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MIDWEST FLOODS *of* 2008 IN IOWA & WISCONSIN

4 Critical and Essential Facilities

Chapter 4 discusses damages observed by the MAT to critical and essential facilities throughout southern and central Iowa and Wisconsin. Most flood damages were the result of riverine flooding and sewer backups. Most site visits were conducted in August and September of 2008; the University of Iowa was visited in October of 2008. In addition to notes taken in the field, the MAT made use of photographs and documentation supplied by the FEMA Joint Field Offices in Des Moines, Iowa, and Madison, Wisconsin.

Building damages assessed by the MAT were categorized according to Table 3-1. Building occupancies are classified into four categories. Chapter 4 discusses Categories III and IV, which are defined as follows:

- **Category III** (Critical Facilities), buildings and other structures that represent a substantial hazard to human life in the event of failure. This category includes water and wastewater treatment facilities, municipal buildings, educational facilities, and non-emergency healthcare facilities.
- **Category IV**, buildings and other structures designated as essential facilities. This category includes hospitals and fire, rescue, ambulance, and police stations.

Facilities reviewed during the MAT included:

- Critical Facilities (Category III)
  - Municipal Facilities
  - Detention Facilities (special evacuation issues are also discussed)
  - Water Treatment Facilities and Wastewater Treatment Facilities
  - Utility Plants
  - Educational Facilities
    - K–12 School Buildings
    - School Administration and Maintenance Buildings
    - University Buildings
- Essential Facilities (Category IV)
  - Medical
  - Police and Fire Stations

Section 4.1 discusses critical facilities including municipal facilities and detention facilities. Section 4.2 discusses essential facilities, including medical facilities and law enforcement facilities. Section 4.3 discusses water and wastewater treatment facilities, and Section 4.4 discusses educational facilities.

Section 4.5 includes a matrix of lessons learned at the facilities visited by the MAT. The matrix categorizes the lessons learned by building type and guidance in existing FEMA publications, including:

- FEMA 348, *Protecting Building Utilities from Flood Damage*, a technical handbook for elevating and otherwise protecting electrical, mechanical, gas, water, and other major building utilities
- FEMA 543, *Design Guide for Improving Critical Facility Safety from Flooding and High Winds*, a technical manual that provides a comprehensive survey of the methods and processes necessary to protect critical facilities from natural hazards
- FEMA 577, *Design Guide for Improving Hospital Safety from Earthquakes, Floods, and High Winds*, a technical manual that provides a multi-hazard approach to protecting hospitals

- NFIP Technical Bulletin 2 (TB 2), *Flood Damage-Resistant Materials Requirements*, an overview and technical guide to selecting and installing flood damage-resistant structural and finish materials
- NFIP Technical Bulletin 4 (TB 4), *Elevator Installation*, regulations and guidelines for installing and protecting elevators in flood-prone areas
- NFIP Technical Bulletin 6 (TB 6), *Below-Grade Parking Requirements*, technical guidelines for designing and constructing below-grade parking garages for non-residential buildings in SFHAs
- *Sharing the Challenge: Floodplain Management Into the 21st Century* (Galloway Report), a study and review of the 1993 Midwest floods

It is anticipated that the facilities reviewed by the MAT will utilize federal funding to recover and rebuild after the 2008 floods. When federal funding is provided for the repair of existing critical facilities located within the 0.2-percent-annual-chance floodplain, the repairs are subject to the requirements of FEMA 543, ASCE 7, and ASCE 24.

Federal agencies with involvement in funding, permitting, and constructing critical facilities are also required to adhere to the requirements of Executive Order (EO) 11988. Under EO 11988 – Floodplain Management, federal agencies are to provide leadership and take action to reduce the risk of flood loss, minimize the impact of floods on human safety, health, and welfare, and protect the natural and beneficial functions of floodplains.

Under EO 11988 implementing guidelines, a critical action, which includes critical facilities, is defined to include any activity for which even a slight chance of flooding is too great. The concept of critical action reflects a concern that the impacts of floods on human safety, health, and welfare for many activities could not be minimized unless a higher degree of protection than the base flood (the 1-percent-annual-chance flood) was provided. For facilities in Zone A, ASCE 24 recommends incorporating a minimum of a 1-foot freeboard for critical facilities and a 2-foot freeboard for essential facilities.

Only one of the critical facilities visited by the MAT had been constructed to a 0.2-percent-annual-chance flood event level of protection; detailed pre-event emergency planning for the remaining critical facilities is an urgent need. FEMA 543 provides further elevation guidance for critical facilities and recommends that the lowest floors of critical facilities be elevated to or above the 0.2-percent-annual-chance flood elevation. The MAT recommends locating critical and essential facilities outside the 0.2-percent-annual-chance floodplain. If that is not possible, critical and essential facilities should be elevated (or otherwise protected) to the 0.2-percent-annual-chance flood elevation or the ASCE 24 minimum elevation requirements, whichever is greater.

The locations of several Cedar Rapids, Iowa, facilities referenced in this chapter are shown in Figure 4-1.

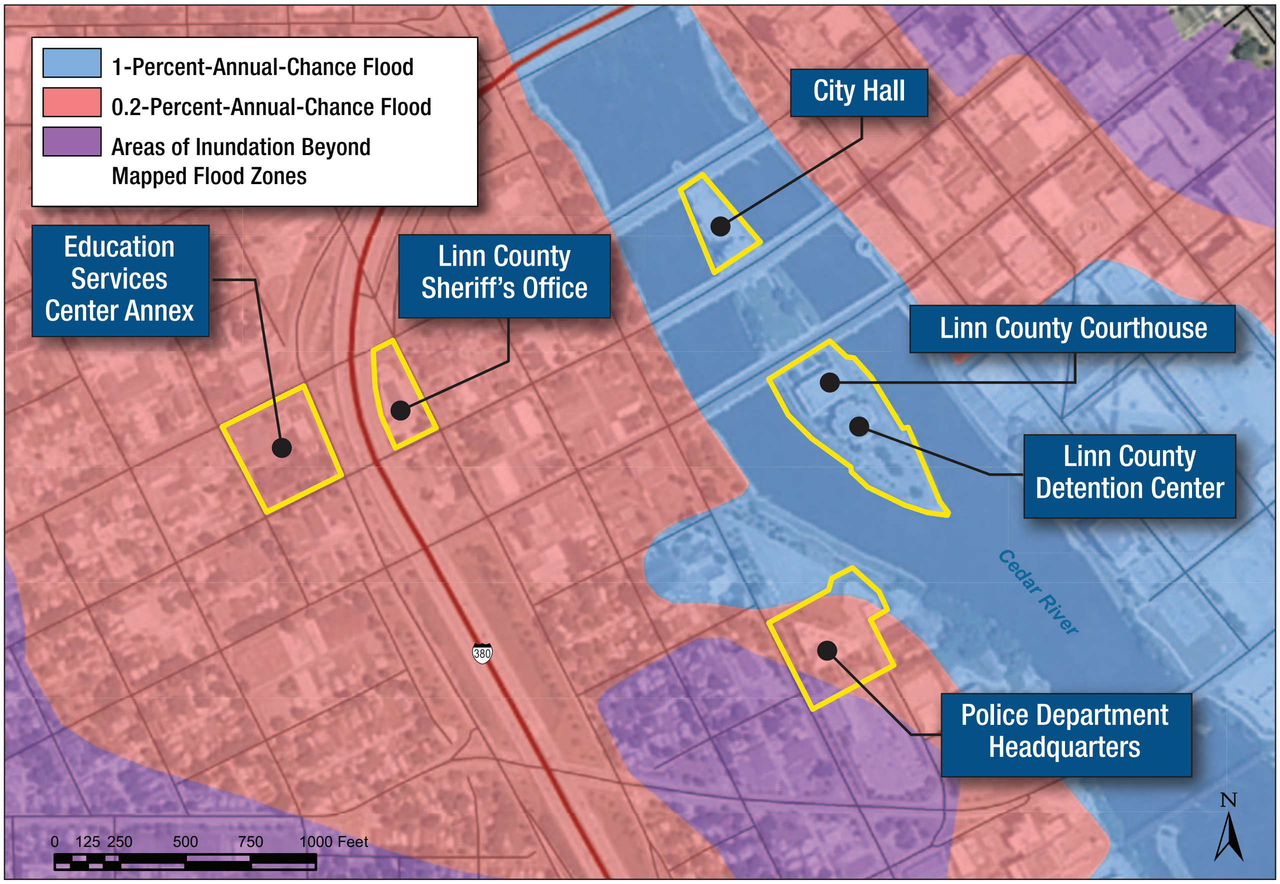

Figure 4-1.
Flood zones and inundation for Cedar Rapids City Hall, Linn County Courthouse, Linn County Detention Center, Cedar Rapids Police Department Headquarters, Linn County Sheriff's Office, and Education Services Center Annex (Cedar Rapids, Iowa)

4.1 Critical Facilities: Local Government

This section discusses building performance of public institutional facilities classified under Category III as defined by ASCE 7-05. The three buildings discussed in this section are Cedar Rapids City Hall, the Linn County Courthouse, and the Linn County Detention Center; all three facilities are in Cedar Rapids, Iowa, and are essential for continued government operations and community security. Table 4-1 summarizes elevation information for these and other facilities.

