatible.

Recommendation: None.

FEMA 85		MHCSS	Analysis
pg. 34	Hydrostatic forces	§3280.305 §3280.306	FEMA 85 describes the application of hydrostatic, hydrodynamic, and impact forces on a manufactured home. The MHCSS does not address the application of hydrostatic forces on the floor diaphragm. However, in Zone I and Zone II homes when designed in accordance with §3280.305 (c), floors are connected to the chassis to resist a net uplift force applied to the roof of 9 psf and 15 psf respectively. This design approach does not generally consider the attachment of the floor sheathing to floor joists to resist hydrostatic loads applied to the underside of the home. However, this connection has some limited resistance to these forces as well. The documents are not incompatible in that FEMA 85 states that the only practical design approach is to elevate the unit above flood waters.

Recommendation: None.

FEMA 85		MHCSS	Analysis
pg. 34	Lateral forces	§3280.305 §3280.306	See above comments for hydrostatic forces.

Recommendation: None.

FEMA 85		MHCSS	Analysis
pg. 35	Buoyancy	§3280.305 §3280.306	See above comments for hydrostatic forces.

Recommendation: None.

FEMA 85		MHCSS	Analysis
pg. 36	Hydrodynamic forces	§3280.305 §3280.306	See above comments for hydrostatic forces.

Recommendation: None.

FEMA 85		MHCSS	Analysis
pg. 39	Impact forces	§3280.305 §3280.306	See above comments for hydrostatic forces.

Recommendation: None.

FEMA 85		MHCSS	Analysis
pg. 39	Scour	§3280.305 §3280.306	The MHCSS and FEMA 85 are not incompatible. However, FEMA 85 sets requirements for consideration to scour in the foundation design. The MHCSS do not contain requirements for flood forces.

Recommendation: See above recommendation for elevated foundations (FEMA 85. pg. 21).

FEMA 85		MHCSS	Analysis
pg. 41	Design loads	§3280.305 §3280.306	FEMA 85 wind, roof, and floor live and dead loads are consistent with the requirements of the MHCSS. However, FEMA 85 also restates design considerations for flood forces. (See also analysis for hydrostatic forces.)

Recommendation: None.

FEMA 85		MHCSS	Analysis
pg. 45	Evaluation of elevated foundations	§3280.305 §3280.306	FEMA 85 describes maximum water velocity as a function of the angle of the support strap and height of flood water above the floor and concludes that elevation is the "optimum strategy." Such analysis is based on typical construction techniques used in manufactured housing. The MHCSS does not require the manufacturer to design the home or foundation for flood forces. (See also analysis for anchoring, FEMA 85, pg. 28.)

Recommendation: See above recommendation for anchoring (FEMA 85, pg. 28).

FEMA 85		MHCSS	Analysis
pg. 45	Design forces and loads	§3280.305 §3280.306	FEMA 85 restates the design loads of the MHCSS for determination of the vertical member loads. The sections are currently compatible.

Recommendation: None.

FEMA 85		MHCSS	Analysis
pg. 48	Vertical support members (piers)	§3280.305 §3280.306	(a) FEMA 85 provides general and in some instances prescriptive guidelines for the construction of foundation components. Although FEMA 85 is not necessarily incompatible with the MHCSS, the MHCSS provide performance criteria for the design of foundations generally without the prescription of construction materials and techniques. Therefore, it is possible for a manufacturer to provide a foundation design that satisfies the MHCSS but may not satisfy FEMA 85. (b) Additionally, Figure 4.32 in FEMA 85, "Typical Ground Anchor Detail," shows incorrect orientation of the ground anchor. (c) FEMA 85 states, ". . . all pier designs must have the bottom of the footing at least 30 inches below grade or to the frostline, (emphasis added) whichever is greater." The MHCSS does not require placement of the footing below grade. However, it is the manufacturer's general practice to require that footings be placed below the frostline.

Recommendation: (a) Prescriptive guidelines in FEMA 85 are generally not incompatible because the typical foundation design provided by the manufacturer does not address flood forces. However, designs provided by the manufacturer may be acceptable for no or very low velocity flood forces but may not satisfy FEMA 85 requirements. Therefore, FEMA 85 should be clarified to describe under what flood conditions (if any) the manufacturer's design is acceptable and under what conditions the prescriptive requirements of FEMA 85 should prevail.

(b) Provide a revised Figure 4.32 in FEMA 85 with correct orientation of the ground anchor. (See also above recommendation for anchoring, FEMA 85, pg. 28.)

(c) None.

FEMA 85		MHCSS	Analysis
pg. 53	Vertical support members (posts and piles)	§3280.305 §3280.306	FEMA 85 restates the design loads of the MHCSS for determination of the vertical member loads. The sections are currently compatible. (See analysis for vertical support members, FEMA 85, pg. 48.)

Recommendation: See above recommendation for vertical support members (FEMA 85, pg. 48).

FEMA 85		MHCSS	Analysis
pg. 58	Horizontal Support beams	§3280.305 §3280.306	FEMA 85 restates the design loads of the MHCSS for determination of the vertical member loads. The sections are currently compatible. (See analysis for vertical support members, FEMA 85, pg. 48.)

Recommendation: See above recommendation for vertical support members (FEMA 85, pg. 48).

FEMA 85		MHCSS	Analysis
pg. 60	Cross bracing	§3280.305 §3280.306	FEMA 85 restates the design loads of the MHCSS for determination of the vertical member loads. The sections are currently compatible. (See analysis for vertical support members, FEMA 85, pg. 48.)

Recommendation: See above recommendation for vertical support members (FEMA 85, pg. 48).

FEMA 85		MHCSS	Analysis
pg. 62	End bracing	§3280.305 §3280.306	FEMA 85 restates the design loads of the MHCSS for determination of the vertical member loads. The sections are currently compatible. (See analysis for vertical support members, FEMA 85, pg. 48.)

Recommendation: See above recommendation for vertical support members (FEMA 85, pg. 48).

FEMA 85		MHCSS	Analysis
pg. 63	Horizontal beam connections	§3280.305 §3280.306	FEMA 85 restates the design loads of the MHCSS for determination of the vertical member loads. The sections are currently compatible. (See analysis for vertical support members, FEMA 85, pg. 48.)

Recommendation: See above recommendation for vertical support members (FEMA 85, pg. 48).

FEMA 85		MHCSS	Analysis
pg. 64	Chassis I-beam connections	§3280.305 §3280.306	FEMA 85 restates the design loads of the MHCSS for determination of the vertical member loads. The sections are currently compatible. (See analysis for vertical support members, FEMA 85, pg. 48.)

Recommendation: See above recommendation for vertical support members (FEMA 85, pg. 48).

FEMA 85		MHCSS	Analysis
pg. 66	Cross bracing connections	§3280.305 §3280.306	FEMA 85 restates the design loads of the MHCSS for determination of the vertical member loads. The sections are currently compatible. (See analysis for vertical support members, FEMA 85, pg. 48.)

Recommendation: See above recommendation for vertical support members (FEMA 85, pg. 48).

FEMA 85		MHCSS	Analysis
pg. 67	End bracing connections	§3280.305 §3280.306	FEMA 85 restates the design loads of the MHCSS for determination of the vertical member loads. The sections are currently compatible. (See analysis for vertical support members, FEMA 85, pg. 48.)

Recommendation: See above recommendation for vertical support members (FEMA 85, pg. 48).

FEMA 85		MHCSS	Analysis
pg. 67	Longitudinal support beams connections	§3280.305 §3280.306	FEMA 85 restates the design loads of the MHCSS for determination of the vertical member loads. The sections are currently compatible. (See analysis for vertical support members, FEMA 85, pg. 48.)

Recommendation: See above recommendation for vertical support members (FEMA 85, pg. 48).

FEMA 85		MHCSS	Analysis
pg. 69	Utility service	§3282.11 §3282.1 Subpart H Subpart I	FEMA 85 requires that utilities be placed in waterproofed risers adjacent to down stream foundation members. The MHCSS do not contain requirements for protection of utilities where they connect to the structure.

Recommendation: None. The MHCSS do not preempt utility service protective measures.

FEMA 85		MHCSS	Analysis
pg. 69	Mechanical systems	§3282.11 §3282.1	FEMA 85 requires that external equipment be elevated above anticipated flooding. The MHCSS do not contain requirements for elevating exterior mechanical systems above the base flood elevation.

Recommendation: None. The MHCSS do not preempt external mechanical equipment elevation.

FEMA 85		MHCSS	Analysis
pg. 70	Access and egress	§3280.105 §3280.106	The MHCSS requires that each home be provided with two exterior exit doors located remote from each other and each sleeping room be provided with an egress window. FEMA 85 requires that "a clear access and egress path to the manufactured home be provided . . . ." FEMA 85 and the MHCSS are not incompatible. However, elevation of a structure by its very nature will reduce the ease with which egress may be provided from the structure.

Recommendation: None.

FEMA 85		MHCSS	Analysis
Appendix D	Calculation procedures for elevated foundation design	§3280.306	MHCSS requires that the design wind loads be increased by a safety factory of 1.5 when used in calculating resistance to overturning and lateral movement. Additionally, the MHCSS does not permit the allowable stresses of materials required to resist such loads to be increased. Otherwise, MHCSS permits any calculation methods to be used in structural analysis, provided it is in accordance with accepted engineering practice. Therefore, except as described above, the design methodologies presented in FEMA 85 Appendix D to determine various loads are compatible with MHCSS requirements.

Recommendation: Although installations of manufactured homes are not preempted by MHCSS, FEMA 85 should be revised to include the 1.5 safety factor in its design methodologies. It should also prohibit any increases to the basic allowable stresses of materials required to resist overturning and lateral movement due to wind loads. Certain tables in FEMA 85 Chapter IV that are based on these design methodologies may also need to be revised.

FEMA 85	MHCSS	Analysis
Appendix E Buoyancy and drag forces	§3280.306	FEMA 85 and MHCSS are not incompatible since the ties designed to resist buoyancy and drag forces are in addition to any ties required for wind anchorage. As previously stated, MHCSS does not address "flood forces." However, MHCSS does require that wind anchoring equipment be capable of resisting a minimum allowable working load of 3150 pounds. FEMA 85 tables and calculations are based on a working load of 2200 pounds.

Recommendation: Tables in FEMA 85 for spacing of ground anchors should be based on ground anchors with a minimum allowable working load of 3150 pounds rather than 2200 pounds.

FEMA 85	MHCSS	Analysis
Appendix F Design worksheet	§3280.306	MHCSS requires that the design wind loads be increased by a safety factor of 1.5 when used in calculating resistance to overturning and lateral movement. Additionally, MHCSS does not permit the allowable stresses of materials required to resist such loads to be increased.

Recommendation: Although installation of manufactured homes are not preempted by MHCSS, FEMA 85 should be revised to include the 1.5 safety factor in its design methodologies. It should also prohibit any increases to the basic allowable stresses of materials required to resist overturning and lateral movement due to wind loads. Certain tables in FEMA 85 Chapter IV that are based on these design methodologies may also have to be revised.

Manufactured Home Installation in Flood Hazard Areas [FEMA 85]

The HUD Permanent Foundations Guide provides design methods and data for site installation of factory-built single family dwelling units that are transportable in one or more sections. These are considered manufactured homes built in accordance with the HUD MCHSS.

FEMA 85		HUD 4930.3	Analysis
pg. 3	Manufactured home characteristics	100-1. and 100-2	FEMA 85 and HUD 4930.3 describe the same general features.

Recommendation: None.

FEMA 85		HUD 4930.3	Analysis
pg. 5	Conventional manufactured home installation techniques	Figure 1.13	FEMA 85 explains that the installation instructions supplied with the home normally do not provide for resistance to loading caused by flooding. HUD Handbook 4930.3 is for permanent foundations, and flooding loads are not provided for. Figure 1.13, Type 2 Tie Down in FEMA 85 depicts an unstable wind resistance system.

Recommendation: This section of FEMA 85 should be clarified to point to specific flood load remedies elsewhere in the document. Figure 1.13 should carry a notice that the method depicted is not stable and is not recommended for any loading – flood or not.

FEMA 85		HUD 4930.3	Analysis
pg. 8	Effects of flooding	201-2	HUD 4930.1 does not provide design loads or procedures for homes in flood-prone sites. References are made to FEMA 85, NFIP, and HUD Handbooks 4135.2 and 4145.1.

Recommendation: None.

FEMA 85		HUD 4930.3	Analysis
pg. 11	Regulatory requirements		FEMA 85 explains how the NFIP works together with state and local jurisdictions. HUD 4930.3 apparently is intended to be used to assist HUD field offices in making determinations of whether or not homes have been installed on permanent foundations, and therefore contains no regulatory requirements.

Recommendation: None.

FEMA 85		HUD 4930.3	Analysis
pp. 15-18	Flood and wind hazards	201-2	HUD 4930.3 does not provide loads or design methods to abate damages from floods; rather, it refers to FEMA 85 for that purpose.

Recommendation: None.

FEMA 85		HUD 4930.3	Analysis
pg. 17	Wind hazards	402-3.C	HUD 4930.3 does not provide for the resistance of severe hurricane wind loads. It refers to the Institute for Disaster Research publication, Mobile Homes in Windstorms. FEMA 85 refers to the MHCSS wind force requirements. The statement on Page 18 of FEMA 85, "wind and flood forces can be additive, thereby taxing the structure, its foundation system, and any anchoring mechanisms," does not appear to be a true statement. It seems that it would be reasonable to design each component individually for wind and for flood, using whichever load produces the more critical design for the component.

Recommendation: Revise the statement on page 18 of FEMA 85 in accordance with the analysis above.

FEMA 85		HUD 4930.3	Analysis
pg. 19	Elevation on fill	303-2	FEMA 85 limits the flood velocity in accordance with the fill materials and fill cover selected. HUD 4930.3 requires that fill be engineered to 90% in accordance with ASTM D1557, Modified Proctor Test. There is no incompatibility.

Recommendation: None.

FEMA 85		HUD 4930.3	Analysis
pg. 21	Elevated foundations	402	While the design methods and design loads provided in HUD 4930.3 would be applicable to elevated foundations, the handbook does not provide the hydrostatic, hydrodynamic and impact loads. HUD 4930.3 references FEMA 85.

Recommendation: None.

FEMA 85		HUD 4930.3	Analysis
pg. 28	Anchoring	A-6 Note №1	FEMA 85 does not discourage the use of auger type ground anchors. HUD 4930.3 requires anchorage into concrete.

Recommendation: FEMA 85 should disallow ground anchors in flood-prone installations.

FEMA 85		HUD 4930.3	Analysis
pg. 31	Evacuation techniques	602	FEMA 85 proposes that evacuation using quick disconnect from foundations is a practicable strategy. HUD 4930.3 requires permanent foundations and attachment thereto. The two approaches are not reconcilable into one standard.

Recommendation: FEMA 85 should be changed to prohibit such quick disconnects, unless further study suggests that manufactured housing be factory-prepared for floating.

FEMA 85		HUD 4930.3	Analysis
pg. 33	Design of elevated foundations	402-2, 402-3	FEMA 85 relies on the HUD MHCSS for roof live loads and wind loads. HUD 4930.3 recommends snow and wind loads from ANSI A58.1-1982.

Recommendation: While the manufactured homes built to the HUD MHCSS have generally less conservative design values for wind and snow loads than recommended in ANSI A58.1, FEMA 85 should consider requiring that the foundation designs be made using the snow and wind loads of ANSI A58.1 as in the HUD 4930.3, even though this introduces an inconsistency with foundations designed for one set of loads and the foundation designed for another.

