Fact Sheet 4.1: Drinking Water Systems

The mitigation objective of this Fact Sheet is to identify ways to maintain or quickly restore the operation of drinking water systems impacted by floods and hurricanes to make sure there is safe drinking water for users.

During hurricanes or severe flooding, the system components needed to ensure the ongoing operation of drinking water systems are at high risk for damage. Flooded rivers and lakes can expose source water intake structures to silt and debris clogging or damage. Contaminated or muddy floodwaters can impact treatment plant processes. All floodwaters can expose system components such as storage tanks, unprotected piping, and chlorination and filtration equipment to moving floodwater forces that exert horizontal pressure and the added risk of flotation, increasing the chances of damage. Moving floodwaters also can damage drinking water system components by causing scour and erosion. Floodwaters can submerge wellheads and contaminate well water.

Damage to drinking water systems can result in loss of system pressure, which could allow ground and floodwater to get into the system, resulting in contamination. Following hurricanes and floods, system pressure loss often results in boil water orders until drinking water systems are disinfected. Hurricanes and floods often can cause power outages due to wind damage to power lines, downed trees, and flooding of transformers and transmission facilities. When drinking water pumps lose power, electrical controls and instrumentation, service often is disrupted. Damaged drinking water system components require rapid repair or replacement to bring the system to full operational capacity.

Figure 4.1.1 shows a typical drinking water treatment system.

Note

Refer to Mitigation Fact Sheet 2.3, *Mitigation of Dams and Reservoirs*, Fact Sheet 3.1, *Foundations*, and Fact Sheet 3.2, *Walls and Openings*, for other mitigation ideas that may apply to drinking water systems.