Table 4-1. Elevation Data for Cedar Rapids Critical Facilities

Facility	Floodplain	First Floor Elevation (Basement)	Lowest Adjacent Grade	Flood Elevation (Approx.)	Base Flood Elevation	0.2-Percent-Annual-Chance Flood Elevation	Recurrence Interval	Date
City Hall	SFHA	714.2	Not available	734	724.7	728.5	>500-year	Pre-FIRM
Linn County Courthouse	SFHA	Not available	726.8	734	724	728	>500-year	Pre-FIRM
Linn County Detention Center	SFHA	Not available	726.4	734	724	728	>500-year	Post-FIRM
Police Department Headquarters	0.2-Percent-Annual-Chance	724.5	724	731	723.5	729	>500-year	Post-FIRM

4.1.1 Cedar Rapids City Hall and Linn County Courthouse, Cedar Rapids, Iowa

Key Issues: Floodwaters entered the Cedar Rapids City Hall and the Linn County Courthouse, two municipal buildings located on an island in the Cedar River, through tunnels and an underground parking garage. As a result, both buildings lost critical contents and functions in their lower levels.

Overview: Cedar Rapids City Hall (Figure 4-2) and the Linn County Courthouse (Figure 4-3) were built in 1927. (The Linn County Detention Center, which is also shown in Figure 4-3, is discussed below.) The buildings are situated on Mays Island in the Cedar River and are in the SFHA (see Figure 4-1). They are both connected to an underground parking structure via underground access tunnels. Figures 4-4 and 4-5 show these areas. As water entered the adjacent parking garage and access tunnels, the buildings experienced significant flooding in their basements. In addition to completely inundated basements, both buildings had about 2 feet of water on their first floors.

Figure 4-2. Mays Island, including City Hall, flooded as the Cedar River rose (Cedar Rapids, Iowa).

Figure 4-3.
The Linn County Courthouse and Detention Center on Mays Island were inundated (Cedar Rapids, Iowa).

Figure 4-4.
The Mays Island underground parking structure connects to City Hall and the County Courthouse and was a major source of floodwater intrusion into both buildings (Cedar Rapids, Iowa).

Figure 4-5.
The tunnel and stairs into City Hall from the underground parking structure were a source of flooding in the basement (Cedar Rapids, Iowa).

Summary of Damages: Both the City Hall and Courthouse lost all interior architectural finishes in their basements as well as significant interior finishes on ground floor levels. In both cases, cleanup was complicated and prolonged by the presence of asbestos building materials, which had to be remediated prior to the rehabilitation of the buildings. Both buildings lost their electrical and mechanical distribution systems including the main electrical service equipment, communications equipment, and life safety equipment (Figure 4-6).

In addition, many public records kept in the basement of City Hall were lost. Several files were moved from the basement of the Courthouse to the first floor prior to the flood; however, the first floor was also inundated and those files were lost. Exhibits and artifacts in the Spanish-American War Museum, also on the first floor of City Hall, were damaged as well.

Functional Loss: City Hall was unusable for over eight months after the floods. After the initial cleanup was complete, ongoing environmental concerns over asbestos and mold growth hindered reconstruction and recovery. As a result, operations in meeting rooms, office space, and historic exhibits were relocated or temporarily suspended.

The Courthouse lost all basement functions, including juvenile, arraignment, small claims, and domestic courts. Because of mold intrusion and other issues, the Courthouse building was not functional for several months after the storm.

Figure 4-6.
City Hall and the Courthouse lost their electrical systems. Cleanup and replacement were prolonged because of asbestos abatement (Cedar Rapids, Iowa).

4.1.2 Linn County Detention Center, Cedar Rapids, Iowa

Key Issues: The Linn County Detention center experienced significant flooding of the basement level and 2 feet of flooding on the ground floor. Flooding in the basement was primarily due to flooding in underground access tunnels that connect it to the underground parking garage on Mays Island. Significant damages were sustained by the electrical, mechanical, and elevator equipment on the basement level and by inmate-detention system electronics and equipment on the ground floor. A last-minute evacuation of inmates occurred after the jail lost power.

Overview: The Linn County Detention Center was built in 1984 and is a cast-in-place and pre-cast concrete, six-story building located on Mays Island in the Cedar River (Figure 4-7). The building is connected to the Linn County Courthouse via an underground access tunnel (Figure 4-8). The jail has an operating capacity of 450 inmates; at the time of the flood, there were between 350 and 400 inmates in custody. The building experienced significant flooding of the basement level and 2 feet of flooding on the ground floor. As the water entered the building, an emergency evacuation was ordered.

Summary of Damages: The Detention Center lost its electrical and mechanical systems, as well as architectural floor and wall finishes, on the basement and ground levels. The elevators needed significant repairs, and mold intrusion as a result of the flooding and subsequent lack of temperature and ventilation control was an ongoing concern during recovery efforts.

Functional Loss: As river water rose over Mays Island, water began entering the jail through the access tunnel to the Courthouse. The Sheriff's Department made a decision to evacuate all inmates to other facilities, which proved to be a challenging effort under emergency conditions. Inmates boarded buses and were driven across bridges over the Cedar River. By the time of the evacuation, water levels were so high over the bridges that the buses were knocked against guardrails as they crossed the river.

Figure 4-7.
The Linn County Detention Center is on Mays Island in the Cedar River (Cedar Rapids, Iowa).

Figure 4-8.
Access tunnel to the Courthouse (Cedar Rapids, Iowa)

In less than 3 hours, Sheriff's Deputies had evacuated male and female county inmates as well as several federal inmates to nearby facilities. All inmates were moved to other facilities, and operations at the Detention Center were temporarily suspended.

The Detention Center was not operational for several months after the storm. Cleanup and mitigation efforts were phased to allow for full occupation of the facility by April of 2009. Flood mitigation measures were planned for later phases. This included:

- Moving the control room from the first floor to the fifth
- Relocating electrical switchgear and air handlers from the basement to higher levels
- Relocating the emergency generator from the basement to a higher level

4.2 Essential Facilities

This section discusses the building performance of essential facilities throughout southern and central Iowa and Wisconsin. All of the facilities discussed in this section are classified under Category IV as defined by ASCE 7.

4.2.1 Mercy Medical Center, Cedar Rapids, Iowa

Key Issues: Mercy Medical Center is near but not directly in the 0.2-percent-annual-chance floodplain (Figure 4-9). During the 2008 flood, the hospital sustained significant damage to contents and functions due to sewer backup and groundwater.

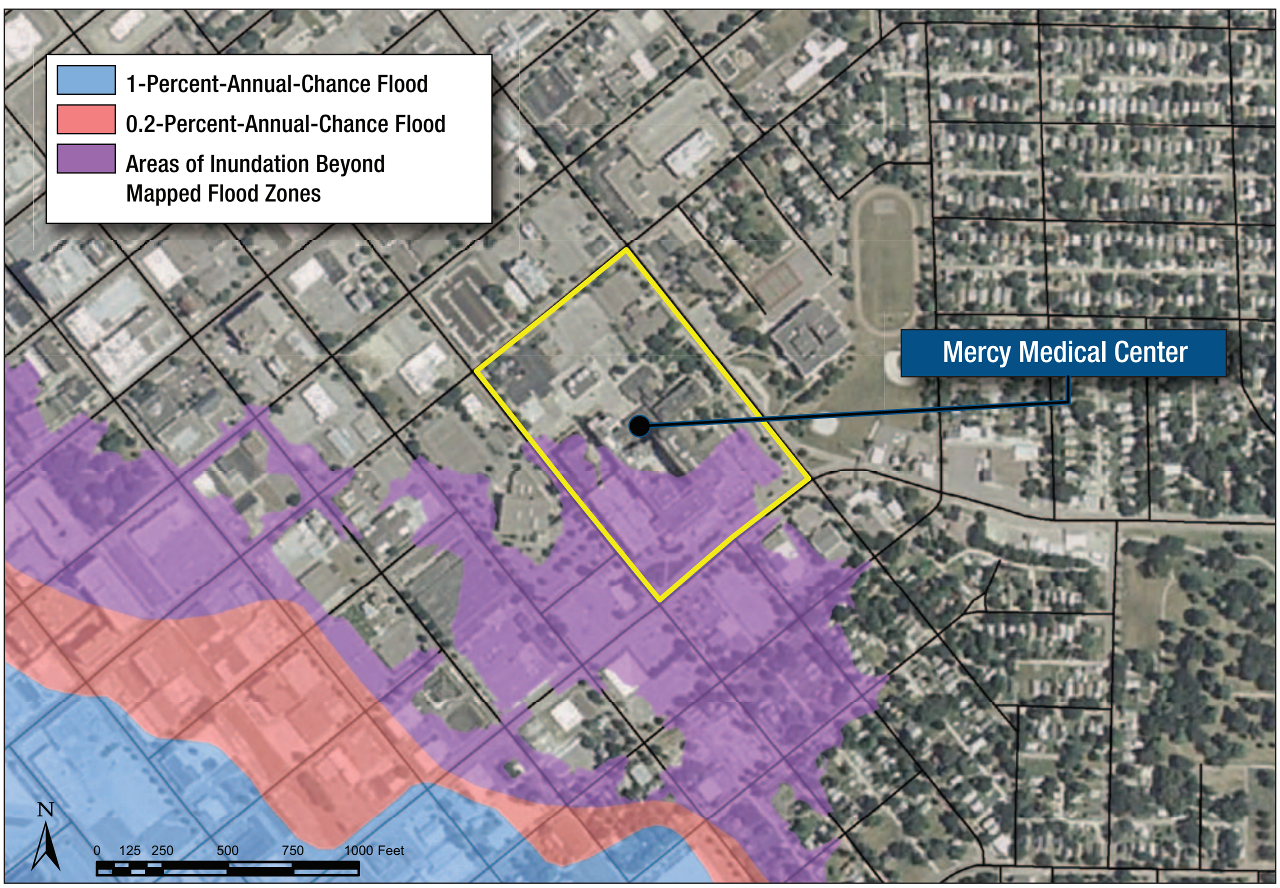

Figure 4-9. Flood zones and inundation for Mercy Medical Center (Cedar Rapids, Iowa)

Overview: Mercy Medical Center is one of two major medical facilities in Cedar Rapids. Located at the edge of the 0.2-percent-annual-chance floodplain, the hospital consists of a series of structures, several of which are connected by a continuous basement. The three main structures in the complex were built in 1923, 1947, and 1969 (Figure 4-10).