FEMA 85		HUD 4930.3	Analysis
pp. 34-40	Flood forces and their application	201-2	HUD 4930.3 does not provide design data or methods for homes in flood sites. It refers to FEMA Flood Maps, HUD Handbooks 4135.1, 4145.1 and the requirements of the NFIP.

Recommendation: None.

FEMA 85		HUD 4930.3	Analysis
pp. 41-42	Design loads	402.2, 402.3	FEMA 85 provides design charts for dead load, live load, snow load, and wind load calculations. The charts use snow and wind loads from the HUD MHCSS. [Homes manufactured since 1976 under the HUD Standards are themselves certified to those loads.] HUD 4930.3 uses ANSI A58.1-1982 for snow and wind loads.

Recommendation: Revise FEMA 85 and HUD MHCSS to incorporate ANSI A58.1 snow and wind loads.

FEMA 85		HUD 4930.3	Analysis
pg. 45	Design forces and loads - Evaluation of elevated foundations		FEMA 85 provides a chart to define limits of effectiveness for ground anchors as a function of water velocity and depth of flood. The accompanying narrative also refers to Appendix E for a discussion of buoyancy, drag and effectiveness of ground anchors in floods. The discussion of buoyancy appears to have overlooked the limits of the connection of the home to the frame. The homes are designed either for 9 psf uplift or 15 psf uplift. This is not sufficient for hydrostatic pressures of more than 7" and 12" ultimate respectively.

Recommendation: The table on pg. 45 of FEMA 85 should either be dropped, or tests should be undertaken to substantiate that ground anchors can perform effectively in saturated soils. Appendix E of FEMA 85 needs to be revised to make provision for the limits of floor-to-frame connections that have been designed according to the wind uplift provisions of the HUD MHCSS. Also it appears that some performance criteria is needed to enable the ground anchor designers, vendors and users to know how to determine whether or not ground anchors can be relied upon.

FEMA 85		HUD 4930.3	Analysis
pp. 47-48	Vertical support members	402.2, 402.3	FEMA 85 provides design charts for dead load, live load, snow load, and wind load calculations. The charts use snow and wind loads from the HUD MHCSS. [Homes manufactured since 1976 under the HUD Standards are themselves certified to those loads.] HUD 4930.3 uses ANSI A58.1-1982 for snow and wind loads.

Recommendation: Revise FEMA 85 and HUD MHCSS to incorporate ANSI A58.1 snow and wind loads.

FEMA 85		HUD 4930.3	Analysis
pg. 48	Piers	App. A	FEMA 85 prescribes designs for piers, and cautions that, due to the likelihood of scouring, pier systems should not be used in areas where flooding velocity is anticipated. Appendix A of HUD 4930.3 recommends Foundation Type C2 [reinforced masonry or concrete piers] for high wind and indicates that engineering design is not required. While the Flood-Prone Sites exclusions provided in Section 201-2 might be sufficient for some designers, it seems prudent that it be repeated in the Appendices.

Recommendation: The design appendices in HUD 4930.3 should repeat the references to the FEMA documents and caution that the designs presented have not taken flood conditions into account.

Suggested Change [or addition]: Add a sentence to Paragraph B, Page A-1: Note that none of the charted designs takes flood loads into account. Refer to FEMA 85 for design loads and procedures.

FEMA 85	HUD 4930.3	Analysis
pp. 53-58 **Posts and Piles**	App. A	FEMA 85 includes provisions for pile foundations with sample load and application charts. HUD 4930.3 lists twelve foundation designs in the Foundation Selection Chart in Appendix A. Piles are not included. HUD Handbook 4930.3 is not for flood resistant installations.

Recommendation: None.

FEMA 85	HUD 4930.3	Analysis
Appendix E Buoyancy and drag forces		Appendix E in FEMA 85 discusses buoyancy, drag and effectiveness of ground anchors in floods. The discussion of buoyancy appears to have overlooked the limits of the connection of the home to the frame. The homes are designed either for 9 psf uplift or 15 psf uplift. This is not sufficient for hydrostatic pressures of more than 7" and 12" ultimate respectively. The issue of whether or not ground anchors are effective needs to be addressed convincingly.

Recommendation: Appendix E of FEMA 85 needs to be revised to make provision for the limits of floor-to-frame connections that have been designed according to the wind uplift provisions of the HUD MHCSS. Resolve whether or not ground anchors are permitted.

Manufactured Home Installation in Flood Hazard Areas [FEMA 85]

Appendix C of the 1989 CABO One and Two Family Dwelling Code addresses those aspects of manufactured homes not preempted by the HUD Manufactured Home Construction and Safety Standards (MHCSS). This includes the construction of foundation and anchorage systems for the installation of the dwelling unit on a privately-owned (nonrental) lot.

The CABO Code generally covers time-tested construction methods. It does not cover seldom-used systems or performance type systems. The construction methods in CABO also do not take into consideration any special loads such as those imposed by floods. It is suggested that CABO Appendix C reference FEMA 85 in order to cover such special loads as flooding. A direct comparison of certain sections was not made because they were beyond the scope of Appendix C of the CABO One and Two Family Dwelling Code. After review, FEMA 85 sections for which comparisons were not made are as follows:

Chapter I	Overview
Chapter II	Hazards from Floods
Chapter III	Elevation on Fill
Chapter III	Elevated Foundations exc. "Piers"
Chapter III	Evacuation
Chapter IV	A. Flood Forces and Applications exc. "Design Loads"
Chapter IV	C. Bracing Support and Connections
Chapter IV	D. Additional Design Considerations
Chapter V	Economics

Comparisons and analysis for applicable sections of FEMA 85 are as follows:

FEMA 85		CABO App. C	Analysis
Pg. 22	Piers	C-602	FEMA 85 limits the spacing of supporting members to ten feet on center whereas CABO Appendix C permits the spacing to be as specified in the manufacturer's installation instructions.

Recommendation: None.

FEMA 85		CABO App. C	Analysis
Pg. 22	Piers	C-603	FEMA 85 generally limits the height of built-up piers to ten feet or to ten times their least dimension. CABO Appendix C does not set a limit on the height of piers. However, piers constructed in accordance with CABO C-602 are not considered to resist any lateral loads. **Note:** CABO R-404.4 does set a height limit of ten times the least dimension for unsupported masonry piers.

Recommendation: None.

FEMA 85		CABO App. C	Analysis
Pg. 22	Piers	C-502.3	FEMA 85 specifies that built-up piers should be at least 12 in. by 12 in. and be reinforced with four No. 5 steel bars. In CABO, the cross section of a built-up pier may vary from 128 sq. in. to 16 in. by 16 in., depending on the height. Piers designed in accordance with CABO are required to be reinforced with four No. 5 steel bars only if they are over 80 inches in height.

Recommendation: Rather than providing only one option, FEMA 85 should have the section on piers expanded to include a variety of pier constructions as in CABO. Depending on the height requirements needed to elevate the home above the flood level, the installer would then be provided with different pier options.

FEMA 85		CABO App. C	Analysis
Pg. 22	Piers	C-602	a) FEMA 85 requires the bottom of the pier footing to extend a minimum of 30 in. below grade. CABO only requires the footings to extend a minimum of 12 in. below finished grade. Both require the footing to extend below the frost line. b) FEMA 85 requires built-up piers to be laid with type M or S mortar. In addition to types M or S, CABO permits Type N mortar. No incompatibilities.

Recommendations: Since the 30 inch requirement would be excessive for piers located in areas where scouring is not a problem, two separate requirements in FEMA 85 and CABO for minimum pier depths should be made depending on the flow conditions likely to be encountered.

Suggested Code Change [or addition]: In §C-602, add to the last sentence . . . wind, flood pressure, scouring, or earthquake forces.

FEMA 85		CABO App. C	Analysis
Pg. 28	Anchoring	C-604	Unlike FEMA 85, CABO does not prescribe an installation method for ground anchors other than to require that they be installed in accordance with the terms of their listing and the anchor manufacturer's instructions. Listing and labeling of ground anchors presently is a problem because there is no standard for their evaluation. It is desirable that local building officials have available some readily recognizable method to determine compliance.

Recommendation: None.

FEMA 85		CABO App. C	Analysis
Pg. 41 Pg. 45	Design Loads Design Forces and Loads	R-201.2	Design loads specified in FEMA 85 are the same as those in HUD MHCSS whereas the design criteria for CABO is established by the jurisdiction. As a guideline, the tables in FEMA 85 appear to be adequate. Where records or experience indicate significant differences, HUD may establish more stringent requirements.

Recommendation: None.

FEMA 85		CABO App. C	Analysis
Pg. 48	Vertical Support Members - "Piers"	C-603	FEMA 85 pier designs A, B, and C do not meet the minimum cross sectional area – 128 square inches – specified by CABO. Design A is for reinforced concrete and B is for 8" x 12" concrete block. Neither of these piers is included in CABO. These differences can be accommodated.

Recommendation: None.

FEMA 85		CABO App. C	Analysis
Pg. 53	Posts and Piles		CABO generally covers time-tested construction methods. It does not cover seldom-used systems such as posts or pile construction methods. The requirements are compatible as long as it is understood that CABO Appendix C is not applicable to flood loads.

Recommendation: Change CABO Appendix C to clarify that it does not consider flood loads.

Suggested Code Change [or addition]: In §C-602, add to the last sentence . . . wind, flood pressure, scouring, or earthquake forces.

Manufactured Home Installation in Flood Hazard Areas [FEMA 85]

The MHI Manufactured Home Installation Manual is intended to assist manufacturers who are required to design at least one acceptable foundation and anchorage method in accordance with the requirements of the Manufactured Housing Construction and Safety Program (MHCSS). The MHCSS does not include provisions for flood loads.

Section 4.4.1 of the Manufactured Home Installation Manual requires that a homeowner with a home intended to be sited in a flood hazard area consult with a registered professional or a structural engineer to make sure that the foundation design and construction conform to applicable federal, state, and local codes and regulations. FEMA 85 is referenced as a source for construction recommendations. If it is assumed that every home located in a flood hazard area is to follow the recommendations made in FEMA 85, the documents are compatible by the reference alone and no further comparison is warranted.

However, a comparison is provided below in consideration that FEMA 85 may be solely intended to supplement the requirements of the MHI design manual or the consulting engineer's design. The following sections in FEMA 85 were found to be not applicable to the Manufactured Home Installation Manual:

pg. 31	Evacuation
Chapter V	Economics
pg. 53	Vertical support members (posts and piles)
pg. 58	Horizontal Support beams
pg. 60	Cross bracing
pg. 62	End bracing
pg. 62	Connections
pg. 63	Horizontal beam
pg. 66	Cross bracing
pg. 67	End bracing
pg. 68	Jacking
pg. 70	Access and egress
Appendix B	Federal and State Contacts
Appendix C	Sources of flood Information
Appendix D	Calculation procedures for elevated foundation design
Appendix E	Buoyancy and drag forces
Appendix F	Design worksheet

Comparisons and analysis for applicable sections of FEMA 85 are as follows:

FEMA 85		MHI-MIM	Analysis
pg. 3	Manufactured home characteristics	4.3 4.5	FEMA 85 states that manufactured homes can be designed for removal of the steel chassis. Subsequent to the publication of FEMA 85, the Department of Housing and Urban Development has ruled that the chassis shall not be removed. MHI draft manual appears to make no provisions for removal of the chassis.

Recommendation: Design methodology and construction details in FEMA 85 should consider that the chassis remains attached to the home. Therefore, only a revision to clarify that the chassis shall not be removed is appropriate.

FEMA 85		MHI-MIM	Analysis
pg. 5	Conventional manufactured home installation techniques	5.4	FEMA 85 describes typical installation techniques and is consistent with the requirements of the MHI-MIM. It should be noted however, that FEMA 85 pg. 6, Figure 1.13, Type 2 will not provide resistance to overturning loads by the strapping method shown.

Recommendation: Clarify pg. 6, Figure 1.13, Type 2 in FEMA 85 to state that additional fastening to prevent overturning loads is required.

FEMA 85		MHI-MIM	Analysis
pg. 8	Effects of flooding	4.5.4 4.4.1	FEMA 85 describes the effects of riverine and coastal flooding on manufactured homes. Flood forces are not currently considered in MHI-MIM because siting in flood prone areas is not recommended.

Recommendation: None.

FEMA 85		MHI-MIM	Analysis
pg. 11	Regulatory requirements	1.2	FEMA 85 describes the NFIP insurance structure and state and local regulations regarding siting manufactured homes in flood hazard areas. MHI-MIM requires coordination with the authority having jurisdiction.

Recommendation: None.

FEMA 85		MHI-MIM	Analysis
pg. 15	Hazards from floods	4.4.1	FEMA 85 defines "hydrostatic," "hydrodynamic," and "debris impact" forces. The section further defines "depth," "velocity," "rate-of-rise," "duration of flooding," "duration of flooding," "frequency of flooding" and "debris load." MHI-MIM does not require that the manufactured home or manufactured home foundation resist flood forces. Consequently, MHI-MIM does not offer any similar definitions. MIM does not recommend siting in flood prone areas.

Recommendation: The requirements of the NFIP (and FEMA 85) are not appreciably strengthened by the possible introduction of the aforementioned "flood" definitions into MHI-MIM.

FEMA 85		MHI-MIM	Analysis
pg. 17	Wind hazards	4.4.2 5.4 5.4.1 5.4.2	FEMA 85 and MHI-MIM are not incompatible; FEMA 85 reiterates the same lateral and uplift design wind pressures as the MHCSS. The requirements of MHI-MIM are based on the design wind loads in the MHCSS. Please note, however, that Section 5.4 in MHI-MIM states that, ". . . the installer should secure the home against the wind unless the local jurisdiction permits otherwise." (emphasis added) It appears that FEMA 85 requires the anchoring of homes against wind loads under all circumstances.

Recommendation: It is not intended that a participant in the NFIP (i.e., local jurisdiction) would not require that a home not be anchored against wind loads. However, the compatibility of the documents would be enhanced by a revision to MHI Section 5.4 to state that anchorage of the unit against wind forces is always required.

Suggested Change [or addition]: **Change Paragraph 5.4 Anchoring Instructions.** After blocking and leveling, the installer should secure the home to resist the wind forces required in this manual or higher wind forces if required by the authority having jurisdiction.

FEMA 85		MHI-MIM	Analysis
pg. 19	Elevation on fill	3.2 3.3 3.4	FEMA 85 describes the application of fill including suggested slopes, minimum distances, etc. to elevate the manufactured home above flood level. MHI-MIM does not include similar requirements for the foundation design to be provided by the manufacturer. However, requirements of FEMA 85 are generally consistent with typical specifications provided by the manufacturer in the manufactured home installation manual.

Recommendation: None.

FEMA 85		MHI-MIM	Analysis
pg. 21	Elevated foundations (piers, posts, horizontal beams)	4.1 4.2	FEMA 85 provides general and in some instances prescriptive guidelines for the construction of built-up and cast-in-place piers, piles, and bracing. MHI-MIM provides several pier construction methods that are primarily designed to withstand vertical loads. MHI-MIM only requires concrete and reinforcement to be used when the pier height exceeds 80 inches. Additionally, FEMA 85 requires the footing to be a minimum of 30 inches below the frost line. MHI-MIM permits the footing to be located directly on the soil if acceptable to the authority having jurisdiction.

Recommendation: None.

FEMA 85		MHI-MIM	Analysis
pg. 28	Anchoring	5.4	FEMA 85 and MHI-MIM are compatible. FEMA 85 describes the typical application of ground anchor requirements. However, neither document currently provides a standard to determine the capacity of the anchoring devices. Commonly, the capacity of the anchor is determined in unsaturated soil. It is anticipated that the withdrawal capacity of the anchor will be reduced under flood conditions.

