Design Considerations for Improving Critical Facility Functionality During Flood Events

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MIDWEST FLOODS RECOVERY ADVISORY

Purpose: This advisory provides recommendations for reducing the effects of flooding on existing critical facilities. It specifically applies to the essential critical facility systems that must remain functional during and after flood events, including:

- Electrical systems (including power, life-safety, communication, and IT equipment)
- Plumbing systems (including water, sanitary, and mechanical piping)
- Heating, ventilating, and air conditioning (HVAC) systems
- Specialized equipment (including conveyance, medical, and detention equipment)
- Non-specialized equipment that may require a long lead time to procure

This advisory discusses two techniques for reducing flood damages to essential critical-facility systems: elevation and dry floodproofing.

Key Issues

FEMA identifies and maps flood hazard areas on its Flood Insurance Rate Maps (FIRMs). One of these areas is the Special Flood Hazard Area (SFHA), which is an area within a floodplain having a 1-percent or greater chance of flood occurrence in any given year.[1] Another area typically depicted on FIRMs is the 0.2-percent-annual-chance flood.[2] People often have a mistaken understanding of this and believe that if a building is located outside of a mapped flood hazard area, it has no risk of flooding. The Midwest floods of 2008 demonstrated the fallacy of this assumption. Many of the buildings that were damaged or destroyed by flooding, including numerous critical facilities, were located outside of the SFHA and, in some cases, outside the 0.2-percent-annual-chance flood area as well. In many observed instances, assumptions regarding flood risk had led to design decisions that made buildings vulnerable to the extraordinary flooding experienced in 2008. Actions taken now can help to reduce damage from future flood events.

The potential for flooding, even for buildings outside of mapped SFHAs, should be considered during the reconstruction of damaged buildings. Even if the probability of repetitive flooding is small, both the cost of repairs and the critical nature of the facility warrant a careful consideration of relatively low-cost design solutions for mitigating future potential flood damages.

Techniques for Reducing Flood Losses

Elevation

In general, essential building systems should be elevated to at least the 0.2-percent-annual-chance flood elevation and higher if it is practical to do so. If sufficient data is not available or if this level of protection is not feasible, utilities should be elevated to at least 2 feet above the 1-percent-annual-chance flood elevation.

A critical facility located outside the mapped flood hazard area in Iowa flooded during the Midwest floods of 2008. Vulnerable equipment that had been mounted in an **integral cabinet** with control switches and

To what types of critical facilities do these loss reduction techniques apply?

Schools, fire and police stations, emergency operations centers, water treatment plants, detention facilities, essential government buildings, and other facilities can all benefit from appropriate flood mitigation measures. Recommendations included in this advisory may also be beneficial to buildings not historically considered critical, such as banks, data centers, etc.

[1] Also referred to as the "100-year floodplain."

[2] Also referred to as the "500-year floodplain."

indicator lights was damaged when the cabinet was inundated with approximately 3 feet of floodwater (Figure 1). This cabinet can be reconfigured and mounted high enough to avoid future losses. Dual electrical panel boards, which consist of two shorter panels mounted side-by-side, can be used instead of a single, taller panel board. This proposed design allows the bottom of the panels to be placed higher above the floor and would reduce exposure to floodwater. To reduce the vulnerability of the feeders that connect the panelboards to the service equipment, feeder wiring should be run as high as possible. Feeders routed along the ceilings are much less vulnerable than feeders run along or under floors.

When elevating utilities, it is also necessary to consider not only each individual component, but how each is interconnected with other building systems and components. Some **emergency generators** during the Midwest floods of 2008, for example, were elevated and did not flood, but could not function because electrical equipment powered by the generator was installed at lower elevations. The generator shown in Figure 2 did not flood, but it was rendered ineffective because the transfer switch that directs electrical loads from the generator when normal utility power is not available was mounted below the transformer and flooded during the event.

