June 14, 2006

To: John M. Lamerato, Acting City Manager

From: Brian Murphy, Assistant City Manager, Services
Mark Stimac, Building and Zoning Director
Steven Vandette, City Engineer

Subject: Agenda Item - Request to Amend Chapter 42, Flood Plain Management Allowing Homes with Basements in Flood Plain Areas

Attached is a letter by Fred Barnes seeking consideration to his suggested changes to the Flood Plain Management ordinance. If Council is so inclined to amend Chapter 42, staff has some concerns with the proposed changes offered by Mr. Barnes.

Staff believes that while some cities in our area have allowed homes with basements in flood plains, subject to additional structural requirements to resist hydrostatic pressures, such an exception to the no basement rule may serve to reward illegally filled flood plain property with a building permit for a house with a basement. The city's intent with the no basement provision has always been not to provide an incentive to build houses in the flood plain. Allowing an exception as requested by Mr. Barnes may actually encourage development in less desirable floodplain areas since houses with basements are more marketable to home buyers in this area.

Should you have any questions or if council desires staff to do any in depth research into this request, please advise.

Prepared by: Steven J. Vandette, City Engineer
G:\Council Reports and Communications\OpinionRevChap42.doc

FRED W. BARNES ASSOCIATES, INC.

39160 Chantilly Drive
Sterling Heights, MI
48313

May 15, 2006

City of Troy
ATTN: John Lamerato, Acting City Manager
500 W Big Beaver
Troy MI 48084

Re: Ordinance amendment request

Dear Mr. Lamerato:

I recently discovered the Troy Ordinance concerned with flood plain management is more strict than the State Law. Since the State Law, as it is currently administered, provides for appropriate management of the State's flood plain, I respectfully request that Chapter 42, Flood Plain Management, of the City of Troy Code of Ordinances be amended. The request concerns Paragraph 6. (1). The specific language revisions, justification and explanations are noted below.

EXISTING LANGUAGE

6. Specific Base Flood Elevation Standards

(1) On the basis of the most recent available base flood elevation data the following standards shall apply in the area of special flood hazard:

> (a) all new construction and substantial improvements of residential structures shall have the lowest floor, including basement, elevated to or above the base flood level. This requirement shall apply for residential properties removed from the area of special flood hazard by the placement of fill, regardless of FEMA Letter of Map Revision determinations.
>
> (b) all new construction and substantial improvements of nonresidential structures shall have either:
>
> > (i) the lowest floor, including basement, elevated to or above the base flood elevation; or
> >
> > (ii) be constructed such that below base flood elevation, together

Phone: 810-217-2161 Email: FredTheEngineer@ Comcast.net

with attendant utility and sanitary facilities:

(a) the structure is watertight, with walls impermeable to the passage of water; and

(b) is constructed with structural components having the ability to neutralize hydrostatic and hydrodynamic loads; and

(c) the effects of buoyancy must be resisted.

A registered professional engineer or architect shall certify that the standards of this subparagraph are satisfied, and that the floodproofing methods employed are adequate to withstand the flood depth, pressures, velocities, impact and uplift forces and other factors associated with a base flood in the location of the structure. Such certification shall be submitted to the City Engineer, and shall indicate the elevation to which the structure is floodproofed.

PROPOSED REVISIONS

Paragraph 6. (1) (a) DELETE this subparagraph in its entirety and renumber the remainder of the paragraph as appropriate.

Paragraph 6. (1) (b) ADD the words, "residential or" before the word "nonresidential" in the first line.

PROPOSED REVISED LANGUAGE

6. Specific Base Flood Elevation Standards

(1) On the basis of the most recent available base flood elevation data the following standards shall apply in the area of special flood hazard:

All new construction and substantial improvements of residential and nonresidential structures shall have either:

(a) the lowest floor, including basement, elevated to or above the base flood elevation; or

(b) be constructed such that below base flood elevation, together with attendant utility and sanitary facilities:

(i) the structure is watertight, with walls impermeable to the passage of water; and

(ii) is constructed with structural components having the ability to neutralize hydrostatic and hydrodynamic loads; and

(iii) the effects of buoyancy must be resisted.

A registered professional engineer or architect shall certify that the standards of this subparagraph are satisfied, and that the floodproofing methods employed are adequate to withstand the flood depth, pressures, velocities, impact and uplift forces and other factors associated with a base flood in the location of the structure. Such certification shall be submitted to the City Engineer, and shall indicate the elevation to which the structure is floodproofed.

NO CHANGES ARE RECOMMENDED FOR THE REMAINDER OF THE ORDINANCE.

JUSTIFICATION

Last Revision to Chapter 42
Chapter 42, Flood Plain Management, hereinafter referred to as the Ordinance was last revised February 1, 1999. As a result of the revision, the Ordinance is stricter than Michigan Law or the Rules of the Federal Emergency Management Agency (FEMA). In paragraph 6. (1) (a), the Troy Ordinance forbids construction of basements in residential buildings located in areas that have been removed from a flood hazard area by placement of fill. For the purpose of this discussion, the term, "filled flood plain" will be used to describe this type of area.

Reason for 1999 revision to Chapter 42
According to Mark Stimac, the intent of the revision was to eliminate the incentive to fill in the flood plain. The only written record of the discussion preceding the amendment to the Ordinance is a copy of a memorandum to the Mayor and City Council from the City Attorney obtained from the City Clerk's Office. A copy of the memorandum is attached as Exhibit A. The key argument in the memorandum is stated in the last sentence of the first paragraph, "The MDEQ is now allowing developers to use artificial fill to remove a property from a flood hazard area."

At the time the Ordinance was amended, the charge was true. The Michigan Department of Environmental Quality (MDEQ) was permitting fill in flood plain

without the requirement of compensating excavation. The potential results of such a policy are discussed below.

Flood plain is natural storage, or detention, for water courses in flood stage. If the natural storage is eliminated without replacement or compensation, more of the storm water that would have been detained is forced downstream faster. The result is a two-fold problem. One: The increased discharge causes the floodplain downstream from the site to increase in height causing additional flood damage. The increased flood plain elevation then backs up the water course, causing higher flood elevations on the property and upstream from the property. Two: The elimination of detention changes the timing of the flood peak. The effects of the change in timing would probably not cause problems on the property, but could cause problems downstream from the site location.

One small site in a drainage basin is not likely to have a significant impact on either the flood discharge or the timing of the flood peak. However, a policy of allowing watershed wide elimination of the natural flood storage of these fringe areas without compensation would definitely result in significantly higher flood elevations.

Therefore, the action of the Troy City Council, in lieu of appropriate controls by the State, was a logical step to take for the protection of the residents of the city.

MDEQ actions taken since the Troy Ordinance revision

MDEQ conducted hydrologic and hydraulic analyses of various watersheds in the State and determined that the policy of allowing flood plain fill without compensating excavation could have a detrimental impact on flood discharges and flood stages. Subsequently, approximately 18 months after the Troy Ordinance revision, MDEQ published a DIVISION GUIDANCE MEMO on August 8, 2000, a copy of which is attached hereto as Exhibit B. MDEQ now requires compensating excavation for floodplain fill.

The specific language in the Guidance Memo is recited here for the convenience of the reader.

> The Guidance Memo specifically addresses six specific river systems in paragraphs 2) a. through 2) f., none of which impact the City of Troy. Paragraph 2) g. reads, in part:
>
> > 2) g. Compensating cut for fill shall be provided on-site at a one-to-one ratio in other areas to the extent practicable. ...If on-site compensation is not feasible, the applicant must provide an evaluation as to the feasibility of providing compensation off site, as close to the fill area as possible.

As a result of the revised MDEQ policy, there is no net loss of flood storage when filling flood plain areas, thus eliminating the potential deleterious effects of the fill operations.

Building protection
The Michigan Law that governs construction in filled flood plain is Section 324.3108 of the Natural Resources and Environmental Protection Act, PA 451 of 1994 (NREPA), a copy of which is attached as Exhibit C hereto for your information. The Law provides that basements may be constructed below the flood elevation in filled flood plain if certain criteria are met. The criteria protect buildings from the additional hydrostatic pressures that may be exerted on basement walls and floors as a result of a flood and the subsequent saturation of the ground around the basement walls and floor.

The State Law criteria are very similar to the criteria stated in 6 (1) (b) of the Troy Ordinance.

The FEMA rules provide exceptions to the no basement rule similar to the exceptions in the Michigan rules stated in NREPA. In fact, FEMA has provided a Technical Bulletin that outlines proper procedures for this type of construction. A copy of this bulletin, Technical Bulletin 10-01, has been attached as Exhibit D to this request, for your information and reading pleasure.

Impact of current ordinance on the City of Troy
Residences without basements are not as desirable in Michigan, therefore more difficult to sell. Lack of a basement also decreases the value of the house, which decreases the assessment, which decreases tax revenue

Protection of homeowners
Houses constructed in accordance with the guidelines dictated in the State Law, NREPA Section 324.3108 and Technical Bulletin 10-01 are *just as safe* from flooding and flood damage as any other structure. In fact, such houses *may be safer* than other buildings constructed in areas adjacent to flood hazard areas without the additional protection provided by the construction measures outlined in the two references.

The following example may illustrate this point. Much of the area in this part of Michigan is very flat. Once the rivers in this area get out of their banks, water will spread hundreds, and sometimes, thousands of feet from the normal top of the river bank. In many cases, the depth of the flood plain is very shallow. Property owners may be able to sacrifice some of the property by excavating adjacent to the river and using the spoil to fill some of the fringe flood plain areas. The Michigan Law requires careful selection, placement and compaction of the fill

material. It also requires an engineer to test the fill, calculate potential hydrostatic pressures, and if necessary provide additional strength in the basement walls and floor with calculations to prove their adequacy. Consider a residential development in such an area with two adjacent houses, one in the area of filled flood plain, the other, although only separated by as little as 15 or 20 feet, not in a filled flood plain area. The house in the filled flood plain area will be safe from flood damage because an engineer has specifically addressed the issues required by State Law. The house not in the flood plain will be constructed without any such additional protective measures. If the soils in the area happen to consist of sand or gravel which transmit groundwater more efficiently, the house not in the floodplain is more likely to have basement problems than the adjacent house constructed on filled flood plain.

SUMMARY

1. Permits are required from MDEQ for fill in flood plain.
2. Letters of Map Revision (LOMR) are required from FEMA to remove areas from flood plain.
3. MDEQ requires compensating excavation for flood plain fill. Therefore, fill operations will not result in increased flood discharges or increases in flood stage or flood plain elevations.
4. Michigan Law requires additional measures when constructing buildings with basements in filled floodplain areas. The houses are protected from additional hydrostatic pressures against basement walls and floors by restrictions in the type and placement of fill, waterproofing, and installation of sump pumps designed for the specific soil types and hydrologic conditions. If necessary, additional strength or reinforcement may be required for basement walls and floors to withstand potential hydrostatic pressures. Anchors are required to prevent the house from floating.
5. FEMA provides Technical Bulletin 10-01, which provides guidance to homeowners and communities for such construction.

CONCLUSION

The State has taken measures to protect communities and property owners from increased flood risk from flood plain filling operations by requiring compensating excavation. The State and FEMA have taken measures to protect homeowners from increased risk when constructing a basement in filled floodplain. The reason for the 1999 amendment to the Ordinance no longer exists. Allowing construction of basements in areas of filled flood plain will increase tax revenues to the City.

RECOMMENDATION

The City of Troy amend the Ordinance as requested herein to comply with the State and National Laws, Rules and Regulations, thus providing an opportunity for homeowners to increase the value of their property for themselves and benefit to the community.

I urge you to initiate a procedure to amend the Ordinance at the earliest possible time. If you have any questions or comments, please contact me.