Figure 4-10. Mercy Medical Center, which sits just outside the 0.2-percent-annual-chance floodplain, was surrounded by 3 feet of water (Cedar Rapids, Iowa).

Although flooding was higher than originally expected, higher river crest predictions were available to Mercy approximately 24 hours in advance. As a result, the staff were able to evacuate patients to other facilities. Flooding came from several sources, although the primary flooding sources were sanitary sewer backup through toilets and sinks, and groundwater seepage. There were also reports that water flowed from the flooded parking garage, across a courtyard, and into the basement.

Mercy staff and volunteers were able to keep the water largely at bay by sandbagging, pumping, and drilling holes in the basement slab to relieve hydrostatic pressure below the slab. Water levels outside the building reached depths of 3 feet, while remediation efforts limited interior water levels to only 2 or 3 inches (Figure 4-11). There was significant damage to some equipment and interior finishes, although other major equipment and contents losses were avoided.

Summary of Damages: The most significant damage was to the Nursing Building, which was built in 1947. This building lost offices, clinics, elevators, and service areas.

Flooding in the basement of the Nursing Building led to irreparable damage to medical equipment including a Magnetic Resonance Imaging (MRI) machine, two Computed Tomography (CT) computers, and pharmaceutical robotics. In addition, the communications systems, UPS systems, electrical distribution panels, mechanical controls, elevators, security systems, and radio center suffered severe damages (Figure 4-12).

Figure 4-11.
Water rose to the level of the window bar outside of Mercy. Massive volunteer efforts helped to keep water levels to a few inches inside (Cedar Rapids, Iowa).

Figure 4-12.
Electrical equipment in the basement of Mercy Medical Center, which was exposed to a few inches of water (Cedar Rapids, Iowa)

There was also significant damage to the interior finishes of the basement and ground floor levels. The emergency area, which had been remodeled one month prior to the flood, lost all of its drywall and flooring. In addition, many basement ceiling panels were saturated and fell during the flood.

Functional Loss: The hospital ceased most functions during the flood, evacuating all of its patients. In addition to the loss of medical and other equipment, and the possible total replacement of the Nursing Building, the loss of function resulted in a loss of revenue for the hospital. However, select parts of the hospital remained operational throughout the flood, including the radiation center. Mercy Medical Center was operating at 90 percent of its full function two months after the flood.

4.2.2 Law Enforcement Facilities and Fire Departments

The MAT visited law enforcement facilities in Iowa and Wisconsin. This section discusses the Linn County Sheriff's Department and Cedar Rapids Police Department Headquarters, both in Cedar Rapids, Iowa, as well as the Fire Station in La Valle, Wisconsin.

4.2.2.1 Linn County Sheriff's Department, Cedar Rapids, Iowa

Key Issues: The Linn County Sheriff's Department kept an emergency generator at ground level in an outdoor enclosure, which was flooded; the generator was completely submerged and could not be used when the facility lost power. The Sheriff's Department lost critical contents that were stored in the basement and ground floor levels.

Overview: The Linn County Sheriff's Department (Figure 4-13) was built in 1921. In 2001, a slab-on-grade garage was added onto the original structure. The building is located in the 0.2-percent-annual-chance floodplain (Figure 4-1). The basement and first floor of the original section were flooded to their full heights, and the second floor was flooded to 2 feet.

Figure 4-13. Linn County Sheriff's Department (Cedar Rapids, Iowa)

Summary of Damages: Several overhead garage doors were damaged. In addition, the emergency generator, which was kept in an outdoor enclosure, was completely submerged (Figure 4-14). The Sheriff's Department also lost significant equipment, including the electrical and mechanical distribution systems, and communications and data systems. There was also damage to interior architectural finishes.

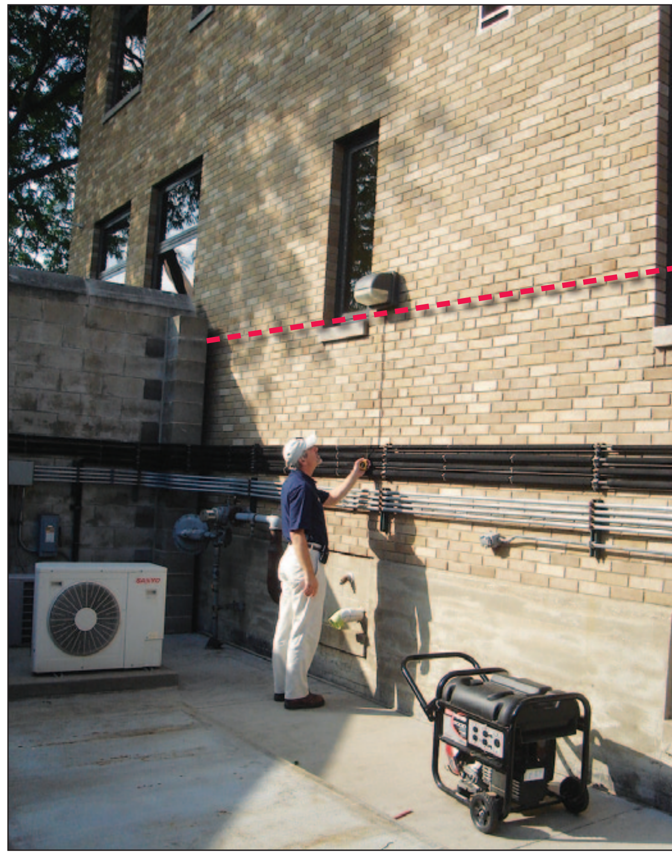

Figure 4-14.
The emergency generator was kept in an outdoor enclosure and was completely submerged. The water reached the floodlight near the second floor window (Cedar Rapids, Iowa).

Functional Loss: The Sheriff's Department building lost all functions during flooding, and operations were temporarily relocated to other facilities.

4.2.2.2 City of Cedar Rapids Police Department Headquarters, Cedar Rapids, Iowa

Key Issues: The Cedar Rapids Police Department (CRPD) Headquarters was built 1 foot above the BFE and 4.5 feet below the 0.2-percent-annual-chance flood elevation. The facility was flooded with 7 feet of water and sustained damage to critical equipment, functions, and contents, including files, evidence, and firearms.

Overview: The CRPD built its headquarters in 1997. The structure is located outside of the SFHA, but in the 0.2-percent-annual-chance floodplain (Figure 4-1). During the June 2008 floods, the walkout basement was inundated with 7 feet of river and sewer water (Figure 4-15). Floodwater entered primarily through a loading dock area. Although officers used several remediation tactics, including constructing a temporary dike, sandbagging, and pumping, their efforts did not prevent losses (Figures 4-16 and 4-17).

Figure 4-15. The CRPD Headquarters had 7 feet of water in its ground floor. The stairs shown here lead up to the first floor (Cedar Rapids, Iowa).

Figure 4-16. Much of the water that entered the CRPD building came in through the loading dock (Cedar Rapids, Iowa).

Figure 4-17.
A temporary dike was built along the back of the CRPD building (Cedar Rapids, Iowa).

Summary of Damages: There was significant damage to the lower level of the building, including the overhead garage doors in the loading dock area, an emergency generator, electrical and mechanical distribution systems, elevators, and communications and data systems. Officers noted that several firearms that might otherwise have been salvaged were corroded beyond repair.

Functional Loss: While components such as computers, generators, and electrical equipment within the police department building were re-located after the flood, many of these components were operational within a few weeks of the event. However, all basement functions, including the crime lab, fitness and weight rooms, locker rooms, the Quartermaster (uniform distribution), and the armory were destroyed and required replacement. In addition, many files, evidence, equipment, and other contents that were stored in the basement were damaged beyond repair or restoration (Figure 4-18).

Figure 4-18.
Contents stored in the basement, including weapons and ammunition, were damaged (Cedar Rapids, Iowa).

4.2.2.3 La Valle Fire Station, La Valle, Wisconsin

Key Issues: Prior to the flood, staff at the La Valle Fire Station moved contents and equipment from the ground level of the one-story facility to a mezzanine level, and therefore, very little damage was sustained.

