Fact Sheet 3.4.3: Building Utility Systems—Plumbing

The mitigation objective of this Fact Sheet is to improve the resilience of the components of plumbing systems to allow a building to continue to be used or quickly repaired following a hurricane, with an end goal of rapidly returning the building to full functionality.

Plumbing systems generally are associated with a building's drinking water systems that supply white (clean) water and wastewater drain/waste/vent (DWV) systems that remove gray (sink) water and black (toilet) water from the building. Plumbing systems also can be used to deliver propane or natural gas or compressed air. They are comprised of two types of components:

- **Primary components**—Plumbing components that must function for the system to operate. When a primary component is damaged, the entire system stops working. Some examples of primary plumbing system components include:
  - Drinking water systems: water meter, domestic water booster pumps and hot water circulator pumps, domestic water heaters (when there is only one), main piping lines, and valves and fittings within main piping lines
  - DWV piping and equipment: sanitary lift pumps, sanitary sewer lateral service connections, drainage waste and vent piping, and backwater valves
  - Fire suppression: all components are considered primary components for fire suppression systems and include service risers (shut off valves, backflow prevention valves, check valves, test points and gauges), fire pump and jockey pump
- **Secondary components**—Plumbing components that can be damaged without causing a complete loss of building system function. When secondary components are damaged, the system may function at a reduced level of service or cause service interruptions to a portion of the building. Examples of secondary plumbing system components include:
  - Drinking water systems: lateral piping lines, valves and fittings within lateral piping lines, plumbing fixtures
  - DWV piping and equipment: lateral drain lines, fixtures, grease traps

Typical components of drinking water and DWV systems for small public buildings connected to public water and sanitary sewer are shown in Figure 3.4.3.11 and Figure 3.4.3.2, respectively.

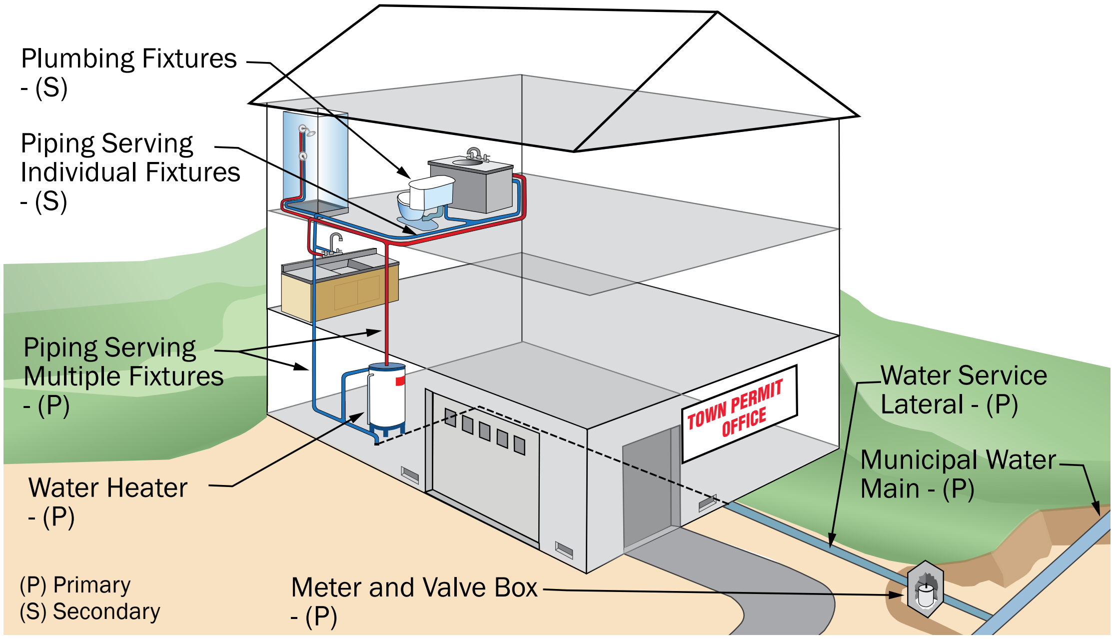


Figure 3.4.3.1. Typical small public building drinking water plumbing system components served by the public water system.