Yours truly,

Fred W. Barnes, PE
President

DATE: JANUARY 27, 1999

TO: HONORABLE MAYOR AND CITY COUNCIL

FROM: JOHN J. MARTIN, III, CITY ATTORNEY JM
LORI GRIGG BLUHM, ASSISTANT CITY ATTORNEY LGB

RE: PROPOSED FLOOD HAZARD AREA ORDINANCE

Michigan law has been amended as it pertains to flood hazard area ordinances. Specifically, the MDEQ has adopted much more lenient standards regarding development in flood hazard areas. The MDEQ is now allowing developers to use artificial fill to remove a property from a flood hazard area.

In the past, the Troy Ordinances deferred to the state and federal standards regarding flood hazard areas. However, the Engineering and Building Departments do not feel that the current state of the law, as recently modified, provides adequate protection to Troy residents who purchase homes and are unaware of the previous flood hazard area designation, and the increased potential for flooding. Therefore, attached please find a more restrictive version of the Troy Flood Hazard Area Ordinances, which are currently found in Chapter 39 of the City of Troy Ordinances.

Please contact us if you have questions regarding this case.

CC: Planning Commission Members
James C. Bacon, Jr.
John Szerlag
Neall Schroeder, Tracy Slintak
Larry Keisling; Mark Stimac
Gary Shripka; Mitch Grusnick

EXHIBIT A

DEQ DEPARTMENT OF ENVIRONMENTAL QUALITY	DIVISION GUIDANCE MEMO LAND AND WATER MANAGEMENT DIVISION	NUMBER: 31-00-01 PAGE: 1 of 4
SUBJECT: Compensating Cut for Fill in Floodplains		EFFECTIVE DATE: 8/8/2000
SECTION AND/OR UNIT: Transportation and Flood Hazard Management Unit, Floodplain Field Staff, Subdivision Floodplain Program	APPROVAL SIGNATURE: Original signed by Hope Croskey TITLE: Chief, Water Management Section	ALSO SEE:

ISSUES:

The Land and Water Management Division's (LWMD) floodplain engineering field staff issue permits to place fill in regulated floodplains. The permitted activities may result in the loss of floodplain storage and long-term impacts to downstream areas if compensating cut is not required.

AUTHORITY:

The Floodplain Regulatory Authority found in Part 31, Water Resources Protection, of the Natural Resources and Environmental Protection Act, 1994 PA 451, as amended (Part 31), provides the authority to require compensating cut for fill placed in floodplain areas.

DISCUSSION:

1) The attached Attorney General's opinion, dated January 8, 1976, indicates that the LWMD has the authority to require permits for the occupation (residential, commercial, or industrial), filling, or grading of any portion of the floodplain, not just the floodway.

2) Section 3104 (1) of Part 31 designates the department as *"the state agency to cooperate and negotiate with other governments, governmental units, and governmental agencies in matters concerning the water resources of the state, **including, but not limited to, flood control**... The department shall have control over the alterations of natural or present watercourses of all rivers and streams in the state to assure that the channels and the portions of the floodplains that are the floodways are not inhabited and are kept free and clear of interference or obstruction that will cause any undo restriction of the capacity of the floodway." (emphasis added)*

3) Section 3107 of Part 31 states that, *"the department may promulgate rules and issue orders for the prevention of harmful interference with the discharge and stage characteristics of streams. The department may ascertain and determine for record and in making its order the location and extent of floodplains, stream beds, and channels and the discharge and stage characteristics of streams at various times and circumstances."* "Harmful interference" is defined in rule R 323.1311 (g) as *"causing an increased stage or change in direction of flow of a river or stream that causes, or is likely to cause, any of the following:*
i) Damage to property, ii) A threat to life, iii) A threat to personal injury, iv) Pollution, impairment, or destruction of water or other natural resources."

Hydrologic analysis of the watersheds that have been studied documents the cumulative impacts on a stream's stage and discharge characteristics when floodplain storage is lost. The cumulative loss of floodplain storage will ultimately increase flood discharges and thus cause an increase in flood stages.

EXHIBIT B

4) Section 3108 (1) of Part 31 states that, "*a person shall not occupy or permit the occupation of land for residential, commercial, or industrial purposes or fill or grade or permit the filling or grading for a purpose other than agriculture of land in a floodplain, stream bed, or channel of a stream, as ascertained and determined for the record by the department, or undertake or engage in an activity on or with respect to land that is determined by the department to interfere harmfully with the discharge or stage characteristics of a stream, unless the occupation, filling, grading, or other activity is permitted under this part.*" (emphasis added)

   Rule 323.315 (3) states that, "*An encroachment in the floodplain, landward of the floodway limits, which, acting alone, or in combination with existing or future similar works, does not cause harmful interference may be permitted.*" (emphasis added)

Clearly a permit is required to fill in the floodplain. Unless it can be shown that filling of the floodplain will not cause "a harmful interference," an application to fill in the floodplain can be denied unless compensating cut is provided to prevent harmful interference.

5) As with other floodplain activities, it is up to the applicant to demonstrate that their project will not cause a harmful interference with the stage and discharge characteristics of a stream. Rule 323.1313 (2) states that, "*An application for a permit to place an encroachment not excluded under Rule 323.1312 in a floodplain, channel, or floodway shall include a site location and a property map showing limits of the proposed encroachment as it relates to the drainage course.* Rule 323.1313 (3) states that, "*The department may ask for the following additional information in order to analyze the effects that a proposed encroachment, acting alone or in combination with existing or future similar works, has on stage or discharge characteristics of the stream:*" (emphasis added). Some of the information that may be requested includes: "cut and fill limits," "volume of cut and fill," and "*a hydraulic report, based on water surface profile computations, which evaluates the effect of the proposed encroachment on stage and discharge characteristics for a range of discharges up to and including the 100-year flood discharge. The report shall be prepared and sealed by an engineer licensed in Michigan.*"

GUIDANCE/ACTION:

The following guidance is provided to staff for the requirements of compensating cut for fill placed in regulated floodplains.

1) The LWMD has the regulatory authority under Part 31 to require compensating cut for fill placed in regulated floodplains if the proposed project, acting alone or in combination with existing or future similar works (cumulative impacts), causes a harmful interference with the stage or discharge characteristics of a stream (either upstream or downstream). Where practicable, compensation shall be provided at approximately the same elevations as were displaced. If the LWMD determines that the proposed project, acting alone or in combination with existing or future similar works, will not cause a harmful interference with the stage or discharge characteristics of a stream, then compensating cut will not be required. Generally, compensating cut will not be required for fill volumes of less than 300 cubic yards as a single and complete project, unless there is evidence that it will cause a harmful interference.

GUIDANCE/ACTION (continued)

2) The collective analysis of the watersheds studied so far supports the conclusion that the stage and discharge characteristics of the majority of streams in the state will be adversely impacted if floodplain filling continues without any requirement to provide compensation. Six areas were evaluated through detailed hydrologic/hydraulic studies to determine the impact due to the loss of floodplain storage. The studies confirm the necessity for requiring compensating cut to offset further increases in flood elevations. Compensating cut is required in the following areas at the following rates:

   a. Clinton River Forks area - land areas within the 100-year floodplain of the Clinton River and branches within Clinton Township and Macomb Township, Macomb County. Compensating cut for fill is required at a one-to-one ratio.

   b. Saginaw River - land areas within the 100-year floodplain of the Saginaw River and tributaries, including Cheboyganing and Dutch Creeks, between the cities of Saginaw and Bay City, Saginaw and Bay counties. Compensating cut for fill is required for 70 percent of the proposed fill volume below the 100-year floodplain elevation.

   c. Shiawassee flats - land areas within the 100-year floodplain of the lower reaches of the Shiawassee, Cass, Flint, Tittabawassee, and Bad Rivers within Saginaw County. Compensating cut for fill is required for 97 percent of the proposed fill volume below the 100-year floodplain elevation.

   d. Snake Creek - land areas within the 100-year floodplain of Snake Creek in the city of Midland, Midland County. Compensating cut for fill is required at a one-to-one ratio.

   e. Rush Creek - land areas within the 100-year floodplain of Rush Creek in Georgetown Township and the city of Hudsonville, Ottawa County. Compensating cut for fill is required for 90 percent of the proposed fill volume below the 100-year floodplain elevation.

   f. Frank and Poet Drain - land areas within the 100-year floodplain of the Frank and Poet Drain in the city of Trenton, Wayne County. Compensating cut for fill is required at a one-to-one ratio.

   g. Compensating cut for fill shall be provided on-site at a one-to-one ratio in other areas to the extent practicable. The applicant shall demonstrate that they have used and or considered all feasible and prudent means to avoid and minimize the amount of fill placed in the floodplain. Some options that the applicant should consider include (this is not intended to be a complete list):

      1. Reducing the building size thereby minimizing the fill footprint.
      2. Reducing the number of building lots.
      3. Leaving parking lot and driveway areas at existing grade.
      4. Elevating structures on piers.
      5. Using another location.

      If fill in the floodplain cannot be eliminated, the applicant must provide an evaluation as to the feasibility of providing on-site compensation. If on-site compensation is not feasible, the applicant must provide an evaluation as to the feasibility of providing compensation off site, as close to the fill area as possible.

GUIDANCE/ACTION (continued)

3) The amount of compensating cut for fill placed in a regulated floodplain may be reduced or eliminated if the applicant provides a valid study, to the DEQ's satisfaction, that documents no harmful interference with the stage or discharge characteristics of a stream will result from the cumulative impacts of long term filling of the floodplain. Per section 3104 (4) the department shall assess the applicant an additional $1500 to cover the department's cost of reviewing the study.

4) As a Part 31 permit condition, the applicant shall be required to obtain a Letter of Map Revision (LOMR) if the proposed or actual cut or fill occurs in the mapped portion of a floodplain of a community that participates in the National Flood Insurance Program. If applicable, the LOMR shall be obtained before a local building permit is issued.

NATURAL RESOURCES AND ENVIRONMENTAL PROTECTION ACT (EXCERPT)
Act 451 of 1994

324.3108 Unlawful occupation, filling, or grading of floodplain, stream bed, or channel of stream; exceptions; construction of building with basement.

Sec. 3108. (1) A person shall not occupy or permit the occupation of land for residential, commercial, or industrial purposes or fill or grade or permit the filling or grading for a purpose other than agricultural of land in a floodplain, stream bed, or channel of a stream, as ascertained and determined for the record by the department, or undertake or engage in an activity on or with respect to land that is determined by the department to interfere harmfully with the discharge or stage characteristics of a stream, unless the occupation, filling, grading, or other activity is permitted under this part.

(2) A person may construct or cause the construction of a building that includes a basement in a floodplain that has been properly filled above the 100-year flood elevation under permit if 1 or more of the following apply:

(a) The lowest floor, including the basement, will be constructed above the 100-year flood elevation.

(b) A licensed professional engineer schooled in the science of soil mechanics certifies that the building site has been filled with soil of a type and in a manner that hydrostatic pressures are not exerted upon the basement walls or floor while the watercourse is at or below the 100-year flood elevation, that the placement of the fill will prevent settling of the building or buckling of floors or walls, and that the building is equipped with a positive means of preventing sewer backup from sewer lines and drains that serve the building.

(c) A licensed professional engineer or architect certifies that the basement walls and floors are designed to be watertight and to withstand hydrostatic pressure from a water level equal to the 100-year flood elevation and that the building is properly anchored or weighted to prevent flotation and is equipped with a positive means of preventing sewer backup from sewer lines and drains that serve the building.

(3) If the community within which a building described in subsection (2) is located is a participant in the national flood insurance program authorized under the national flood insurance act of 1968, title XIII of the housing and urban development act of 1968, Public Law 90-448, 82 Stat. 572, 42 U.S.C. 4001, 4011 to 4012, 4013 to 4020, 4022 to 4102, 4104 to 4104d, 4121 to 4127, and 4129, then the developer shall apply for and obtain a letter of map revision, based on fill, from the federal emergency management agency prior to the issuance of a local building permit or the construction of the building if 1 or both of the following apply:

(a) The floodplain will be altered through the placement of fill.