Flooding can damage most **electrical equipment,** and, once flooded, the equipment often needs to be

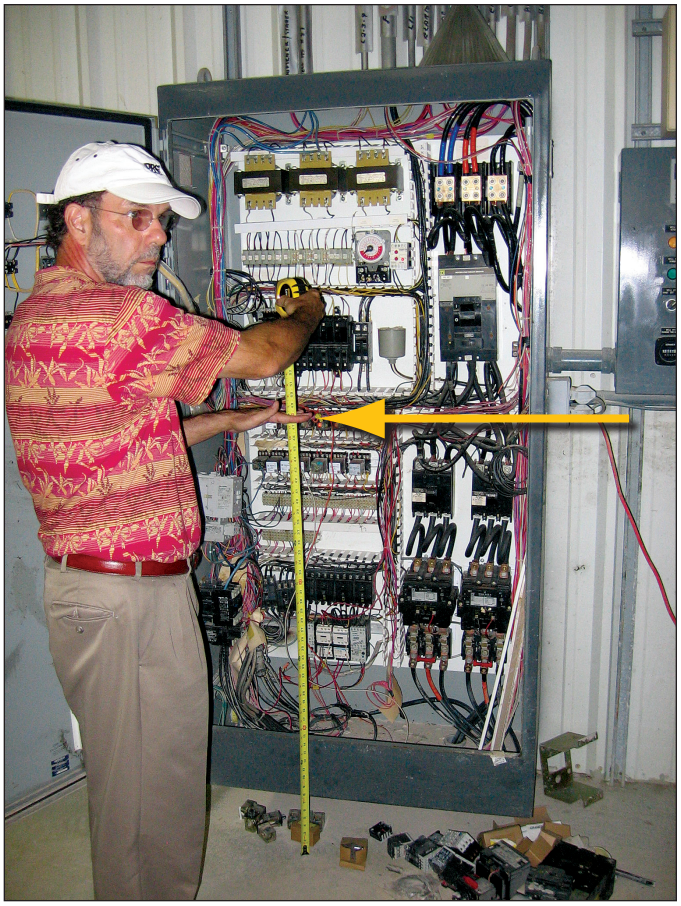

Figure 1. This control cabinet was inundated with approximately 3 feet of floodwater (yellow arrow). Sensitive electronic equipment was damaged (Columbus Junction, Iowa).

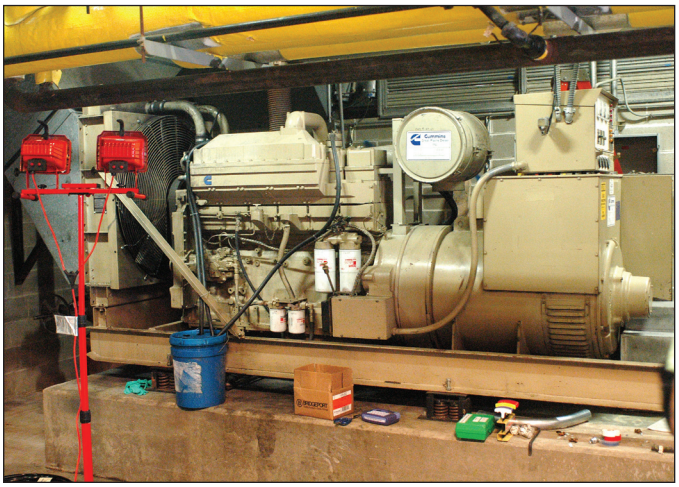

Figure 2. This emergency generator—elevated 2 feet above the floor on a concrete base—was not directly affected by floodwaters, but was rendered ineffective because the transfer switch was mounted below the transformer and flooded during the event (Cedar Rapids, Iowa).