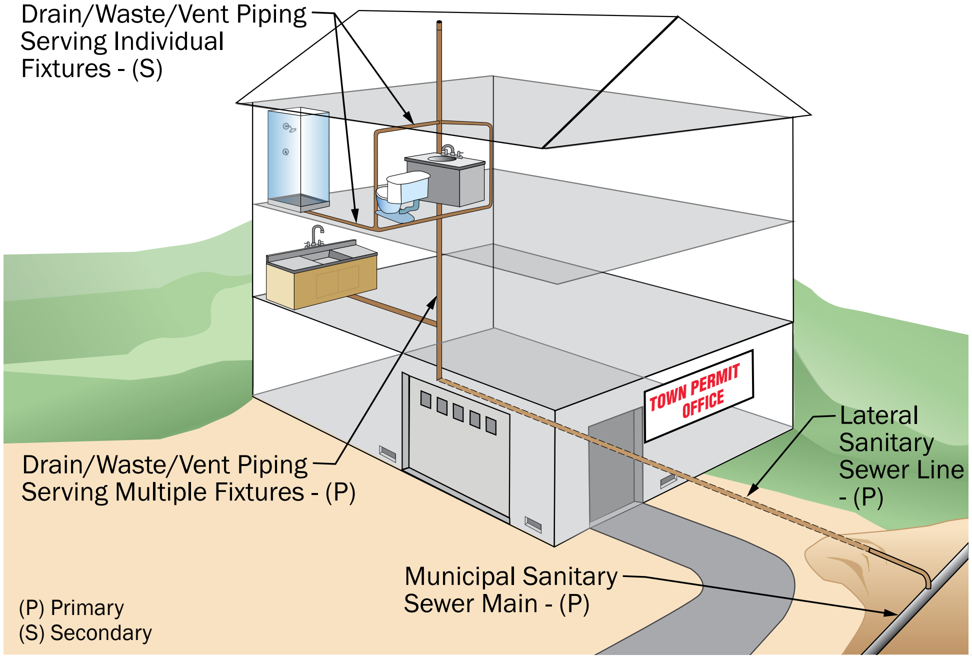


Figure 3.4.3.2. Typical small public building wastewater DWV system components served by the public sanitary sewer system.

Figure 3.4.3.3 and Figure 3.4.3.4, respectively, show alternate components of drinking water and wastewater systems for small public buildings supplied by a well and discharging into an onsite waste disposal (septic) system. Typical components of drinking (domestic) water and wastewater DWV systems for large public buildings connected to public and sanitary sewer, as well as fire suppression systems, are shown in Figure 3.4.3.5.

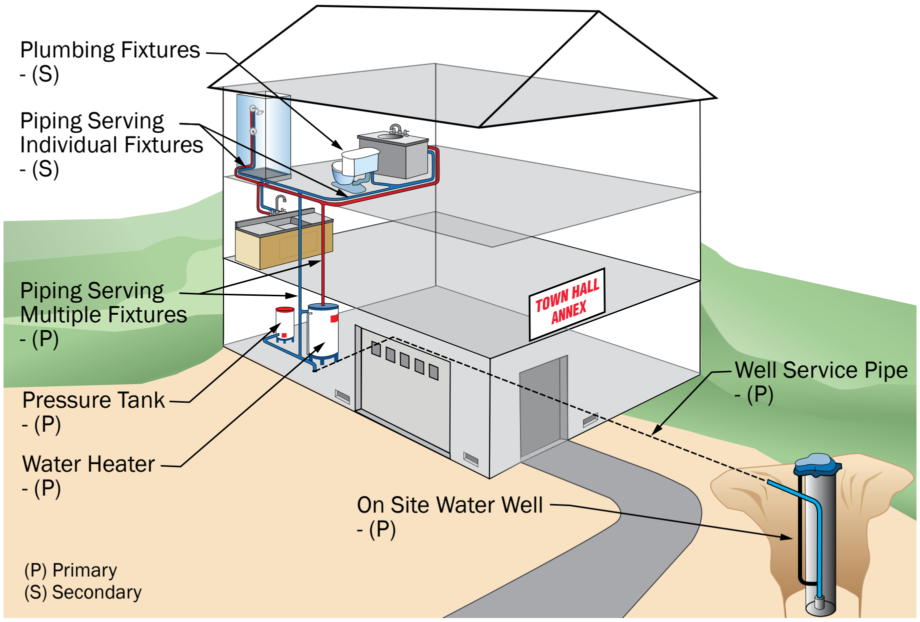


Figure 3.4.3.3. Alternative small public building drinking water plumbing system components supplied by a well.

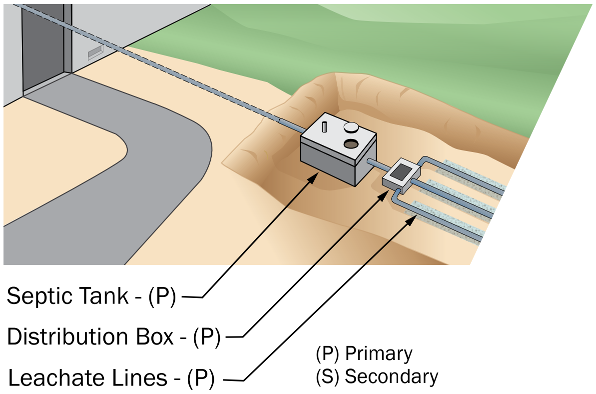


Figure 3.4.3.4. Alternative small public wastewater DWV system components served by onsite waste disposal (septic).

