Flood Protection and Elevation of Building Utilities

FEMA

IOWA FLOODS OF 2016 RECOVERY ADVISORY *RA4, April 2017*

Purpose and Intended Audience

The Federal Emergency Management Agency (FEMA) deployed a Mitigation Assessment Team (MAT) to review utility damage in Linn County and Black Hawk County, Iowa after the floods of 2016. The Team noted numerous residential buildings where mechanical, electrical, and plumbing (MEP) systems (called "utility systems" in this Recovery Advisory) located above the base flood elevation (BFE) were protected from floodwaters. The damage could have been particularly severe for equipment located in basements, below-grade (ground) garages, crawlspaces, and at-grade areas near areas subject to riverine flooding, but by elevating utilities communities had reduced the severity of damages. The purpose of this Recovery Advisory is to describe methods of protecting utility systems in a similar manner that minimizes damages and reduces the system restoration time following future storms. The intended audience for this Recovery Advisory is homeowners and the material presented is applicable for one- and two-family residential buildings.

This Recovery Advisory addresses houses that were not Substantially Damaged during the floods of 2016 and are not undergoing Substantial Improvement (see text box for NFIP definitions of these terms). Repair and restoration work on these houses must be done in compliance with all floodplain management requirements in effect when the home was originally built (though protecting utilities to newer floodplain management ordinances may also be acceptable and will further reduce vulnerability to flood damage). Homeowners should always check with local building departments, as locally enforced codes and standards may differ from what is described in this Recovery Advisory. For example, some communities may require that all utility system restoration or alteration work must comply with the applicable sections of the current code, even in houses that are not determined to be Substantially Damaged. When considering relocating or elevating systems, all applicable codes, regulations, and manufacturers' installation requirements should be followed.

Background information on the general requirements of the National Flood Insurance Program (NFIP) is provided so homeowners can understand acceptable practices and efforts which will increase their home's flood-resistance. The remainder of this advisory describes how to protect utilities in homes, including the specific NFIP requirements related to utility systems.

Terminology

Substantial Damage: Defined by the National Flood Insurance Program (NFIP) as "damage of any origin sustained by a structure whereby the cost of restoring the structure to its before-damaged condition would equal or exceed 50 percent of the market value of the structure before the damage occurred."

Substantial Improvement: Defined by the NFIP as "any reconstruction, rehabilitation, addition, or other improvement of a structure, the cost of which equals or exceeds 50 percent of the market value of the structure before the 'start of construction' of the improvement. This term includes structures that have incurred 'Substantial Damage,' regardless of the actual repair work performed."

Refer to FEMA P-758, *Substantial Improvement/ Substantial Damage Desk Reference* (2010) for more information. Homeowners should consult a local building official to determine whether their local codes and regulations have more restrictive definitions.

Key Issues:

1. Utility systems originally constructed at or below grade (such as furnaces, boilers, water heaters, air handlers, and similar equipment) are highly susceptible to flood damage.
2. Floods can damage electrical utility meters and disconnect switches and other electrical service components. Damaged components can delay recovery time and extend the duration of power outages.
3. Preventing flood damage requires placing all electrical equipment above the flood level, but utility company requirements and the National Electrical Code (NEC) place limits on where electrical service equipment can be located.

This Recovery Advisory Addresses:

- General NFIP background
- NFIP requirements for utility systems
- NEC and local utility requirements
- General mitigation considerations for residential utility systems
- Considerations for specific equipment and systems
- Useful links and resources

Evaluation, repair work, and installation of utility systems should be done by qualified, licensed contractors to ensure they are installed safely and in compliance with codes.

General NFIP Background and Requirements for Utility Systems

The NFIP regulates buildings in regulatory floodplains, also called Special Flood Hazard Areas (SFHAs). For houses in the SFHA, the NFIP regulations restrict the use of areas located below the base flood elevation (BFE). Allowable uses are vehicle parking, building access (e.g., foyers and stairwells), and storage. The following items are not allowed below the BFE because they may be damaged and their presence is inconsistent with allowable uses: appliances, heating and cooling equipment, and plumbing fixtures. Electrical equipment and wiring is permitted below the BFE only if needed to satisfy life safety and electric code requirements for the allowable uses, and as long as it meets the code requirements for wet locations.

