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. Another area typically depicted on FIRMs is the 0.2-percent-annual-chance flood. 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.

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

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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

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**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**

- *Protecting Building Utilities from Flood Damage* (FEMA 348)
- FEMA Technical Bulletins