Overview: The La Valle Fire Station, which houses the volunteer fire department, consists of two engine bays, equipment storage, offices, and a meeting room (Figure 4-19). The building is outside of the SFHA, but is close to the Baraboo River (Figure 4-20). The building came close to flooding in August 2007; in June 2008, the building had 22 inches of water due to river water and street run-off. The building did not lose power and, thanks to volunteer efforts, much of the building's contents and equipment were moved to the mezzanine floor and avoided damage. The mechanical equipment was also on the mezzanine level.

Figure 4-19. La Valle Fire Department (La Valle, Wisconsin)

Summary of Damages: There was some damage to interior wall finishes, and the drywall in the office and meeting areas was torn out and replaced to 4 feet above the floor. The gas meter was also damaged.

Functional Loss: The fire station did not lose power, although there was a temporary disruption of operations.

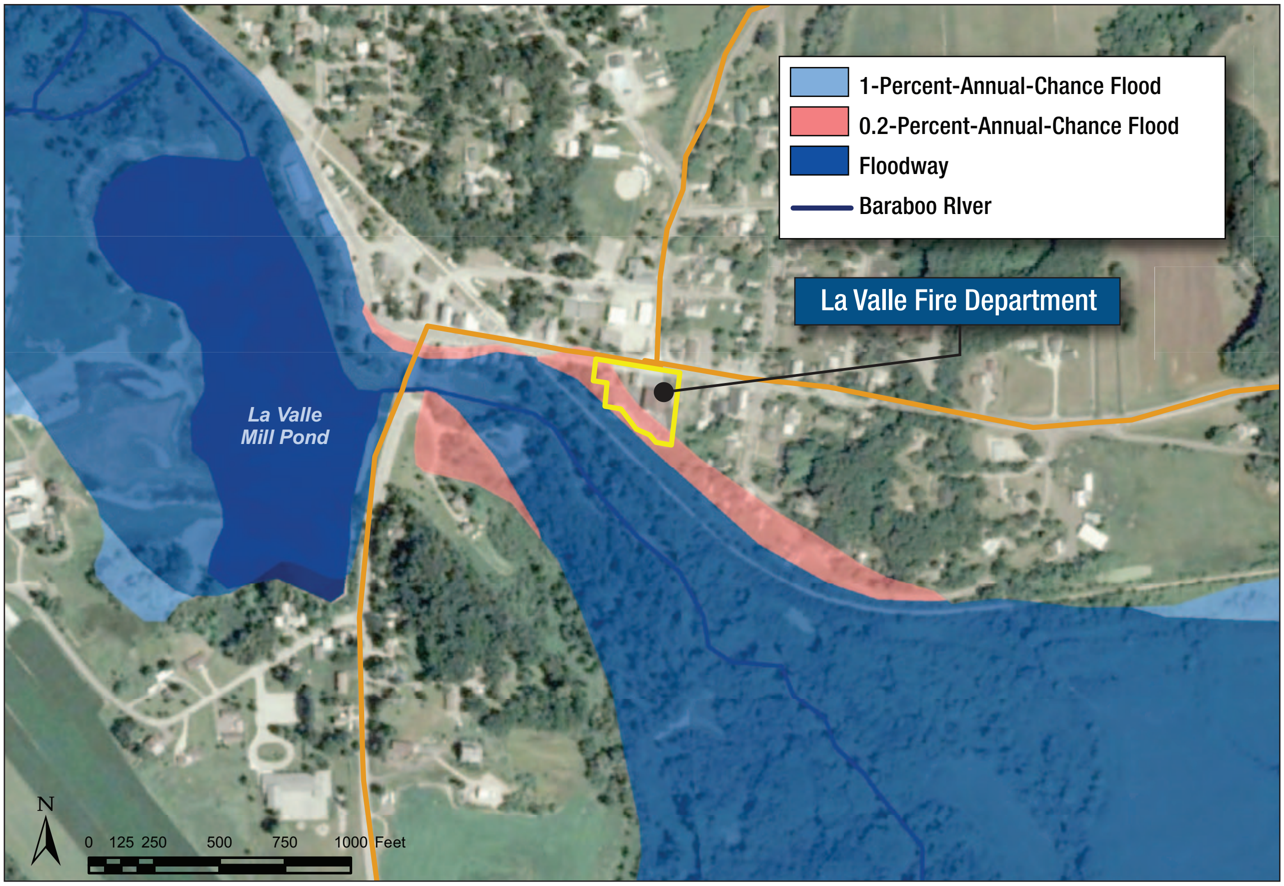

Figure 4-20. Floodway and flood zones for the La Valle Fire Department (La Valle, Wisconsin)

4.3 Utility Plants and Wastewater Treatment and Water Distribution Facilities

The MAT evaluated multiple wastewater treatment facilities and one water distribution pump station in Iowa and Wisconsin. Wastewater facilities are typically located in low-lying areas adjacent to water bodies to utilize as much gravity flow into the facility as possible and for accessible effluent discharge capabilities. This poses many risks to the community when these facilities experience flooding from surface water and excessive inflow. In addition to the possible loss of expensive equipment and facilities, the risks extend to the health and safety of downstream and upstream communities, drinking water systems, sewer backups within the system, discharge violations and associated fines, and loss of daily operational functions for the area the plant serves.

4.3.1 Wastewater Treatment Facility, Reedsburg, Wisconsin

Key Issues: The earthen berm protecting the Reedsburg Wastewater Treatment Facility (WWTF) was overtopped during the 2008 floods, causing the plant to cease operations. As a result of the shut-down, untreated sewer water was discharged into the Baraboo River. In addition, the access road to the facility was flooded and became impassable.

Overview: The Reedsburg WWTF, which was constructed in 1939, is in the SFHA (Figure 4-21). The facility is currently designed with a 2.6-million-gallons-per-day (MGD) capacity to serve approximately 10,000 people. Over the past decades, several additions and upgrades have increased its overall capacity and efficiency. The most notable renovation was the reconstruction and systems replacement completed in 2006, which upgraded most of the systems except for the modernized sludge handling equipment.

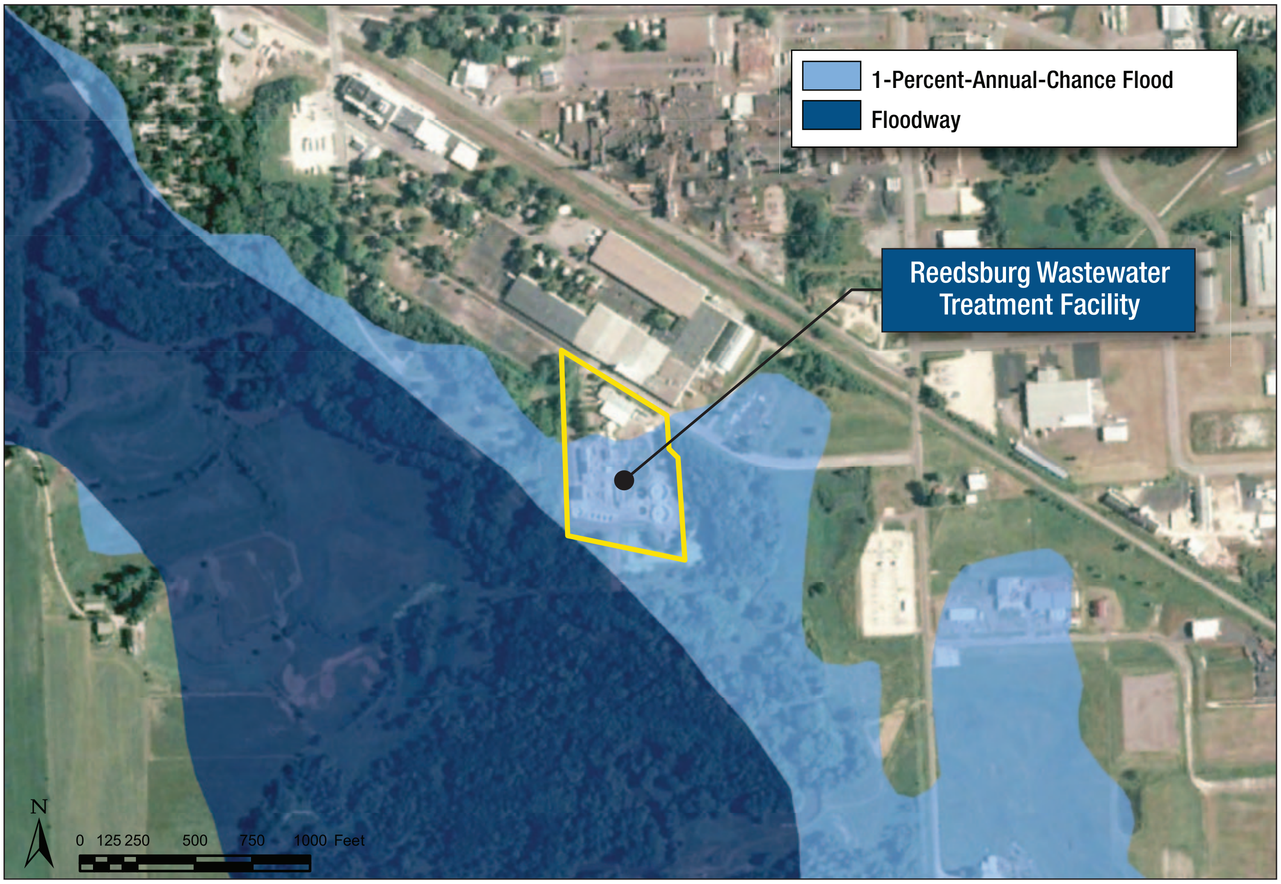

Figure 4-21. Floodway and SFHA for Reedsburg WWTF (Reedsburg, Wisconsin)

The Reedsburg WWTF layout includes one main interceptor pipe entering the plant and capturing flows from the west side of town. The system discharges by gravity through eight lift stations. The WWTF has a berm (elevation 879.0 feet) surrounding the facility and elevated to 1 foot above the BFE of 878.0 feet (Figure 4-22). The 0.2-percent-annual-chance flood elevation at the facility is approximately 881 feet. The facility's first floor elevation is at 874.6 feet with utilities and the majority of the electrical and instrumentation equipment at this level. Final clarifiers were elevated 1to 2 feet above the first floor elevation.