Recommendation: Further research/study is recommended to determine the capacity of anchors and to consider the withdrawal capacity of the anchor under saturated soil conditions. This study should be undertaken in a collaborative effort by HUD, FEMA, and the manufactured housing industry.

FEMA 85		MHI-MIM	Analysis
pg. 33	Design of elevated foundations	4.1.3	FEMA 85 reiterates the design parameters of the HUD MHCSS. The tables provided in MHI-MIM are based on roof and wind loads specified in the MHCSS. The sections are currently compatible.

Recommendation: None.

FEMA 85		MHI-MIM	Analysis
pg. 34	Hydrostatic forces	4.4.1 5.4.3	FEMA 85 describes the application of hydrostatic, hydrodynamic, and impact forces on a manufactured home. MHI-MIM recommends that homes to be located in flood-prone areas be designed in accordance with FEMA 85. Manufactured homes designed for Wind Zones I or II are connected to the chassis to resist a net uplift force applied to the roof of 9 psf and 15 psf respectively. This design approach does not generally consider the attachment of the floor sheathing to floor joists to resist hydrostatic loads applied to the underside of the home. However, this connection has some limited resistance to these forces as well. The documents are not incompatible in that FEMA 85 states that the only practical design approach is to elevate the unit above flood waters.

Recommendation: None. The current approach to elevate units above flood waters appears to be appropriate.

FEMA 85		MHI-MIM	Analysis
pg. 34	Lateral forces	5.4.3	See above analysis for "hydrostatic forces."

Recommendation: None.

FEMA 85		MHI-MIM	Analysis
pg. 35	Buoyancy	5.4.3	See above analysis for "hydrostatic forces."

Recommendation: None.

FEMA 85		MHI	Analysis
pg. 36	Hydrodynamic forces	4.4.1 5.4.3	See above analysis for "hydrostatic forces."

Recommendation: None.

FEMA 85		MHI	Analysis
pg. 39	Impact forces	4.4.1 5.4.3	See above analysis for "hydrostatic forces."

Recommendation: None.

FEMA 85		MHI	Analysis
pg. 39	Scour	4.4.1 5.4.3	MHI-MIM and FEMA 85 are not incompatible. However, FEMA 85 sets requirements for consideration to scour in the foundation design. MHI-MIM does not contain requirements for flood forces.

Recommendation: See recommendation for "elevated foundations."

FEMA 85		MHI-MIM	Analysis
pg. 41	Design loads	4.1.3	FEMA 85 and MHI-MIM wind and roof loads are consistent with the requirements of the HUD MHCSS. However, FEMA 85 also restates design considerations for flood forces. (See also analysis for "hydrostatic forces.")

Recommendation: None.

FEMA 85		MHI-MIM	Analysis
pg. 45	Evaluation of elevated foundations	4.4.1 5.4.3.3	FEMA 85 describes maximum water velocity as a function of the angle of the support strap and height of flood water above the floor and concludes that elevation is the "optimum strategy." Such analysis is based on typical construction techniques used in manufactured housing. MHI-MIM recommends that when the home is to be located in flood-prone areas the anchoring systems be designed by an engineer. (See also analysis for "anchoring.")

Recommendation: See recommendation for "anchoring."

FEMA 85		MHI-MIM	Analysis
pg. 45	Design forces and loads	3.1.1	Both the MHI-MIM and FEMA 85 restate the design parameters of the MHCSS for determination of the vertical member loads. The sections are therefore compatible.

Recommendation: None.

FEMA 85		MHI-MIM	Analysis
pg. 48	Vertical support members (piers)	4.1 4.2.2	(a) FEMA 85 provides general and in some instances prescriptive guidelines for the construction of built-up and cast-in-place piers, piles, and bracing. MHI-MIM provides several pier construction methods that are primarily designed to withstand vertical loads. MHI-MIM only requires that concrete and reinforcement be used when the pier height exceeds 80 inches. Additionally, FEMA 85 requires the footing to be a minimum of 30 inches below the frost line. MHI-MIM permits the footing to be located directly on the soil if acceptable to the authority having jurisdiction. (b) Additionally, Figure 4.32 in FEMA 85, "Typical Ground Anchor Detail," shows incorrect orientation of the ground anchor.

Recommendation: (a) Prescriptive guidelines in FEMA 85 are generally not incompatible because the typical foundation design provided by the manufacturer does not address flood forces. However, designs provided by the manufacturer may be acceptable for no or very low velocity flood forces but may not satisfy FEMA 85 requirements. Therefore, FEMA 85 should be clarified to describe under what flood conditions the manufacturer's design is acceptable and under what conditions the prescriptive requirements of FEMA 85 should prevail.

(b) Provide a revised detail with correct orientation of the ground anchor in FEMA 85, Figure 4.32. (See also related concerns pg. 28, "Anchoring.")

FEMA 85		MHI-MIM	Analysis
pg. 64	Chassis I-beam	5.4	MHI-MIM provides for anchors to be used to secure the home against wind and does not address special flood forces such as "buoyancy." Since FEMA 85 recommends that the home be elevated above the flood level, these provisions are compatible.

Recommendation: None

FEMA 85		MHI-MIM	Analysis
pg. 68	Longitudinal support beams	4.1.5	MHI-MIM does not recommend any perimeter installation methods which could be considered incompatible with FEMA 85.

Recommendation: None

FEMA 85		MHI-MIM	Analysis
pg. 69	Utility service	Chapter 8	FEMA 85 requires that utilities be placed in waterproofed risers adjacent to down stream foundation members. MHI-MIM does not contain requirements for protection of utilities where they connect to the structure but references FEMA 85.

Recommendation: None.

FEMA 85		MHI-MIM	Analysis
pg. 69	Mechanical systems	8.5.1	FEMA 85 requires that external equipment be elevated above anticipated flooding. MHI-MIM states that an oil tank should be located where it is accessible and also safe from hazards.

Recommendation: None.

Manufactured Home Installations in Flood Hazard Areas [FEMA 85]

NFPA 501A-1987, covers the firesafety requirements for the installation of manufactured homes and manufactured home sites. This standard includes only the firesafety portions of the scope previously covered by ANSI A225.1/NFPA 501A. The non-firesafety aspects are published separately as ANSI A225.1. Because NFPA 501A is essentially provisions for fuel supply piping and connections, a direct comparison with the provisions of FEMA 85 are for the most part not applicable. After review, the FEMA 85 sections for which comparisons were not made are as follows:

p 3	Manufactured home characteristics	p 45	Design forces, loads, evaluation of elevated foundations
p 5	Conventional mh installation	pp 47-48	Vertical support members
p 8	Effects of flooding	p 48	Piers
p 11	Regulatory requirements	pp 53-58	Posts and piles
pp 15-18	Flood and wind hazards	pp 58-68	Bracing and connections for elevated foundations
p 17	Wind hazards	pp 71-75	Economics
p 19	Elevation and anchoring techniques	Appendix A	Bibliography
p 19	Elevation and fill	Appendix B	Federal and state contacts
p 21	Elevated foundations	Appendix C	Sources of information
p 28	Anchoring	Appendix D	Calculational procedures
p 31	Evacuation techniques	Appendix E	Buoyancy
p 33	Design of elevated foundations	Appendix F	Design worksheets
pp 34-40	Flood forces and their application		
pp 41-42	Design loads		

Comparisons and analysis of applicable sections of FEMA 85 are as follows:

FEMA 85		NFPA 501A	Analysis
p. 69	Additional design considerations Utility service	§2-4.3	FEMA 85 recommends that the utility services, water, sewer and gas entering a structure that has been elevated to avoid flooding be protected using waterproof risers. Propane and fuel oil tanks are to be located on the downstream side of the home to afford protection from debris impact. NFPA 501A §2-4.3 requires that gas outlet risers, regulators, meters, valves, or other exposed equipment be protected against accidental damage.

Recommendation: None.

ANSI A225.1-1987, Manufactured Home Installations [A225.1]

Manufactured Home Installation in Flood Hazard Areas [FEMA 85]

The ANSI A225.1 Manufactured Home Installations Standard is intended to be adopted by jurisdictions having responsibility for the safety and health of manufactured home users and for establishing regulations applicable to manufactured home communities. They are applicable to single family dwelling units that are built in accordance with the HUD Manufactured Home Construction and Safety Standards (MHCSS), which require that the manufacturer of the home provide instructions for the site installation using at least one system of support and anchorage that can resist the design dead, live, and wind loads.

Some of the site installation issues of FEMA 85 are topically out of range of ANSI A225.1. Thus a direct comparison of those provisions is not applicable. After review, the FEMA 85 sections for which comparisons were not made are as follows:

p 19	Elevation and anchoring	Appendix A	Bibliography
pp 58-68	Bracing support and connections	Appendix B	Federal and state contacts
pp 68-70	Additional design considerations	Appendix C	Sources of information
pp 71-75	Economics	Appendix D	Calculational procedures
		Appendix F	Design worksheet

Comparisons and analysis for applicable sections of FEMA 85 are as follows:

FEMA 85		A225.1	Analysis
Pg. 3	Manufactured home characteristics	1-3	FEMA 85 and A225.1 describe the same general features.

Recommendation: None.

FEMA 85		A225.1	Analysis
pg. 5	Conventional manufactured home installation techniques	2-1.2, 2-1.3	FEMA 85 states that the installation instructions supplied with the home and A225.1 are not adequate to resist flood forces. Figure 1.13, Type 2 Tie Down in FEMA 85 depicts an unstable wind resistance system. Section 2-1.2 of A225.1 calls a manufactured home foundation system one that is constructed in accordance with the instructions supplied with the home. Provision is made in 2-1.3 for the homeowner to design for unusual installations.

Recommendation: This section of FEMA 85 should be clarified to point to specific flood load remedies elsewhere in the document. Figure 1.13 therein should carry a notice that the method depicted is not stable and is not recommended for any loading – flood or not.

FEMA 85		A225.1	Analysis
pg. 8	Effects of flooding	Appendix B Appendix C Appendix I	A225.1 does not provide design loads or procedures for homes in flood-prone sites, nor does A225.1 provide notice that the specifications are not applicable to installations in flood-prone sites. Appendices G and I in A225.1 make reference to the NFIP. No specific FEMA documents, however, are specified.

Recommendation: None.

FEMA 85		A225.1	Analysis
pg. 11	Regulatory requirements	Appendix G	FEMA 85 explains how the NFIP works together with state and local building code jurisdictions. Appendix G of A225.1, included in A225.1 for informational purposes only, simply provides notice of the existence of the NFIP and that manufactured housing is included in the NFIP definition of the word "building."

Recommendation: None.

FEMA 85		A225.1	Analysis
pg. 19	Elevation on fill	2-5.1	FEMA 85 limits the flood velocity in accordance with the fill materials and fill cover selected. Section 2-5.1.3(b) in A225.1 requires that fill be free of grass and organic material and have a minimum bearing capacity of 1000 psf.

Recommendation: None.

FEMA 85		A225.1	Analysis
pg. 21	Elevated foundations	Chapter 2	The design methods and design loads provided in A225.1 are not applicable to elevated foundations, and no provisions are made for hydrostatic, hydrodynamic and impact loads.

Recommendation: None.

FEMA 85		A225.1	Analysis
pg. 28	Anchoring	2-4.4	FEMA 85 does not discourage the use of auger type ground anchors. A225.1 requires that ground anchor application instructions include load capacities for various types of soil and the standard provides a calibration chart to determine soil quality using a torque measuring instrument. Information is not provided in FEMA 85 or in A225.1 to caution about the possible reduction in anchor resistance in saturated soils.

Recommendation: Further study is needed to determine load capacities in saturated soils or ground anchors in flood-prone installations.

FEMA 85		A225.1	Analysis
pg. 31	Evacuation techniques	Not applicable	FEMA 85 proposes that evacuation using quick disconnect from foundations is a practicable strategy. No such provision is found in A225.1. Evacuation might be a viable strategy for small park model homes. It is not a viable strategy for multi-wides or for large single-wide homes.

Recommendation: FEMA 85 should remove the recommendation for evacuation.

FEMA 85		A225.1	Analysis
pg. 33	Design of elevated foundations	Appendix B B-4.1	FEMA 85 and A225.1 use the roof live loads and wind loads from the HUD MHCSS. A225.1 states that areas where recurrent winds up to 90 miles per hour (25 psf) are experienced should use similarly designed manufactured homes.

Recommendation: ANSI A225.1 should define the specific areas where wind loads of higher magnitude than the 25 psf limit are needed.

Suggested Standard Change [or addition]: Change Paragraph **B-4.1 The Wind Zone Map**, last sentence as follows: Consult the authority having jurisdiction. Note that an enlarged supplementary map of the Gulf and Atlantic Coastal areas has been supplied in order to more reliably determine the high wind zones. Provide such a map.

FEMA 85		A225.1	Analysis
pp 34-40	Flood forces and their application		A225.1 does not provide design data or methods for homes in flood sites, nor does it refer to FEMA Flood Maps or specific requirements of the NFIP.

Recommendation: None.

FEMA 85		A225.1	Analysis
pp 41-42	Design loads	Table 2-4.2.1	FEMA 85 provides design charts for dead load, live load, snow load, and wind load calculations. A225.1 provides Table 2-4.2.1 for design loads. The loads are nearly identical (5 psf difference in dead loads.)

Recommendation: None.

FEMA 85		A225.1	Analysis
pg. 45	Design forces and loads - Evaluation of elevated foundations		FEMA 85 provides a chart to define limits of effectiveness for ground anchors as a function of water velocity and depth of flood. The accompanying narrative also refers to Appendix E for a discussion of buoyancy, drag and effectiveness of ground anchors in floods. The discussion of buoyancy appears to have overlooked the limits of the connection of the home to the frame. The homes are designed either for 9 psf uplift or 15 psf uplift. This is not sufficient for hydrostatic pressures of more than 7" and 12" ultimate respectively.

Recommendation: The table on p.45 of FEMA 85 should either be dropped, or tests should be undertaken to substantiate that ground anchors can perform effectively in saturated soils. Appendix E of FEMA 85 needs to be revised to make provision for the limits of floor-to-frame connections that have been designed according to the wind uplift provisions of the HUD MHCSS. Also it appears that some performance criteria is needed to enable the ground anchor designers, vendors and users to know how to determine whether or not ground anchors can be relied upon. Notices are needed in A225.1 to either caution that flooding is not included in the charted loads or provide flood loads for homes to be sited in flood-prone areas, or require the application of the flood loads.

FEMA 85		A225.1	Analysis
pp 47-48	Vertical support members	Appendix B	FEMA 85 provides design charts for dead load, live load, snow load, and wind load calculations. The charts use snow and wind loads from the HUD MHCSS. [Homes manufactured since 1976 under the HUD Standards are themselves certified to those loads] A225.1 uses the same live, snow, and wind loads as FEMA 85.

Recommendation: Revise ANSI A225.1, Appendix B, to incorporate ASCE-7 snow and wind loads.

Suggested Standard Change [or addition]: Add a Paragraph:

B-4.3 Flood Loads:

Refer to FEMA 85 for flood loading. The loads in these Tables do not include loads attributable to flooding.

FEMA 85		A225.1	Analysis
pg. 48	Piers	Appendix C	FEMA 85 prescribes designs for piers, and cautions that, due to the likelihood of scouring, pier systems should not be used in areas where flooding velocity is anticipated. Appendix C of A225.1 provides designs for pier foundations and issues no cautions concerning scouring. (Note that overall A225.1 is not for homes sited in flood- prone areas.)

Recommendation: Appendix C of A225.1 should reference the FEMA documents and caution that the designs presented have not taken flood conditions into account.