(b) The watercourse is relocated or enclosed.

History: 1994, Act 451, Eff. Mar. 30, 1995;—Am. 1996, Act 162, Imd. Eff. Apr. 11, 1996.

Popular name: Act 451

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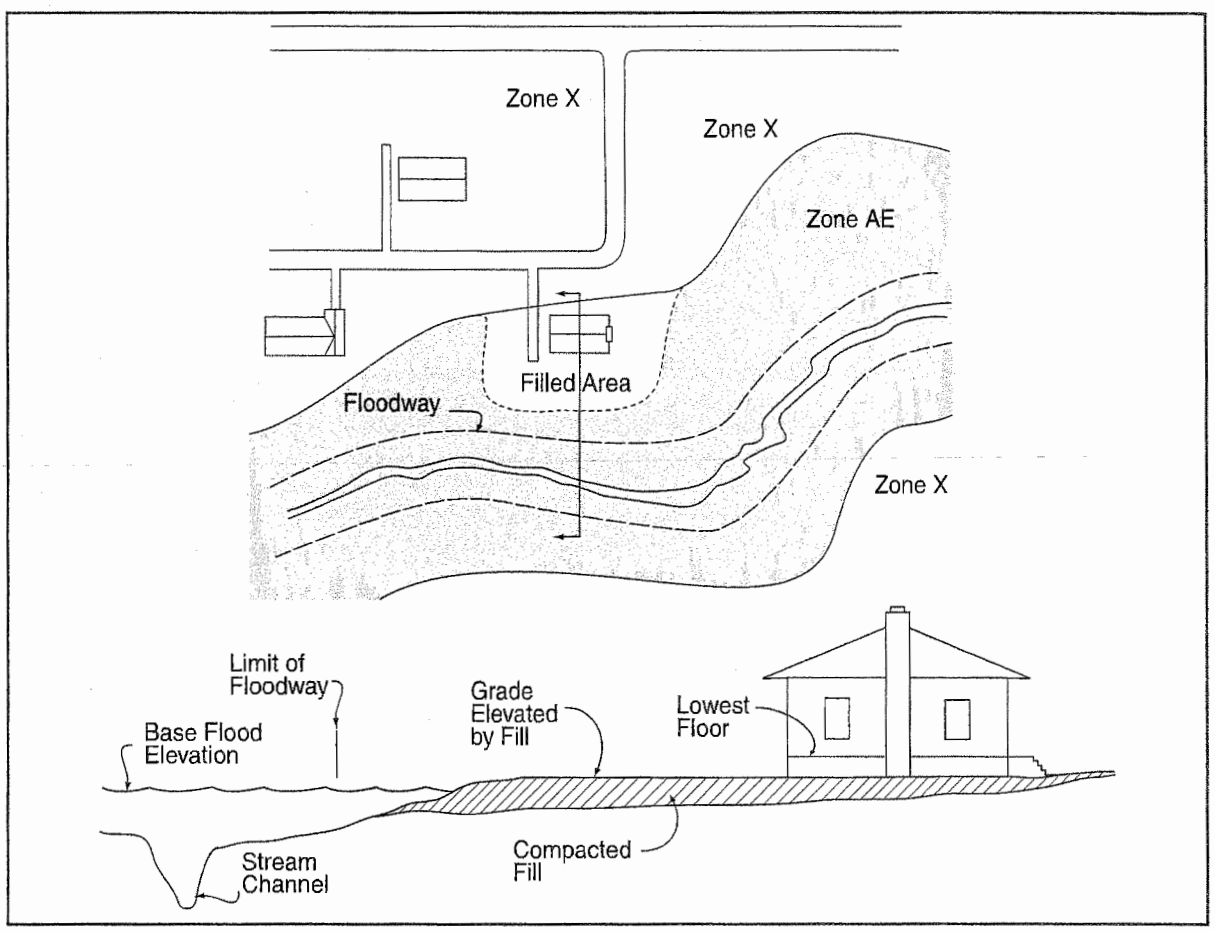
EXHIBIT C

Technical Bulletin 10-01

Ensuring That Structures Built on Fill In or Near Special Flood Hazard Areas Are Reasonably Safe From Flooding

in accordance with the
National Flood Insurance Program



FEDERAL EMERGENCY MANAGEMENT AGENCY
MITIGATION DIRECTORATE

FIA-TB-10
(5/01)

EXHIBIT D

Key Word/Subject Index

This index allows the user to locate key words and subjects in this Technical Bulletin. The Technical Bulletin User's Guide (printed separately) provides references to key words and subjects throughout the Technical Bulletins. For definitions of selected terms, refer to the Glossary at the end of this bulletin.

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Any comments on the Technical Bulletins should be directed to:

Federal Emergency Management Agency
Mitigation Directorate
Program Policy and Assessment Branch
500 C Street, SW.
Washington, DC 20472

Wave design on cover based on the Japanese print *The Great Wave Off Kanagawa*, by Katsuchika Hokussai (1760–1849), Asiatic Museum of Fine Arts, Boston.

TECHNICAL BULLETIN 10-01

Ensuring That Structures Built on Fill In or Near Special Flood Hazard Areas Are Reasonably Safe From Flooding in accordance with the National Flood Insurance Program

Introduction

For the purpose of administering the National Flood Insurance Program (NFIP), FEMA identifies and maps flood hazard areas nationwide by conducting flood hazard studies and publishing Flood Insurance Rate Maps (FIRMs). These flood hazard areas, referred to as Special Flood Hazard Areas (SFHAs), are based on a flood having a 1-percent probability of being equaled or exceeded in any given year (also referred to as the 100-year flood or Base Flood).

Structures within the SFHA in a community participating in the NFIP are subject to floodplain management regulations that impact building standards and are designed to minimize flood risk. For example, Title 44, Part 60, Section 3(c)(2) of the Code of Federal Regulations—abbreviated as 44 CFR 60.3(c)(2)—requires that the lowest floor of a residential structure, including basement, built within the SFHA be at or above the Base Flood Elevation (BFE). In addition, flood insurance must be purchased for these structures if they are used as collateral to secure a loan provided by a federally regulated lender. Flood insurance coverage may be purchased for all eligible structures within a participating community. Insurance rates for structures located within the SFHA differ from the rates for structures located outside the SFHA.

When permitted under applicable Federal, state, and local laws, ordinances, and regulations, earthen fill is sometimes placed in an SFHA to reduce flood risk to the filled area. Under certain conditions, when engineered earthen fill is placed within an SFHA to raise the surface of the ground to or above the BFE, a request may be submitted to FEMA to revise the FIRM to indicate that the filled land is outside of the SFHA. When such revisions are warranted, FEMA usually revises the FIRM by issuing a Letter of Map Revision based on fill (LOMR-F). After FEMA has revised the FIRM to show that the filled land is outside the SFHA, the community is no longer required to apply the minimum NFIP floodplain management standards to any structures built on the land and the mandatory flood insurance purchase requirements no longer apply. It is worth noting that states and local communities may have floodplain regulations that are more restrictive than the minimum requirements of the NFIP and may continue to enforce some or all of their floodplain management requirements in areas outside the SFHA.

Although a structure built on a site that has been elevated by the placement of fill may be removed by FEMA from the SFHA, the structure may still be subject to damage during the Base Flood and higher-magnitude floods. Constructing the entire structure at or above the level of the BFE will minimize the flood risk from the Base Flood and is therefore the most prudent approach to constructing on fill. Conversely, a structure with a basement (subgrade area) adjacent to or near the floodplain may well be impacted by subsurface flooding brought on by surface flooding.

This bulletin provides guidance on the construction of buildings on land elevated above the BFE through the placement of fill. Several methods of construction are discussed, and the most prudent—those that result in the entire building being above the BFE—are recommended.

In some areas of the country, basements are a standard construction feature. Individuals may wish to construct basements on land after it has been removed from the floodplain by a FEMA revision. Buildings with basements built in filled areas are at an added risk of flooding when compared to buildings on other types of foundations. However, there are two major ways to minimize this additional risk from subsurface flooding. First, the building should be located farther back from the edge of the fill closest to the flooding source. Second, the higher the basement floor is elevated, the less the risk. This technical bulletin provides guidance on how to determine that these buildings will be reasonably safe from flooding during the occurrence of the Base Flood and larger floods. To be reasonably safe from flooding during the Base Flood condition, the basement must (1) be dry, not have any water in it, and (2) be structurally sound, not have loads that either exceed the structural capacity of walls or floors or cause unacceptable deflections. In practice, this means that soils around the basement must have low permeability to minimize or stop water infiltration to the basement wall and floors. Any water that does permeate to the basement must be removed by a drainage layer on the outside (soil side) of the basement. In addition, the foundation walls and floor slab must be designed and constructed for any increased loads that may occur during the Base Flood condition.

NFIP Regulations

Part of a community's application to participate in the NFIP must include "a commitment to recognize and duly evaluate flood hazards in all official actions in the areas having special flood hazards and to take other such official actions reasonably necessary to carry out the objectives of the program" [44 CFR 59.22 (a)(8)].

NFIP regulations at 44 CFR 60 include Subpart A: Requirements for Flood Plain Management Regulations. Each community participating in the NFIP adopts a floodplain management ordinance that meets or exceeds the minimum requirements listed in 44 CFR 60. Subpart A establishes specific criteria for determining the adequacy of a community's floodplain management regulations. The overriding purpose of the floodplain management regulations is to ensure that participating communities take into account flood hazards, to the extent that they are known, in all official actions relating to land management and use.

One of the minimum requirements established by the regulations is set forth at 44 CFR 60.3 (a)(3), which states that, for all proposed construction or other development within a participating community, the community must "Review all permit applications to determine whether the proposed building sites will be reasonably safe from flooding." 44 CFR 59.1 defines "development" as

> *"…any manmade change to improved or unimproved real estate, including but not limited to buildings or other structures, mining, dredging, filling, grading, paving, excavation or drilling operation or storage of equipment or materials,"*

Warning

Construction of a residential building in an identified SFHA with a lowest floor below the BFE is a violation of the floodplain management requirements set forth at 44 CFR 60.3(c)(2), unless the community has obtained an exception to NFIP requirements from FEMA and has approved procedures in place.

By issuance of this Technical Bulletin, FEMA is noting that residual flood hazards may exist in areas elevated above the BFE by the placement of engineered earthen fill. Residual risks in these areas include subsurface flood conditions and flooding from events that exceed the base flood. This bulletin is intended to guide local floodplain management officials in determining whether structures placed in filled areas are reasonably safe from flooding. FEMA will require that the jurisdiction having authority for floodplain management determine that an area is reasonably safe from flooding before removing it from the SFHA.

Floodways, V Zones, and Alluvial Fan Flood Hazard Areas

This bulletin does **not** apply to the following:

- Construction in the floodway. The NFIP prohibits encroachments into the floodway that would cause increases in flood stage.
- Construction in SFHAs designated Zone V, VE, or V1-V30 on FIRMs. The NFIP prohibits the use of structural fill for support of buildings in V zones. Buildings constructed in a V zone must be constructed on an open foundation consisting of piles, piers, or posts and must be elevated so that the bottom of the lowest horizontal structural member is at or above the BFE. In addition, this bulletin strongly recommends that structural fill **not** be used to elevate buildings constructed in A zones in coastal areas. Detailed guidance concerning proper construction methods for buildings in coastal areas is presented in FEMA's *Coastal Construction Manual* (FEMA 55) and in NFIP Technical Bulletin 5, *Free-of-Obstruction Requirements*.
- Construction in SFHAs subject to alluvial fan flooding (designated Zone A0 with depths and velocities shown on FIRMs). The NFIP will not remove land from the floodplain based on the placement of fill in alluvial fan flood hazard areas.