Figure 4-22.
Reedsburg WWTF flooded on June 9, 2008. The red line follows the berm (Reedsburg, Wisconsin).

Summary of Damages: The Reedsburg WWTF was inundated with nearly 4.5 feet of water on June 9, 2008. During the flooding, the berm held, but was overtopped by the adjacent Baraboo River. Wet wells overflowed. Effluent from the surcharged sewer system started flooding the WWTF. Groundwater "boiled up" from the paved surfaces of the parking and facility areas. The access roads to the WWTF were inundated, and the facility was accessible only by boat (see Figure 4-23).

Figure 4-23.
Reedsburg WWTF access road flooded (Reedsburg, Wisconsin).

Damages to the Reedsburg WWTF were estimated to be approximately $2 million. During the peak of the flooding, the facility ceased operations, the power was shut-off, and personnel abandoned the site for safety. The following summarizes the damages incurred by the facility:

- Electrical transformer and main breaker flooded.
- Entire lab, including all furniture and equipment were lost.
- Office drywall, casework, doors, and flooring were destroyed.
- Underground electrical wiring was damaged (some electrical equipment was cleaned and refurbished).
- Some computers were lost.
- Some vehicles were lost.
- Variable Frequency Drives (VFDs) could not be salvaged and needed to be replaced.
- Future mitigation plans include raising the berm surrounding the facility nearly 5 feet higher than its current elevation and acquiring additional emergency pumps.

Figure 4-24. Reedsburg WWTF offices and processing facilities flooded (Reedsburg, Wisconsin).

Functional Loss: Operators stayed at the facility as long as safely possible until shutting off the electrical power and abandoning the facility. All three Motor Control Centers were submerged but were salvaged after being dried out and cleaned. The facility was shut down and abandoned when water levels rose to an elevation of 883.5 feet. At that point, inflow readings had reached 11 MGD, nearly five times more than the facility's design capacity.

After the rain stopped and the river started to recede, it took two full days to remove floodwaters from the plant using six pumps ranging from 6 to 10 inches. The contaminated floodwaters were pumped directly into the Baraboo River. The facility was cleaned, temporarily repaired, and operating on permanent power by June 25. While the facility was able to function at its pre-flood capacity immediately, higher than normal levels of phosphorus—a nutrient that can lead to excessive plant growth and decay—were reported in the first two weeks of operation.

4.3.2 Sewer Pump Station, Reedsburg, Wisconsin

Key Issues: When power at the Reedsburg Sewer Pump Station was lost, the emergency generator could not be run because natural gas had been shut off by the city as part of its emergency procedures. As a result, the Sewer Pump Station failed, and the incoming raw sewage at the station could not be pumped from the drainage area. The pump station's wet well and portions of the sewer collection system backed up and became surcharged. This event resulted in sewer backups in homes, commercial buildings, and public facilities.

Overview: The Sewer Pump Station (Figure 4-25) on Grand Avenue, which is two years old, is located in the SFHA, approximately 2 feet above the BFE. The surrounding area was inundated and access to the pump station was limited, but floodwater did not enter the building (Figure 4-26). However, the natural gas supply was shut down to this part of the city, and, when the station lost power, a natural gas powered emergency generator could not be used. The failure of this lift station resulted in the inability to convey raw sewage flows from this part of Reedsburg, causing the sewer inflows to back up, affecting numerous homes, commercial facilities, and public buildings.

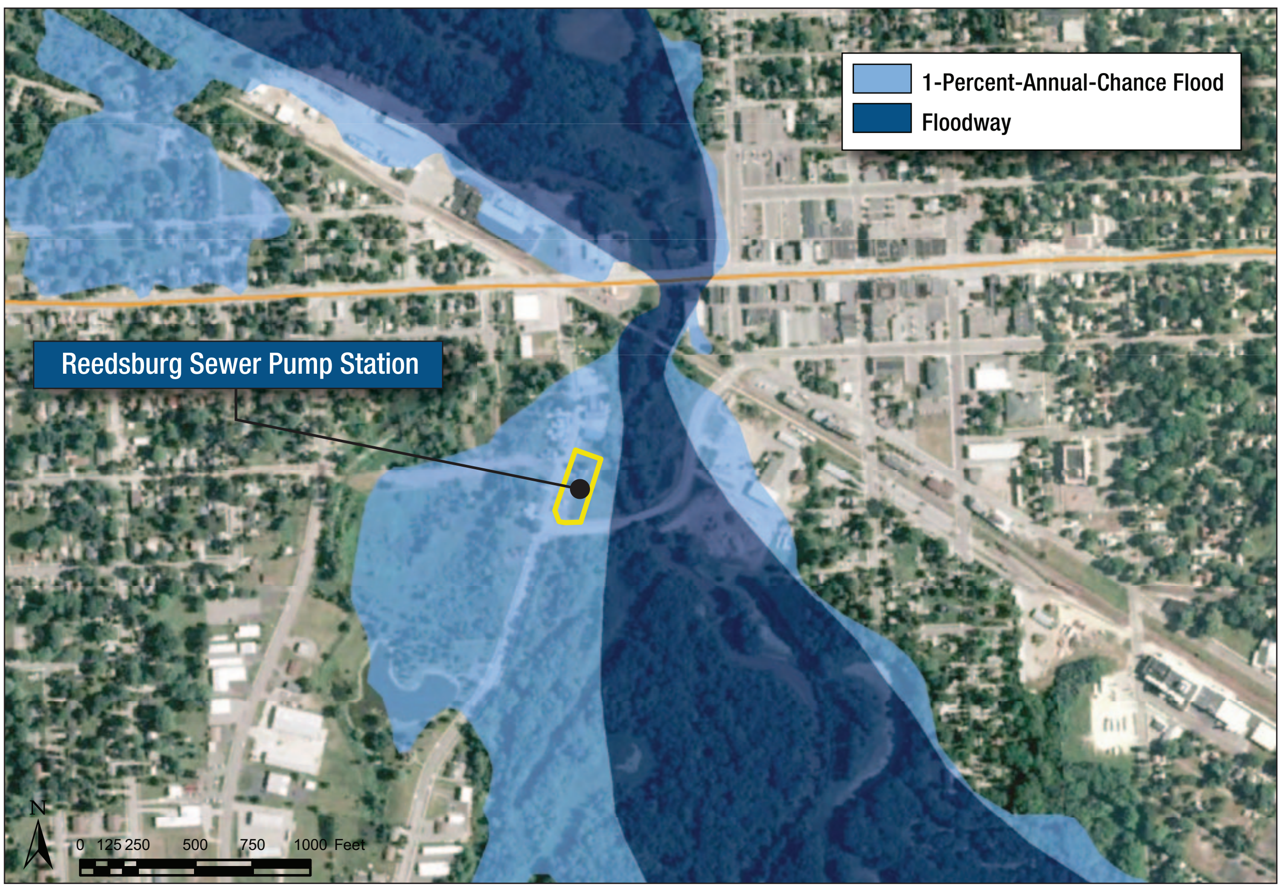

Figure 4-25. Floodway and SFHA for Reedsburg Sewer Pump Station (Reedsburg, Wisconsin)

Figure 4-26.
Reedsburg Sewer Pump Station flooded (Reedsburg, Wisconsin)

4.3.3 Wastewater Treatment Facility, Baraboo, Wisconsin

Key Issues: The Baraboo WWTF was able to maintain operations throughout the 2008 flood events thanks to elevated equipment, watertight manhole covers, and pre-flood preparations. However, the access road to the main plant was flooded and impassable. Due to the flooding on the access road, it was not possible to transport a generator to a pump station that had lost power.

Overview: The Baraboo WWTF treats wastewater from the Village of West Baraboo, Devil's Lake State Park, and the Baraboo Sanitary District, in addition to the city. The WWTF structures were built 2 feet above the BFE, which is approximately 819 feet. The 0.2-percent-annual-chance flood elevation is approximately 821 feet. In 2004, the city began a 3-year project to upgrade the facility based on projected needs over the next 20 years. Some portions of the existing facility date back to 1933. The system includes two lift stations: one that serves nine residential homes and a second that serves nearly 300 homes. The rest of the system flows to the facility by gravity. There are also three siphons carrying flow under the river to the facility.