Suggested Standard Change [or addition]: Add a paragraph after the introductory paragraph to Appendix C, second column:

Flood Designs:

Refer to FEMA 85 for flood designs and design methods. These designs do not include loads attributable to flooding.

FEMA 85		A225.1	Analysis
pp 53-58	Posts and Piles	Appendix A	FEMA 85 includes provisions for pile foundations with sample load and application charts. Piles are not included in A225.1. [A225.1 is not for flood resistant installations.]

Recommendation: None.

FEMA 85		A225.1	Analysis
App. E	Buoyancy and drag forces		Appendix E of FEMA 85 discusses buoyancy, drag and effectiveness of ground anchors in floods. The discussion of buoyancy appears to have overlooked the limits of the connection of the home to the frame. The homes are designed either for 9 psf uplift or 15 psf uplift. This is not sufficient for hydrostatic pressures of more than 7" and 12" ultimate respectively. The issue of whether or not ground anchors are effective needs to be addressed convincingly.

Recommendation: Appendix E of FEMA 85 should be revised to make provision for the limits of floor-to-frame connections that have been designed according to the wind uplift provisions of the HUD MHCSS. Resolve whether or not ground anchors are permitted.

APPENDIX F

COMPARISON BETWEEN THE CABO ONE AND TWO FAMILY DWELLING CODE AND THE NFIP STANDARDS AND TECHNICAL GUIDELINES

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CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construction with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

NFIP (Regulations for Floodplain Management and Flood Hazard Identification) (44 CFR 59.1, 60.3 and 60.6)

59.1 - Definitions

NFIP	OTFDC	Analysis
Base Flood Breakaway Wall Critical Feature Development Elevated Building Flood Floodplain or Flood-Prone Area Lowest Floor 100-year Flood Storm Cellar Substantial Improvement	R-115	NFIP contains definitions which only apply to floodplain management. OTFDC does not contain these definitions.

Recommendation: None since NFIP addresses only flood-prone areas.

NFIP	OTFDC	Analysis
Appurtenant Structure Basement Building Existing Construction Existing Structures Manufactured Home Structure	R-115	The definitions of "appurtenant structure/accessory structure" and "basement" are compatible. NFIP definition of "building (structure)" applies to any walled and roofed building while OTFDC addresses only one-and two-family dwellings. NFIP definition of "existing construction" applies to construction begun before the date of FIRM while OTFDC definition applies to buildings erected before the adoption of the Code. NFIP definition of "manufactured home" applies only to structures transportable in one or more sections, built on a permanent chassis, and designed for use with or without a permanent foundation while OTFDC also contains dimensional parameters.

Recommendation: NFIP should expand definition of manufactured home to include dimensional parameters.

60.3 Floodplain Management Criteria for Flood-Prone Areas

NFIP	OTFDC	Analysis
60.3(b)(8) Manufactured Home Installation	Appendix C	Appendix C contains provisions which apply to the construction, alteration and repair of any foundation system which is necessary to provide for the installation of a manufactured home unit; construction, installation, addition, alteration, repair or maintenance of the building service equipment which is necessary for connecting manufactured homes to water, fuel, or power supplies and sewage systems. See NCSBCS comparison to Appendix C.

Recommendation: None.

NFIP	OTFDC	Analysis
60.3(c)(2) Elevation for Residential Structures	N/A	NFIP requires the lowest floor of residential structures to be elevated to or above the base flood level. OTFDC does not address floodplain management or elevation of structure.

Recommendation: None.

NFIP	OTFDC	Analysis
60.3(c)(3) Elevation for Non-Residential Structures; Flood-Proof Walls for Non-Residential Structures	N/A	NFIP requires the lowest floor of non-residential structures to be elevated to or above the base flood level or flood-proof the structure that is below the base flood level. OTFDC does not address non-residential structures.

Recommendation: None.

NFIP	OTFDC	Analysis
60.3(c)(5) Flood Openings	R-311	NFIP requires fully enclosed areas below the lowest floor, other than basements, to be provided with flood openings to equalize hydrostatic flood forces. OTFDC does not address floodplain management; however, it does require openings for crawl space ventilation.

Recommendation: OTFDC should address openings for floodwater and equalize hydrostatic forces.

NFIP	OTFDC	Analysis
60.3(e)(4) Pilings	R-301.2	NFIP requires structures to be elevated to or above the base flood level and anchored to resist flotation, collapse, and lateral movement due to the effects of wind and water loads acting simultaneously. OTFDC requires the foundation and its structural system to be capable of accommodating all superimposed live, dead, snow, wind, seismic and any other loads in accordance with accepted engineering practice.

Recommendation: NFIP should address snow and seismic loads.

NFIP	OTFDC	Analysis
60.3(e)(5) Breakaway Walls	N/A	NFIP requires areas below the lowest floor to be free of obstruction or constructed with nonsupporting breakaway walls, open wood lattice, or insect screening intended to collapse under wind and water loads. OTFDC does not address floodplain management or breakaway walls.

Recommendation: None.

NFIP	OTFDC	Analysis
60.3(e)(6) Fill	N/A	NFIP prohibits only in V zones the use of fill material to support buildings in flood-prone areas. OTFDC does not address floodplain management and does not prohibit the use of fill material to support buildings.

Recommendation: None.

60.6 Variances and Exceptions

NFIP	OTFDC	Analysis
60.6(c)(2)(i) Floodproof walls 60.6(c)(2)(ii) Basement Top of Floor Elevation 60.6(c)(2)(iii) Fill 60.6(c)(2)(iv) Use of a Registered Professional 60.6(c)(2)(v) Building Inspection	N/A	NFIP requires the basement area, together with utilities and sanitary facilities below the floodproofed design level , to be watertight with walls that are impermeable to the passage of water without human intervention. NFIP permits the basement floor to be up to five feet below the elevation of the base flood. NFIP permits the area surrounding the structure to be protected by fill material to or above the elevation of the base flood. OTFDC does not address floodplain management.

Recommendation: None.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional constructi with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Elevated Residential Structures (FEMA 54)

FEMA 54	OTFDC	Analysis
Posts Post Embedment Post Anchorage (Pages 68-71)	R-303	FEMA 54 addresses the use of wood, concrete, or steel posts as the foundation to elevate residential structures; hole depth, end bearing, hole size, and backfilling of posts; and anchorage of post foundations. OTFDC does not specifically address post foundations but does permit foundations of any type provided it is designed to safely support the loads imposed.

Recommendation: None.

FEMA 54	OTFDC	Analysis
Piers (Page 75)	R-404.4	FEMA 54 describes the suitability of pier foundations and types of pier foundations and types of pier foundations which are suitable for the flood areas with low velocity and minimal erosion. OTFDC does not address the suitability of any type of foundations in any area. OTFDC requires the foundations to be of sufficient design to support safely the loads imposed.

Recommendation: None.

FEMA 54	OTFDC	Analysis
Brick and Concrete Masonry Piers (Pages 75, 76)	R-404.4 R-602.2.1	FEMA 54 provides minimum reinforcing, minimum dimensional requirements, maximum height, spacing, and recommended shape. FEMA 54 requires the piers to be filled with concrete. OTFDC bases the height on the least dimension whether the pier is filled with concrete or not. OTFDC does not require reinforcing. FEMA 55 permits the maximum spacing to be 8 ft or 12 ft. OTFDC permits the spacing to be based on girder span and girder spacing.

Recommendation: FEMA 54 and OTFDC are in general agreement.

FEMA 54	OTFDC	Analysis
Concrete Piers (Page 77)	R-303 R-404.4	FEMA 54 provides a general description and discussion of poured-in-place concrete piers. OTFDC does not specifically address concrete piers. OTFDC requires foundations to be of sufficient design to support safely the loads imposed.

Recommendation: None since both FEMA 54 and OTFDC basically require the foundation to be based on a structural analysis.

FEMA 54	OTFDC	Analysis
Pier Footings (Page 77)	R-303	Both FEMA 54 and OTFDC require the footing sizes to be based on the properties of the soil.

Recommendation: None.

FEMA 54	OTFDC	Analysis
Shear Walls and Floor Diaphragm (Page 79)	R-303	FEMA 54 addresses the use of plywood shear walls and floor diaphragms to brace piles or post foundations. OTFDC requires the foundation to be of sufficient design to support safely the loads imposed.

Recommendation: FEMA 54 should address the use of shear walls and floor diaphragms as a method of bracing but should permit the building designer to choose the method.

FEMA 54	OTFDC	Analysis
Pier Foundation Connection (Pages 84, 85)	R-401.2 R-601.2	FEMA 54 addresses anchorage of platform framing construction to pier foundations. OTFDC requires the wall and floor construction to be capable of accommodating all loads imposed and transmitting the resulting loads to its supporting structural elements. OTFDC does not address pier anchorage but does address continuous masonry wall foundations.

Recommendation: OTFDC should provide requirements for pier foundation anchorage.

FEMA 54	OTFDC	Analysis
Floor Beams (Page 86, Paragraph 2)	R-602.2.1 Table R-402.3a	FEMA 54 provides a general discussion of built-up floor beams, (nailing, location of splices, and size). OTFDC provides nailing requirements and sizes based on girder span and spacing.

Recommendation: FEMA 54 should provide better nailing and splice location requirements.

FEMA 54	OTFDC	Analysis
Cantilevers (Page 86, 87)	R-601.2	FEMA 54 describes a cantilevered beam with general discussion of why cantilevers are used. FEMA 54 provides a "rule of thumb" for the length of the cantilever. OTFDC requires the wood members to be capable of accommodating all loads imposed.

Recommendation: FEMA 54 should delete the "rule of thumb" or add better guidance for the design of the cantilever.

FEMA 54	OTFDC	Analysis
Floor Beam to Floor Joist Connection (Page 88)	R-601.2	FEMA 54 requires positive connection between the floor joists and floor beams with a general discussion of the connection and connectors. OTFDC requires the floor system to be capable of accommodating all loads imposed and transmitting the resulting loads to its supporting structural elements.

Recommendation: None.

FEMA 54	OTFDC	Analysis
Figure 4.48, Protective Utility Shaft (Page 92)	M-1901	FEMA 54 requires mechanical and plumbing piping serving a elevated structure to be attached to the leeward side of posts/columns or enclosed in a protective shaft. The OTFDC requires (1) water service and DWV to be protected from freezing and (2) fuel piping to conform to good practice. The OTFDC does not address flooding.

Recommendation: None.

FEMA 54	OTFDC	Analysis
Mechanical Equipment Page 93, Paragraph 2)	M-1106 M-1306 M-1307 M-1308	FEMA 54 requires all mechanical equipment to be elevated above expected floodwaters, with indoor components, preferably installed in attics. The OTFDC allows attic installation, but does not specify minimum elevations for equipment. The OTFDC does not address flooding.
	M-1602	FEMA 54 requires ductwork to have minimum slopes to opening at lowest levels to allow drainage. The OTFDC does not require such slope on air ducts, and does not address flooding.

Recommendation: None.

FEMA 54	OTFDC	Analysis
Septic Tanks (Page 93, Paragraph 3	P-2503 P-2506.2	FEMA 54 requires that septic tanks be floodproofed to stop floating and potential discharge of effluent. The OTFDC requires that septic tanks be designed to withstand all anticipated loads.

Recommendation: None since both approach the problem from different directions. FEMA - prescriptive OTFDC - performance.

FEMA 54	OTFDC	Analysis
Building Materials (Pages 93, 94)	N/A	FEMA 54 requires protection of the building materials which may be exposed to flood waters. OTFDC does not address flood waters.

Recommendation: None.

FEMA 54	OTFDC	Analysis
Wood (Page 94)	R-309	FEMA requires wood exposed to the elements to be preservative treated. OTFDC requires wood subject to decay damage to be pressure preservatively treated or decay-resistant wood.

Recommendation: FEMA 54 should include "decay resistant wood."

FEMA 54	OTFDC	Analysis
Steel (Pages 94, 95)	N/A	FEMA 54 addresses the need for galvanization of steel exposed to the elements to prevent corrosion. OTFDC does not address corrosion protection of steel members.

Recommendation: None.

FEMA 54	OTFDC	Analysis
Concrete and Masonry (Page 95)	R-404.14.1	FEMA 54 addresses the need to increase the durability of reinforced concrete and masonry by the use of chemical additives and coatings. OTFDC requires minimum corrosion protection of joint reinforcement, anchor ties and wire fabric for use in masonry wall construction.

Recommendation: None.

FEMA 54	OTFDC	Analysis
Insulation (Pages 95, 96)	M-1706	FEMA 54 requires underfloor exposed pipes to be insulated with impermeable or inexpensively replaced insulation. The OTFDC does not address flooding. It does address refrigerant piping insulation and where it is required.

Recommendation: None.

FEMA 54	OTFDC	Analysis
Glossary (Pages 113-115)	N/A	FEMA 54 contains definitions of terms which are relevant to floodplain management. OTFDC does not address floodplain management.

Recommendation: None.

FEMA 54	OTFDC	Analysis
Performance Criteria (Pages 125-135)	R-201.2 R-303 R-401.2 R-601.2 R-701.2 Appendix A (Seismic Risk Map, Wind Probability Map, and Snow Load Map	FEMA 54 addresses performance criteria used to design buildings to withstand the design flood (1) without causing unacceptable risks to its occupants or to adjacent property owners, (2) without causing unacceptable health hazards to its occupants, or (3) without sustaining damage of unacceptable magnitude. OTFDC requires the construction to be capable of accommodating all loads imposed and transmitting the resulting loads to its supporting structural elements.

Recommendation: FEMA 54 should includes snow and seismic loads. The use of the phrases, "unacceptable risks", "unacceptable health hazards", and "unacceptable magnitude" are too subjective.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construction with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Coastal Construction Manual (FEMA 55)

FEMA 55	OTFDC	Analysis
4.1 Flood Frequency (Page 4-1, Paragraph 4)	N/A	FEMA 55 addresses the wave crest elevation that would be present during the base (100 year) flood. OTFDC does not address floodplain management.

Recommendation: None.

FEMA 55	OTFDC	Analysis
4.1.1 Wind (Page 4-1, Paragraphs 6 & 7. Page 4-2, Figure 4-1, Page 4-3, Paragraphs 2 & 3, Page 4-6)	Appendix A (Wind Probability Map)	FEMA 55 references the procedures of ANSI A58.1-1982 for design with particular emphasis placed on elevation of the roof above grade and high wind pressures at the corners of the house, at and under roof eaves, and at the peak of the roof. OTFDC contains a wind probability map with wind design loads based on ANSI A58.1-1982.

Recommendation: FEMA 55 should confirm that the wind load provisions are consistent with ASCE 7-88. The 1992 OTFDC does reference ASCE 7-88.

FEMA 55	OTFDC	Analysis
4.1.2 Salt Air Moisture and Wind-Driven Rain (Pages 4-7, 4-8)	R-309 R-404.14.1	FEMA provides general discussion of the hazards of salt air, moisture, and wind-driven rain on wood, nails, and connectors. OTFDC requires wood subject to decay damage to be naturally durable or pressure treated but does not address nails or connectors. OTFDC does address corrosion protection of joint reinforcement, anchor ties, and wire fabric for use in masonry wall construction.

Recommendation: OTFDC should address corrosion protection.

FEMA 55	OTFDC	Analysis
4.1.3 Water, Waves, and Debris (Page 4-8, Paragraph 4)	R-303	FEMA 55 addresses the impact loads exerted on the piles as the result in the movement of debris (fences, porches, stairs, utility poles, etc.) FEMA 55 has provided for the collision of a 300 pound object moving at surface water velocity and decelerating over a maximum of 0.5 ft. OTFDC requires the foundation and its structural elements to be capable of accommodating all superimposed live, dead, snow, wind, seismic, and all lateral loads in accordance with accepted engineering practice.