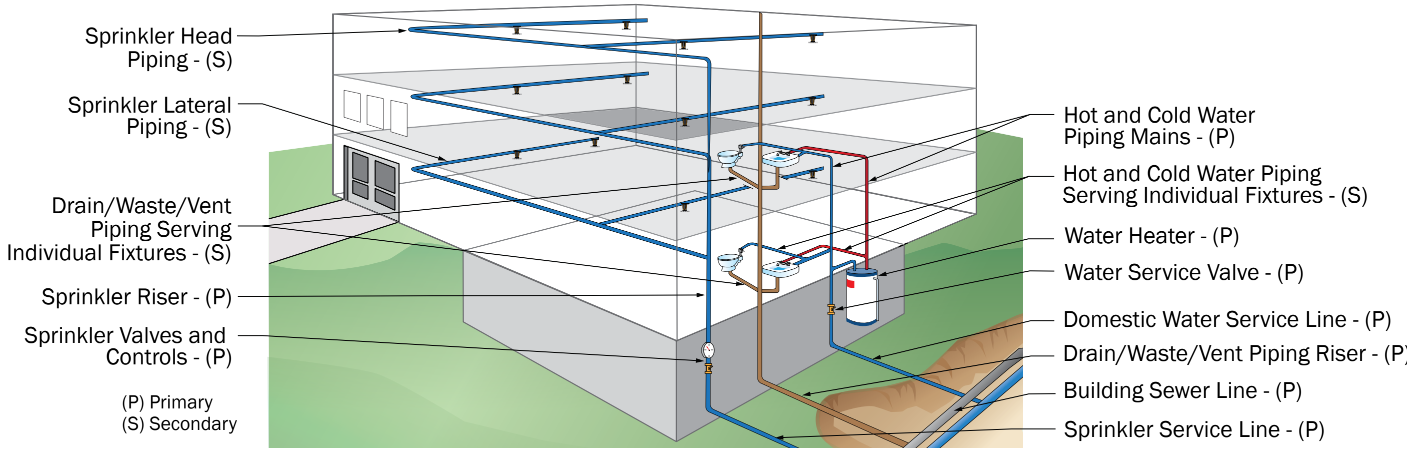


Figure 3.4.3.5. Simplified large public building drinking water plumbing, wastewater DWV, and fire suppression system components with utilities supplied by public water and sanitary sewer.

Typical components of liquid fuel and flammable gas systems, including liquid propane (LP) and natural gas (NG), for small public buildings are shown in Figure 3.4.3.6 and Figure 3.4.3.7, respectively. Typical components of liquid fuel or flammable gas systems for large public buildings are shown in Figure 3.4.3.8.

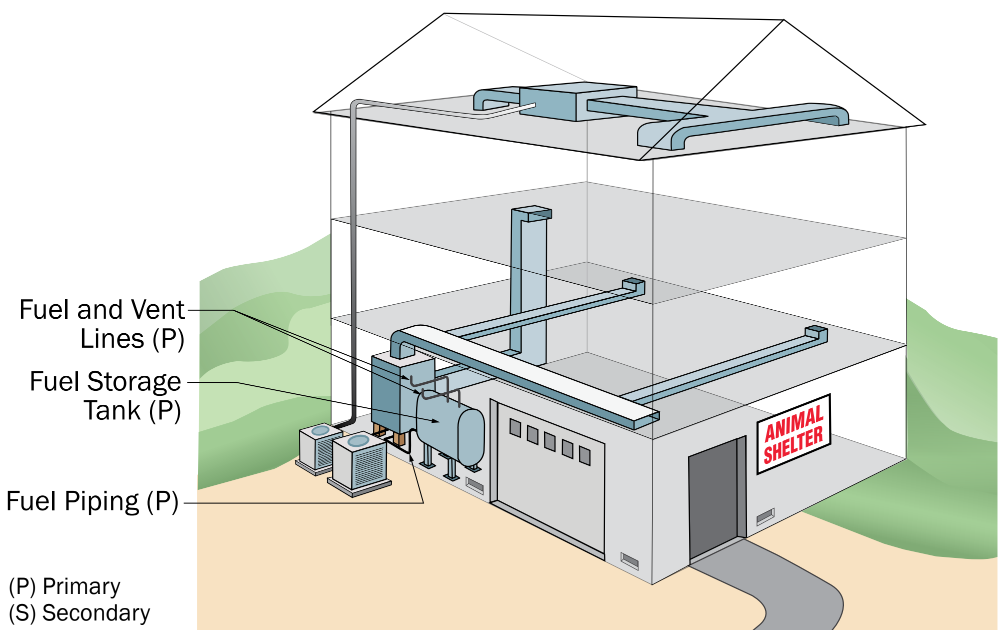


Figure 3.4.3.6. Typical small public building liquid fuel system.