More Restrictive State and Local Requirements

NFIP Technical Bulletins provide guidance on the **minimum** requirements of the NFIP regulations. State or local requirements that exceed those of the NFIP take precedence. Design professionals should contact community officials to determine whether more restrictive state or local regulations apply to the building or site in question. All applicable standards of the state or local building code must be met for any building in a flood hazard area.

Notes for Local Officials

Professional Certification

As required by state and local floodplain management ordinances, a proposed development must be determined to be reasonably safe from flooding. The official having the authority to make this determination should require all appropriate information for making the determination. This may include a certification by a qualified design professional that indicates the land or structures to be removed from the SFHA are reasonably safe from flooding, according to the criteria described in this technical bulletin. Such a professional certification may come from a professional engineer, professional geologist, professional soil scientist, or other design professional qualified to make such evaluations. A sample of such a certification is shown in Figure 1.

Project Name and Address

I, _____ certify that the design for the aforementioned development is reasonably safe from flooding in accordance with the guidance provided within FEMA's Technical Bulletin 10-01 related to ensuring that structures are reasonably safe from flooding and in accordance with accepted professional practices.

Signature _____ Date _____

Title _____

Type of License _____ License Number _____

Address and Phone

Professional Seal

License Expiration Date

Figure 1 Sample of professional certification form.

Administrative Options for Community Permitting

Communities may choose a variety of administrative procedures to assist them in gathering information that can be used to determine whether a proposed development is reasonably safe from flooding. Communities are encouraged to establish procedures that alert them to potential future development of a filled area. These procedures should allow for the evaluation of future development and a means to determine whether it will be reasonably safe from flooding. The following are examples of such procedures:

- Require building sites to be identified on final subdivision plats and evaluate those building sites against the standards described in this Technical Bulletin.
- Require grading plans as a condition of issuing fill permits and require that those grading plans include building sites, and evaluate those building sites based on this Technical Bulletin.
- Require buffer zones or setback zones around the perimeter of fill pads or at the edge of the floodplain and establish construction requirements within these buffer zones to ensure that buildings are safe from residual risk.
- Require as a condition of final subdivision plat approval that the developer agree that no basements will be built in any flood areas.
- Adopt or have regulations that control development of areas immediately adjacent to floodplains that would ensure that any construction is reasonably safe from flooding. For example, under the Minnesota State Building Code, communities designate areas outside of the floodplain as "Secondary Flood Hazard Areas" where building officials evaluate plans for basements and can require modifications to the basement if an official believes there is a residual risk.
- When issuing a permit for the placement of fill only in the SFHA, stipulate that no buildings will be built on the site without a subsequent building permit.

Placement of Fill

Properly placing fill requires an understanding of soil mechanics, local site conditions, the specific characteristics of the soils being placed, the methods used to place and compact the fill, and soil testing procedures. Standard engineering and soil mechanics texts cover these subjects in detail. The performance of these filled areas should consider, but is not limited to, the following:

- the consolidation of the fill layers and any underlying layers
- the effect of this consolidation on either excessive settlement or differential settlement
- how the permeability of the soils affects water infiltration on any structures built on the site

Loss of Storage and Conveyance

The placement of fill in the SFHA can result in an increase in the BFE by reducing the ability to convey and store flood waters. This can result in increased flood damage to both upstream and downstream properties. To prevent these possible results, some communities prohibit fill, require compensatory storage for filled areas, and/or identify a more restrictive floodway.

Risk of Flood Damage in Areas Adjacent to the SFHA

Areas adjacent to the SFHA may have residual risks of flood damage similar to those in areas removed from the SFHA through the placement of fill. Both areas are subject to residual risk from subsurface water related to flooding and from floods greater than the Base Flood. Methods of construction discussed in this bulletin should also be used in these areas.

Building on Land Removed From the SFHA by the Placement of Fill

The safest methods of constructing a building on filled land removed from the SFHA are those that result in the entire structure being above the BFE. Methods that place the lowest floor of the building at, rather than above, the BFE are at greater flood risk, and methods that result in the lowest floor (including a basement floor) below the BFE have the highest flood risk of all. Placement of the lowest floor of these structures below the BFE, even through they are outside the SFHA, will result in an increased threat from subsurface flooding and magnified damages from flooding that exceeds the BFE.

Freeboard

Freeboard is an additional height used as a factor of safety in determining the elevation of a structure, or floodproofing, to compensate for factors that may increase the flood height (ASCE 24-98, *Flood Resistant Design and Construction*). When fill is used to protect buildings from the Base Flood, the community should consider whether freeboard should be required. This consideration should include whether better information exists or conditions have changed (from when the BFE was originally established) that indicate that the BFE may be higher than originally expected. One example of when the BFE may be higher is when a culvert or bridge is blocked by debris. Flood modeling assumes an open channel or culvert. Even when the BFE is not expected to be higher, freeboard may be appropriate to provide increased protection from flood events less frequent than the Base Flood or to account for future changes that may increase the BFE.

The foundation types for buildings outside the SFHA described in the following sections are listed in order of their increasing risk of flood damage.

Non-Basement Foundations

Non-basement foundations consist primarily of stem wall, crawlspace, and slab-on-grade foundations.

Stem Wall Foundation

A stem wall foundation can be used to raise the lowest floor above the surrounding grade. After the stem walls have been constructed and extended to the desired elevation, the area enclosed by the stem walls is filled with engineered compacted fill and a slab is poured on top (see Figure 2). Through the placement of additional fill, the site may be elevated above the BFE. This approach provides freeboard—an additional amount of elevation that helps protect against subsurface flooding and floods that exceed the Base Flood. Constructing a stem wall foundation and placing this additional fill on the site provide the highest level of flood protection.

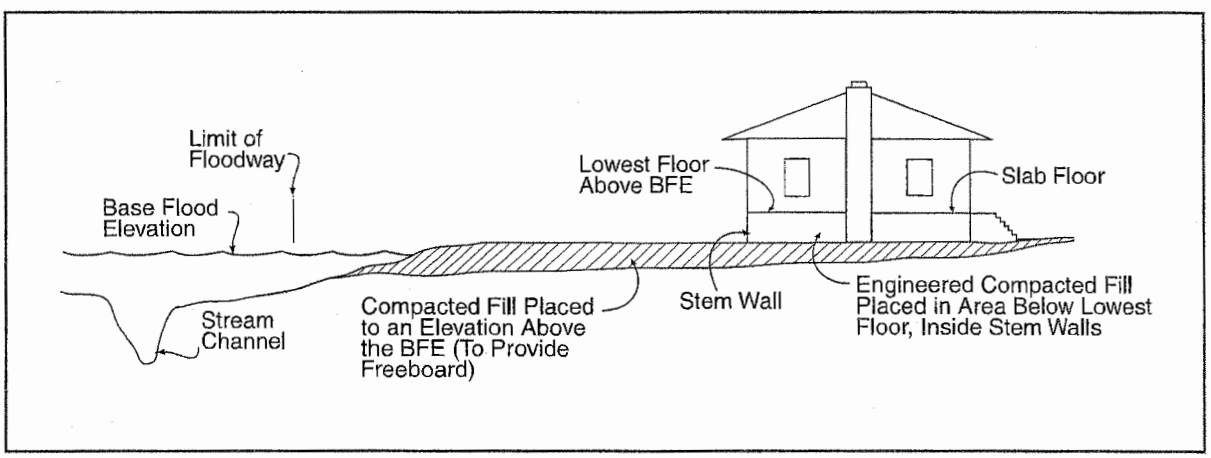

Figure 2 Structure on a stem wall foundation. The lowest floor is raised above the BFE. The space enclosed by the stem walls is filled with engineered compacted fill.

Crawlspace Foundation

Constructing a crawlspace beneath the first floor will raise the lowest floor of the structure above the surrounding grade (see Figure 3). Openings in the foundation walls are recommended. If flooding reaches the building, the openings allow flood waters to enter the area below the lowest floor and equalize the hydrostatic pressure on the foundation walls (see NFIP Technical Bulletin 1, *Openings In Foundation Walls*).

The crawlspace alternative is less preferable than stem wall construction, which does not result in an enclosed area under the first floor and therefore requires no flood openings. Placing additional fill to a level above the BFE provides freeboard that helps protect against subsurface flooding and floods that exceed the Base Flood. Constructing a crawlspace foundation and placing additional fill on the site provide increased flood protection.

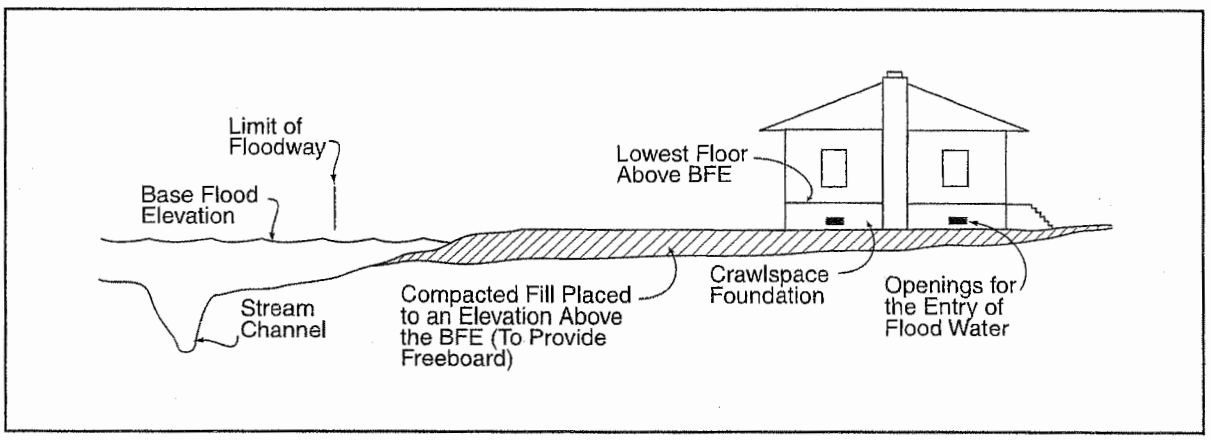

Figure 3 Structure on a crawlspace foundation. The lowest floor is raised above the BFE. Openings in the foundation walls allow water from floods higher than the fill elevation to enter the crawlspace and equalize the pressure on foundation walls.

Slab-On-Grade Foundation

This method normally provides less flood protection than crawlspace construction because it does not elevate the house above the adjacent grade (see Figure 4). As a result, the lowest floor of the house can be as low as the BFE and would be inundated by any flood greater than the BFE. Placing additional engineered fill beneath the building to a level above the BFE would provide freeboard and therefore increased flood protection.

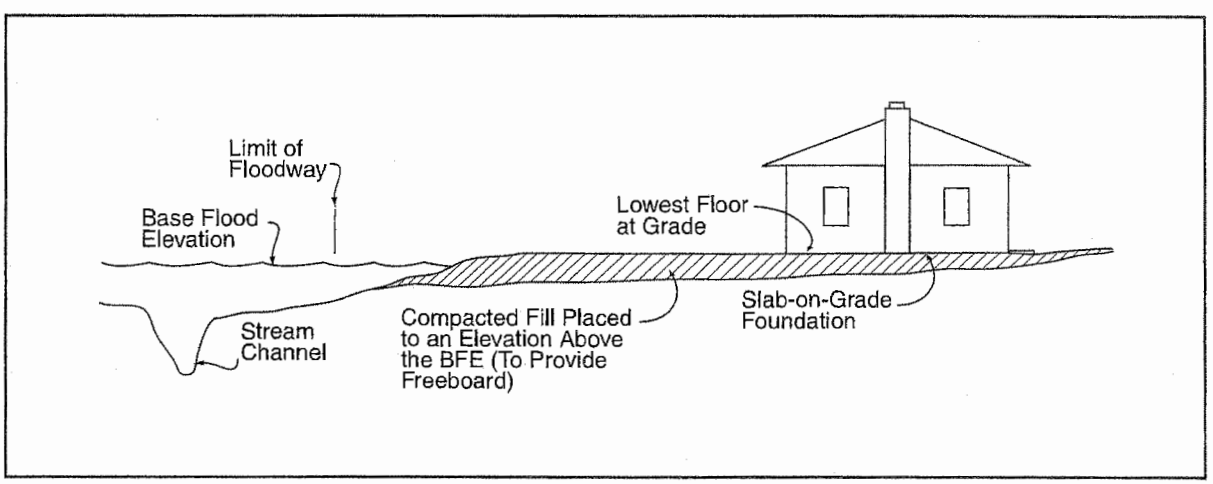

Figure 4 Structure on a slab-on-grade foundation. The lowest floor is typically slightly higher than the surrounding grade.