NFIP requirements apply to buildings located in the SFHA, specifically new construction, buildings undergoing Substantial Improvement or buildings that received Substantial Damage and are undergoing repair. Installing features below the BFE that are not consistent with the allowed uses of building access, parking, and storage renders an enclosed area below the BFE non-compliant. Exceptions to the requirement to locate utility systems above the BFE may be permitted by a floodplain manager or a local code official, provided the element of the system is designed and/or located to prevent water from entering or accumulating within it during flooding conditions. Meeting the exceptions can be costly or difficult in many cases. Equipment manufacturers should be consulted before approving such exceptions to verify that the equipment is designed to prevent damage from, or allow accumulation of, floodwaters.

Terminology

Flood Insurance Rate Map (FIRM): A map produced by FEMA to show flood hazard areas and risk premium zones. The SFHA and BFE are both shown on FIRMs.

Special Flood Hazard Area (SFHA): Land areas subject to a 1 percent or greater chance of flooding in any given year. These areas are indicated on FIRMs as Zone AE, A1-A30, A99, AR, AO, AH, V, VO, VE, or V1-30. Mapped zones outside of the SFHA are Zone X (shaded or unshaded) or Zone B/Zone C on older FIRMs.

Base Flood Elevation (BFE): Elevation of flooding, including wave height, having a 1 percent chance of being equaled or exceeded in any given year (also known as “base flood” and “100-yearflood”).

The BFE is the basis of insurance and floodplain management requirements and is shown on FIRMs.

NOTE: The SFHAs discussed herein are for inland flooding conditions. Please refer to https://www.fema.gov/special-flood-hazard-area for additional SFHA definitions.

All building materials below the BFE must be flood damage-resistant. Information on flood damage-resistant materials can be found in FEMA Technical Bulletin 2, *Flood Damage-Resistant Materials Requirements* (2008).

Requirements for Houses with Substantial Damage

Houses that the local building official or floodplain manager determines to be Substantially Damaged must be brought into compliance with the flood provisions of current building codes, local floodplain ordinances, and NFIP regulations. Requirements include elevating utility systems above the flood elevation specified in the codes and regulations. It is important for homeowners to verify with their local building department that they have all permits required to do the project. Relocating or elevating systems in conjunction with other projects may result in the local building department determining the house is being Substantially Improved. Homeowners should consult a local building official to determine whether their local codes and regulations have more restrictive definitions of Substantial Improvement and Substantial Damage than provided in this Recovery Advisory.

Flood Insurance Implications

Houses built after communities joined the NFIP were required to be elevated to minimize flood damage. These houses should already have elevated utility systems and components. However, if some equipment was not elevated (such as a furnace located in a crawlspace), owners may be paying much higher NFIP flood insurance premiums than necessary. Replacing damaged equipment on elevated platforms not only minimizes future damage, but may result in lowering the cost of flood insurance coverage. Owners should check with insurance agents to find out whether taking this action will affect their flood insurance premiums.

National Electrical Code and Local Utility Requirements

NEC Requirements

The NEC contains requirements for electrical services that significantly affect their design and construction. Therefore, it is important to understand the NEC requirements. However, the NEC requirements do not directly address flood protection needs. The NEC dictates:

- Clearance to energized conductors
- Means to disconnect electrical power from a home
- Clearances around electrical service components

And while the NEC may dictate the locations for some electrical service components because of clearance requirements, it is important to note that local utilities may have additional requirements that dictate the location of electrical service components. Further, local utilities may also require an external disconnection at the metering equipment so that emergency response personnel can safely de-energize all power without entering the structure.

NEC ***clearance requirements*** are specified to prevent people from coming into contact with energized conductors (electrical lines). Clearances above roofs, doors, windows, driveways, and walking surfaces (stair landings, decks, balconies, etc.) must meet NEC requirements. When electrical components are elevated to avoid flooding, the NEC requirements for clearance must still be maintained.