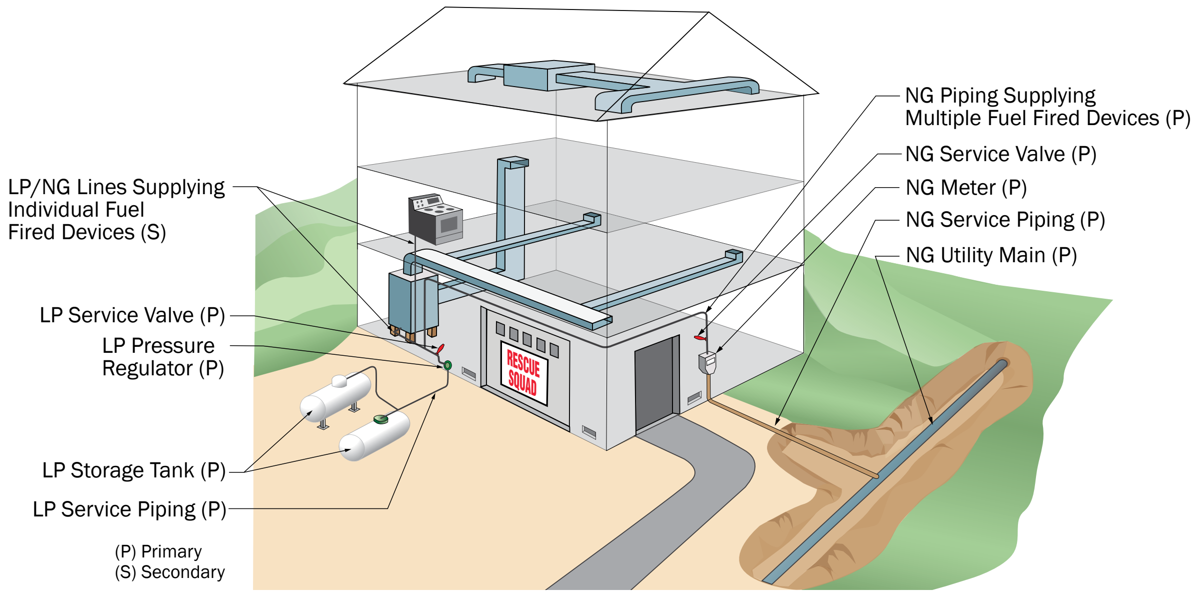


Figure 3.4.3.7. Typical small public building flammable gas system liquid propane (LP) with tank and pressure regulator (left side); natural gas (NG) with meter (right side).

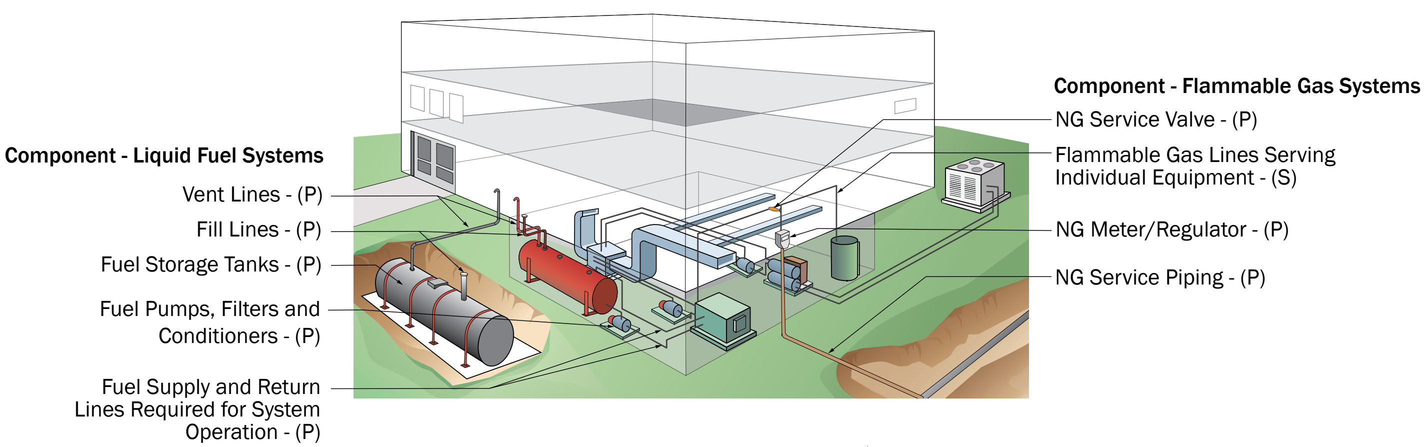


Figure 3.4.3.8. Typical large public building supplied with liquid fuel (LP) or flammable gas (NG) systems.

Although fuel systems and tanks technically include primary components and secondary components, fuel systems usually contain only a few secondary components since nearly all components need to work to supply fuel-burning devices.

The nature of plumbing systems as carriers of fluids makes them resistant to flood damage. Plumbing systems also tend to be less at risk for damage by wind than other building systems. Consequently, the risk to these systems is less than other building systems and the mitigation solutions are fewer. However, water heaters, booster pumps, lift pumps and some valve components and fittings can be damaged by flood. Exposed piping can be damaged by fast-moving flood water, wave action and debris impacts.

A unique risk to drinking water systems comes from the fact that public drinking water systems may not be watertight. Groundwater getting into the system outside the building can result in a loss of water pressure. A loss of water pressure often results in an order to boil water being issued. Plumbing systems inside a building usually are watertight, so infiltration is less likely inside the building even if there is a loss in pressure.

Table 3.4.3.1 summarizes some common mitigation solutions that can improve the performance of building plumbing system components. These strategies then are discussed in the sections that follow.

Table 3.4.3.1. Common Plumbing System Mitigation Solutions

Solutions and Options	***Coastal Flood***	***Riverine Flood***
Mitigation Solution: Elevate or Relocate		
Option 1: Elevate or relocate	✓	✓
Mitigation Solution: Seal or Isolate		
Option 1: Seal or Isolate	✓	✓
Mitigation Solution: Secure		
Option 1: Secure	✓	✓
Mitigation Solution: Dry Floodproof		
Option 1: Dry Floodproof		✓

Mitigation of drinking water components typically involves a combination of raising and sealing or isolating. Mitigation of DWV systems is more limited because they must be sloped to drain to the sanitary sewer lateral, but there may be some opportunities to re-route them to reduce flood risk. To mitigate fuel system components, refer to FEMA P-348, *Protecting Building Utility Systems from Flood Damage*, for additional details.