Basement Foundations

Although basements are a desired feature in some areas of the United States, NFIP minimum requirements generally do not allow their construction in the SFHA, because of the increased risk of flood damages. The only instances where this is not the case are buildings for which FEMA has granted a special exemption to allow floodproofed basements. However, once land is removed from the SFHA through a map revision, these NFIP minimum requirements no longer apply. As a result, builders and property owners who build on land removed from the SFHA sometimes elect to install basements, which are at a higher risk of flood damage than the foundation types described previously.

Constructing a basement on such land is **not** recommended, because the basement (i.e., lowest) floor and portions of the basement walls may well be subjected to subsurface flooding. The basement may therefore be subject to seepage and lateral hydrostatic and uplift pressure caused by high groundwater levels associated with flooding in surrounding areas. Additionally, when flooding exceeds the BFE, the basement area may be totally inundated with floodwater. When builders and homeowners decide to accept the additional risk associated with basement construction on filled land, they need to ensure that the basement and the rest of the house are reasonably safe from flooding.

Warning

In filled areas adjacent to floodplains, floods can still greatly influence the groundwater at the filled site. High groundwater at a site with a basement can result in water infiltrating the basement or greatly increased hydrostatic pressures on the walls and basement slab that can cause failure or permanent deformation. Even when floods have not reached houses with basements, FEMA has seen numerous examples of flooded basements, bowed basement floors, and collapsed basement walls that have resulted from the effects of high groundwater caused by flooding. In addition, the collapse of flooded basements has also occurred when water is rapidly pumped from basements surrounded by saturated soils whose pressure exceeds the capacity of the basement walls.

Flood Insurance Coverage for Basements

It is extremely important to note that the NFIP offers only limited coverage for basement flooding. First, in order for a claim to be paid, there must be a general condition of overland flooding where floodwaters come in contact with the structure. Secondly, the NFIP does not provide coverage for finished nonstructural elements such as paneling and linoleum in basement areas. Contents coverage is restricted to a limited number of items listed in the flood insurance policy. Contact a local insurance agent for more information.

Four basement construction methods are described below in increasing order of flood risk.

Basement Foundation With Lowest Floor At or Above BFE

Placing the lowest floor of the basement at or above the BFE has the effect of eliminating flood-induced damage up to the BFE (see Figure 5). In general, the higher the basement floor is above the BFE the lower the risk of damage from seepage and hydrostatic pressure caused by flood-related groundwater. Where possible, the basement should be built with its floor at or above the BFE. An added benefit is that floods that exceed the BFE will cause significantly less damage to a structure with this type of basement than to structures with basements whose floors are at greater depths.

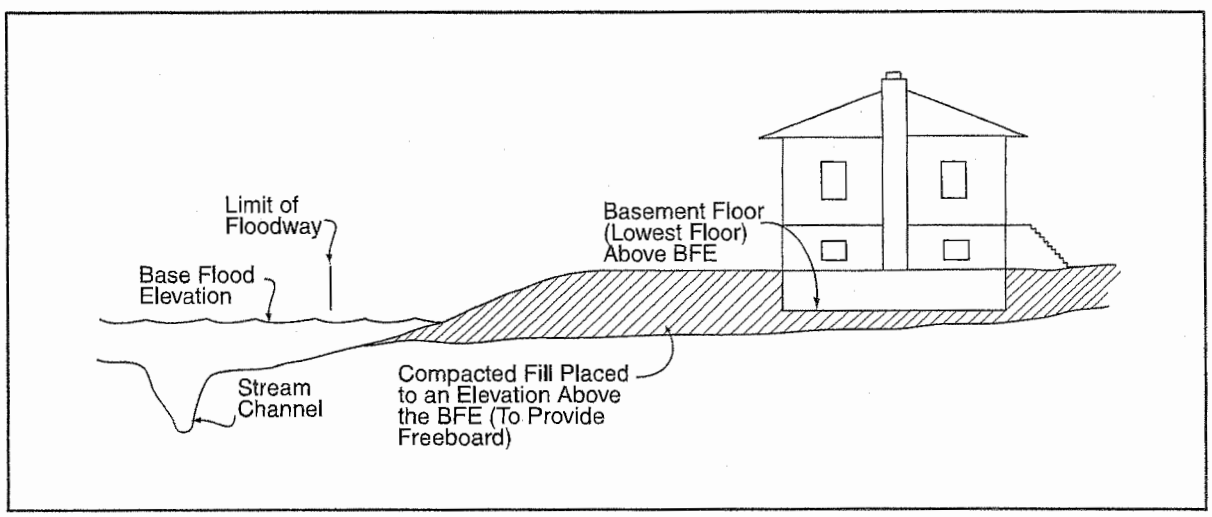

Figure 5 Basement foundation with lowest floor above the BFE. Damage from floods below the BFE is eliminated.

Basement Foundation in Fill Placed Above BFE

Placing fill to a level higher than the BFE has the effect of reducing the depth of the basement floor below the BFE (see Figure 6). It is recommended that fill be placed to a level at least 1 foot above the BFE. In general, the higher the basement floor the lower the risk of damage from seepage and hydrostatic pressure caused by flood-related groundwater. Where possible, enough fill should be properly placed so that the lowest grade adjacent to the structure is raised to an elevation greater than the BFE. An added benefit of fill placed above the BFE is that it helps protect the building from floods greater than the Base Flood. These floods are less likely to reach the structure.

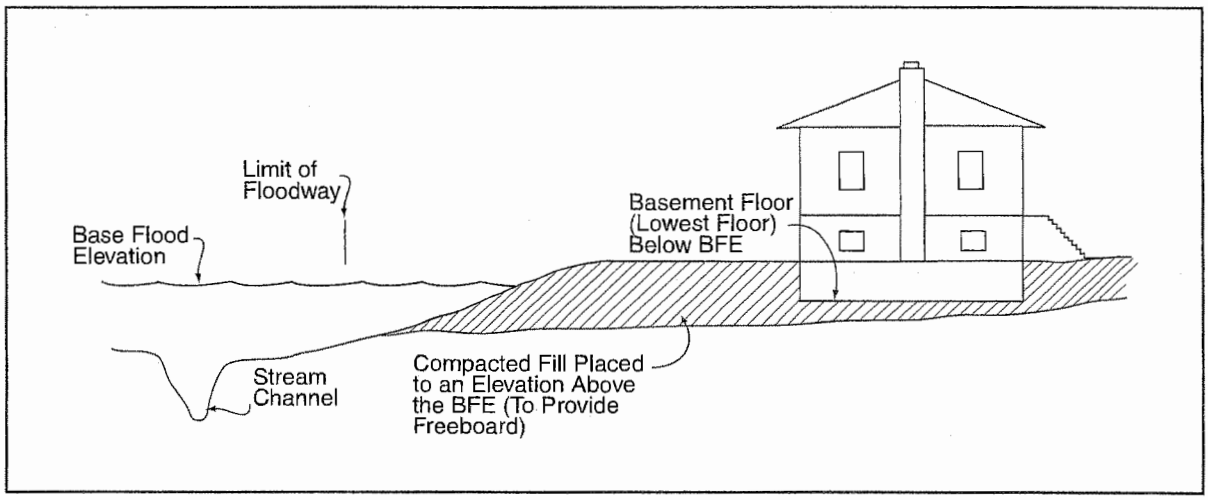

Figure 6 Basement foundation in fill placed above the BFE. The depth of the basement floor below the BFE is less than when no fill is placed.

Basement Foundation With Lowest Opening Above BFE

In the event that the lowest floor is not elevated to or above the BFE and fill is not placed to a level above the BFE, the next best method of reducing flood risk is to place the lowest opening into the basement (e.g., window well) at a level higher than the BFE (see Figure 7). This will reduce the chances that surface flooding will enter and inundate the basement. However, the basement walls and floor slab will still be subjected to hydrostatic pressure with the potential for damage and seepage into the basement. In addition, the above-grade basement walls will be exposed to water from floods greater than the Base Flood. For this reason, the lowest opening in the basement walls should be above the BFE, as shown in Figure 7.

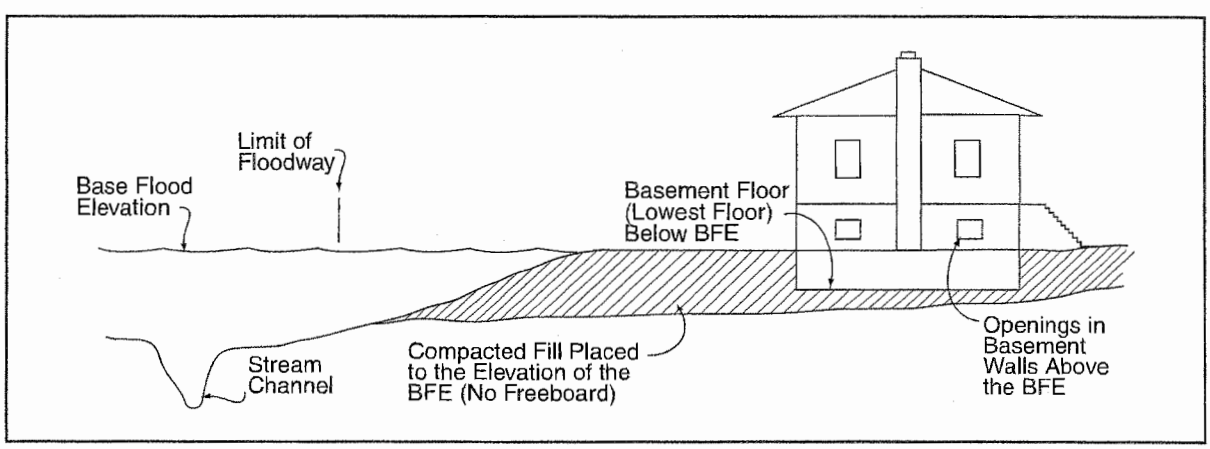

Figure 7 Basement foundation with lowest opening above the BFE. Surface flooding is less likely to enter and inundate the basement.

Basement Foundation With Lowest Opening at BFE

This is the least preferable condition of all because it results in the highest flood risk and is not recommended (see Figure 8). The lack of fill above the BFE, coupled with the lowest floor being below BFE and lowest opening at the BFE, exposes the basement to flooding from both subsurface flooding and any flood greater than the Base Flood.