The Baraboo WWTF had adequate warning and had made previous preparations for flooding. Manholes in Baraboo were inspected and replaced regularly to ensure they were watertight as part of a "clean sewers" program. During the 2008 floods, manholes were submerged for nearly three to four days and performed well. Operators also had an adequate supply of sand bags and adequate time to install them because the river rose slowly (Figure 4-28).

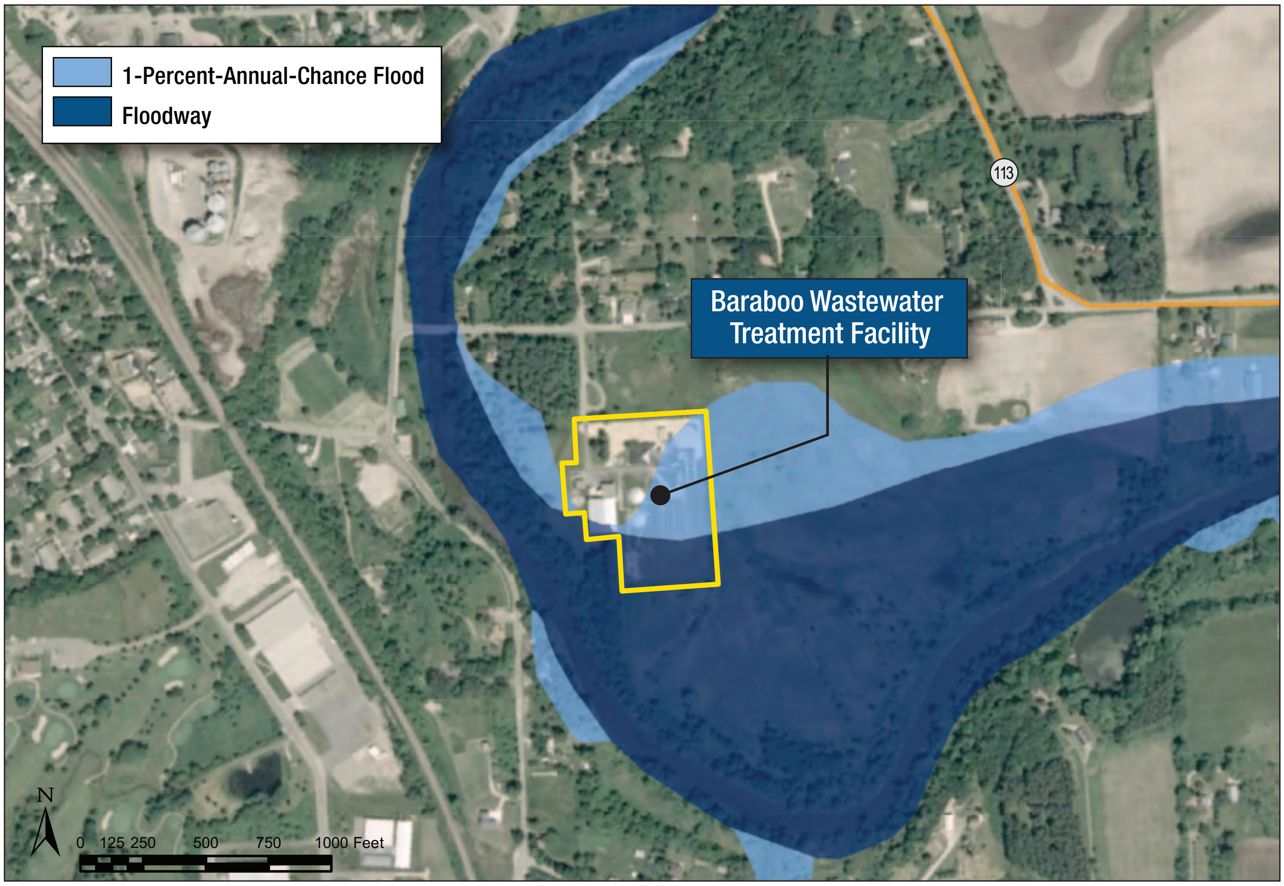

Figure 4-27. Floodway and SFHA for Baraboo WWTF (Baraboo, Wisconsin)

Figure 4-28. Sandbagging protecting the office building (Baraboo, Wisconsin)

Summary of Damages: During the June 2008 storms, the facility retained 1.5 feet of standing ground and surface water. The facility was capable of handling the excess inflows; however, operators were unable to keep river flow from entering the site. The major equipment was not damaged, except for level sensors (Figure 4-29).

Figure 4-29.
Some electrical equipment elevated on concrete pads and on wall (Baraboo, Wisconsin)

Functional Loss: The Baraboo WWTF remained operational despite inflow levels of 4 to 5 times higher than normal levels (1,500-1,800 gallons per minute). All pumps and electrical equipment for wet wells were elevated above the BFE, although mechanical equipment for the wet wells was below the BFE. One local lift station was out of service for 5 hours when its electrical equipment shorted out; operators were able to obtain a used starter from a local electrician to keep the facility operational.

Remediation efforts at the WWTF were complicated because floodwater impeded access to the facility (Figure 4-30). The facility's current plans for mitigation include raising the access road.

Figure 4-30.
Flooded access road at the Baraboo WWTF (Baraboo, Wisconsin).

4.3.4 Wastewater Treatment Facility, Jefferson, Wisconsin

Key Issues: A continuous berm around the Jefferson WWTF was not compromised despite uneven levels of protection. By controlling influent, the facility was able to continue operation throughout the floods.

Overview: The Jefferson WWTF is located in the SFHA (Figure 4-31) and has an operating capacity of 2.5 MGD. The WWTF has two main interceptors: one from the north under the river that is controlled by a sluice gate and another from the west. Flows from the west travel beneath the river through a 12-inch and 8-inch double siphon. There are five lift stations in Jefferson—four small stations and one large station that are located outside of the flood-impacted areas.

The WWTF is below the BFE and is protected by a berm. The berm is intended to be 2 feet above the BFE; however, an access road cuts through the berm, disrupting the continuity of protection.

During the flood, a citywide bulletin was issued to encourage the reduction of water use and sewage flows. Inflow to the plant was also substantially reduced when the city worked with Tyson Foods and Nestle Pet Foods to cut inflow from these facilities. Two emergency crews were set up on each side of the river since both bridges were impassable preventing access to the WWTF site from portions of the city. The WWTF operators had an effluent pump platform built to allow for an emergency diesel pump (Figure 4-32). They also had installed an emergency generator to power the entire facility, and when power was lost to the WWTF, operators were able to switch to generator power. However, the generator was installed several feet below the BFE. Although the WWTF's berm kept water out of the site and, therefore, kept the generator dry, the generator could have been lost had the berm been overtopped.

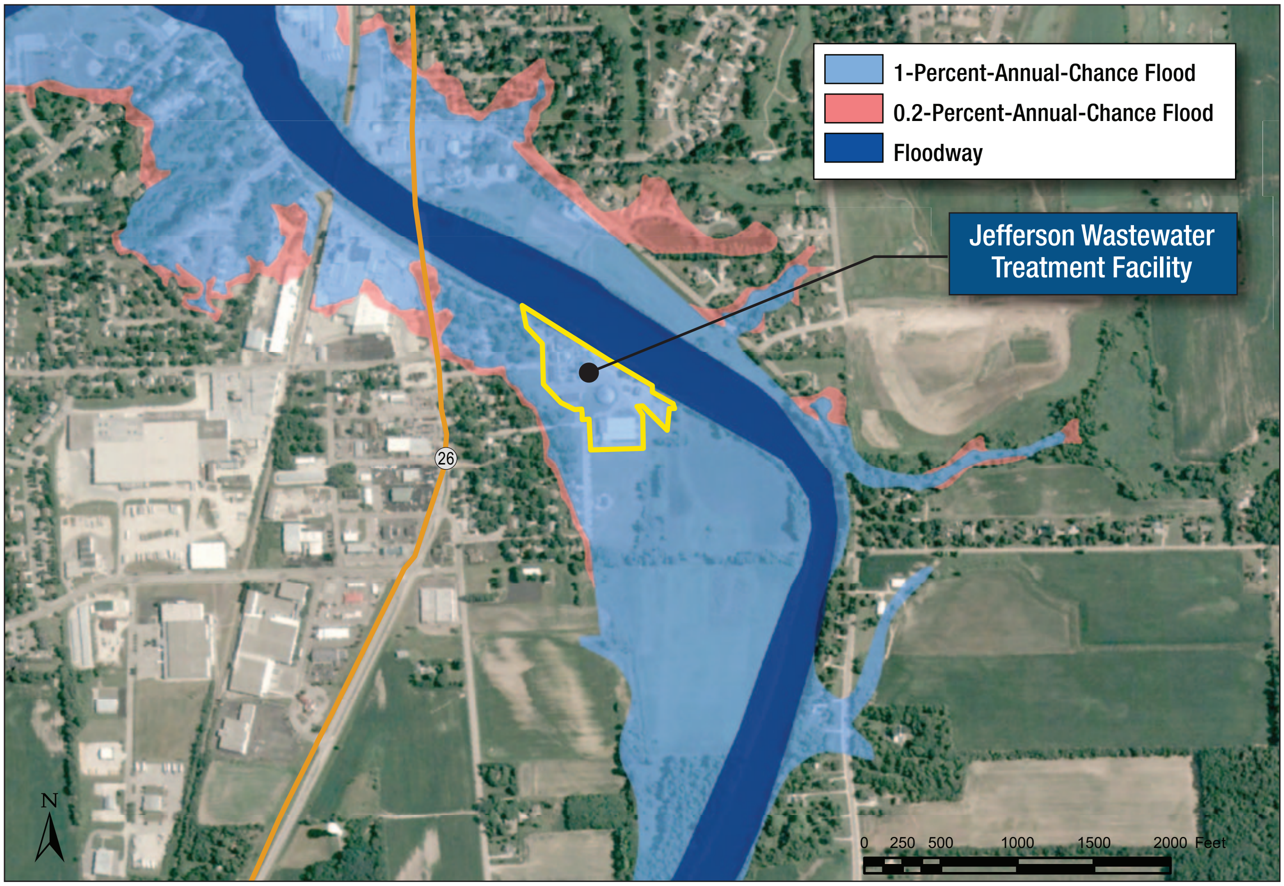

Figure 4-31. Floodway and floodplains for Jefferson WWTF (Jefferson, Wisconsin)