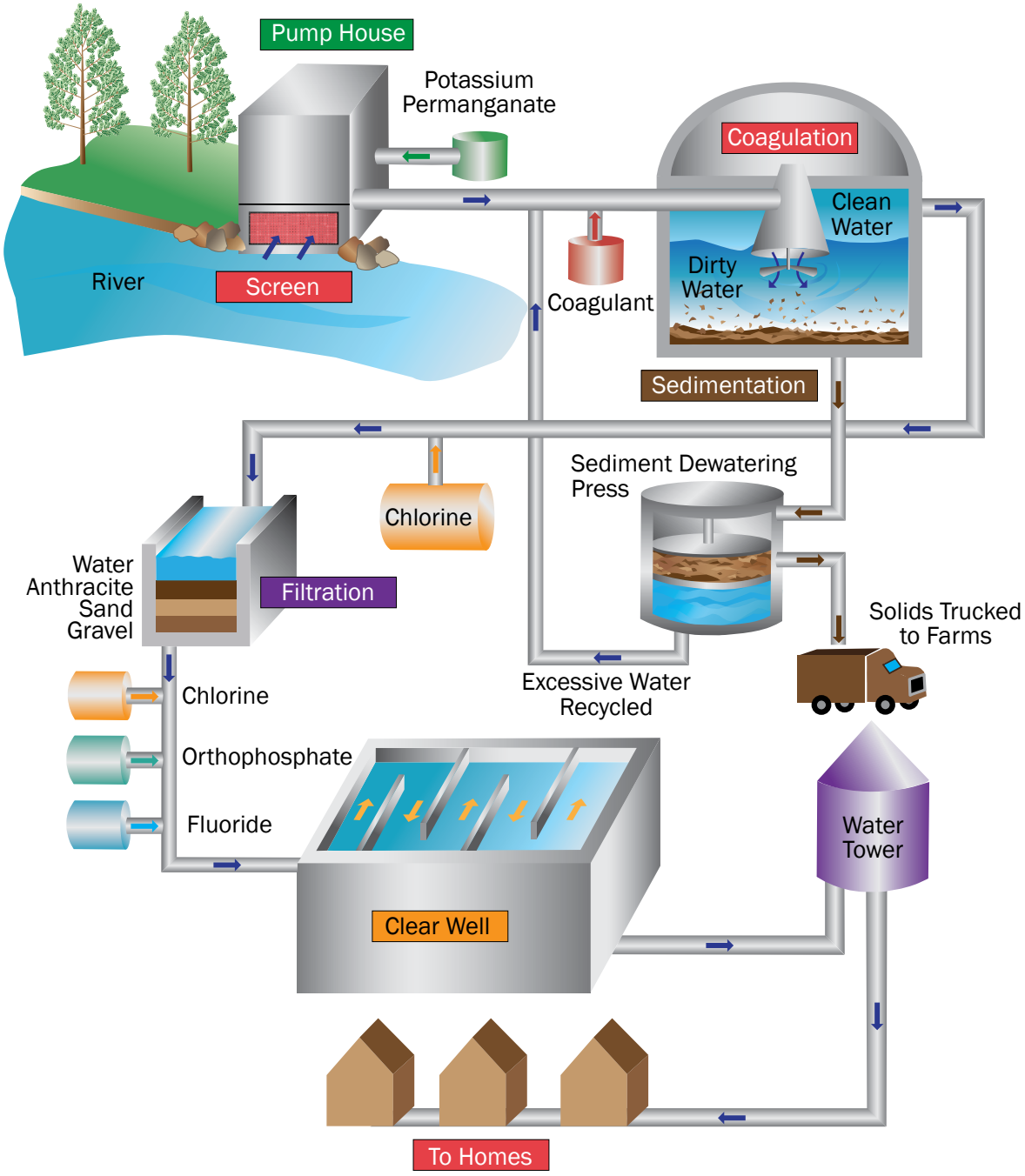


Figure 4.1.1. The typical water treatment process has opportunities for hazard mitigation. (Source: City of Rockville, Maryland, 2012)

Table 4.1.1 summarizes some common mitigation strategies that can improve the resilience of drinking water systems. These strategies are then discussed in the sections that follow.

Table 4.1.1. Common Mitigation Solutions for Drinking Water Systems

Solutions and Options	*Wind*	*Wind-Driven Rain*	*Flooding*
Mitigation Solution: For Water Intake, Distribution and Storage Components			
Option 1: Elevate or Relocate			✓
Option 2: Protect or Divert			✓
Option 3: Floodproof			✓
Option 4: Increase Storage Volume			✓
Mitigation Solution: For Drinking Water Treatment Facilities			
Option 1: Elevate or Relocate			✓
Option 2: Floodproof		✓	✓
Option 3: Provide Redundant Systems	✓	✓	✓
Mitigation Solution: For Booster Stations and Other Pumps			
Option 1: Elevate or Relocate			✓
Option 2: Floodproof		✓	✓
Option 3: Provide Redundant Systems	✓	✓	✓
Mitigation Solution: For Chemical and Fuel Storage Tanks			
Option 1: Elevate or Relocate			✓
Option 2: Floodproof			✓
Option 3: Secure or Anchor	✓		✓
Option 4: Provide Redundant Systems	✓		✓
Mitigation Solution: For Instrumentation and Electrical Controls			
Option 1: Elevate or Relocate			✓
Option 2: Floodproof			✓
Mitigation Solution: For Power Supplies			
Option 1: Elevate or Relocate			✓
Option 2: Floodproof		✓	✓
Option 3: Provide Redundant Systems	✓	✓	✓

Mitigation Solution: For Water Intake, Distribution and Storage

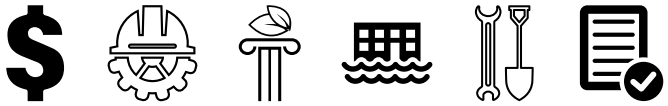
Water intake, distribution and storage components can be at risk for damage from flooding. Intake structures can be clogged by soil and debris; they also can be physically damaged by debris hitting them. Underground distribution pipes can be exposed by fast-flowing floodwaters eroding the soil covering them, making them vulnerable to damage by the flowing water and debris. Well casings and wells can be submerged by floodwaters, which can lead to contamination. Water storage tanks can be moved off their foundations by swiftly flowing floodwater. Steps can be taken to mitigate against this damage and make water intake, distribution and storage components more resilient to floods and hurricanes.

Option 1: Elevate or Relocate

When evaluating this option, consider the following:

- Elevate or relocate pump houses and distribution system elements to at least the 0.2%-annual-chance (500-year) flood elevation to reduce the chance of the structure flooding, which can cause damage or system shutdown.
- Relocate system components if susceptible to flood damage or contamination.
- Bury all distribution lines crossing streams or water bodies to prevent damage from scour or debris.
- Extend well casings above the 0.2%-annual-chance (500-year) flood elevation.

CONSIDERATIONS:



Option 2: Protect or Divert

When evaluating this option, consider the following:

- Install or upgrade intake screens to prevent debris blockages.
- Use jetties or breakwaters to divert debris and silt away from intake structures.
- Grade land to slope away from wells.
- Use stainless steel or PVC piping components.