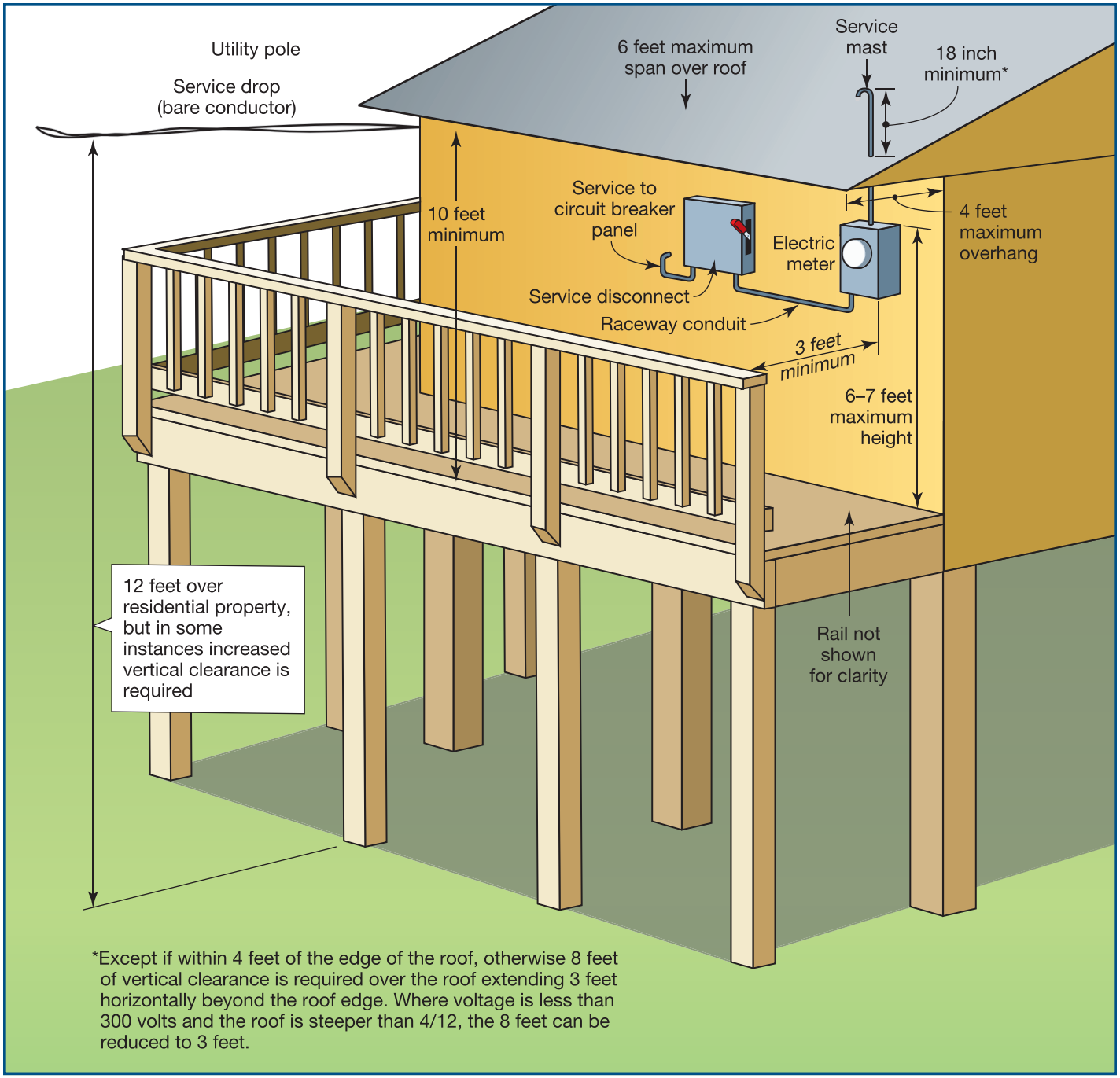

Figure 1. Illustration identifies some of the electrical service components and some of the NEC requirements for residential electrical service. Other clearance requirements come into effect if the service drop (an overhead electrical line running from a utility pole to a home) is attached near a door or window or is attached to the side of the house rather than to the roof as shown in the illustration.

Electrical Utility Company Requirements

In addition to the NEC requirements for electrical services, electrical utility companies also have requirements that must be met. Utility companies commonly require the center of electrical meters to be placed within 4- to 6-feet of the finished grade to allow access for recording electrical usage from manually read meters. The 4- to 6-feet requirement also allows utility workers to remove the electrical meters from meter boxes if they need to discontinue electric service to a home. The specific requirements for the elevation of the center of the meter above grade should be verified with the utility company. Some utility companies allow electric meters to be accessed from elevated stairs, walkways, or decks, particularly when not used solely for meter access (and thus more likely to be maintained in a serviceable condition). When accessible from elevated structures, the electrical meters and other service components can be elevated to reduce or alleviate flood risk without restricting access for utility company personnel.