Emergency Generators

For emergency generators to protect vital equipment and processes during and after a flood event, the following actions are recommended:

- Locate emergency generators as high as practical. At a minimum, the generator should be placed above the main electrical service equipment and above the utility company pad-mount transformer.
- Locate the emergency generator's transfer switch(es), and all electrical distribution equipment that the generator serves, at elevations that are at least as high as the generator.
- Supply the generator with a reliable source of fuel that will not be interrupted during an event. If a fuel tank is provided on site, anchor tank to resist floatation.

Ensure access is provided to the generator for generator operation, refueling, and, for events where long duration operation may be needed, for periodic maintenance.

completely removed and replaced. Although some electrical devices are designed for submerged use, locating electrical equipment above floodwater, in most cases, is the only effective mitigation measure for reducing flood risk to electrical components. Locating the equipment on a higher floor, for example, can significantly reduce its exposure to flooding. In some cases, locating the equipment on elevated concrete slabs or frames will provide the needed protection. This often is relatively inexpensive, but the effectiveness depends on a number of factors including the anticipated depth of flooding in the location.

Electrical conduits and raceway, on the other hand, often do not need to be removed and replaced after flooding, particularly if exposed to freshwater flooding. Some conduits can be cleaned, dried, and reused (this may require removing and reinstalling conductors). Conduits that provide equipment grounding should only be reused after it can be confirmed that flooding did not adversely affect the electrical continuity of the mechanical connections. If flooding has affected the electrical continuity of the metal raceway, the conduit should be removed and replaced, or a separate bonding conductor should be installed.

Dry Floodproofing

Some equipment can be protected by dry floodproofing. One example of this technique involves constructing **flood barriers** to prevent floodwater from reaching critical equipment. For this and other types of dry floodproofing to be successful, however, equipment to discharge water that can seep through the dry floodproofing (for example, sump pumps connected to emergency power) needs to be installed, and structural systems need to be put in place to resist the large buoyancy forces that dry floodproofing can create. Without installing costly and expensive equipment, dry floodproofing is typically effective for only up to 3 to 4 feet of floodwater (dry floodproofing over 4 feet is typically impractical due to strength and buoyancy considerations).

Conclusions

Hazard mitigation measures should be incorporated into all stages and at all levels of planning and designing for the reconstruction and rehabilitation of existing critical facilities. Building professionals and decision makers should seek information and guidelines for implementing a variety of mitigation measures to reduce the vulnerability to damage and disruption of operations during severe flood events. By building more robust critical facilities that can remain operational during and after a major disaster, people's lives and the community's vitality can be better preserved and protected.

Additional Resources

- *Risk Management Series Design Guide for Improving Critical Facility Safety from Flooding and High Winds* (FEMA 543)
- *Protecting Building Utilities from Flood Damage* (FEMA 348)
- FEMA Technical Bulletins

Considerations for Rebuilding Your Flood-Damaged House

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MIDWEST FLOODS RECOVERY ADVISORY

Purpose: The Midwest floods of 2008 caused riverine flooding, sanitary sewer back up, levee/floodwall failure or overtopping, and/or rising lake levels, resulting in upwards of $6 billion in damage. Homeowners impacted by the floods are now faced with fundamental rebuilding decisions. This advisory provides information to assist with rebuilding decisions in the aftermath of the 2008 Midwest Floods, as well as any future flood events.

Background:

- The U.S. Congress established the National Flood Insurance Program (NFIP) with the passage of the National Flood Insurance Act of 1968. The NFIP is a federal program enabling residents in participating communities to purchase flood insurance. Currently 20,000+ communities participate in the NFIP.
- When a community chooses to join the NFIP, it must adopt and enforce minimum floodplain management standards. The floodplain management requirements are designed to prevent new development from increasing the flood risk and to reduce flood damages to new and existing buildings from future flood events.
- The Federal Emergency Management Agency (FEMA) works closely with state and local officials to identify flood hazard areas and flood risks, in particular the Special Flood Hazard Area (SFHA). This is the area that has a 1-percent or greater chance of being flooded in any given year. FEMA maps this and other flood hazard areas on Flood Insurance Rate Maps (FIRMs).
- Flood insurance is required for insurable structures within the SFHA to compensate floodplain occupants for flood damages and to remove some of the financial burden of flood losses from taxpayers, such as for Federal disaster assistance and casualty loss deductions under Federal income taxes.
- For more information about NFIP regulations, FIRMs, flood insurance policies, and preparation and recovery during flood events, please visit the official site of the NFIP: http://www.floodsmart.gov/.