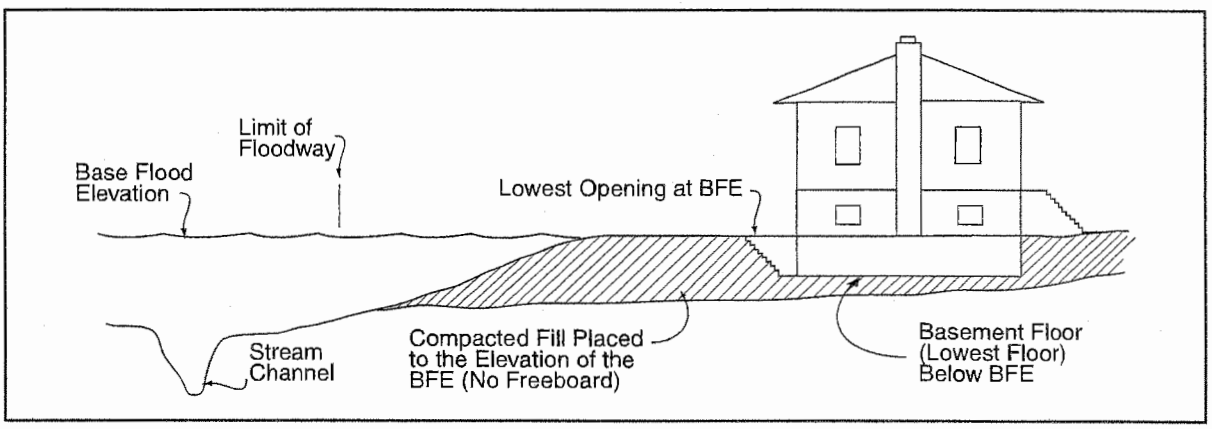

Figure 8 Basement foundation with lowest opening at the BFE. The basement is exposed to flooding from any flood greater than the Base Flood.

Flood Risk by Foundation Type

Table 1 summarizes the foundation construction methods described in this bulletin and ranks them in order of increasing flood risk—the safest foundation types appear near the top; the less safe foundation types appear near the bottom. The foundation construction methods that result in a building that is reasonably safe from flooding are shown in the dark gray area of the table. If the basement construction methods shown in the light gray area are used, the requirements described in the following sections of this bulletin must be met in order for the building to be considered reasonably safe from flooding.

Table 1 Flood Risk by Foundation Construction Method

Foundation Flood Risk

Flood Risk During the Base Flood	Fill		Foundation Construction Method										
			Stem Walls		Crawlspace		Slab-On-Grade		Basement				
									Floor Level			Openings	
	Above BFE	At BFE	Above BFE	At BFE	Above BFE	At BFE	Above BFE	At BFE	Above BFE	At BFE	Below BFE	Above BFE	At BFE
Increasing Level of Flood Risk	■		■										
	■				■								
	■						■						
		■		■									
		■				■							
		■						■					
	■								■			■	
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Reasonably Safe From Flooding

Follow Guidance in This Bulletin To Ensure That Building Is Reasonably Safe From Flooding

Basement Construction Guidance

For those who have chosen to accept the additional risk associated with basement construction below the Base Flood on filled land that has been removed from the SFHA, this bulletin provides technical guidance about measures that can be taken to protect basements and meet the requirement that buildings be made reasonably safe from flooding. A simplified approach, including the requirements that must be met for its use, is presented first. For buildings that do not meet the criteria for the simplified approach, this bulletin provides technical guidance for the development of an engineering design tailored to the site conditions.

Structural Design

Design of foundation elements is addressed in model building codes. This technical bulletin does not address the structural design of basement walls or foundations. Floors and slabs should be designed for the hydrostatic pressures that can occur from the Base Flood. For the structural design, it is recommended that the full hydrostatic pressures be assumed unrelieved by the drainage system. Foundation walls that have not been designed for hydrostatic pressures, such as unreinforced masonry or pressure-treated wood wall systems, should not be used (see Figure 9).

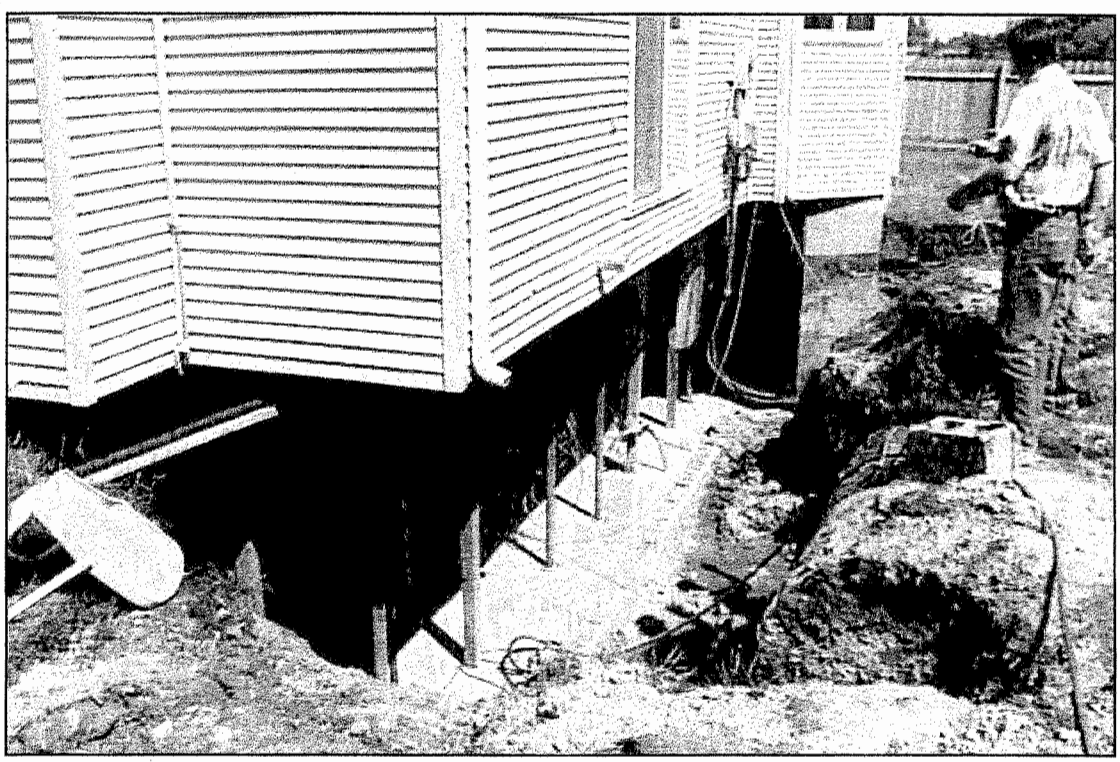


Figure 9 Failure of this unreinforced masonry basement during flooding in East Grand Forks, MN, in 1997 caused approximately $32,000 in damage.

Simplified Approach

Design Requirements

If, for a building and building site, **all** the requirements listed below are met (see Figure 10), the building is reasonably safe from flooding. If all of these requirements are not met, the more detailed analysis described under Engineered Basement Option, on page 19 of this bulletin, should be performed to determine whether the building is reasonably safe from flooding.

- ☐ The ground surface around the building and within a defined setback distance from the edge of the SFHA (see next item) must be at or above the BFE.
- ☐ The setback is the distance from the edge of the SFHA to the nearest wall of the basement. The minimum allowable setback distance is 20 feet.
- ☐ The ground around the building must be compacted fill; the fill material—or soil of similar classification and degree of permeability—must extend to at least 5 feet below the bottom of the basement floor slab.
- ☐ The fill material must be compacted to at least 95 percent of Standard Laboratory Maximum Dry Density (Standard Proctor), according to ASTM Standard D-698. Fill soils must be fine-grained soils of low permeability, such as those classified as CH, CL, SC, or ML according to ASTM Standard D-2487, *Classification of Soils for Engineering Purposes*. See Table 1804.2 in the 2000 *International Building Code* (IBC) for descriptions of these soil types.
- ☐ The fill material must be homogeneous and isotropic; that is, the soil must be all of one material, and the engineering properties must be the same in all directions.
- ☐ The elevation of the basement floor should be no more than 5 feet below the BFE.
- ☐ There must be a granular drainage layer beneath the floor slab, and a ¼-horsepower sump pump with a backup power supply must be provided to remove the seepage flow. The pump must be rated at four times the estimated seepage rate and must discharge above the BFE and away from the building. This arrangement is essential to prevent flooding of the basement or uplift of the floor under the effect of the seepage pressure.
- ☐ The drainage system must be equipped with a positive means of preventing backflow.
- ☐ Model building codes (such as the 2000 International Residential Code) also address foundation drainage (IRC Section R405) and foundation walls (IRC Section R404). Model building codes generally allow foundation drains to discharge through either mechanical means or gravity drains. In addition, there is often an exception to the requirement for drainage systems in well-drained soils. However, in or near floodplains, well-drained soils can, in fact, help convey groundwater towards the building foundation. Therefore, this exception should not apply in or near floodplains.

- In some cases in or near floodplains, even with standard drainage systems, hydrostatic pressures from groundwater against the basement can result. When a standard drainage system is unable to eliminate hydrostatic pressure on the foundation, model building codes, including the 2000 International Residential Code (IRC Section R404.1.3), require that the foundation be designed in accordance with accepted engineering practice. **The simplified approach contained in this Technical Bulletin assumes no hydrostatic pressure on the foundation and should be used only when a standard drainage system, discharged by a sump pump that is equipped with backup power and that discharges above BFE, is employed.** For other drainage systems, the designer should use the engineered basement option presented on page 19 of this bulletin and other appropriate building code requirements.

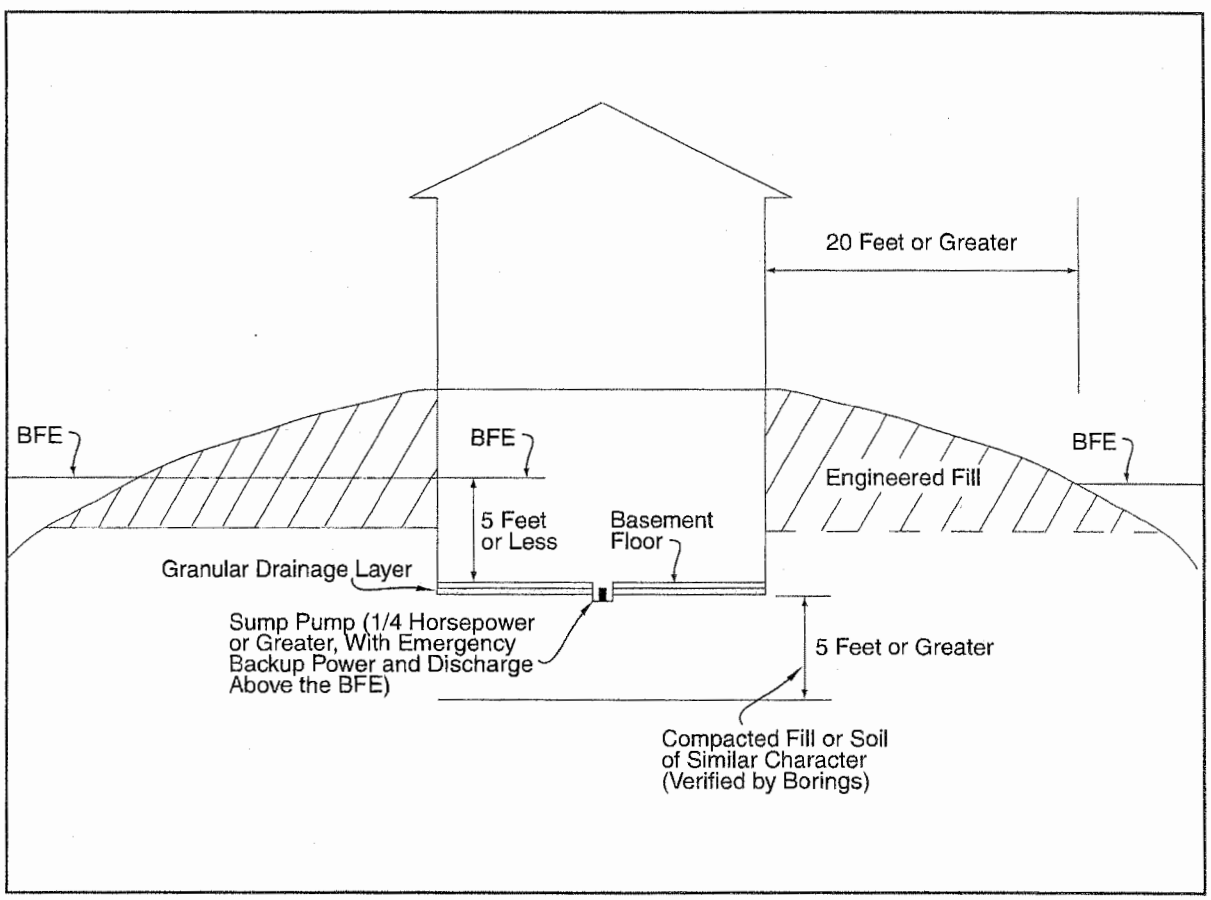


Figure 10 Requirements for use of the simplified approach to basement construction.