Figure 4-32. Discharge pump platform with space and hook ups for emergency diesel pump (Jefferson, Wisconsin)

Summary of Damages: The WWTF remained in operation during the peak wet weather event because influent flows were controlled. Approximately half of the influent flows (raw sewage) were routed around the WWTF and sent directly to the river with temporary pumping units. Because of the high peak wet weather flow rates, the biological components were washed out of the treatment system, resulting in higher ammonia levels several days after the flood. During and after the flood, nutrient effluent levels were not exceeded, and the plant operators met their discharge permit requirements, largely because the effluent was diluted with storm water.

The influent pump station temporarily lost one of its pumping units when its VFD was struck by lightning. The plant operators were able to run the pumping unit without the VFD and maintain operations. The VFD was replaced within about a month.

Functional Loss: Officials were able to curb inflows to the facility by issuing a citywide bulletin to reduce water use, close influent sluice gates, and take two major industrial users offline. One major user was able to truck their sewage for two days to keep operations going. Plant operators made the decision to have a portion of the influent bypass the facility and discharge directly into the river with temporary pumping units. The bypassed flow concentrations were diluted and, therefore, no discharge permit violations were reported.

The city's fuel station quickly flooded (Figure 4-33) and fuel supply for WWTF equipment became a primary concern to keep the facility operating. Operators were able to obtain fuel from a local gas station and have more fuel delivered to the facility on regular intervals throughout the remainder of the storm event.

Figure 4-33. The Jefferson WWTF is protected by a berm, outlined in red. The fuel station, shown by the arrow, is not protected and was flooded (Jefferson, Wisconsin).

At the peak of the flood event, the facility experienced 7.5 MGD, nearly three times the typical inflow rates, due to the high inflow into the sewer system caused by floodwater surcharging the sewer collection system through manholes, flooded homes and basements allowing inflows into the sewer system, and groundwater infiltration due to the saturated conditions. The river stage rose above the outlet discharge pump, and the operators quickly installed stop planks to keep flow out. An emergency diesel pump and both discharge effluent pumps were run continuously.

The Jefferson WWTF plans to create an emergency action plan and contact list to expedite repairs, such as finding additional portable pumps, contractors, and suppliers. Future plans under consideration may include re-designing the pumping units and the discharge piping elevation to the river to ensure that during high river water levels, the plant effluent can be adequately discharged into the river.

4.3.5 Utility Plant, Cedar Falls, Iowa

Key Issues: Two floodwalls protect the Cedar Falls Utility Plant, and large openings in the floodwalls are sealed with a combination of floodgates and water-filled bladders prior to a flood event, such that the floodwalls are continuous and protect to the 0.2-percent-annual-chance level. The redundant systems could have protected the facility well; however, actual flood levels were approximately 2 feet higher than expected, and the floodwall assemblies were overtopped.

Overview: The Cedar Falls Utility Plant has a complex of several plants on varied terrains and staff has taken measures to mitigate both flood and wind hazards. The complex is in the SFHA (Figure 4-34) and equipment is elevated to maintain operability during floods.

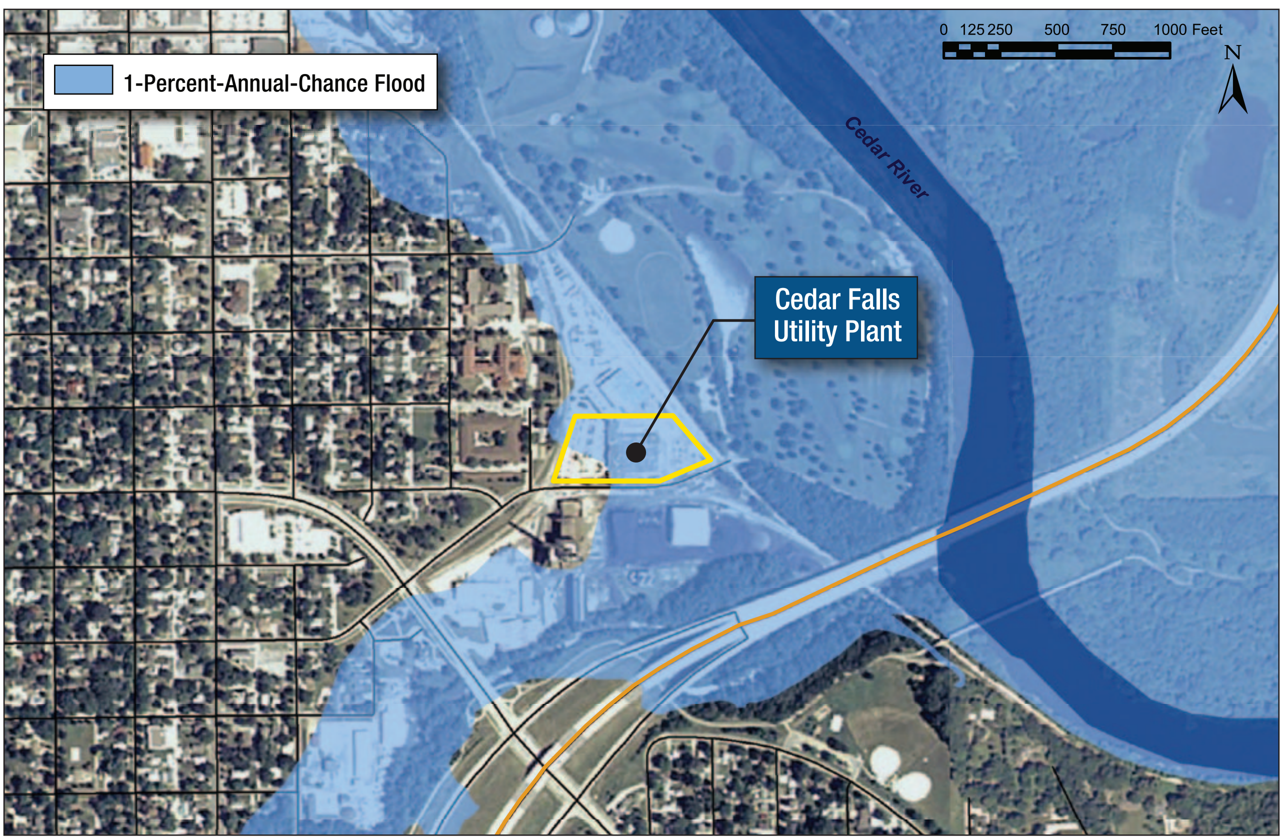

Figure 4-34. SFHA for Cedar Falls Utility Plant (Cedar Falls, Iowa)

The coal fired electric generation station was inundated during the flood. The station has two floodwalls in place: one around the entire site, and the other around the power plant building. The perimeter floodwall is not continuous; during normal operations, breaks in the floodwall allow for access to the plant and staging areas for trucks. When a flood threat is perceived, the plant staff deploys bladders to fill the gaps and build the wall to a continuous height. The bladders are an engineered system that can be stored on site (Figure 4-35) and positioned and filled with water in one to two days. Bladders are easy to fill and repair. In conjunction with the floodwall, they could have been an effective means of protecting the plant; however, the floodwater crest was higher than expected and overtopped the floodwall assembly.

Figure 4-35. Inflatable bladders are stored on site and deployed when a flood threat is perceived. The Cedar Falls Utility Plant maintained hourly monitoring of the latest flood levels to determine deployment of barrier systems (Cedar Falls, Iowa).

In the days leading up to the 2008 floods, plant staff had been tracking reports and anticipated river crests. Water-filled bladder systems were prepared and assembled to protect against the anticipated flood levels. However, just before the floods began, river crest predictions rose by 3 feet. Though they had the capability to raise the protection level, plant staff did not have enough time to fill additional bladders and construct the additional bracing necessary to hold them in place. Actual flood levels were 1 to 2 feet above the floodwalls, and, as a result, the facility was inundated (Figure 4-36).

Future mitigation plans for the Cedar Falls utility plant call for protection to the 0.2-percent-annual-chance flood elevation plus 3 feet.