Wind and wind-related hazard mitigation of plumbing system components and equipment located inside the building or in rooftop enclosures can be achieved by ensuring the building envelope or rooftop enclosure is constructed to resist wind pressures, wind-borne debris and wind-driven rain. Additional protection can be gained by following best practices, which often go beyond minimum codes and standards. Additional information about measures that can be implemented to mitigate against wind is discussed in Fact Sheet 3.2, *Wall Systems and Openings*; Fact Sheet 3.3.1, *Sloped Roof Systems*; and Fact Sheet 3.3.2, *Low-Slope Roof Systems*.

Mitigation Solution: Elevate or Relocate

As with other building utilities, elevation is the most effective overall solution for mitigating primary and secondary drinking water system components in buildings. When raising the components is not possible, relocating them may be an option. Elevation of DWV systems generally is not an option because these systems must connect to other plumbing fixtures in the building, as well as the sanitary sewer lateral, and they must be sloped to drain. There may be opportunities to reconfigure the system to reduce flood risk. Because many DWV system components are naturally flood-damage-resistant, their location does not significantly affect overall building flood risk.

Option 1: Elevate or Relocate

For some existing buildings, it may be possible to relocate all primary water system components to an upper floor above the flood protection level, as shown in Figure 3.4.3.9. For existing buildings with many complex components, elevation above the flood protection level often is limited to key water equipment, such as booster pumps, water heaters and main water and wastewater piping within the building.

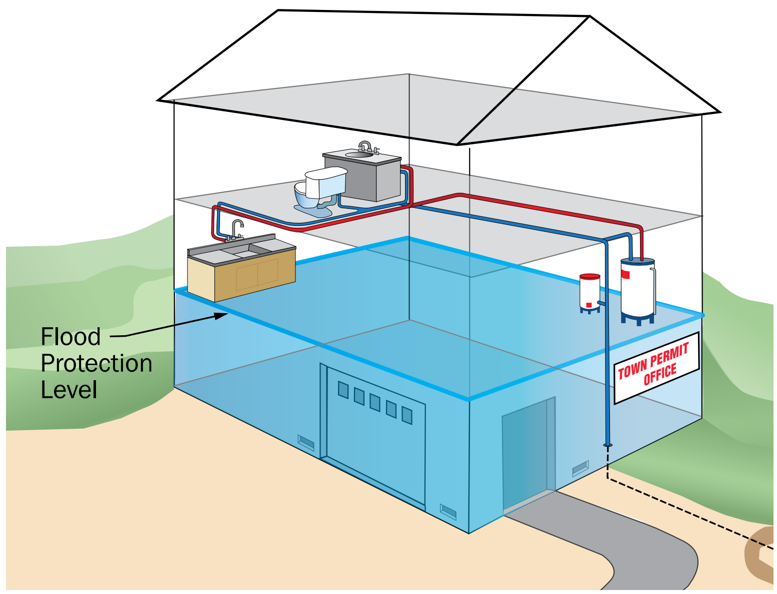


Figure 3.4.3.9. Elevation of primary plumbing system components to the upper floor of an existing small public building.

For some buildings, it may be possible to elevate primary fuel components on pedestals at or above the flood protection level, as shown in Figure 3.4.3.10.

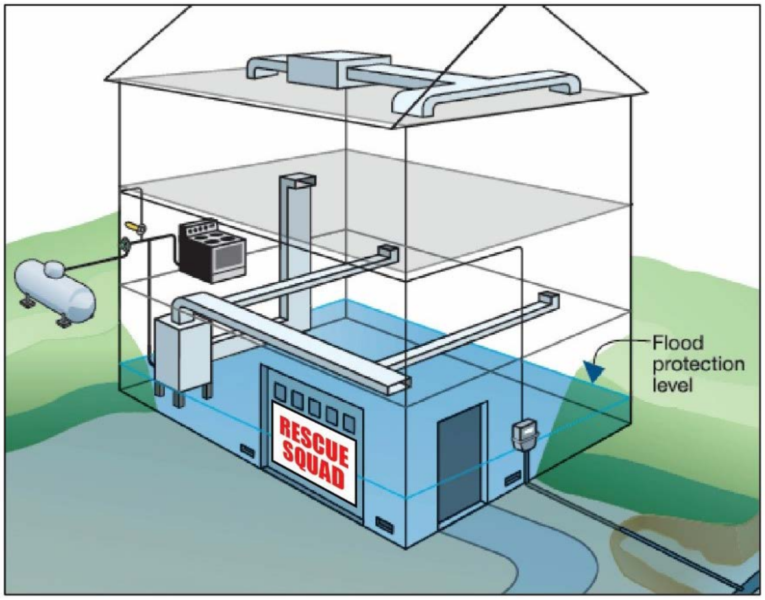


Figure 3.4.3.10. Elevation of primary fuel system components on pedestals for a small public building.