Technical Background for the Simplified Approach

The simplified approach is based on the following conditions:

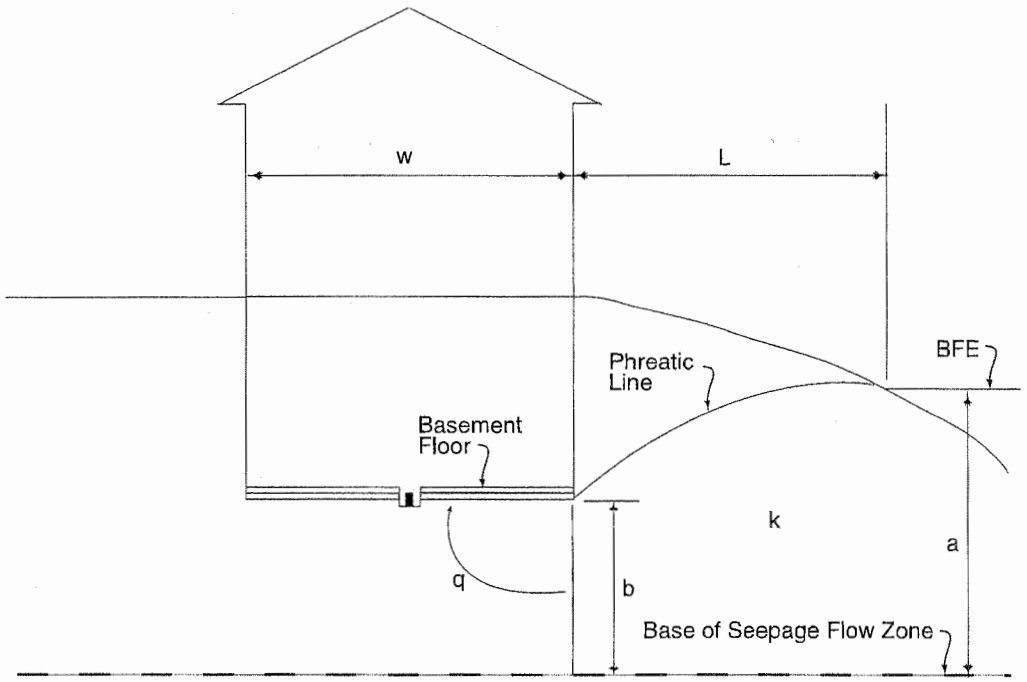
1. The area of the footprint of the basement is less than or equal to 1,200 square feet.

2. The soil is saturated; therefore, there is no time lag in the development of the seepage pattern with a change in flood water level. The groundwater table in floodplains is typically very shallow, and fine-grained soils have a substantial potential for maintaining saturation above the water table by capillary rise.

3. The tailwater level is at the elevation of the BFE. For this bulletin, "tailwater" is defined as the groundwater level beyond the structure, on the side away from the flood water surface. This is a reasonably conservative assumption because the flood would raise the groundwater level in the general area. In some cases, the tailwater level can be higher than the flood level because there is higher ground, as a valley wall, that feeds the groundwater into the floodplain soils.

4. The effective elevation of the base of the seepage flow zone can be defined (see Figure 11). This elevation is needed to permit calculation of the quantity of seepage flow. If the base elevation is not known, its depth below the base of the floor slab can be conservatively approximated as one-half of the building width most nearly perpendicular to the shoreline of the flood water. This would approximate the boundary effects of the three-dimensional seepage flow, in that it would represent the flow coming in from all sides and meeting in the center beneath the floor slab. This approach assumes a constant soil type and density over the flow zone. If the site has stratified soil layers, the engineered basement option should be used (see page 19 of this bulletin).

5. The quantity of seepage flow can be calculated by a simplified method based on Dupuit's assumption that equipotential lines are vertical. (The Dupuit method uses Darcy's law with specific physical characteristics. A more detailed description can be found in the first two references listed under "Further Information," on page 23 of this bulletin.) The elements of the method are presented in Figure 11. The entry surface, with hydraulic head "a," is a vertical line extending downward from the edge of the flood surface. The exit surface, with hydraulic head "b," is a vertical line extending downward from the side of the structure closest to the flood water's edge. The length of the flow path, "L," is the setback distance. Flow is assumed to be horizontal, and the horizontal coefficient of permeability is the effective permeability. For simplicity, the small inclined entry zone at the river bank and the exit zone below the basement floor are ignored. This is a reasonably conservative measure. The phreatic line, or the line below which the seepage flow occurs under positive pressure, extends from the edge of the flood water to the elevation of the bottom of the basement floor slab. If the exit zone below the basement floor were included, the hydraulic head at "b" would be higher. As shown in Figure 11, the phreatic line is not a straight line, but within the limits of the assumed boundary values, it is close to a straight line.



(1) $q = k(a^2 - b^2)/2L$

where: q = flow in cfs for a 1-foot width of seepage zone
k = soil permeability in feet per second
a = head at entry surface in feet
b = head at drain surface in feet
L = length of seepage zone (setback distance) in feet

(2) $Q = Pq$

where: Q = total seepage flow into drain in cfs
P = 2(basement length + width)
(for a square basement, P = 4w)

(3) Required sump pump capacity = 4Q for a safety factor of 4

Figure 11 Method for calculation of seepage flow.

The Dupuit equation for the quantity of seepage flow is:

$$q = k(a^2 - b^2)/2L$$

where: q is the flow in cubic feet per second for a 1-foot width of seepage zone

k is the soil permeability in feet per second (fps) (maximum value of k is 1×10^{-3} fps)

a and b are hydraulic heads in feet ($a < b + 5$)

L is the length of the flow zone in feet ($L > 20$ feet)

To obtain Q, the total seepage flow, in cubic feet per second, q must be multiplied by the length around the periphery of the four sides of the structure. This is a simplifying approach that obviates the need for a three-dimensional flow net calculation and is reasonably conservative.

It should be noted that the soil permeability does not affect the geometry of the seepage zone or the geometry of the phreatic line. The permeability does have a significant effect on the quantity of seepage that must be collected and discharged by the drainage layer and the sump pump. The calculation of the quantity Q provides a basis for the selection of a sump pump of adequate capacity. To allow for possible errors in the estimation of the soil permeability, the pump should have a capacity of at least four times the calculated value of Q. As noted in the requirements section, a standard sump pump of ¼ horsepower or greater will generally satisfy the requirements of seepage removal for the conditions described above.

Engineered Basement Option

If the requirements specified for the simplified approach are not met, a licensed soils engineer or geologist should perform a detailed engineering analysis to determine whether the structure will be reasonably safe from flooding. The analysis should consider, but is not limited to, the issues described in the following sections.

Depth, Soil Type, and Stratification of Subsurface Soils

The depth, soil type, and stratification of the subsurface soils may be complex. Four potential generalized scenarios are shown in Figures 12 and 13. Figure 12 shows two cases of homogeneous soil. The depth of penetration of the basement and the depth of the flow zone are not limited to the assumptions on which the simplified approach is based. Case I represents a foundation consisting of clayey soils, either fill or natural deposits or a combination, which are more or less homogeneous because they have similar engineering properties. If an adequate setback distance is provided, the seepage quantity would be relatively low, and uplift pressure beneath the slab could be controlled by an appropriately sized sump pump because of low permeability.

Case II represents a foundation consisting of sandy soils, either fill or natural soil deposits or a combination, which are more or less homogeneous because they have similar engineering properties. The seepage quantity would be fairly large, and more attention would have to be given to the setback distance and to the provision of an adequately sized sump pump to prevent excessive uplift pressure beneath the floor slab because of high permeability.

Figure 13 shows two simple cases of stratified soils, with impervious clays overlying pervious sands. This is a common occurrence in natural floodplain deposits. In Case III, the contact between the two soil strata is at some distance **below** the basement floor. This case would involve a moderate quantity of seepage, depending on the thickness, d, of the impervious stratum below the basement floor. There is also a potential for excessive uplift pressure beneath the floor, at the level of the bottom of the clay stratum. If d is equal to h, the net hydraulic head between the flood level and the floor level, the safety factor against uplift would be approximately 1.0. If d is less than h, there would be excessive uplift, with a safety factor equal to less than 1.0.

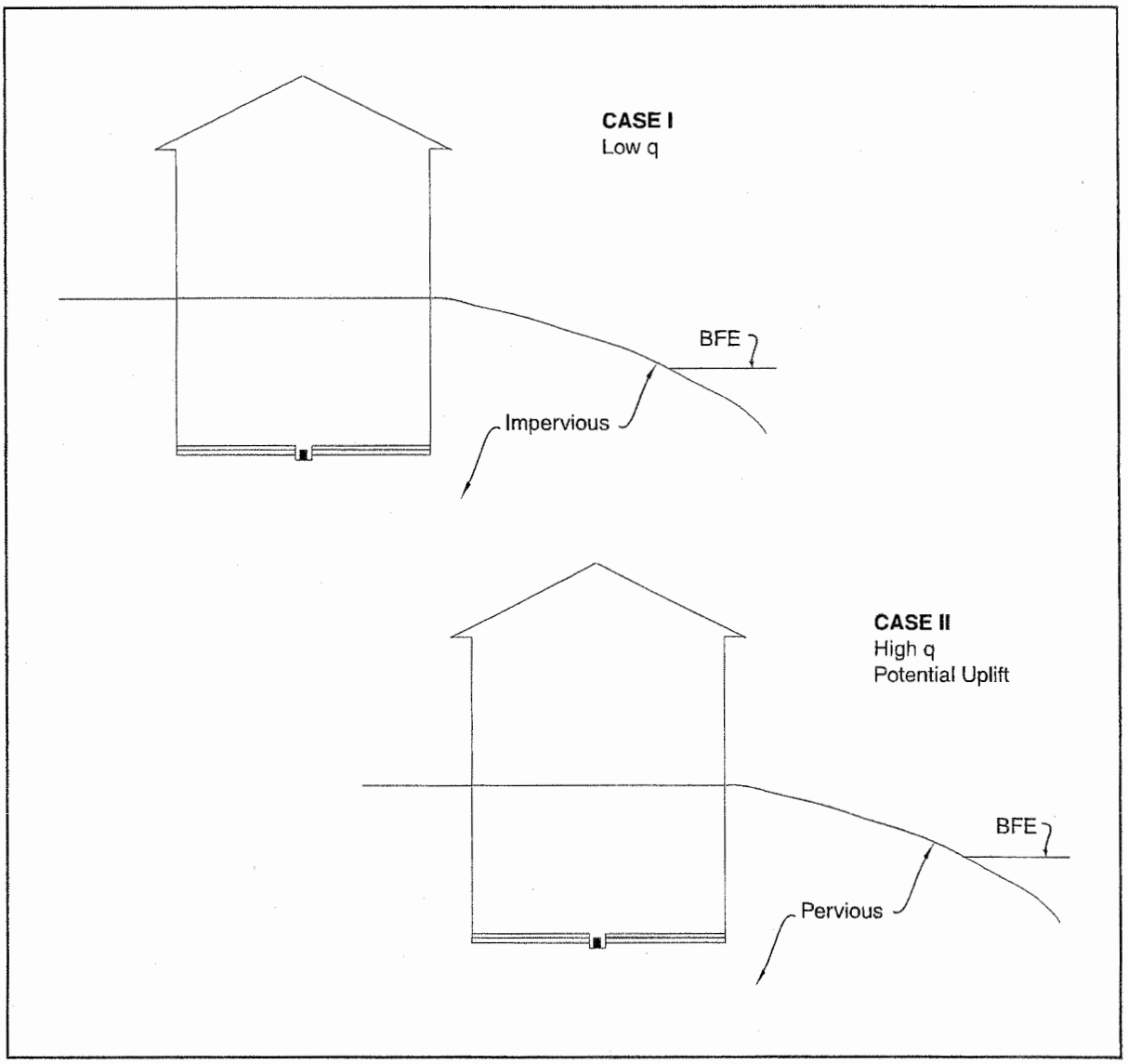


Figure 12 Case I and Case II – homogeneous soil.