Recommendation: None.

FEMA 55	OTFDC	Analysis
4.1.4 Effects of Forces on Higher and Larger Structures (Pages 4-9)	Appendix A (Wind Probability Map)	FEMA 55 discusses the higher wind forces, uplift and overturning with respect to the height of the building. OTFDC contains a factor to increase the wind design loads when the mean roof height is greater than 30 ft but less than 50 ft.

Recommendation: FEMA 55 should provide velocity pressures (psf) for varied wind speeds and building height.

FEMA 55	OTFDC	Analysis
4.2 Construction Materials (Pages 4-9)	Ch. 3, 4, 5, 6 & 7	FEMA 55 provides a general discussion of the types of construction materials (wood, steel, concrete) and their use in the coastal environment. OTFDC provides requirements for the use of these materials in any environment.

Recommendation: None.

FEMA 55	OTFDC	Analysis
4.2.1.1 Pilings (Wood) (Pages 4-9, 4-10)	R-301.2	FEMA 55 provides general comments on the use of wood pilings (species and decay resistance). OTFDC does not specifically address pile foundations but does require the foundation and its structural elements to be capable of accommodating all superimposed live, dead, snow, wind, seismic, and all lateral loads in accordance with accepted engineering practice.

Recommendation: FEMA 55 should address snow and seismic loads.

FEMA 55	OTFDC	Analysis
4.2.1.2 Main Supporting Members (Beams, Wood) (Page 4-10)	T. R-402.3a R-602.2.1 T. R-602.2.1a T. R-602.2.1b	Both FEMA 55 and OTFDC address the use of built-up beams and girders. FEMA 55 provides general nailing requirements and splice location. OTFDC provides allowable spans and nailing requirements for built-up beams.

Recommendation: FEMA 55 should provide more specific nailing and splice details. OTFDC should provide more specific splice details.

FEMA 55	OTFDC	Analysis
4.2.1.3 Other Wood Construction Members (Page 4-10)	R-309	FEMA 55 does not require preservative treatment of miscellaneous wood members but highly recommends it. OTFDC requires wood subject to decay to be a naturally durable species or pressure treated.

Recommendation: None.

FEMA 55	OTFDC	Analysis
4.2.1.4 Wood Preservative (Page 4-10)	R-309	FEMA 55 requires wood members to be treated to resist insect infestation, dry rot, decay fungi, and the effects of exposure to salt air and water and provides general discussion of wood preservatives. OTFDC requires wood subject to decay to be a naturally durable species or pressure treated and provides a list of AWPA standards.

Recommendation: FEMA 55 should list some of the AWPA standards.

FEMA 55	OTFDC	Analysis
4.2.2 Masonry Materials and Concrete (Page 4-11)	R-302.2 R-304.1 R-404	FEMA 55 addresses the use of masonry and concrete in the coastal environment. OTFDC provides a chart to determine the minimum compressive strength of concrete based on weathering potential but does not address exposure of masonry.

Recommendation: FEMA should add reference to ACI 318.

FEMA 55	OTFDC	Analysis
4.2.3.1 Aluminum (Page 4-11)	R-403 R-605 R-705.2	FEMA 55 addresses the problem of corrosion of aluminum in the coastal environment. OTFDC only addresses the use of aluminum structurally in buildings and references aluminum standards.

Recommendation: None.

FEMA 55	OTFDC	Analysis
4.2.3.2 Steel (Page 4-11)	R-403 R-605 R-705	FEMA 55 addresses the problem of corrosion of unprotected steel shapes and anchoring devices (nails, bolts, etc.) and the need for regular inspection, maintenance, and replacement of corroded metal parts. OTFDC requires the steel to comply with the appropriate standards. OTFDC does not address corrosion in coastal environment.

Recommendation: OTFDC should address corrosion protection.

FEMA 55	OTFDC	Analysis
4.2.3.3 Dissimilar Metals (Page 4-11)	N/A	FEMA 55 addresses the corrosion which occurs when dissimilar metals are placed in contact with each other (brass screws and aluminum frame). OTFDC does not address dissimilar metals.

Recommendation: None.

FEMA 55	OTFDC	Analysis
4.3.1 Foundations (Design Details) (Pages 4-11, 4-12)	R-303	FEMA 55 recommends foundation types which are suitable for supporting elevated structures in coastal high hazard areas. OTFDC requires the foundation system to be of sufficient design to support the loads imposed as determined from the character of the soil. OTFDC does provide minimum foundation sizes. OTFDC does not address coastal high hazard areas.

Recommendation: None.

FEMA 55	OTFDC	Analysis
4.3.1.1 Soil Conditions (Pages 4-12, 4-13)	R-301.4	Both FEMA 55 and OTFDC address the need to determine the quality of the soil foundation purposes. FEMA 55 provides commentary type information also.

Recommendation: None.

FEMA 55	OTFDC	Analysis
4.3.1.2 Piles (Pages 4-13 to 4-18)	R-303	FEMA 55 provides general information on types of piles, the need for sufficient pile embedment, methods of pile installation. OTFDC does not specifically address pile foundations but does require the foundation system to be of sufficient design to support the loads imposed.

Recommendation: FEMA 55 should emphasize that type of pile, pile depth, and method of installation should be based on the soil's investigation.

FEMA 55	OTFDC	Analysis
4.3.1.3 Posts (Wood) (Page 4-18)	R-303	FEMA 55 explains that wood posts are recommended in areas subject to wave forces and/or scour and erosion. OTFDC does not specifically address post foundations but does require the foundation system to be of sufficient design to support the loads imposed.

Recommendation: None.

FEMA 55	OTFDC	Analysis
4.3.1.4 Piers (Pages 4-18 to 4-20)	R-303 R-404.4	FEMA 55 addresses the use of piers to elevate structures and the need for reinforcing and anchorage to the footing in V zones and coastal A zones. FEMA 55 also provides general construction guidelines. OTFDC requires the foundation system to be of sufficient design to support the loads imposed. OTFDC provides minimum guidelines to height to the least dimension ratio for unreinforced masonry piers.

Recommendation: FEMA 55 should clarify that the reinforcing, footing size, and grade beam size should be based on the design forces.

FEMA 55	OTFDC	Analysis
4.3.2.1 Framing Methods (Pages 4-20, 4-21)	R-601.2	Both FEMA 55 and OTFDC addresses platform framing. FEMA 55 addresses pole construction and provides commentary on the types of construction.

Recommendation: None.

FEMA 55	OTFDC	Analysis
4.3.2.2 Beams (Pages 4-21, 4-22)	T. R-402.3a R-602.2.1 T. R-602.2.1a T. R-602.2.1b	FEMA 55 addresses the preferable direction of floor beams to reduce the impact of the storm water. FEMA 55 and OTFDC addresses built-up beams and solid members. FEMA 55 mentions "glulam" beams. OTFDC provides nailing requirements for built-up members.

Recommendation: FEMA 55 should provide nailing requirements for built-up members.

FEMA 55	OTFDC	Analysis
4.3.2.3 Joists and Rafters (Page 4-22)	R-602.2.1 R-602.4	The title of the section in FEMA 55 is joist and rafters but rafters are not addressed. FEMA 55 describes manufactured wooden I-beams, recommends cross bridging for all floor joists located in the V-zone. FEMA 55 and OTFDC describe typical cross bridging methods. FEMA 55 requires cross bridging at a maximum of 8 ft while OTFDC requires cross bridging for joists having a depth-to-thickness ratio exceeding six at a maximum of 10 ft.

Recommendation: FEMA 55 should delete the reference to rafters.

FEMA 55	OTFDC	Analysis
4.3.2.4 Subflooring (Pages 4-22, 4-23)	R-602.2.2 R-606.1 R-607.1.2	Both FEMA 55 and OTFDC permit the use of lumber and plywood subflooring. OTFDC also permits the use of particleboard subfloors. FEMA 55 recommends the use of plywood with exterior glue and annular ring nails or deformed shank nails. FEMA 55 recommends nailing and gluing of plywood with tongue-and-grove joints to avoid the need for blocking and to produce a stronger diaphragm. OTFDC permits the use of smooth common or deformed shank nails with no mention of gluing. OTFDC provides minimum thickness, span of subfloor, and nail spacing.

Recommendation: The provisions are compatible. FEMA 55 should provide some recommended nail spacing and spans. FEMA 55 should permit the use of particleboard subfloors.

FEMA 55	OTFDC	Analysis
4.3.2.5 Studs (Page 4-23)	R-402.3	FEMA 55 recognizes that 2x4 wood studs at 16 inches o centers are commonly used and permits 2x6 wood studs and metal studs. OTFDC addresses the use of wood studs based on lateral unsupported stud height, spacing of studs, and number of stories.

Recommendation: FEMA 55 should address the length of the stud in addition to the number of stories which the stud supports.

FEMA 55	OTFDC	Analysis
4.3.2.6 Wall Sheathing (Page 4-23)	R-402.3	FEMA 55 provides the minimum thickness and nail spacing for plywood wall sheathing for two cases (1) structures elevated not more than 10 ft and (2) structures elevated more than 10 ft. OTFDC list permits plywood and particleboard wall sheathing.

Recommendation: FEMA 55 should provide additional information addressing the wind speed in addition to height above grade.

FEMA 55	OTFDC	Analysis
4.3.2.7 Wall Bracing (Page 4-24)	R-404.10 T. R-402.3b T. R-402.3c	Both FEMA 55 and OTFDC permit the use of let-in diagonal wood bracing and plywood. FEMA permits diagonal boards. OTFDC permits particleboard or approved metal strap devices.

Recommendation: FEMA 55 should combine 4.3.2.6 Wall Sheathing and 4.3.2.7 Wall Bracing into one section and address the design requirements for the wall bracing method chosen.

FEMA 55	OTFDC	Analysis
4.3.2.8 Roof Details (Pages 4-24 to 4-27)	N/A	FEMA 55 discusses the use of trusses, gable roofs, hip roofs, flat roofs, gambrel roofs, roof overhangs and porches and their performance in high wind conditions. OTFDC does not provide details or discuss performance of specific designs.

Recommendation: None.

FEMA 55	OTFDC	Analysis
4.3.3 Foundation Bracing (Pages 4-27 to 4-29)	R-303	FEMA 55 addresses the need for bracing wood foundation piles. OTFDC requires the foundation to be of sufficient design to support safely the loads imposed.

Recommendation: None.

FEMA 55	OTFDC	Analysis
4.3.3.1 Knee Bracing (Page 4-29)	R-303	FEMA 55 recommends the use of knee braces for wood piles even though bracing may not be needed. OTFDC requires the foundation to be of sufficient design to withstand the loads imposed.

Recommendation: FEMA 55 should emphasize that the wood foundation piles should be designed for the additional moment introduced into the pile from the knee brace.

FEMA 55	OTFDC	Analysis
4.3.3.2 Grade Beams (Pages 4-29, 4-30)	R-303	FEMA 55 recommends the need for lateral support of the piles at the ground line. OTFDC requires the foundation to be of sufficient design to withstand the loads imposed.

Recommendation: FEMA 55 should emphasize the need to design the grade beams to assure that they are actually providing lateral support of the piles.

FEMA 55	OTFDC	Analysis
4.3.3.3 Truss Bracing (Pages 4-30, 4-31)	R-303	FEMA 55 recommends the use of truss bracing of the piles when the structure is 10 ft or more above grade and the design wind speed is 100 mph or greater. OTFDC requires the foundation system to be of sufficient design to safely support the loads imposed.

Recommendation: FEMA 55 should emphasize the need to design the bracing members.

FEMA 55	OTFDC	Analysis
4.3.3.4 Shear Walls (Page 4-31)	R-303	FEMA 55 addresses only reinforced concrete or reinforced masonry sheer walls. OTFDC does not specifically address shear walls but does require foundation systems to be of sufficient design to safely support the loads imposed.

Recommendation: FEMA 55 should address wood shear walls for wood pile foundation.

FEMA 55	OTFDC	Analysis
4.3.4 Connections 4.3.4.1 Roof to Wall 4.3.4.2 Wall to Floor Joist 4.3.4.3 Floor Joist to Floor Beam (Pages 4-31 to 4-35)	R-303 R-401.2 R-601.2 R-701.2	FEMA provides commentary type language that the roof to wall, wall to floor joist, and floor joist to floor beam connections to be sufficient to withstand the anticipated forces. OTFDC requires that the interconnection of the roof to wall to floor to foundation be capable of transmitting the resulting loads to its supporting structure elements.

Recommendation: None since both FEMA 55 and OTFDC require sufficient connection.

FEMA 55	OTFDC	Analysis
4.3.4.4 Floor Beam to Pile, Post, or Pier (Pages 4-35 to 4-40)	R-303 R-601.2	FEMA 55 provides commentary type language and typical details for floor beams to pile, post, or pier connections, but permits other methods provided they are designed. OTFDC requires that the interconnection be capable of transmitting the resulting loads to its supporting structural elements.

Recommendation: FEMA 55 should provide some design values or wind speeds for which the connections are appropriate.

FEMA 55	OTFDC	Analysis
4.3.5 Breakaway Walls 4.3.5.1 Breakaway Wall Design 4.3.5.2 Design Considerations for Breakaway Walls (Pages 4-41 to 4-49)	N/A	FEMA 55 permits breakaway walls to enclose the space below the lowest elevated floor and provides commentary type language for different types of breakaway walls. FEMA 55 provides breakaway wall designs and details for screening, lattice, wood stud walls, metal stud walls, and masonry walls. FEMA 55 provides the design process for breakaway walls and commentary type language for wind forces, water forces, working/ultimate strength of fasteners, distribution of wall loads, and bracing considerations for breakaway walls. OTFDC does not address breakaway walls.

Recommendation: None.

FEMA 55	OTFDC	Analysis
4.3.6 Utilities (Pages 4-50 to 4-52)	M-1102 M-1106 M-1306 M-1307 M-1308 M-1901 P-2003	FEMA 55 requires all mechanical equipment to be elevated above BFE and fuel, water service, and DWV to be on the leeward side of posts/columns or enclosed in shafts. The OTFDC does not address flooding. The OTFDC does allow attic or elevated installations with minimum clearances to combustibles and accessibility. The OTFDC requires water service and DWV to be protected from freezing and fuel piping to conform to good practice.

Recommendation: None.

FEMA 55	OTFDC	Analysis
4.3.7 Wind and Storm Protection of Interior (Page 4-52)	R-411	FEMA 55 provides commentary on the need to protect the buildings from glass breakage in order to prevent water damage. OTFDC does not address glass breakage. OTFDC requires the windows to be tested and certified to indicate compliance with AAMA (ANSI) 101, ANSI/NWWDA I.S.2, or ASTM D 4099.

Recommendation: FEMA 55 should reference the window standards and require the windows to be designed for the wind pressures.

FEMA 55	OTFDC	Analysis
4.3.7.1 Window Selection (Pages 4-52, 4-53)	R-208.5 R-411	FEMA 55 addresses the importance of window selection to reduce water infiltration. OTFDC requires the windows to be tested and certified to indicate compliance with AAMA (ANSI) 101, ANSI/NWWDA I.S.2, or ASTM D 4099 and be capable of safely withstanding the wind loads.

Recommendation: FEMA 55 should reference the window standards and require the windows to be designed for the wind pressures.

FEMA 55	OTFDC	Analysis
4.3.7.2 Operable Shutters (Pages 4-53, 4-54)	R-208.5 R-411	FEMA 55 addresses the need for shutters to protect against wave and wind action. OTFDC requires the windows to be tested and certified to indicate compliance with AAMA (ANSI) 101, ANSI/NWWDA I.S.2, or ASTM D 4099 and be capable of safely withstanding the wind loads.