National Electrical Code and National Electrical Safety Code

The Standards Council at the National Fire Protection Association (NFPA®) created a standard for the safe installation of electrical wiring and equipment over 100 years ago. Now known as NFPA 70, the National Electrical Code (NEC®) is the minimum standard to address the installation of electrical conductors, equipment, and raceways; signaling and communications conductors, equipment, and raceways; and optical fiber cables and raceways in commercial, residential, and industrial occupancies. The NEC has subsequently been incorporated by many building codes and adopted by many States and municipalities. The NEC governs all wiring downstream of the electrical service point, which delineates on premise wiring from that operated by the electrical utility. Wiring upstream of the electrical service point is governed by other standards, such as the National Electrical Safety Code (NESC, ANSI/IEEE C2).

For more information, refer to: http://standards.ieee.org/about/nesc/2012.html.

General Mitigation Considerations for Residential Utility Systems

This section describes general mitigation related to flood protecting utility systems, such as relocating or elevating equipment systems, which helps minimize future flood damage. In the process of relocation or elevation, homeowners need to consider horizontal and vertical clearances; venting; and unions, fittings, and valves. During the process of replacing damaged utility systems, homeowners also should consider the opportunity of improving the energy efficiency of their homes. Newer utility systems can reduce the utility supply usage and reduce utility costs.

Utility systems within the SFHA must be located at or above the BFE per NFIP criteria. Moreover, FEMA recommends that all utility systems be elevated as high as practicable for existing, non-Substantially Damaged and non-Substantially Improved construction (see FEMA P-348, Edition 2 – Table 4-1). Since Iowa has adopted the use of a 1-foot freeboard above the BFE as their minimum elevation requirement within their model floodplain ordinance, utility systems that are compliant with this locally adopted requirement are better protected against flood hazards. Some homeowners who have experienced flooding multiple times have accepted the hazard in their community and have chosen to elevate higher than their regulatory minimum. Elevating as high as possible reduces the future damages that come from not elevating high enough during reconstruction. The utility system shown in Figure 2 shows a house which is surrounded by flood waters. The elevated platform supporting the air conditioning unit is safely positioned out of the reach of flood damage. This situation illustrates a case in which a homeowner has learned from past flood events.

Figure 2: Elevated exterior air conditioning unit elevated above flood waters in Cedar Falls, Iowa.

Relocating and Elevating Equipment

Relocating equipment to a higher floor is particularly important for houses where the equipment is currently in basements and below-grade garages. If there is insufficient space on a higher floor, a homeowner may choose to build an elevated addition to the house to be used as a utility room. If equipment cannot be relocated to a higher floor or a utility room cannot be added, the equipment should be raised as high as practicable in its current location. However, homeowners should understand the risks associated with elevating equipment in basements and below-grade garages. These measures may have limited success until flooding exceeds the elevated equipment height and causes damages to the utility systems. Houses with sump pumps have some additional protection, but the protection is highly dependent on the type of flooding that may occur at the house. Most sump pumps are designed to remove rainwater that enters the home from the adjacent

ground or down the driveway. For houses near a river, the volume of floodwater infiltrating the home from riverine flooding can exceed the capacity of a residential sump pump, causing deep flooding and damage to equipment in any below-grade space. For houses located away from a river and subject to flooding from rainwater only, sump pump systems are less likely to be overwhelmed. In these situations, placing equipment as high as practical, on elevated platforms in walkout basements or sub-grade garages, may be effective.

Elevated Platforms and Anchorages

Elevated platforms are often used for improving flood resistance of heating and cooling equipment. In such cases, indoor equipment is not moved to a different floor but simply raised above the floor using a solid pad (such as masonry or concrete) or a framed platform (wood or steel) (see Figure 3). Outdoor equipment can be elevated on a platform attached to the side of the house.

A number of cities within Iowa are increasing their resistance to utility flood damage by incorporating elevated exterior utility platforms positioned above the BFE with freeboard. Figure 4 shows one residence in a SFHA that mitigated the utility systems after the Midwest flooding of 2008 to at least 1 foot above the BFE. When more recent flooding events occurred this residence, and nearby homes where similar mitigation measures were implemented, were better protected and offered homeowners lower flood insurance premiums and a greater peace of mind.