CONSIDERATIONS:

Option 3: Floodproof

When evaluating this option, consider the following:

- Floodproof or reinforce fire hydrants, valve vaults and other system elements if they are susceptible to flood damage or contamination.
- Retrofit all system pumps vulnerable to floodwaters with submersible pumps with waterproof pump motors.
- Seal tops of well casings.
- Waterproof well caps.

CONSIDERATIONS:

Option 4: Increase Storage Volume

When evaluating this option, consider the following:

- Increase the storage volume of emergency finished water (treated water stored at a drinking water treatment facility ready for distribution), as needed, or set up a different storage location.

CONSIDERATIONS:

Mitigation Solution: For Drinking Water Treatment Facilities

Flooding can damage drinking water system buildings and destroy process equipment, communications controls, data records, and field administrative equipment. Flooding also can wash out treatment plant tanks and filter beds, damage equipment, cause equipment to malfunction, and contaminate the water supply.

Option 1: Elevate or Relocate

When evaluating this option, consider the following:

- Elevate the pads that support process tanks and critical equipment to be above the 0.2%-annual-chance (500-year) flood level.
- Elevate or relocate equipment, control centers and furnishings critical to operations to a higher floor in a building or above the design flood elevation.
- Maintain any generators or critical electrical components above the 0.2%-annual-chance (500-year) flood elevation.

CONSIDERATIONS:

Option 2: Floodproof

When evaluating this option, consider the following:

- Install a floodwall or berm to protect the facility (Figure 4.1.2).
- Install waterproof protection, such as shields, on building entry points, including windows, doors and garages.
- Use flood-damage-resistant building materials below the design flood elevation to prevent water damage.
- Use green infrastructure or stormwater management strategies near the plant to redirect floodwater away from the facility.
- Install pumping systems, channels or culverts that also may redirect floodwater away from treatment facilities.
- Seal all potential wall and floor water entry points.
- Install backflow prevention devices on sewers and drains in buildings that are at risk.

Figure 4.1.2. Constructing a floodwall around a water treatment plant can protect buildings and equipment from flood damage. (Source: U.S. Army Corps of Engineers, 2013)

- Create ways to pump sewage generated within buildings that are at risk.
- Outfit Motor Control Centers (MCCs) with waterproof models.
- Install backflow preventers on low-profile pipes to protect treated water from contamination.
- See Fact Sheet 3.1, *Foundations*, and Fact Sheet 3.2, *Walls and Openings*, for additional information.

CONSIDERATIONS:

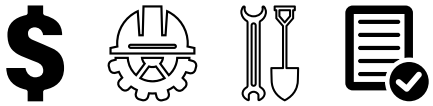
Option 3: Provide Redundant Systems

Installing backup systems and equipment can keep water treatment plants working during a flood (Figure 4.1.3, below). When evaluating this option, consider the following:

- Provide hardwired backup controls that are independent of Supervisory Control and Data Acquisition (SCADA) systems.
- Install wiring to make it possible to use temporary generators if needed.
- Provide redundant systems for the motor control center.

Figure 4.1.3. Installing an emergency backup generator can provide power to help a water treatment plant continue to operate during a flood. (Source: U.S. Environmental Protection Agency [EPA], 2014)

CONSIDERATIONS:



Mitigation Solution: For Booster Stations and Other Pumps

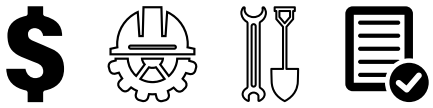
Pumps move water throughout the water treatment system and are an important element of the system. Pumps and control systems, including pump controls, electrical panels, and the Motor Control Center are at risk for flood damage, which may cause the system to shut down. The following options provide mitigation strategies against floods and hurricanes for booster stations, other pumps and associated equipment.

Option 1: Elevate or Relocate

When evaluating this option, consider the following:

- Elevate or relocate instrumentation, computers and records.
- Replace below-ground booster stations with above-ground stations raised to 0.2%-annual-chance (500-year) flood elevation.

CONSIDERATIONS:



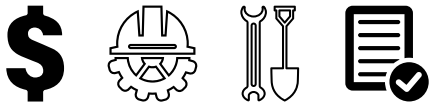
Option 2: Floodproof

When evaluating this option, consider the following:

- Install permanent flood barriers, such as flood walls or berms, around buildings and any important outside equipment.
- Install flood shields on doors and openings (Figure 4.1.4).
- Replace non-submersible pumps with submersible pumps.
- Install sump pumps to remove any leakage in facilities that are below ground level.
- Use electrical panel enclosures rated for submersion.