Recommendation: FEMA 55 should require the shutter to be designed for the wind loads.

FEMA 55	OTFDC	Analysis
4.3.7.3 Gable and Eave Vents (Page 4-54)	R-701.1 R-701.2 R-707	FEMA 55 addresses the vulnerability of vents to wind and wind-driven rain and emphasizes the importance for the careful selection of attic ventilators in or to assure that they will withstand the wind loads. OTFDC requires ventilation of the attic space based on a ratio of free ventilating area. OTFDC requires the roof-ceiling construction to be capable of accommodating all loads imposed.

Recommendation: OTFDC should clarify that the ventilators that are to withstand the wind loads. This is implied in R-701.1.

FEMA 55	OTFDC	Analysis
4.3.7.4 Roof Materials (Page 4-54)	R-801.2	FEMA 55 emphasizes the need to use self-sealing, heavyweight shingles to avoid the possible loss of roofing material in high winds. OTFDC requires the roof covering to be capable of accommodating the imposed loads and provide a barrier against the weather.

Recommendation: FEMA 55 should emphasize the need to have the roof covering to withstand the uplift from the wind.

FEMA 55	OTFDC	Analysis
4.3.8 Maintenance (Pages 4-54, 4-55)	N/A	FEMA 55 emphasizes the need for maintenance of all parts of buildings exposed to the coastal environment because of the accelerated deterioration. OTFDC does not address maintenance but does require repairs or rehabilitation to comply with the requirements of the OTFDC for new construction.

Recommendation: None.

FEMA 55	OTFDC	Analysis
Chapter 5 - Larger Structures 5.1 General Design Considerations 5.2 Foundations 5.3 Slabs at Grade 5.4 Superstructure 5.5 Elevated Floors 5.6 Exterior Walls 5.7 Recommendations (Pages 5-1 to 5-9)	N/A	Chapter 5 of FEMA 55 addresses the design and construction of mid- to high-rise structures located in coastal high hazard areas. OTFDC only addresses one- or two-family dwellings and one-family townhouses not more than three stories in height.

Recommendation: None.

FEMA 55	OTFDC	Analysis
Appendix A Design Tables Figure A-1 number of piles required Table A-1 downward loads per pile Table A-2 horizontal wind loads per pile in 80 mph winds Table A-3 minimum embedment depth of piles Table A-4 maximum unbraced height of piles in 80 mph winds and flood forces Table A-4.1 maximum unbraced height of piles supporting breakaway walls Table A-5 uplift loads per foot of wall in 80 mph winds Table A-6 uplift loads per pile in 80 mph winds Table A-7 capacity per bolt of floor beam connections Table A-8 concrete masonry unit piers Table A-9 concrete piers Figure A-2 concrete pier cross section Figure A-3 grade beams and slabs Table A-10 fastener capacities in shear Table A-11 fastener schedule for breakaway walls (Pages A-1 to A-47)	Ch. 2, 3, 4, 6, 7 & 8	FEMA 55 provides design tables. OTFDC is more performance oriented than specification oriented.

Recommendation: None.

FEMA 55	OTFDC	Analysis
Appendix B - Bracing B.1 knee bracing B.2 truss bracing B.2.1 diagonals B.2.1.1 lumber diagonals B.2.1.2 threadbar diagonals B.2.2 struts B.3 grade beams Table B-1 horizontal water loads per pile in 80 mph winds Table B-2 loads of transverse truss members Table B-3 allowable loads for single 2x8 diagonals Table B-4 allowable loads for single 3x8 diagonals (Pages B-1 to B-15)	R-303	FEMA provides various recommendations and details for bracing methods. OTFDC is more performance oriented than specification oriented.

Recommendation: None.

FEMA 55	OTFDC	Analysis
Appendix D - Design Equations and Procedures D.1 Procedure A-1: downward loads per pile D.2 Procedure A-2: horizontal wind loads per pile D.3 Procedure A-3: minimum embedment depth of piles D.4 Procedure A-4: maximum unbraced height of piles D.5 Procedure A-4.1: maximum unbraced height of piles supporting breakaway walls D.6 Procedure A-5: uplift loads per foot of walls D.7 Procedure A-6: uplift loads per pile D.8 Procedure B-1: horizontal water loads per pile D.9 Procedure B-2: loads transferred to foundation truss members (Pages D-1 to D-32)	N/A	FEMA 55 contains design equations and procedures which are needed to evaluate individual designs. OTFDC is more performance oriented than specification oriented.

Recommendation: None.

FEMA 55	OTFDC	Analysis
G-2. Purpose (Page G-1)	R-102	FEMA 55 states that the purpose of the Coastal Code is to provide minimum standards for the design and construction of residential structures in Coastal High Hazard Areas and where wave action can be expected. The purpose of the OTFDC is to provide minimum standards for the protection of life, limb, health, property, environment and for the safety and welfare of the consumer, general public and the owners and occupants of residential buildings regulated by the Code.

Recommendation: None since the intent of both FEMA 55 and OTFDC is to provide minimum requirements for structures.

FEMA 55	OTFDC	Analysis
G-3 Scope (Page G-2)	R-103	Both FEMA 55 and OTFDC apply to new construction and improvements on additions to existing structures. FEMA 55 permits improvements up to 49% of the market value of the structure without compliance with the Coastal Construction Code but the OTFDC requires all improvements to comply with the Code.

Recommendation: Since market value is a variable based on location, economy, etc., FEMA 55 should require compliance for all improvements since noncompliance of any part of the structure makes the entire structure out of compliance.

FEMA 55	OTFDC	Analysis
G-4 Definitions (Pages G-2, G-3)	R-115	FEMA 55 contains only definitions which are related to coastal construction. OTFDC contains definitions which are applicable to one- and two-family dwellings in any location. Dead load, live load, and grade have similar definitions.

Recommendation: None.

FEMA 55	OTFDC	Analysis
G-5 Elevation Standards (Page G-3)	N/A	FEMA 55 prohibits new construction or substantial improvements from being seaward of an established setback line and requires it to be elevated above the BFE. OTFDC does not prohibit construction in any location.

Recommendation: None since these types of requirements are local specific and should be addressed on the local level.

FEMA 55	OTFDC	Analysis
G-6 Determination of Loading Forces G-6.1 Water Loads G-6.2 Wind Loads (Page G-3)	R-303 R-401.2 R-402.3 R-601.2 R-701.2 App. A (Wind Probability Map)	Both FEMA 55 and OTFDC require the structure to be of sufficient strength to support the loads and forces encountered. The loads in the OTFDC are dead, live, snow, wind, and seismic. FEMA 55 references ANSI A58.1-1982 for the wind load provisions. OTFDC contains a wind zone map with wind design loads based on ANSI A58.1-1982. OTFDC does not specifically address water loads.

Recommendation: FEMA 55 should update its reference to ASCE 7-88. FEMA 55 should also address snow and seismic loads. The 1992 OTFDC does reference ASCE 7-88.

FEMA 55	OTFDC	Analysis
G-7. Foundation Standards (Page G-4)	R-303	Both FEMA 55 and OTFDC require the foundations to be designed to support the loads and forces encountered.

Recommendation: None.

FEMA 55	OTFDC	Analysis
G-7.1 Pile Foundation Design (Pages G-4, G-5)	R-303	FEMA 55 requires the pile spacing to pile diameter ratio to not be less than 8:1 with a maximum spacing of 12 ft. FEMA 55 provides minimum embedment of foundation piles based on mean sea level and BFE. FEMA 55 requires the piles to be analyzed as a column for the unsupported length. FEMA 55 provides dimensional criteria for round and square wood piles. FEMA 55 provides commentary type language for methods of bracing piles to resist the horizontal forces. OTFDC does not specifically address pile foundations but requires the foundation to be of sufficient design to support safely the loads imposed.

Recommendation: None.

FEMA 55	OTFDC	Analysis
G-7.2 Column Foundation Design (Page G-5)	R-303 R-404.4	FEMA 55 requires reinforcing of masonry piers or poured-in-place concrete piers. OTFDC requires piers to be of sufficient design to support safely the loads imposed.

Recommendation: None.

FEMA 55	OTFDC	Analysis
G-8 Anchoring Standards G-8.1 Connection and Fasteners G-8.2 Beam to Pile Connections G-8.3 Floor to Deck Connections G-8.4 Exterior Wall Connections G-8.5 Ceiling Joist/Rafter Connections G-8.6 Projecting Members (Pages G-5 to G-6)	R-303 R-401.2 R-601.2 R-701.2	FEMA 55 requires anchorage to prevent flotation, collapse, or permanent lateral movement during the base flood concurrent with the 100 year design wind velocity. Both FEMA 55 and OTFDC require the connectors to support the loads and forces encountered but FEMA 55 prohibits the use of toe nailing. FEMA 55 provides prescriptive requirements for the beam to pile connection, floor joists to floor beam/girders, exterior wall connections and ceiling joist/rafter connections. OTFDC provides some prescriptive requirements but also requires the construction to be capable of accommodating all loads and transmitting the resulting loads to its supporting structural elements.

Recommendation: FEMA 55 should not prohibit toe nailing if the connection is adequate for the calculated loads. FEMA should address snow and seismic loads.

FEMA 55	OTFDC	Analysis
G-9 Roof Sheathing (Pages G-6, G-7)	R-703 R-704	FEMA 55 requires roof sheathing to be a minimum of 15/32 inch thick plywood. OTFDC also permits particleboard of 3/8 inch thickness. FEMA 55 requires corrosion resistant fasteners and the application of waterproof industrial adhesive to all bearing surfaces of plywood used in the sheathing of corners, gable and/or roof overhang. FEMA 55 also provides commentary type language addressing the roof slopes and construction at points of discontinuity of the roofing surface.

Recommendation: FEMA 55 should permit particleboard roof sheathing provided it is of the appropriate strength and does not deteriorate in the moist coastal environment.

FEMA 55	OTFDC	Analysis
G-10. Protection of Openings (Page G-7)	R-208.5 R-411 R-412	FEMA 55 requires exterior openings to be designed to withstand the appropriate windloads. OTFDC requires glass areas in exterior walls subject to wind loading to be capable of safely withstanding the wind loads and be tested and certified that they comply with AAMA (ANSI) 101, ANSI/NWWDA I.S.2, ANSI/NWWDA I.S.3 and ASTM D 4099.

Recommendation: None.

FEMA 55	OTFDC	Analysis
G-11. Use of Space Below the Lowest Elevated Floor G-11.1 Breakaway Wall Design Standards G-11.2 Certification of Breakaway Walls (Pages G-7, G-8)	N/A	FEMA 55 prohibits the use of the space below the elevated floor to be used for any other purpose than parking or building access and be either free of obstructions or constructed of breakaway walls. OTFDC does not prohibit the use of the space below the elevated floor and does not address breakaway walls.

Recommendation: None.

FEMA 55	OTFDC	Analysis
G-12 Utilities (Page G-8)	M-1106 M-1306 M-1307 M-1308 M-1102	FEMA 55 requires all mechanical equipment to be elevated above expected flood waters. The OTFDC does not address flooding. However, it does allow elevated installations with minimum access and clearance to combustibles.
	P-2016 P-2111	FEMA 55 requires sanitary sewer and storm drainage systems, which have openings below the BFE, to have backflow valves where these lines penetrate the building envelope. The OTFDC does not address flooding, but does allow backwater valves.

Recommendation: None.

FEMA 55	OTFDC	Analysis
G-13 Certification Requirements (Page G-8)	R-108	FEMA 55 requires new and substantial improvements to be designed by a professional engineer or architect. OTFDC does not require design by a professional engineer or architect. OTFDC permits alternate materials and methods provided that the method of design or construction is equivalent to that of this Code.

Recommendation: FEMA 55 should provide parameters for which sections 7 and 8 are appropriate (wind load, height above grade, etc.).

FEMA 55	OTFDC	Analysis
G-14 Reference Documents (Page G-8)	Chapter 26	FEMA 55 references ANSI A58.1-1982, Shore Protection Manual by the Department of the Army, and the Coastal Construction Manual by FEMA. OTFDC does not reference any of these documents.

Recommendation: FEMA 55 should update its reference to ASCE 7-88.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional constructi with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Manufactured Home Installation in Flood Hazard Areas (FEMA 85)

FEMA 85	OTFDC	Analysis
Chapter III Elevation and Anchoring Techniques Chapter IV Design of Elevated Foundations Appendix D Calculational Procedure for Elevated Foundation Design Appendix E Buoyancy and Drag Forces (Pages 19-101)	Appendix C	Appendix C contains provisions which applies to the construction, alteration and repair of any foundation system which is necessary to provide for the installation of a manufactured home unit; construction, installation, addition, alteration, repair or maintenance of the building service equipment which is necessary for connecting manufactured homes to water, fuel, or power supplies and sewage systems. See NCSBCS comparison to Appendix C.

Recommendation: None.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construction with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Floodproofing Non-Residential Structures (FEMA 102)

FEMA 102	OTFDC	Analysis
Chapter I - VI Appendices A-E (Pages 8-193)	N/A	The OTFDC is applicable only to detached one- or two-family dwellings and one-family townhouses not more than three stories in height (residential occupancies only) therefore, FEMA 102 does not apply.

Recommendation: None.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construct with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Retrofitting Flood-Prone Residential Structures (FEMA 114)

FEMA 114	OTFDC	Analysis
3.5 Elevation Onto Extended Foundation Walls (Pages 46-49)	R-103 R-303	FEMA 114 addresses the method of elevating the structure by increasing the foundation wall height. When this is done, consideration must be taken for the additional load imposed on the footings and the foundation wall. OTFDC requires alterations and repair to comply with the Code. OTFDC requires the foundation systems to be of sufficient design to support safely the loads imposed.

Recommendation: None.

FEMA 114	OTFDC	Analysis
3.12 Technical Design Criteria Extended Wall Foundations (Pages 61-63)	R-303	Both FEMA 114 and OTFDC require the foundation system with the increased foundation wall height to be of sufficient design to support safely the loads imposed.

Recommendation: None.

FEMA 114	OTFDC	Analysis
3.13 Technical Design Criteria Anchorage of Superstructure to Foundation (Pages 63-67)	R-303 R-401.2 R-601.2	FEMA 114 provides design details for the anchorage of the superstructure to the foundation system. OTFDC requires the construction to be capable of accommodating all loads and transmitting the resulting loads to its supporting structural elements.

Recommendation: None.

FEMA 114	OTFDC	Analysis
3.14 Technical Design Criteria Open Foundations (Pages 67-68)	R-303	FEMA 114 describes three types of open foundation systems, (piers, columns, or piles) and requires them to be designed for the loads encountered. OTFDC does not address piles. OTFDC addresses columns or piers and requires them to be of sufficient design to support safely the loads imposed.

Recommendation: None.

FEMA 114	OTFDC	Analysis
6.2 Considerations (Floodwalls) 6.3 Construction Techniques and Materials (Floodwalls) 6.5 Technical Design Criteria (Floodwalls) (Pages 111-129)	N/A	FEMA 114 addresses the use of floodwalls to protect structures from flooding and emphasizes that tremendous forces are created by high water levels and velocities. FEMA 114 addresses techniques and types of materials for the construction of floodwalls. FEMA 114 contains design criteria for floodwall design which addresses materials, soils, loads, overturning resistance, sliding resistance, and actual foundation requirements. OTFDC does not address floodplain management; therefore, it does not address the use of floodwalls.

Recommendation: None.