Flood Insurance Rate Map (FIRM) – The community's official FEMA map delineating both the flood hazard areas and the risk insurance premium zones.

Special Flood Hazard Area (SFHA) – The area that has a 1-percent or greater chance of flooding in any given year. A structure located within the SFHA has a 26-percent chance of suffering flood damage during the term of a 30-year mortgage. Flood insurance is mandatory for properties located within the SFHA that receive Federal financial assistance.

How to Determine Your Flood Risk:

- Using the FIRM, you can determine your house's location relative to the flood risk zones. If your house is located within the SFHA, you can also determine the elevation of the base (1-percent annual chance) flood elevation (BFE) at your location. You can then compare your floor elevations with the BFE and determine your risk of damage from flooding.
- Non-SFHA Zones B, C, and X are areas outside the 1-percent-annual-chance flood risk, or 100-year, floodplain. It is important to note that even if your house is located within a non-SFHA, there is still a possibility that your house will be subjected to flood damage and possibly even catastrophic flooding. Figure 1 shows an example of a FIRM with arrows indicating pertinent information.

NFIP Regulations That May Impact Your Decision to Rebuild

If your house was damaged during a flood and is located within the SFHA, you need to be aware of NFIP regulations related to substantial improvement, substantial damage, and the increased cost of compliance provision in flood insurance policies, as you make a decision to rebuild.