Figure 4.1.4. Water-tight doors can be used to protect pumps and other equipment in pump houses and booster stations.

CONSIDERATIONS:

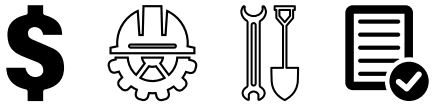


Option 3: Provide Redundant Systems

When evaluating this option, consider the following:

- Install wiring that is compatible with portable generators.
- Invest in energy-efficient equipment that uses less fuel to extend the operating capacity of a backup system during a power outage.
- Explore the possibility of temporarily removing and safely storing critical components in advance of a storm.

CONSIDERATIONS:



Mitigation Solution: For Chemical and Fuel Storage Tanks

If access is blocked or the supply chain fails during or after a flood or hurricane, this can slow down delivery of treatment chemicals and fuel. Without chemicals or fuel, the operation of drinking water systems may be stalled for some time, even if the facilities themselves are not damaged.

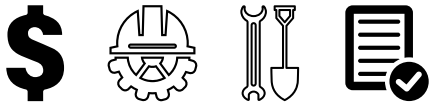
Storage tanks are also at risk from damage and rupture, which can cause tanks to leak or float if not properly raised and anchored.

Option 1: Elevate or Relocate

When evaluating this option, consider the following:

- Elevate or relocate tank platforms above the 0.2%-annual-chance (500-year) flood elevation.
- Elevate fill and vent lines above 0.2%-annual-chance (500-year) flood elevation.

CONSIDERATIONS:



Option 2: Floodproof

When evaluating this option, consider the following:

- Install protective barriers around tanks to keep water and debris out.
- Install sump pumps to pump out water that leaks inside the protective barrier.
- In coastal areas, use saltwater-resistant equipment and storage tanks to avoid corrosion.

CONSIDERATIONS:

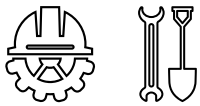
Option 3: Secure or Anchor

When evaluating this option, consider the following:

- Fill storage tanks to full volume prior to a storm to increase the tank's weight.
- Anchor tanks to platforms with corrosion-resistant straps to prevent the tank from becoming loose and floating (Figure 4.1.5).

Figure 4.1.5. Secure tanks with non-corrosive straps to prevent flotation. (Source: U.S. Environmental Protection Agency [EPA], 2014)

CONSIDERATIONS:



Option 4: Provide Redundant Systems

When evaluating this option, consider the following:

- Install larger-volume tanks or a second tank to ensure adequate treatment chemicals and fuel are available to run the needed systems until the supply chain or access is restored.

CONSIDERATIONS:

Mitigation Solution: For Instrumentation and Electrical Controls

Instrumentation, electrical controls and electrical wiring are essential components of drinking water systems. Motor control centers or SCADA systems also are vital to system operation. If these elements are damaged or unusable, operations and data collection in operations centers, treatment facilities, remote distribution locations, collection valve chambers and pump stations are at risk.

Option 1: Elevate or Relocate

When evaluating this option, consider the following:

- Relocate motor control centers or SCADA systems to facilities outside of the Special Flood Hazard Area.
- Elevate individual instruments, motor control centers and critical components to above 0.2%-annual-chance (500-year) flood elevation (Figure 4.1.6).

Figure 4.1.6. Elevating instrumentation can protect it from flood damage. (Source: U.S. Environmental Protection Agency [EPA], 2014)

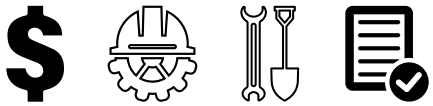
CONSIDERATIONS:

Option 2: Floodproof

When evaluating this option, consider the following:

- Replace enclosures that house instrumentation and controls with water-resistant models.
- Isolate the equipment that is likely to be exposed to floodwaters for rapid removal, repair, replacement and installation.
- Make sure that staff can operate all systems manually.

CONSIDERATIONS:



Mitigation Solution: For Power Supplies

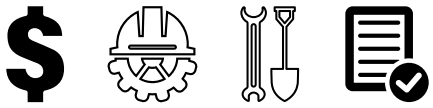
Hurricanes and floods often result in power outages caused by wind damage to power lines, downed trees and flooding of transformers and transmission facilities. This can disrupt service and cause public health and safety concerns (for instance, boil water advisories). Improving the resilience of power supplies to drinking water systems can help decrease or even eliminate the amount of time these systems are unavailable.