The materials selected to construct elevated platforms should meet the requirements for being resistant to flood damage as described in FEMA Technical Bulletin 2, Flood Damage-Resistant Materials Requirements (2008), and should be non-combustible when required by code. When an equipment pad is utilized to provide elevation of the systems, the pad should be properly anchored to the floor system or slab, and the equipment should be properly anchored to the pad. In regions subject to seismic requirements, additional bracing of the equipment may be required.

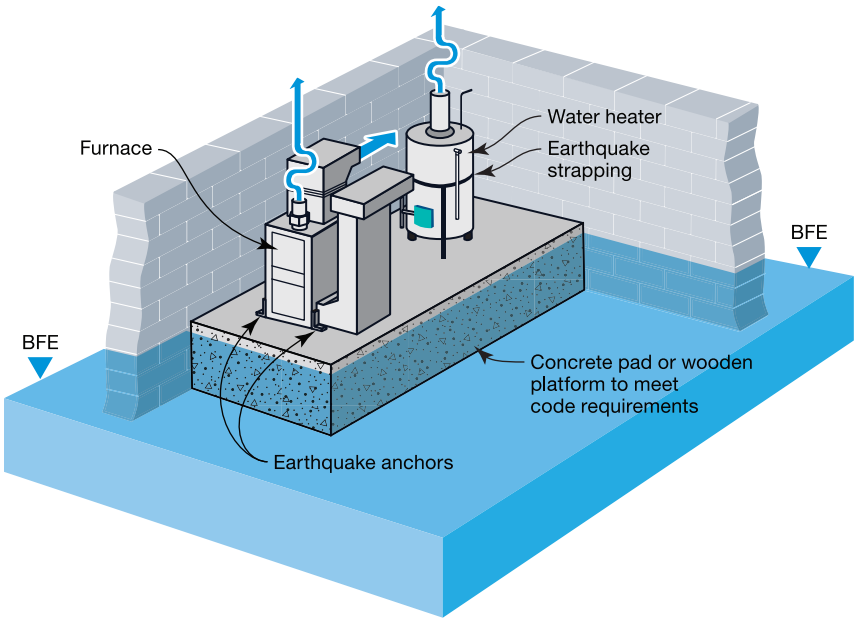

Figure 3: Elevated concrete platform for protection of utility systems in which the original slab is below the BFE.

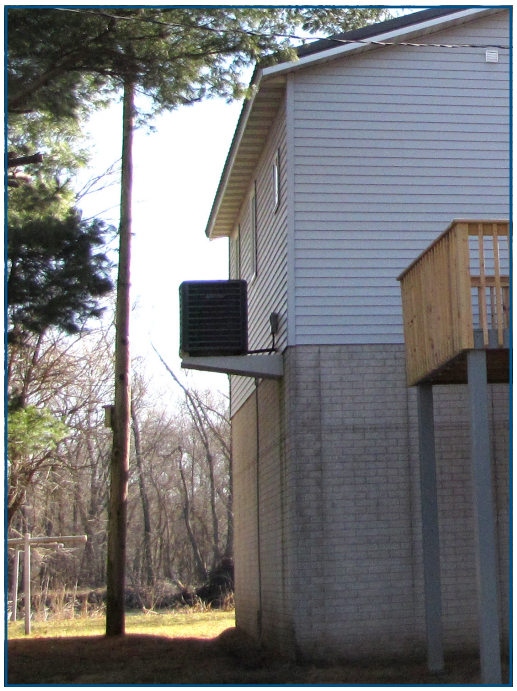

Figure 4: Elevated platform supporting heating and cooling equipment in Linn County, Iowa. *(Photo courtesy of Linn County, Iowa Planning & Development)*

Maintaining Horizontal and Vertical Clearances

When equipment is moved, either to another floor or elevated on a platform, it is important to maintain the recommended horizontal and vertical clearance around it as required by residential building codes, the NEC, or as recommended by manufacturers' specifications. Minimum clearances required for equipment, conduits, piping, and duct work should be considered before relocating or elevating equipment. Designing for the minimum clearance is important to maintain air circulation, meet insurance or code requirements related to the distance from combustible building materials, and provide space for maintenance. Most codes dictate

that clearance requirements should follow those specified on the appliance label or installation instructions. Required clearance typically ranges from 6 to 36 inches, and can sometimes be reduced by installing heat shields if allowed by the building code. The use of a heat shield or other method to reduce clearance should be verified in codes and manufacturers' installation requirements. Failure to maintain proper clearance can result in safety issues including fire, and can void equipment warranties.