In some situations, raising primary fuel system components is limited to elevating outdoor fuel tanks above the flood protection level using a supporting frame or structural fill, depending on flood conditions, as shown in Figure 3.4.3.11. In coastal areas, be sure to elevate tanks on supporting frames that are designed to resist all coastal flood and wind forces and are built using corrosion-resistant connectors and fasteners in accordance with NFIP Technical Bulletin 8, *Corrosion Protection for Metal Connectors and Fasteners in Coastal Areas.*

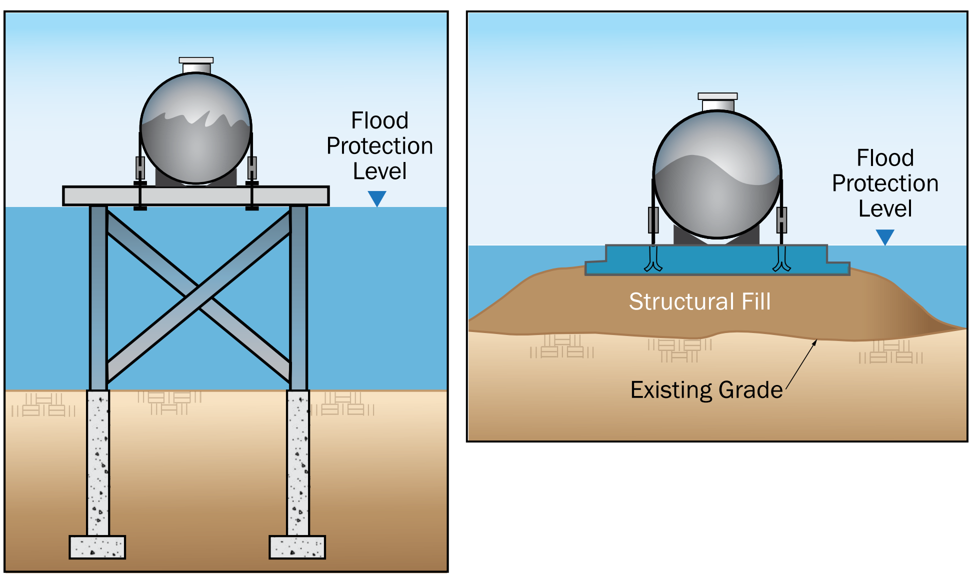
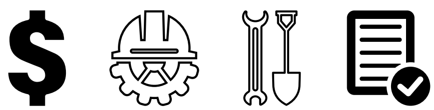


Figure 3.4.3.11. Outdoor fuel tank elevated on supporting frame (left); fuel tank elevated on structural fill (right).

When evaluating this option, also take note of these considerations:

- Fire suppression components, especially fire pumps and controls, should be elevated at or above the flood protection level whenever possible so they will remain undamaged and continue to operate during an emergency. Avoiding contact with floodwaters to reduce the risk of corrosion.
- Pool and spa equipment should be elevated at or above the flood protection level whenever possible.
- Backflow prevention valves located above ground that pose a tripping hazard may be relocated closer to the building. Alternatively, bollards may be placed around the valve for protection.

CONSIDERATIONS:



Mitigation Solution: Seal or Isolate

Since many water and wastewater components are designed to convey water and are connected to underground supply or discharge lines, there are more options to seal primary and secondary building plumbing system components in place or isolate them from the rest of the system. While fuel system components may be more susceptible to flood, in-place protection options can be implemented if elevation is not feasible.

Option 1: Seal or Isolate

For water, DWV, fire suppression and pool and spa system components, consider the following:

- Protect private wells and septic tanks using sealed caps or covers to prevent floodwater infiltration, as shown in Figure 3.4.3.12.

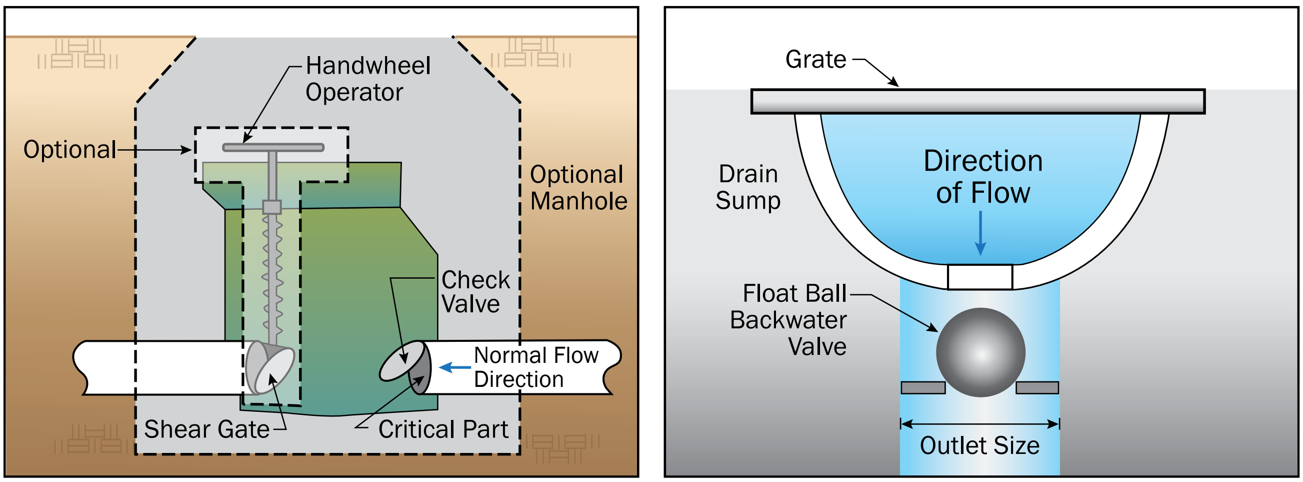


Figure 3.4.3.12. Backflow protection valves including a combination check valve and gate valve (left) and floor drain with ball float valve (right).