Case IV shows impervious soils overlying pervious soils, with the contact between the soil strata at some distance **above** the basement floor. This case would involve a large quantity of seepage and potential for excessive uplift beneath the basement floor.

Geotechnical Investigations

Geotechnical investigations must be made for cases that do not conform with the assumptions on which the simplified approach is based. Information that is needed to permit an adequate engineering analysis includes the following:

- The BFE, which is to be used as the design flood water surface for calculating expected seepage.

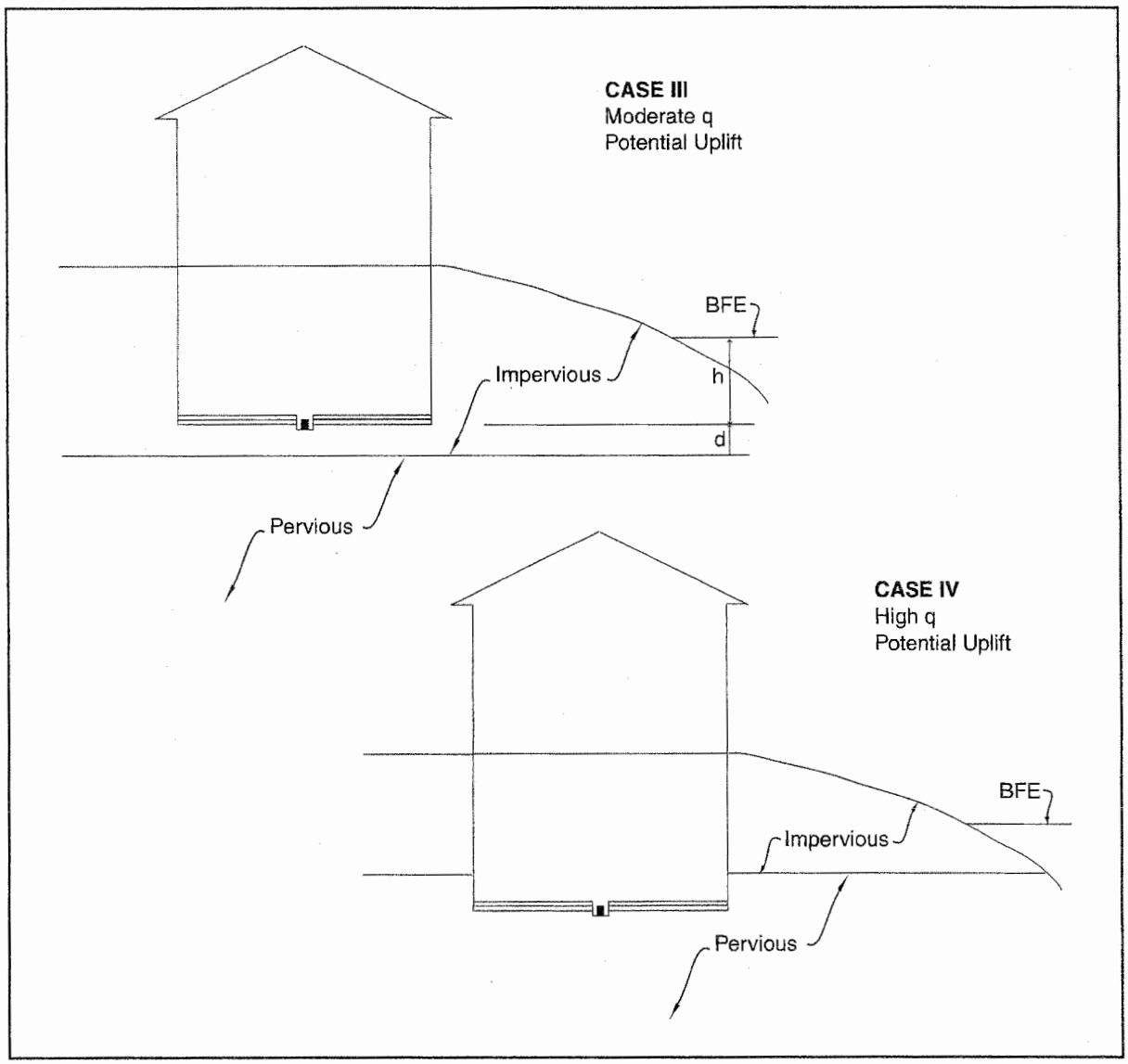


Figure 13 Case III and Case IV – stratified soils.

- The elevation of the **bottom** of the basement floor. This can be adjusted as needed to achieve more suitable conditions.
- The setback distance of the basement wall from the edge of the flood water. This can be adjusted to achieve more suitable seepage control or to accommodate available space restraints.
- The elevation of the groundwater table and its seasonal variations. A high water table would cause problems with groundwater control during construction of a basement, even without a flood event.
- The stratification of the subsurface materials, for both natural and fill soils. In general, borings should be drilled to a depth below the bottom of the floor slab that is at least two times as great as the depth of the bottom of the floor slab below the BFE.

- The engineering classification of the soils, for both natural and fill soils. This must be done in accordance with ASTM D2487, *Classification of Soils for Engineering Purposes*. This is the Unified Soil Classification System that is universally used throughout the United States. Local or county agricultural soil survey maps should not be used, because they do not give specific information about location and depth of soils, and their designations are not pertinent to civil engineering use.
- Subsurface conditions landward from the structure. This includes information about the location of the water table, whether it is higher or lower than the flood level, and information about any penetrations of the soil, such as ponds. Attention should be given to the possibility that higher ground, such as valley walls, could contribute to the groundwater level in the floodplain, either perennially or during periods of heavy rain.
- Information about any penetrations through the basement walls below the BFE, such as utility lines and other openings.
- Analysis of seepage quantity. The analysis can be made by the conservative simplified method described in Item 5 in the section titled Technical Background for the Simplified Approach (illustrated in Figure 11), or by the construction of a flow net that takes into account all of the boundary conditions more rigorously. A flow net may be required to permit analysis of uplift pressures. Uplift pressures may be more significant in laminated or stratified soil deposits.

Buildings in Existing Filled Areas

In evaluating buildings in existing filled areas, the two approaches already described—the simplified approach or the engineered basement option—can be used. If the simplified approach is used, all the requirements for the use of this approach must be met. Some possible means for evaluating whether these requirements are met include soil tests and investigations, including soil borings and hand augers; field records from the time the fill was placed; and soil surveys. If the requirements for the simplified approach are not met, a licensed soils engineer or geologist should perform a more detailed engineering analysis as described under Engineered Basement Option on page 19. More extensive soil investigations and testing may be required to complete the analysis.

The NFIP

The NFIP was created by Congress in 1968 to provide federally backed flood insurance coverage, because flood coverage was generally unavailable from private insurance companies. The NFIP is also intended to reduce future flood losses by identifying floodprone areas and ensuring that new development in these areas is adequately protected from flood damage. The NFIP is based on an agreement between the Federal government and participating communities that have been identified as floodprone. FEMA, through the Federal Insurance Administration (FIA), makes flood insurance available to the residents of a participating community, provided the community adopts and enforces adequate floodplain management regulations that meet the minimum NFIP requirements. The NFIP encourages communities to adopt floodplain management ordinances that exceed the minimum NFIP criteria set forth in Part 60 of the NFIP Floodplain Management Regulations (44 CFR 60). Included in the NFIP requirements, found under Title 44 of the U.S. Code of Federal Regulations, are minimum building design and construction standards for buildings located in SFHAs. Through their floodplain management

ordinances or laws, communities adopt the NFIP performance standards for new, substantially improved, and substantially damaged buildings in floodprone areas identified on FEMA's FIRMs.

Technical Bulletins

This publication is one of a series of Technical Bulletins that FEMA has produced to provide guidance concerning the building performance standards of the NFIP. These standards are contained in 44 CFR 60.3. The bulletins are intended for use primarily by state and local officials responsible for interpreting and enforcing NFIP regulations and by members of the development community, such as design professionals and builders. New bulletins, as well as updates of existing bulletins, are issued periodically, as necessary. The bulletins do not create regulations; rather they provide specific guidance for conforming with the minimum requirements of existing NFIP regulations. Users of the Technical Bulletins who need additional guidance concerning NFIP regulatory requirements should contact the Mitigation Division of the appropriate FEMA regional office or the local floodplain administrator. NFIP Technical Bulletin 0, the *User's Guide to Technical Bulletins,* lists the bulletins issued to date, provides a key word/subject index for the entire series, and lists addresses and telephone numbers for FEMA's 10 Regional Offices.

Ordering Information

Copies of FEMA Technical Bulletins can be obtained from the FEMA Regional Office that serves your area. In addition, Technical Bulletins and other FEMA publications can be ordered from the FEMA Publications Distribution Facility at 1-800-480-2520. The Technical Bulletins are also available at the FEMA web site at www.fema.gov.

Further Information

The following publications contain information related to the guidance presented in this bulletin:

American Society of Civil Engineers. 1998. SEI/ASCE 24-98, *Flood Resistant Design and Construction.*

Cedergren, H. R. 1977. *Seepage, Drainage and Flow Nets*. Wiley. New York.

Harr, M. E. 1977. *Mechanics of Particulate Media*. McGraw Hill. New York.

International Code Council. 2000. *International Building Code*. Birmingham, AL.

International Code Council. 2000. *International Residential Code*. Birmingham, AL.

U.S. Department of the Army, Corps of Engineers. 1986. EM 1110-2-1901, *Seepage Analysis and Control for Dams*. Washington, DC.

U.S. Department of the Army, Corps of Engineers. 1978. EM 1110-2-1913, *Design and Construction of Levees*. Washington, DC.

Glossary

Base Flood – The flood that has a 1-percent probability of being equaled or exceeded in any given year (also referred to as the 100-year flood).

Basement – Any area of a building having its floor subgrade (below ground level) on all sides.

Community – Any state or area or political subdivision thereof, or any Indian tribe or authorized tribal organization, or Alaska Native village or authorized native organization, which has the authority to adopt and enforce floodplain management regulations for the areas within its jurisdiction.

Federal Emergency Management Agency (FEMA) – The independent Federal agency that, in addition to carrying out other activities, administers the NFIP.

Federal Insurance Administration (FIA) – The component of FEMA directly responsible for administering the flood insurance aspects of the NFIP.

Flood Insurance Rate Map (FIRM) – The insurance and floodplain management map issued by FEMA that identifies, on the basis of detailed or approximate analysis, areas of 100-year flood hazard in a community.

Floodprone area – Any land area susceptible to being inundated by flood water from any source.

Mitigation Directorate – The component of FEMA directly responsible for administering the flood hazard identification and floodplain management aspects of the NFIP.

New construction/structure – For floodplain management purposes, new construction means structures for which the start of construction commences on or after the effective date of a floodplain management regulation adopted by a community and includes subsequent improvements to the structure. For flood insurance purposes, these structures are often referred to as "post-FIRM" structures.

Special Flood Hazard Area (SFHA) – Area subject to inundation by the base flood, designated Zone A, A1-30, AE, AH, AO, V, V1-V30, or VE.