Option 1: Elevate or Relocate

When evaluating this option, consider the following:

- Raise all critical electrical equipment that might be at risk above the 0.2%-annual-chance (500-year) flood elevation.
- Relocate electrical vaults and relocate or elevate service panels away from the floodplain.

CONSIDERATIONS:

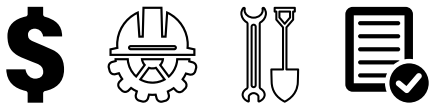


Option 2: Floodproof

When evaluating this option, consider the following:

- Replace or upgrade connections and junction boxes with water-resistant equipment.
- Use submersible pumps in areas at risk for flooding.

CONSIDERATIONS:



Option 3: Provide Redundant Systems

When evaluating this option, consider the following:

- Install an additional power feed to the drinking water system.
- Create more reliable connections to the power source or a dedicated feeder between the power station and the drinking water treatment plant.

- Install permanent standby generators at locations having priority.
- Wire pump stations and other key equipment with quick-connect capability to work with portable backup generators.
- Consider options for using equipment that can run on more than one type of fuel. This can allow equipment to work even if it becomes difficult to get one fuel type.
- Install larger-volume fuel tanks or a second fuel tank to increase fuel availability.
- Connect to solar panels or wind turbines with battery storage or use combined heat and power plants (CHP) to reduce dependency on the electrical grid.
- Consider the addition of a flood- and wind-resistant microgrid system to power the facility (Figure 4.1.7).

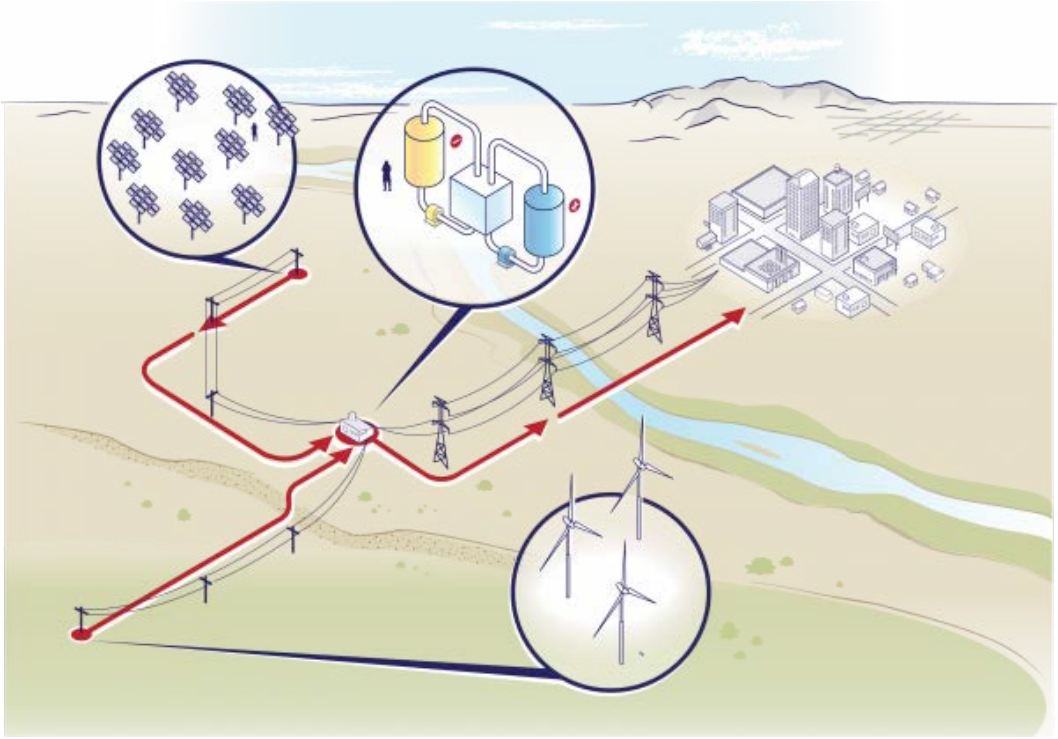


Figure 4.1.7. Microgrids can provide power to a facility to reduce its dependence on the main electrical grid. (Source: Sandia National Laboratories, 2020)

- Store temporary or backup equipment, like replacement pumps, away from areas at moderate to high risk for flooding or limited access.
- See Fact Sheet 4.3, *Electric Power*, for additional information.

CONSIDERATIONS:

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