- Install check valves in gravity storm drain systems to prevent water from surcharged storm drains from backflowing into the building. Consider installing ejector systems with backflow prevention valves for all drains located below the maximum expected surcharge level.
- For facilities that may need to discharge wastewater during flood events, consider incorporating ejector systems with backflow prevention to serve all fixtures with flood rim elevations that are below the maximum anticipated surcharge of the sewer system that they discharge into.
  - Drain fixtures below the maximum surcharge level into sumps and pump the effluent out to the municipal line or on-site wastewater system.
  - Make sure pipes and ejector pumps are sized for the maximum expected surcharge pressure and the volume of wastewater anticipated.
- Install backflow prevention valves on wastewater lines to prevent floodwater mixed with sewage from entering buildings.

- There are a range of backflow prevention valves, as shown in Figure 3.4.3.13.
    - Check valves can automatically restrict flow to one direction.
    - Gate valves may need to be manually closed and opened.
    - Ball float valves can be used to protect floor drains.

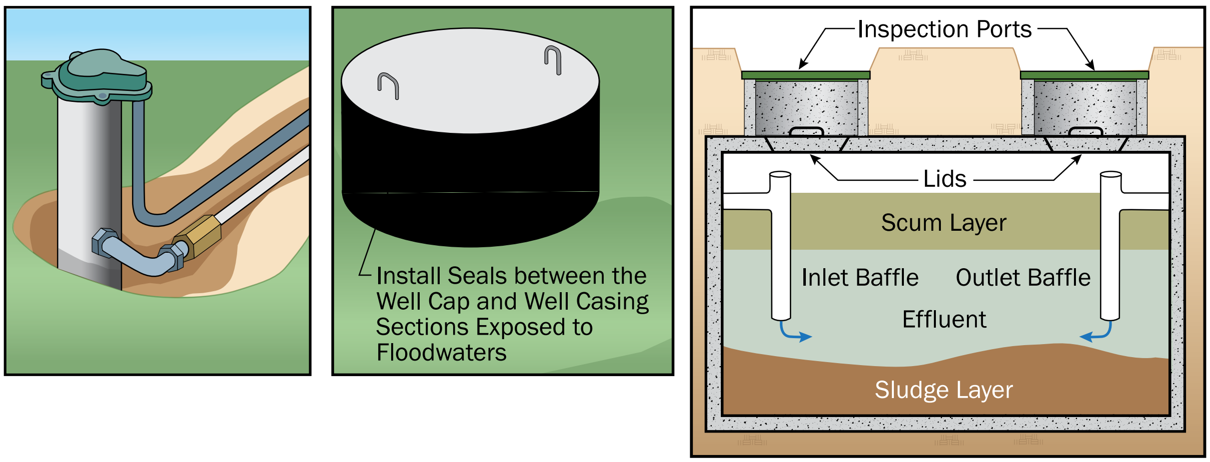
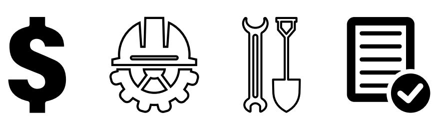


Figure 3.4.3.13. Protection of private well using a sanitary well cap (left) or concrete well cap (middle), and protection of septic tank with lids and gasketed access covers, concrete risers and riser caps (right).

- Note that a combination check valve and gate valve, shown in Figure 3.4.3.12 (on the left side of the figure), provides the most-effective protection against sewage backflow.
- Fire suppression piping that must be installed below the flood protection level can be protected in the same way as water and wastewater piping.
- Tank inlets and vents that extend above the flood protection level must be fitted with covers designed to prevent the inflow of floodwater and the outflow of tank contents.

CONSIDERATIONS:



Mitigation Solution: Secure

Some building plumbing or fuel system components may be subjected to flood, wind, and debris forces. These forces could dislodge them if the components are not properly secured.

Option 1: Secure

When evaluating mitigation options to secure building plumbing and fuel system components, consider the following:

- Service connections such as meters and risers can be attached to the land side (for coastal areas) or downstream side (for river areas) of a vertical structural member such as a pile.
- Outdoor underground fuel tanks can be sealed with a watertight cover to prevent floodwater infiltration and anchored to concrete pads, as shown in Figure 3.4.3.14.