Venting Considerations

Oil- or gas-fueled boilers, furnaces, and water heaters require adequate combustion air and venting of exhaust gases. While some units may vent exhaust directly out of the unit through an exterior wall, other units may need to vent exhaust through a chimney. If elevating equipment, the type of venting system and the clearances necessary for the venting system may limit the height to which equipment can be elevated.

The venting system should be tested to ensure it draws adequate air and backdrafting does not occur. Backdrafting is a dangerous explosion of hot gases that occurs when oxygen re-enters an oxygen starved environment, which can result in a dangerous explosive reaction. If relocating equipment, homeowners should hire appropriate licensed contractors and consider the appropriate venting requirements, as it may affect the final placement of the unit.

Unions, Fittings, and Valves

When it is not feasible to relocate or elevate equipment, it may be possible to replace unions, fittings, or valves to allow faster replacement of equipment when damaged, or to disconnect equipment prior to a flood event and relocate it to a higher floor. While this approach will not bring a non-conforming building into compliance with NFIP requirements, it may reduce potential flood damage to utility systems.

Considerations for Specific Equipment and Systems

Relocating and elevating utility equipment and systems can vary from being a simple process, like elevating a water heater on a small platform, to a complex process involving relocating equipment to a higher floor or to a new addition built specifically as a utility room. Each type of system has specific vulnerabilities, characteristics, and restrictions on placement that can affect a homeowner's ability to relocate or elevate it.

Electrical Panels

Power outages after a flood event are often greatly extended if a house's electrical panel is located below the flood elevation. To reduce this problem, the electrical panel ideally should be relocated to an elevation above the lowest floor (into the living space). When moving electrical panels to an elevation above the lowest floor, additional components, such as a service disconnect, may need to be incorporated to meet the requirements of the NEC. Homeowners should be aware of the local code requirements. In some cases, codes may stipulate that significant portions of the house's wiring be replaced when an electrical panel is relocated.

Electrical Wiring

In many houses, some wiring is located below the BFE, especially where the utility service is routed underground. If wiring is located below the BFE and the wiring is not rated for wet locations, the wiring should be encased in a non-corrosive metal or plastic pipe (conduit) when allowed by code. The conduits should be installed vertically to promote thorough drainage when the floodwaters recede. It is easier to replace damaged wiring if it is installed in a conduit.

Mechanical Systems

Mechanical systems include the heating, ventilation, and air conditioning (HVAC) system, duct work, and the air handler that delivers the conditioned air throughout the house. Elements of the heating and cooling system below the BFE are subject to flooding. Ductwork beneath a house's floor system is susceptible to flooding and should be removed and replaced if it is inundated by floodwaters. Specifically, the ductwork connected to the furnace and air handler is often the most at risk of flood damage because the furnace is often located in the basement.

In many instances, it may not be possible to elevate mechanical systems above the BFE, but they should be elevated as high as practical. Relocating mechanical equipment may require replacing ductwork and moving electrical supply and refrigerant lines. Physical obstructions, such as walls or framing, may restrict the relocation of ductwork and the final location of the system components.

Condensing units. Protecting the condensing unit for an air conditioning system can often be achieved by attaching a platform to the side of the house or elevating it on a platform. A cantilevered platform is preferred over a platform using posts because posts are more vulnerable to damage and failure. Flood-borne debris can damage posts, and scour or erosion can undermine the posts and lead to failure.

Heating systems. Boiler systems heat water and either force hot water or steam through radiators or baseboards throughout the home and are typically oil- or gas-fired. A hot water boiler system consists of the main boiler, heat exchanger and burner, circulation pumps or control valves, and an expansion tank. Many components of a boiler system can be damaged by floodwaters. Protecting a boiler system from flooding usually requires raising the system in its entirety to reduce flood vulnerability. Although most systems in residential use are hot water systems, the mitigation of a steam boiler is similar. Relocating a boiler heating system to an upper level is ideal, but can present some significant challenges. It may often be more practical to elevate the boiler as high as possible on its current floor. The main concerns when elevating a boiler are clearances, venting the exhaust, and protecting the supply tank from contamination.

Systems using heating oil rely on either an above- or below-ground storage tank. The storage tank should be evaluated to make sure it is properly anchored and sufficiently sealed to prevent floodwater from contaminating the heating oil or allowing the oil to be released. Figure 5 demonstrates a braced steel support structure for an above ground storage tank in Cedar Falls, Iowa.