FEMA 114	OTFDC	Analysis
7.2 Considerations (Closures) 7.3 Low Profile Permanent Closures 7.4 Closure Materials and Construction 7.6 Technical Design Criteria (Closures) (Pages 133-142)	N/A	FEMA 114 addresses the use of closures (covering openings such as doors, windows, driveways, etc.) to act as shields to keep water away from the residence or entering the residence. OTFDC does not address floodplain management nor does it address the use of closures to keep water from entering the building.

Recommendation: None.

FEMA 114	OTFDC	Analysis
8.2 Considerations (Sealants) 8.3 Sealing Techniques 8.4 Closures (Sealants) 8.5 Design Details (Sealants) 8.7 Technical Design Criteria (Sealants) (Pages 145-156)	N/A	FEMA 114 addresses the sealing, making watertight, or dry floodproofing of the structure to prevent the entry of water during low level flooding. OTFDC does not address floodplain management; therefore, it does not address sealing, making watertight, or dry floodproofing of the structure.

Recommendation: None.

FEMA 114	OTFDC	Analysis
9.4 Permanent Protective Measures (Utilities) (Pages 160-165)	M-1102 Ch. 13 M-1301 M-1303 M-1305 M-1306 M-1307 M-1308	FEMA 114 requires (1) utility connections to be above flood level, (2) shielding for basement appliances, (3) elevated installation for exterior appliances, (4) suspension of underfloor/crawlspace equipment, and (5) anchoring of fuel storage tanks. The OTFDC does not address flooding. The OTFDC does not prohibit such equipment installations but does require minimum access and clearances to combustible materials.

Recommendation: None.

FEMA 114	OTFDC	Analysis
9.5 Utility Relocations to Existing Space (Pages 163-164)	M-1102 Ch. 13	FEMA 114 addresses relocation of mechanical equipment fror a basement to the upper levels or attic. The OTFDC does not address flooding, but does allow elevated installations with access and minimum clearance to combustibles.

Recommendation: None.

FEMA 114	OTFDC	Analysis
9.6 Utility Relocations to New Spaces (Pages 164-165)	M-1102 Ch. 13	FEMA 114 addresses relocation of mechanical equipment below BFE to newly constructed spaces above BFE. The OTFDC does not address flooding; however, it does allow mechanical rooms which must have adequate access for equipment and afford clearance to combustibles.

Recommendation: None.

FEMA 114	OTFDC	Analysis
9.8 Storage Tank Anchorage (Page 166)	M-1914	FEMA 114 requires anchorage of fuel storage tanks. The OTFDC does not address flooding. The OTFDC does require oil tanks to resist all loads and stresses to which they are subjected.

Recommendation: None.

FEMA 114	OTFDC	Analysis
10.4 Floating Structures (Pages 176-177)	N/A	FEMA 114 permits "floating structures" as a method of floodproofing. OTFDC does not address "floating structures."

Recommendation: None.

FEMA 114	OTFDC	Analysis
Appendix C - Forces (Pages 197-207)	R-201.2 R-303 R-401.2 R-601.2 R-701.2	FEMA 114 addresses hydrostatic loads, hydrodynamic loads, impact loads, and wind loads. FEMA 114 also provides definitions, application and methodology for design. OTFDC requires the structure to be capable of accommodating all loads imposed and transmitting the resulting loads to its supporting structural elements.

Recommendation: FEMA 114 should update the wind speed maps to the latest editions and address snow and seismic loads.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construction with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Alluvial Fans: Hazards and Management (FEMA 165)

FEMA 165	OTFDC	Analysis
Windows and Doors (Page 10)	R-208.5 R-411 R-412	FEMA 165 prohibits openings on the uphill side of the structure to prevent debris and floodwater from entering the building. OTFDC does not address floodplain management; therefore, it does prohibit openings on the uphill side of the structure. OTFDC requires the glass areas subject to wind loading to be capable of withstanding the wind loads. OTFDC requires windows and sliding glass doors to be tested and certified in accordance with AAMA (ANSI) 101, ANSI/NWWDA I.S.2, ANSI/NWWDA I.S.3, or ASTM D 4099.

Recommendation: None.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construc with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Manual for the Construction of Residential Basements in Non-Coastal Flood Environs (MCRB)

Chapter III Basement Construction

A. Construction Types – Walls

MCRB	OTFDC	Analysis
III.A.1 Unreinforced Block (Page 13)	R-304.1 R-304.3 R-404.3.1 R-405	MCRB provides commentary type language for minimum thickness, lack of reinforcing, and lack of resistance to lateral pressures. OTFDC provides minimum thickness of foundation walls based on type of wall construction, depth of unbalanced fill, soil condition, and seismic zone. OTFDC permits unreinforced masonry to be designed and constructed in accordance with BIA "Building Code Requirements for Engineered Brick Masonry" and ACI/ASCE 530.

Recommendation: MCRB should reference BIA and ACI/ASCE 530.

MCRB	OTFDC	Analysis
III.A.2 Reinforced and Grouted Block (Pages 13, 14)	R-304.1 R-404.3.2 R-408 R-409 R-410	MCRB provides commentary and prescriptive type language for minimum thickness, vertical and horizontal reinforcing, bond beam, and the capacity to resist lateral loads. OTFDC requires reinforced masonry to be designed and constructed in accordance with BIA "Building Code Requirements for Engineered Brick Masonry" and ACI/ASCE 530.

Recommendation: MCRB should reference BIA and ACI/ASCE 530.

MCRB	OTFDC	Analysis
III.A.3 Structural Plain Concrete (Page 14)	R-304.3	MCRB provides commentary and prescriptive type language for minimum thickness, lack of reinforcing, minimum compressive strength, and limits on resistance to lateral pressure. SBC provides minimum thickness of foundation walls based on type of wall construction and depth of unbalanced fill.

Recommendation: None.

MCRB	OTFDC	Analysis
III.A.4 Reinforced Concrete (Pages 14, 15)	R-304.1 R-304.3	MCRB provides commentary and prescriptive type of language for minimum thickness, reinforcing, and ability to resist lateral loads. OTFDC provides minimum thickness and reinforcing based on depth of unbalanced fill. OTFDC also permits foundation walls to be constructed in accordance with ACI 318.

Recommendation: MCRB should reference ACI 318.

MCRB	OTFDC	Analysis
III.A.5 Cut Stone, Rubble Stone, and Cribbing and Planking (Page 15)	R-304.3	MCRB provides commentary type language and will not consider them any further because they are not commonplace. OTFDC provides minimum thickness and limit on height of rubble stone foundations.

Recommendation: None.

MCRB	OTFDC	Analysis
III.A.6 Treated Wood Foundations (Page 15)	R-302.1 R-304.5	MCRB explains that sufficient research is not available on treated wood foundations under flooded conditions, therefore they are not included in the MCRB. OTFDC contains details for wood foundation basement walls and requires them to be constructed in accordance with NFoPA Technical Report No. 7, however the OTFDC does not address floodplain management.

Recommendation: None.

MCRB	OTFDC	Analysis
III.A.7 Variations (Pages 15, 16)	N/A	MCRB provides commentary type language for partially reinforced masonry, unreinforced masonry, reinforced masonry, structural plain concrete, and reinforced cast-in-place concrete walls. OTFDC does not provide commentary language.

Recommendation: None.

MCRB	OTFDC	Analysis
III.A.8 Excavation and Backfill (Pages 16-18)	R-303 R-304.2 R-311.3	MCRB requires all organic material to be removed from the foundation excavation, the footings to be built on undisturbed or properly compacted soil, the bottom of the footing to be below the depth of frost penetration, foundations on expansive soils to be a mat or raft foundation, and backfill to be placed in lifts and compacted in a manner which does not damage the waterproofing or foundation wall. OTFDC contains basically the same provisions.

Recommendation: None.

MCRB	OTFDC	Analysis
III.A.9 Formwork (Pages 18, 19)	N/A	MCRB requires the forms to be substantial and sufficiently tight to prevent leakage of cement paste, properly braced to maintain position, and removed in such a manner as not to damage the concrete. OTFDC does not address formwork but requires concrete to be constructed in accordance with ACI 318.

Recommendation: None.

B. Other Construction Features

MCRB	OTFDC	Analysis
III.B.1 Basement Slab (Page 19)	R-603	MCRB states that basement slabs are typically between 3 and 4 inches thick, with and without steel wire reinforcement. OTFDC provides minimum compressive strength, distance between control joints with and without wire reinforcement based on thickness of slab, site preparation requirements and vapor barrier requirements.

Recommendation: MCRB should provide site preparation requirements, minimum compressive strength, and vapor barrier requirements.

MCRB	OTFDC	Analysis
III.B.2 Structural Basement Slab (Pages 19, 20)	N/A	MCRB provides commentary type language on the use of a structural basement slab to resist water pressures up to 5 feet above the bottom of the slab for an "undrained system." OTFDC does not address structural basement slabs.

Recommendation: None.

MCRB	OTFDC	Analysis
III.B.3 Footing (Foundation) (Page 20)	R-303	Both MCRB and OTFDC require the bottom of the footing to below the depth of frost penetration and provide "typical" footing sizes.

Recommendation: None.

MCRB	OTFDC	Analysis
III.B.4 Underdrain Systems-Sumps and Pumps (Pages 20-23)	R-305 R-306	MCRB requires waterproofing (subsurface drain and/or sump pump) where hydrostatic pressure conditions exist. OTFDC requires foundation drainage and dampproofing of foundation walls enclosing basements regardless of whether hydrostatic pressure conditions exist or not.

Recommendation: None.

MCRB	OTFDC	Analysis
III.B.5.a Ground Surface Slope - Site Investigation (Pages 23, 24)	R-305 R-306	MCRB provides commentary type language addressing site investigation of the soil to determine the drainage method needed to maintain a dry basement. OTFDC requires foundation drainage and dampproofing of foundation walls enclosing basements without a site investigation.

Recommendation: None.

MCRB	OTFDC	Analysis
III.B.5.b Ground Surface Slope - Grading and Surface Drainage (Pages 24, 25)	R-301.3	Both MCRB and OTFDC require the finish grade to slope away from the foundation for drainage. MCRB requires provisions to be made to prevent soil erosion.

Recommendation: None.

MCRB	OTFDC	Analysis
III.B.6 Seepage Quantities (Pages 25-31)	N/A	MCRB provides a "flow net analysis" to determine if the drainage is feasible. OTFDC does not provide sample calculations for "flow net analysis."

Recommendation: None.

MCRB	OTFDC	Analysis
III.B.7.a Penetrations, Cracks, Joints, and "Waterproofing" - Utility Openings (Page 31)	R-306 P-2003.8 P-2012	MCRB requires penetrations through walls to be watertight. OTFDC requires waterproofing (dampproofing) of basement walls. OTFDC requires plumbing penetrations to be watertight.

Recommendation: None.

MCRB	OTFDC	Analysis
III.B.7.b Penetrations, Cracks, Joints, and "Waterproofing" - Techniques That Lessen Cracking in Concrete (Pages 31-34)	R-603.1	MCRB provides commentary type language addressing crack control of concrete. OTFDC requires control joints spaced according to slab thickness and type of wire-reinforcing.

Recommendation: None.

MCRB	OTFDC	Analysis
III.B.7.c Penetrations, Cracks, Joints, and "Waterproofing" - "Waterproofing" Basements (Pages 34, 35)	R-305 R-306	MCRB addresses the use of drains and sump pumps. OTFDC addresses the use of foundation drainage but does not address sumps.

Recommendation: None.

MCRB	OTFDC	Analysis
III.B.8 Subsystems (Plumbing) (Pages 35, 36)	N/A	MCRB recommends the use of a 1/3 to 1/2 HP sump pump. OTFDC does not require sump pumps. MCRB requires sanitary sewer outlets below the flood level to be provided with gate valves. MCRB requires water supply systems located in a Flood Hazard Area to be designed and installed to prevent contamination from flood waters. OTFDC does not address floodplain management.

Recommendation: None.

MCRB	OTFDC	Analysis
III.B.9 Anchorage (Pages 36, 37)	R-303	MCRB provides calculations to determine the anchorage requirements. MCRB requires a minimum of 1/2 inch anchor bolts spaced a maximum of 8 ft anchored into 2 block courses or 16 inches with a minimum of 2 bolts per plate. OTFDC requires a minimum of 1/2 inch anchor bolts spaced a maximum of 6 ft anchored 15 inches into masonry or 7 inches into concrete and not more than 12 inches from corners.

Recommendation: The MCRB should be changed to comply with current model codes.

MCRB	OTFDC	Analysis
III.B.10 Some Concrete Construction Practices (Pages 37-46)	R-304.1	MCRB contains provisions for handling and depositing concrete, consolidating concrete, cold weather considerations, additives, placing reinforcement, etc. OTFDC does not contain the specific provisions but does reference ACI 318 which contains similar provisions.

Recommendation: None.

MCRB	OTFDC	Analysis
III.B.11 Some Block Construction Practices (Pages 47-50)	R-404 R-405	MCRB contains commentary type language addressing ways to improve the waterproofing quality of concrete masonry walls. OTFDC contains minimum requirements for all types of masonry construction.

Recommendation: None.

MCRB	OTFDC	Analysis
III.C. Loads III.C.1 Soil III.C.1.a Sand, Silt, Clay III.C.1.b Expansive Soils III.C.1.c Permeability III.C.1.d Saturation (Pages 50-57)	R-301.4 R-301.5 R-303	MCRB contains commentary type language on soil types, expansive soils, permeability, and saturation. MCRB contains sample calculations. OTFDC requires the "character of the soil" to be determined and slabs on expansive soils to be designed and installed in accordance with PTI or WRI.

Recommendation: None.

MCRB	OTFDC	Analysis
III.C. Loads III.C.1 Soil III.C.1.e Erosion (Page 58)	R-301.3	MCRB addresses methods of inhibiting erosion by soil treatment, seeding, and mulching. OTFDC does not address erosion. OTFDC requires the lots to be provided with adequate drainage and shall be graded so as to drain surface water away from foundation walls.

Recommendation: None.

MCRB	OTFDC	Analysis
III.C. Loads III.C.1 Soil III.C.1.f Backfill Material Related to Lateral Pressure (Pages 58-63)	R-304.2	MCRB provides commentary type language addressing lateral pressures exerted from backfill material. OTFDC prohibits the backfill from being placed until the wall has sufficient strength or has been sufficiently braced to prevent damage by the backfill.

Recommendation: None.

MCRB	OTFDC	Analysis
III.C.2 Water Table (Page 63)	N/A	None. The OTFDC does not address the water table.

Recommendation: None.

MCRB	OTFDC	Analysis
III.C.3 Superstructure Loads and Buoyancy (Pages 63-71)	N/A	MCRB contains sample calculations to determine the superstructure loads imposed by buoyancy. OTFDC does not provide sample calculations.

Recommendation: None.

MCRB	OTFDC	Analysis
III.C.4 Flood Waters III.C.4.d Velocity III.C.4.e Sediment III.C.4.f Rate of Rise III.C.4.g Hydraulic/Hydrologic Relations (Pages 72-75)	N/A	MCRB provides commentary type language addressing increased structural damage which may result from the high velocity of flood waters. MCRB provides commentary type language addressing flood water deposited sediment. MCRB provides commentary type language addressing the rate of rise of flood water causing unequal loading on basement walls which could cause damage to the wall. MCRB references a separate Hydraulic/Hydrologic manual which could be used to evaluate a site (i.e. for velocity of flood waters, erosion, sediment, flood water depth, and watershed hydrology). OTFDC does not address floodplain management.

Recommendation: None.

MCRB	OTFDC	Analysis
III.C.5 Debris, Wind, Impact, Snow, Ice, and Other Live Loads (Page 75)	R-201.1 R-201.2 R-301.1 R-301.2 R-401.2 R-601.2 R-701.2	MCRB states that other than debris and impact loads; wind, snow, and ice are not considered to alter the designs in the MCRB. OTFDC requires every building to be designed and constructed to support safely all loads and forces encountered.