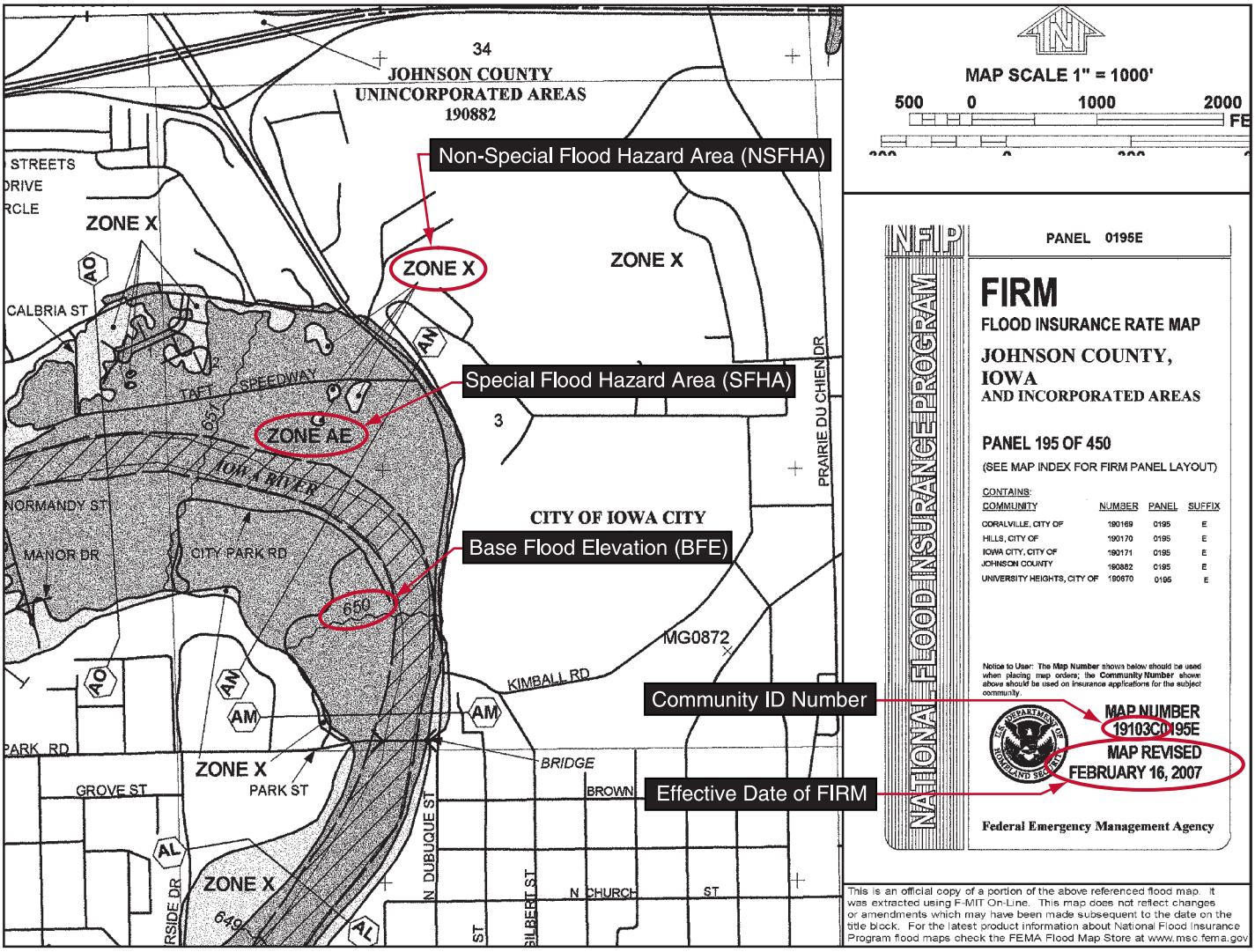

Figure 1. A FIRM panel illustrating information pertinent to the homeowner

Substantial improvement means any reconstruction, rehabilitation, addition, or other improvement of a structure when the cost of the improvement equals or exceeds 50 percent of the market value of the structure before the start of construction of the improvement. The term includes structures that have incurred substantial damage.

Substantial damage means damage of any origin sustained by a structure when the cost of restoring the structure to its pre-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred. Substantial damage is determined regardless of the actual repair work performed.

- Floodplain management requirements for new construction apply to substantial improvements, and the structure must be brought into compliance with the NFIP. This can be done by elevating the structure, relocating the structure to an area outside of the SFHA, or demolishing the structure and rebuilding in compliance.
- The substantial damage determination will be made by your local floodplain manager and/or building official, who can help you decide the best option for rebuilding and provide specific details regarding local ordinance requirements.

Increased Cost of Compliance (ICC) is a standard provision in flood insurance policies that pays the policyholder up to $30,000 to comply with a state or local floodplain management law or ordinance affecting repair or reconstruction of a flood-damaged structure. The structure must meet certain eligibility criteria, including a substantial damage or repetitive loss determination by a local official. Mitigation activities eligible for payment are elevation, relocation, and demolition.

Construction funded by ICC payments must be completed within 4 years of the substantial damage determination. ICC funds are available in addition to federal assistance provided to floodproof your house.

Options to Minimize Risk of Future Flooding when Rebuilding

Several options are available for protecting your house from future flood damage. Building codes, floodplain management policies, local regulations, and personal preferences must all be taken into account. Choosing the right option requires research, planning, contacting local officials, and benefit-cost assessments (e.g., relocating or elevating the building will impact flood insurance premiums, while other options will not).

Relocate to a site outside of the SFHA:

- If your house is structurally sound, it may be possible to move it to a higher elevation on the same lot or to another location outside of the floodplain.