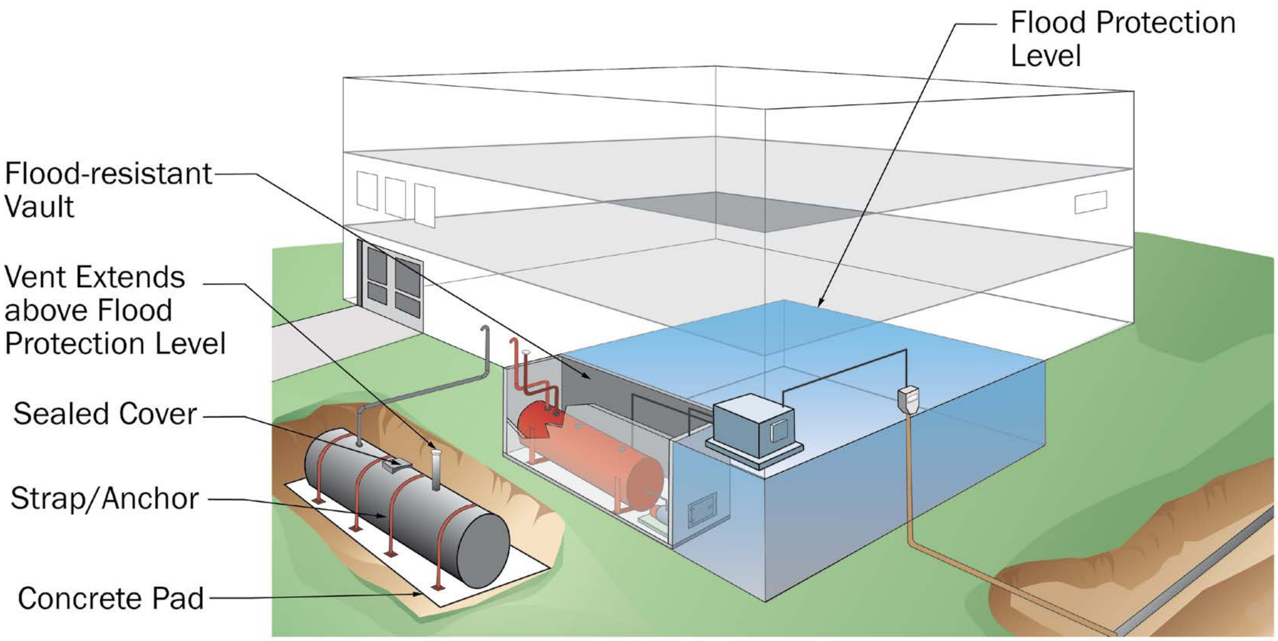
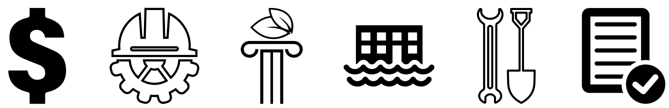


Figure 3.4.3.14. Secure and seal underground tanks to protect them from flood damage.

- Underground fuel tanks, underwater fuel system components and aboveground tanks must be designed to prevent flotation, collapse, or horizontal movement from flood loads.
- Fill and vent piping must be properly attached to prevent horizontal movement from flood forces.
- Underground tanks must be designed to resist crushing forces that act on them as floodwaters get deeper.
- In flood zones subject to moving floodwaters or storm surge, waves, wind, erosion and scour, fuel lines need to be attached to risers, buried well below the expected frost and scour depths, and strapped to the tank and tank supports with additional bracing.

- Fuel lines, straps, anchors, bracing and other connectors and fasteners should be made of corrosion-resistant materials.
- Fuel tanks can be filled to reduce flood forces acting on them. For this to be effective, though, fill and vent piping must reach above the flood protection level. If it does not, there is the potential for floodwaters to enter the tank through this piping and displace the fuel, resulting in a fuel spill.

CONSIDERATIONS:



Mitigation Solution: Dry Floodproof

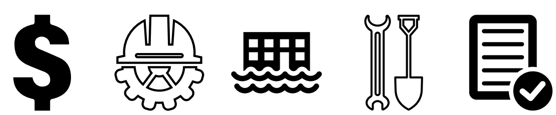
Option 1: Dry Floodproof

While many components of building plumbing systems have some natural resistance to flood damage, a few components could benefit from dry floodproofing if they cannot be elevated or relocated. Booster pumps, water heaters, fire pumps and controls for fire suppression systems, pool and spa filters and pump equipment and fuel pumps can be at risk for flood damage and should be protected. Current codes that reference ASCE 24, *Flood Resistant Design and Construction*, require fuel system equipment and utilities to be elevated to a specified height or dry floodproofed when placed in areas of buildings that have identified flood risk.

Evaluate these considerations about dry floodproofing:

- Place flood-susceptible plumbing and fuel system components that cannot be elevated in rooms or vaults that are substantially impermeable. These vaults should be built to resist flood forces. An example of a vault is shown in Figure 3.4.3.14, above.
- To dry floodproof, make sure the frames around doors, hatches or other access points are properly sealed as well to prevent water entry.
- For dry floodproofing to be effective, sump pumps connected to emergency power sources should be installed in the protected areas to remove any water that may seep in.

CONSIDERATIONS:



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Detailed information on hurricane mitigation of building plumbing systems can be found in these publications. Much of the residential information applies to non-residential buildings as well.

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