Recommendation: MCRB should include wind, snow, and seismic loads.

Chapter V Basements in Floods

MCRB	OTFDC	Analysis
V.A. Structural Design/Analysis V.A.2 Designs, Methods, and Tables V.A.2.a Building Model, Dimensions, and Loading V.A.2.b Structural Analysis Model(Wall) V.A.2.c Structural Plain Concrete V.A.2.d Reinforced Concrete V.A.2.e Plain Masonry Block V.A.2.f Reinforced Masonry Block V.A.2.g Flood Waters Above Grade V.A.2.h Slab Thickness (Based on Bending) V.A.2.i Structural Slab Design (Ultimate Strength Design) (Pages 88-114)	N/A	MCRB contains sample structural calculations. MCRB refers to the UBC in V.A.2.e and V.A.2.f. OTFDC does not provide sample calculations.

Recommendation: MCRB should not reference a single model code. MCRB should reference only national consensus documents.

MCRB	OTFDC	Analysis
V.B. Soil/Water Load Philosophy V.B.1 Weir Level Load V.B.2 Buoyancy V.B.3 Slab Bending V.B.4 Wall Loads V.B.5 Clay vs. Sand or Drain and Sump vs. Sealed "Barge" V.B.5a Drained or Sump System V.B.5b Undrained or Barge System (Pages 114-126)	N/A	MCRB contains commentary type language addressing the design philosophy of the lateral pressures exerted by soil and/or water loadings. OTFDC does not provide commentary type language or address design philosophy.

Recommendation: None.

VIII. Appendices

MCRB	OTFDC	Analysis
Appendix A-Soils Data Allowable Bearing Pressures (Page 164) Allowable Soil Pressures Beneath Footings (Page 166)	R-303	MCRB contains allowable bearing pressures for various soil types. OTFDC assumes that the soil has a minimum of 2000 pounds per square foot.

Recommendation: None.

VIII. Building's Guide

MCRB	OTFDC	Analysis
VIII.A. Introduction VIII.A.2.a Soil and Water Loading on Wall Cross-Section (Page 198) VIII.A.2.c "Waterproofing" System (Page 206) VIII.A.2.d Wall Design (Page 209) VIII.A.2.e Slab Design (Page 211) VIII.B. Acceptable Wall Designs VIII.B.1 Structural Plain Concrete (Unreinforced) VIII.B.2 Reinforced Concrete VIII.B.3 Unreinforced Masonry Block VIII.B.4 Reinforced Masonry Block VIII.B.5 Buoyancy Wall (Pages 212-239) VIII.C. Acceptable Slab Designs (Pages 240-246) VIII.D. Acceptable Control Joint Designs, Underdrain, and "Waterproofing" and Seals VIII.D.1 Overview and Control Joints VIII.D.2 Sump, Pump, and Underdrain (for Drained System) VIII.D.3 "Waterproofing" and Seals VIII.D.3.a Underdrained Slab and Wall System VIII.D.3.b Drained Slab and Wall System VIII.D.3.c Slab/Wall/Footing Juncture (Pages 247-262)	Part III-Construction	MCRB contains details and design charts for wall design, slab design, control joints, sumps, and/or waterproofing. OTFDC does contain details and design charts but not details and design charts for basement design in flood prone areas.

Recommendation: None.

MCRB	OTFDC	Analysis
Hydraulic/Hydrologic Manual I. Introduction I.B. Flood Waters I.B.4 Velocity I.B.5 Sediment (Pages 7-9)	N/A	MCRB contains commentary type language addressing increased structural damage which may result from the high velocity of flood waters and flood water deposited sediment. OTFDC does not address floodplain management.

Recommendation: None.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construct with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Technical Standards Bulletin: Wet Floodproofing, No. 85-1

No. 85-1	OTFDC	Analysis
I. Definition (Page 1)	N/A	No. 85-1 provides a definition of wet floodproofing and explains the justification for this type of floodproofing. OTFDC does not address floodplain management; therefore, it does not address wet floodproofing or floodproofing of any type.

Recommendation: None.

No. 85-1	OTFDC	Analysis
II. Protection Goals (Page 2)	N/A	No. 85-1 explains that wet floodproofing consists of protection of the structure, protection of interior finishes, protection of mechanical and electrical systems, protection of major equipment and machinery, and protection of contents. OTFDC does not address floodplain management; therefore, it does not wet floodproofing or floodproofing of any type.

Recommendation: None.

No. 85-1	OTFDC	Analysis
III.B. Structural Features (Pages 4-5)	R-303 R-305 R-306	No. 85-1 addresses the superstructure materials as far as their durability, resistance to flood forces, resistance to the deterioration caused by flood waters, and water resistance. OTFDC does not address floodplain management; therefore, it does not address durability, deterioration, or water-resistance of the foundation. OTFDC does require the foundation system to be of sufficient design to support safely the loads imposed, foundation drainage, and foundation dampproofing.

Recommendation: None.

No. 85-1	OTFDC	Analysis
III.C. Building Activity and Use (Pages 5-6)	R-103	No. 85-1 addresses the need to determine the feasibility of wet floodproofing based on building activity and use. OTFDC only addresses one type of building use which is residential.

Recommendation: None since it would not be appropriate to intentionally flood a residence.

No. 85-1	OTFDC	Analysis
IV.A.1 Foundations (Page 6)	N/A	No. 85-1 emphasizes the importance of the need to investigate the influence of hydrologic and hydraulic conditions on the foundation when wet floodproofing is used. OTFDC does not address floodplain management; therefore, it does not address wet floodproofing or floodproofing of any type. OTFDC does require the foundation system to be of sufficient design to support safely the loads imposed.

Recommendation: None.

No. 85-1	OTFDC	Analysis
IV.A.2 Cavity Wall Construction (Pages 6-7)	N/A	No. 85-1 addresses the need to drain the cavity space at a rate approximately equal to the flood rate. OTFDC does not address floodplain management; therefore, it does not address wet floodproofing or floodproofing of any type.

Recommendation: None.

No. 85-1	OTFDC	Analysis
IV.A.3 Solid Wall Construction (Pages 7-8)	R-305 R-306	No. 85-1 addresses the need for the interior and exterior wall cladding to be relatively impervious to prevent the intrusion of the floodwaters into the wall. OTFDC does not address floodplain management; therefore, it does not address wet floodproofing or floodproofing of any type. OTFDC does require foundation drainage and foundation dampproofing.

Recommendation: None.

No. 85-1	OTFDC	Analysis
IV.A.4 Interior Walls (Page 8)	N/A	No. 85-1 emphasizes that the criteria for cavity wall and solid wall construction applies to interior walls. OTFDC does not address floodplain management; therefore, it does not address wet floodproofing or floodproofing of any type.

Recommendation: None.

No. 85-1	OTFDC	Analysis
IV.A.5 Interior Wall Finishes (Page 8)	N/A	No. 85-1 addresses the need for the interior finishes to be able to withstand inundation for a minimum of 160 hours without damage, not be subject to deterioration from chemicals in the floodwaters, and capable of being easily cleaned. OTFDC does not address floodplain management; therefore, it does not address wet floodproofing or floodproofing of any type.

Recommendation: None.

No. 85-1	OTFDC	Analysis
IV.A.6 Floors (Pages 8-9)	N/A	No. 85-1 addresses the need for floor systems to be capable of withstanding the hydrostatic pressure generated by a water level differential of two feet between the exterior and interior of the structure. OTFDC does not address floodplain management; therefore, it does not address wet floodproofing or floodproofing of any type.

Recommendation: None.

No. 85-1	OTFDC	Analysis
IV.A.7 Ceiling and Roofs (Page 9)	N/A	No. 85-1 addresses the need for the ceiling materials to be of a type to withstand prolonged exposure to moisture and humidity. OTFDC does not address floodplain management; therefore, it does not address wet floodproofing or floodproofing of any type.

Recommendation: None.

No. 85-1	OTFDC	Analysis
IV.A.8 Building Envelope Penetrations (Page 10)	N/A	No. 85-1 addresses the need for building penetrations (doors, louvers, vents, skylights, etc.) to be capable of resisting damage for a minimum of 160 hours of inundation, be essentially nonporous, and be conducive to easy cleaning. OTFDC does not address floodplain management; therefore, it does not address wet floodproofing or floodproofing of any type.

Recommendation: None.

No. 85-1	OTFDC	Analysis
IV.A.9 Electrical System (Pages 10-11)	N/A	No. 85-1 addresses the need to prevent vulnerable electrical components from coming in contact with the floodwaters. OTFDC does not address floodplain management. See NFiPA comparison to NFiPA 70.

Recommendation: None.

No. 85-1	OTFDC	Analysis
IV.A.10 HVAC (Pages 11-12)	Ch. 13 M-1102	No. 85-1 requires mechanical equipment to be elevated above BFE or enclosed for protection. The OTFDC does not address flooding. The OTFDC would allow such installations with minimum access and clearance to combustibles.

Recommendation: None.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construction with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Technical Standards Bulletin: Foundation Wall Openings, No. 85-2

No. 85-2	OTFDC	Analysis
Flood Forces (Pages 1-3)	R-303	No. 85-2 provides commentary type language on flood forces (hydrostatic and hydrodynamic pressure) and formulas to determine these pressures. OTFDC requires the foundation system to be of sufficient design to support safely the loads imposed, (wind, water, seismic, and snow).

Recommendation: No. 85-2 should address snow and seismic loads.

No. 85-2	OTFDC	Analysis
Openings Design Criteria (Pages 4-6)	R-311 Ch. 13	No. 85-2 provides the design criteria to size the openings needed to allow floodwaters into an enclosure for the purpose of equalizing hydrostatic pressures. OTFDC only addresses crawl space openings needed for ventilation and equipment access.

Recommendation: None.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construct with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Technical Standards Bulletin: Breakaway Walls, No. 85-3

No. 85-3	OTFDC	Analysis
II. Wind and Water Forces (Pages 2-3)	R-201.2 R-303 R-401.2 R-601.2 R-701.2	No. 85-3 addresses wind and flood water loads. OTFDC requires the construction to be capable of accommodating all loads imposed. OTFDC does not specifically address floodwater forces but does address wind, snow, and seismic loads. No. 85-3 references the building codes on ANSI A58.1-1982 for information on wind loads.

Recommendation: No. 85-3 should update reference to ASCE 7-88 and address snow and seismic loads.

No. 85-3	OTFDC	Analysis
III. Design Approach (Page 4)	R-401.2	No. 85-3 requires the breakaway wall to be designed to withstand at least 10 psf but no more than 20 psf. OTFDC does not address breakaway walls. OTFDC requires the construction to be capable of accommodating the loads imposed.

Recommendation: None.

No. 85-3	OTFDC	Analysis
IV. Design Considerations (Pages 4-10)	R-401.2	No. 85-3 provides commentary type language and details for various types of breakaway walls. OTFDC does not address breakaway walls. OTFDC requires the construction to be capable of accommodating the loads imposed.

Recommendation: None.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construction with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Technical Standards Bulletin: Wind Design Standards and the NFIP, No. 88-1

No. 88-1	OTFDC	Analysis
Pages 1-5	R-201.2 R-303 R-401.2 R-601.2 R-701.2 App. A (Wind Probability Map)	No. 88-1 addresses wind loads and references ANSI A58.1-1982. OTFDC contains a wind probability map with wind design loads. OTFDC requires the construction to be capable of accommodating the loads imposed.

Recommendation: No. 88-1 should update reference to ASCE 7-88. The 1992 OTFDC does reference ASCE 7-88.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional constructio, with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Technical Standards Bulletin: Flood Resistant Materials, No. 88-2

No. 88-2	OTFDC	Analysis
Pages 1-7	N/A	No. 88-2 provides data and guidance to determine "materials resistant to flood damage" and how the material should be used to improve a structure's ability to withstand flooding. OTFDC does not address flood resistant materials.

Recommendation: None.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construction with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Technical Standards Bulletin: Free of Obstruction Requirement in Coastal High Hazard Areas, No. 88-3

No. 88-3	OTFDC	Analysis
Lower Area Obstructions (Pages 2-4)	R-201.2 R-303 R-401.2 R-601.2 R-701.2	No. 88-3 prohibits the construction of anything except breakaway walls, open wood latticework, or insect screening, beneath the lowest horizontal structural member. OTFDC does not prohibit construction provided it is capable of accommodating all loads imposed.

Recommendation: None.

No. 88-3	OTFDC	Analysis
Obstructions Outside the Perimeter of the Coastal Building (Pages 4-6)	R-201.2 R-303 R-401.2 R-601.2 R-701.2	No. 88-3 requires structures outside the perimeter of the coastal building to be anchored to resist flotation, collapse, and lateral movement due to combined effects of wind and water loads. OTFDC requires the construction to be capable of accommodating the loads imposed and transmitting the resulting loads to its supporting structural elements. OTFDC does not address flotation.

Recommendation: None.

No. 88-3	OTFDC	Analysis
Obstruction Attached to But Outside the Building Perimeter (Page 6)	R-201.2 R-303 R-401.2 R-601.2 R-701.2	No. 88-3 explains that anything attached to the building is considered part of the building and has to meet the same requirements as the building. OTFDC requires the building or structure to comply with the Code.

Recommendation: None.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construct with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Technical Standards Bulletin: Protection of Elevator Equipment in Flood Hazard Areas, No. 88-4

No. 88-4	OTFDC	Analysis
Recommendations (Page 3)	N/A	No. 88-4 recommends that the elevator-related hydraulic equipment and elevator-related electrical equipment be located above the BFE. No. 88-4 recommends that electrical equipment that cannot be placed above the BFE to be of water resistant models. No. 88-4 recommends that the elevator cab automatically stay above flood waters by interlocking the controls with "float" switches in the elevator shaft. OTFDC does not address floodplain management or elevators.

Recommendation: None.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construction with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Technical Standards Bulletin: NFIP Requirements for Below Grade Parking Garages in Flood Hazard Areas, No. 90-2

No. 90-2	OTFDC	Analysis
Pages 1-4	N/A	No. 90-2 provides a summary of the National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification) requirements for below grade parking garages in flood hazard areas. OTFDC does not address floodplain management or below grade parking.

Recommendation: None.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construct. with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Technical Standards Bulletin: Non-Residential Floodproofing Certification Requirements of the National Flood Insurance Program, No. 90-3

No. 90-3	OTFDC	Analysis
Pages 1-6	N/A	No. 90-3 provides a summary of the National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification) requirements to obtain certification by floodproofing the non-residential structure. No. 90-3 also provides the forces that the structure would be subjected to when the structure is subjected to the base flood. The OTFDC is applicable only to detached one- or two-family dwelling and one-family townhouses not more than three stories in height (residential occupancies only) therefore, No. 90-3 does not apply.

Recommendation: None.

CABO ONE AND TWO FAMILY DWELLING CODE (OTFDC) COMPARISON

The prescriptive requirements of the CABO One and Two Family Dwelling Code are for conventional construction with wind pressures less than 30 psf and seismic zones 0, 1, and 2.

Technical Standards Bulletin: Installation of Manufactured Homes in Special Flood Hazard Areas, No. 90-4

No. 90-4	OTFDC	Analysis
Pages 3-19	Appendix C	No. 90-4 provides a summary of the National Flood Insurance Program (Regulations for Floodplain Management and Flood Hazard Identification) requirements which affect the placement of manufactured homes in flood hazard areas. Manufactured home installation is addressed in Appendix C. See NCSBCS comparison to Appendix C.

Recommendation: None.

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