Participate in a buyout or acquisition program:

- Property acquisition is the most permanent form of flood hazard mitigation. It removes people and property from harm's way forever. In a property acquisition project, the community buys private property, acquires title to it, and then clears it. By law, that property, which is now public property, must forever remain open space land. The community can use it to create public parks, wildlife refuges, etc., but it cannot sell it to private individuals or develop it.
- Property acquisitions work the same way as any other real estate transaction. Property owners who want to sell their properties will be given fair prices for them. It is an opportunity for people who live in or near hazard areas to relocate to a safer location.
- If you are interested in a buyout, you can contact your community's floodplain manager to see if a buyout program is available in your community.

Elevate the house:

- This is one of the most common mitigation methods. When a house is properly elevated, the living area will be above less severe potential flood conditions (such as less than the 0.2-percent-annual-chance flood). Most houses can be elevated; however, the cost of elevation varies based upon multiple factors such as the size of the house; type of foundation (e.g., slab-on-grade, crawlspace, basement); whether the house is wood-frame, masonry, or concrete; and the required elevation, which is based upon the BFE.
- Although elevating a substantially damaged house can be expensive, it can also provide a number of benefits such as reducing future flood damage, lowering your insurance premium, adding value to the house, increasing usable space for parking or storage, improving the appearance of the house, helping protect contents, and reducing anxiety about future floods. For more information regarding elevating your house, please refer to the guidance document *Above the Flood: Elevating your Floodprone House* (FEMA 347) (see below for website).

What elevation should I use when rebuilding/elevating my home? The FIRM establishes the expected elevation of floodwater during the 1-percent-annual-chance flood event (the BFE). In general, you should elevate the top of the lowest floor to this elevation. It is important that you contact your local floodplain management official because he/she can tell you the locally mandated flood elevation. Many states and local jurisdictions add an additional factor of safety, called a "freeboard" requirement, to the flood elevation. You should also ask your local officials how recent flood heights compare to the mapped 1-percent-annual-chance and 0.2-percent-annual-chance flood elevations. In general, the higher you elevate above the BFE, the more likely you are to prevent future flood damages, and the lower your flood insurance premiums might be.

Elevate the utilities:

- Utilities in existing houses can often be effectively protected from flood damage. The easiest and most practical time to undertake this effort is during a renovation or repair project. If your house has been substantially damaged and/or is being substantially improved, the NFIP requires that its utility systems be protected from flood damage to the same criteria required for new construction. However, if your house has suffered less than substantial damage, you have three basic options for protecting utilities.

- **Replace the system with a like system** – This option is typically the least expensive option, but provides no improved protection from future flood damage.
- **Elevate your utilities** – This option is usually the most costly, but it can protect you from the inconvenience of repeated future flood damages and is highly recommended by floodplain managers. For more information on protecting the utilities in your house, please refer to the guidance document *Protecting Building Utilities from Flood Damage* (FEMA 348) (see below for website).
- **Implement low-cost retrofits to utility systems** – For a minimal additional cost, large benefits may be realized especially when protecting from smaller future flooding events. For example, two short electrical panel boards can be elevated side-by-side versus one long panel that stretches from the floor to the ceiling.

Wet and Dry Floodproofing:

- Wet floodproofing prevents or provides resistance to damage from flooding by allowing floodwater to enter the house. Allowing floodwater to enter portions of the house (such as a crawl space or unfinished basement) equalizes the interior and exterior pressures on the wall during a flood. Equalized pressures reduce the likelihood of structural damage during a flood event. For information on wet floodproofing your house, please refer to the document *Wet Floodproofing Requirements for Structures Located in Special Flood Hazard Areas in accordance with the National Flood Insurance Program* (TB 7-93) (see below for website).

Floodproofing – Any combination of structural and non-structural additions, changes, or adjustments to structures that reduce or eliminate flood damage to structures and their contents.

- Another way to floodproof your house and its contents is sealing it so that floodwater cannot enter. This method, referred to as "dry floodproofing," encompasses a variety of measures. Popular methods of dry floodproofing include applying a waterproof coating or membrane to the exterior walls of the house, installing watertight shields over openings, and strengthening walls so that they can withstand the pressures of floodwater and the impacts of flood-borne debris.

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