A furnace or forced air heating system uses oil or natural gas (and sometimes electricity) to heat air blown across heating coils in the system. It may be possible to relocate these systems to upper floors or attic areas. If elevating the furnace to an upper floor is not possible and elevating the furnace in its existing location below the living area is the only practical mitigation measure, homeowners will need to accommodate the required clearances and venting of the unit.

Figure 5: Elevated storage tank surrounded by flood water in Cedar Falls, Iowa.

Water Heaters

Water heaters are powered from an electric coil or are oil or gas-fired. Conventional residential water heaters that use storage tanks typically range in capacity from 40 to 80 gallons. When exposed to floodwater, the internal components of the water heater can be damaged, which is not always apparent externally, yet necessitate replacement of the entire unit.

Electric water heaters. In some residences, electric water heaters can be relocated to a higher floor. Relocating the unit will require plumbing and electrical work, as well as a method to drain the tank and catch unexpected leaking water. For situations where a unit needs to be elevated in place, low ceiling height restrictions can sometimes be overcome by replacing a standard-height water heater with a lowboy model, which can be 12 to 16 inches shorter.

Oil or gas-fired water heaters. Oil- or gas-fired water heaters must be vented and may therefore be difficult to move into a main living space. If an appropriate location for the water heater on a higher floor is not available, it can potentially be elevated in its current location. Elevating the tank usually requires a small pad or platform, an appropriate location to vent the exhaust, and extending or shortening water supply lines and distribution lines.

Other water heaters. A homeowner may consider using a tankless water heater, which has little storage capacity and heats water instantaneously. Although more expensive than conventional water heater systems, tankless systems require significantly less space and may present a flood mitigation opportunity due to their smaller size. Converting a conventional water heater unit fueled by natural gas to a tankless system requires minimal additional work. Electric tankless water heaters, by comparison, may not be practical because of the electrical system upgrades needed in some houses to provide the additional electrical power for the water heater.

Washer/Dryer Units

Many washing machines and clothes dryers are located in basements, where they are vulnerable to flooding. To protect these units from flooding, homeowners can relocate or elevate the units. Relocating the equipment to a higher floor may not be practical if space is limited in the living area. If it is not feasible to elevate these units significantly, even minimal elevation may prevent them from being damaged in low-level flooding situations. A permanent pad or platform should be constructed to elevate these units; dry stacked bricks or blocks should not be used because they can shift and result in injuries to people or damage to the equipment. Elevating washing machines and clothes dryers may require altering the water and drain piping, electrical connections, and gas connections.

Resources and Useful Links

If a house is subject to flooding, homeowners should consult FEMA flood retrofitting publications to determine if other mitigation options or projects may be appropriate to consider during house renovations. The publications cover a variety of topics, including additional items related to utility system mitigation, such as installing backflow preventers to prevent damage to a system. The FEMA documents referenced can be downloaded from the FEMA Building Science Web site located at http://www.fema.gov/building-science-publications.

The FEMA Region VII Web page provides useful information and links for disaster survivors and recovering communities about available FEMA assistance and recovery initiatives. Please refer to https://www.fema.gov/region-vii-ia-ks-mo-ne

- FEMA (Federal Emergency Management Agency) P-348. 2017. *Protecting Building Utility Systems from Flood Damage*. Washington, DC. Available at https://www.fema.gov/media-library/assets/documents/3729.
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- FEMA. 2012. 2012 *Uniform Codes by the International Association of Plumbing and Mechanical Officials*. Washington, DC. Available at https://www.fema.gov/media-library/assets/documents/29689.
- ICC (International Code Council). 2009/2012/2015. *International Building Code*. Country Club Hills, IL. The ICC offers a free viewer that shows the codes at http://www.iccsafe.org/content/pages/freeresources.aspx.
- ICC. 2009/2012/2015. *International Residential Code for One- and Two-Family Dwellings*. Country Club Hills, IL.
- National Electrical Code (2008/2011/2014). National Fire Protection Association (NFPA) 70. Quincy, MA.

- FEMA P-765. 2009. *Midwest Floods of 2008 in Iowa and Wisconsin: Mitigation Assessment Team Report*. Washington, DC. Available at https://www.fema.gov/media-library/assets/documents/17329.

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