Summary of Damages: Damage to the utility plant was approximately $5 million, and additional damage to the utility complex was approximately $2.5 million. Most of the equipment inside the plant, including feed pumps and coal mills, was damaged. Plant staff estimated that total repairs would cost approximately $15 million.

Figure 4-36.
The water level at the Cedar Falls power plant was approximately 2 feet higher than the anticipated flood levels and overtopped the floodwalls (Cedar Falls, Iowa).

Functional Loss: Staff estimated that the plant would be down for five months, amounting to approximately $26,000 per day in lost function. However, lost service to customers was minimal due to the existence of other plants on higher terrain that the Cedar Falls Utility Plant owns and operates.

4.4 Educational Facilities

The MAT visited numerous educational facilities in both Iowa and Wisconsin, including elementary schools, school administration facilities, and university campuses. Local officials should consult FEMA 424, *Design Guide for Improving School Safety,* for guidance and recommendations on protecting educational facilities against floods and other hazards.

4.4.1 Education Services Center and Annex, Cedar Rapids Community School District, Cedar Rapids, Iowa

Key Issues: The basement of the Education Services Center (ESC) Annex, where school system files and an emergency generator were stored, was flooded. As a result, the facility could not set up emergency power, and the school record-keeping systems were destroyed.

Overview: The Cedar Rapids Community School District includes 31 schools, of which only two were damaged in the floods:

- Harrison Elementary School, which reopened for the 2008 fall sessions, experienced both riverine and sewer backup flooding, but major sandbagging and pumping efforts helped to reduce damages.
- Taylor Elementary School experienced mostly riverine flooding. The slab-on-grade school did not reopen for the beginning of the 2008–2009 academic year.

Four administrative buildings were also damaged in the floods. Two of them, the ESC and Annex buildings, are both masonry buildings located in the 0.2-percent-annual-chance floodplain (see Figure 4-1). Both buildings had 8 to 9 feet of flooding on the ground floor. The ESC basement was filled with water for nearly seven days (Figure 4-37). The ESC Annex building is slab-on-grade.

Figure 4-37.
The ESC had about 8 feet of water on its ground floor, in addition to a flooded basement (Cedar Rapids, Iowa).

Summary of Damages: The ESC basement housed the building's emergency generator, which was completely submerged. The generator ran on natural gas, which was shut off by the local utility provider during the flood; therefore, even if the generator had been moved from the basement, it would not have been operational. Other losses included the electrical and mechanical systems, as well as interior architectural finishes. Plaster walls and ceilings and wood flooring on the ground floor were damaged. Clean-up and repairs were complicated by the presence of asbestos building materials.

The ESC annex wall system consists of clay tile and was saturated (Figure 4-38). School officials were reluctant to reopen the building because of concern about mold growth inside the clay walls. The building's electrical and mechanical systems also sustained significant damages.

Functional Loss: After the flood, both buildings were closed for ongoing repairs and asbestos abatement. Operations were moved to modular buildings. While many files and other important contents were lost, computers were removed from the ESC by boat during the flood, which allowed the school system to save much of its data and resume operations quickly.

Figure 4-38.
Clay tile wall system of the ESC Annex (Cedar Rapids, Iowa)

4.4.2 South School, Reedsburg, Wisconsin

Key Issues: South School in Reedsburg, Wisconsin, sustained flooding due to sewer backup through drains in the basement. Damaged equipment and finishes were refurbished, not completely replaced.

Overview: South School, which was built in 1937, is in a residential area of Reedsburg. The school is not in the SFHA (Figure 4-39). Flooding inside the building was the result of storm sewer backup, which allowed water to enter through floor drains (Figure 4-40). The school had about 2 feet of standing water in the basement, which houses the kitchen, a cafeteria/multi-purpose room, and storage areas. In addition, the sub-basement was totally flooded.

Summary of Damages: The flooding resulted in the loss of two boilers and kitchen equipment, including a freezer, cooler, and stove. There was also damage to the interior wall and floor finishes in the cafeteria (Figure 4-41). The school district refurbished an air compressor and the main electrical panel, which were also damaged.

Functional Loss: The basement and sub-basement were cleaned and repaired during the summer break. Boiler replacement continued into the beginning of the 2008–2009 school year.

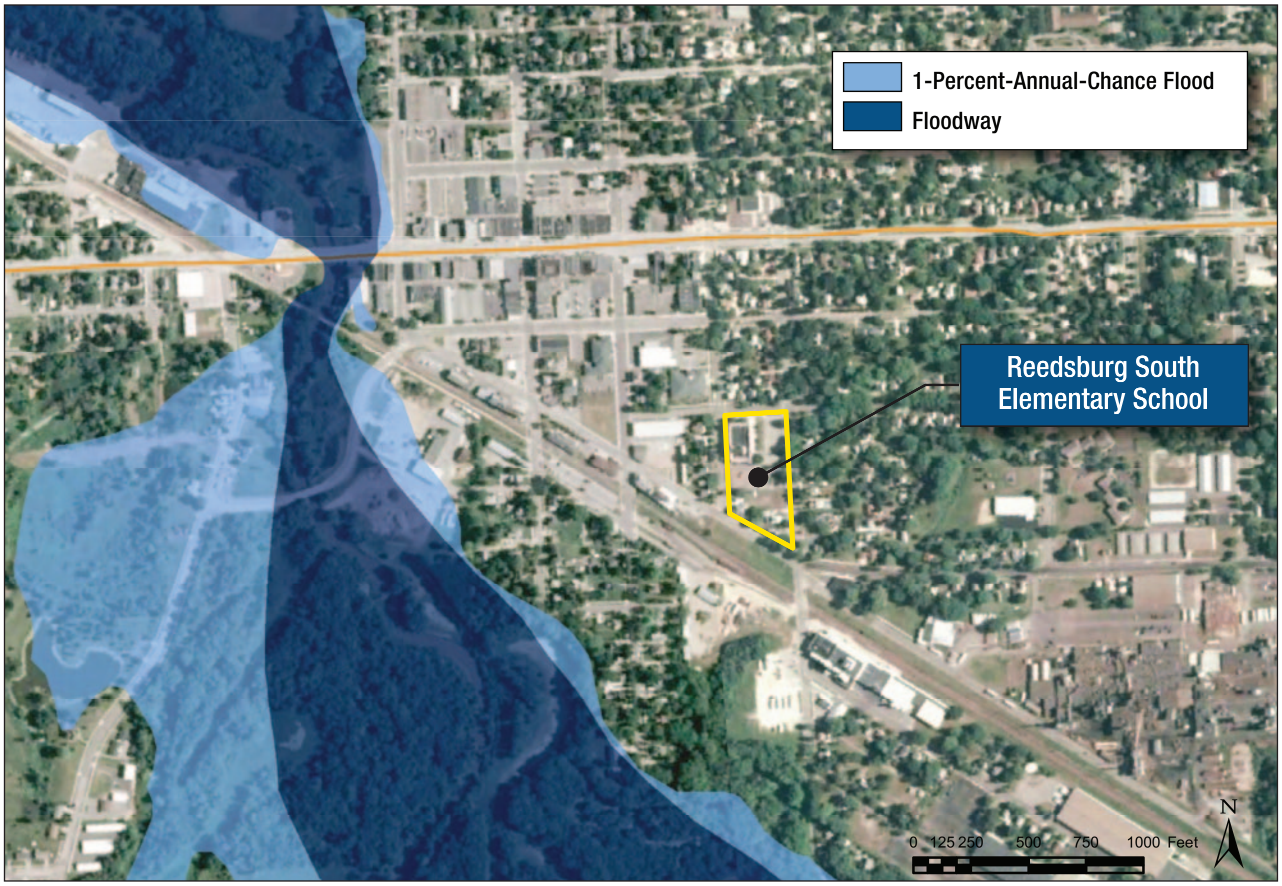

Figure 4-39. Floodway and SFHA for South Elementary School (Reedsburg, Wisconsin)

Figure 4-40.
Flooding in South School was due to backup through floor drains such as the one shown in this photo (Reedsburg, Wisconsin).

Figure 4-41.
Damaged paneling in the Pine Room, South School's cafeteria and multi-purpose room, was refurbished to maintain the room's character (Reedsburg, Wisconsin).

4.4.3 Academic Buildings, University of Wisconsin at Oshkosh, Oshkosh, Wisconsin

Key Issues: Backup in storm sewers caused surface water to enter steam tunnels and, through the steam tunnels, several academic buildings at the University of Wisconsin (UW) at Oshkosh. Backflow valves installed at the site successfully prevented some flooding from sanitary sewers. Following the flood, repairs were made to damaged buildings using flood damage-resistant materials and construction practices.

Overview: UW Oshkosh was founded in 1871 and is the third largest university in Wisconsin. The school's total enrollment is approximately 12,700 students.[1]

The school is located near the Fox River (Figure 4-42), although river water was not the cause of flooding on campus. Flooding in university facilities was the result of backup in city-owned storm sewers (Figure 4-43), which allowed water to infiltrate buildings such as the Nursing & Education Building, the Clow Social Science Center, Swart Hall, and Oviatt House through utility tunnels. In most cases, standing water inside buildings was limited to a few inches. Massive flooding at the River Center, discussed in Section 4.4.4, led to a campus-wide power loss.

1 Chancellor's Welcome, UW Oshkosh website. http://www.uwosh.edu/chancellor/welcome.php

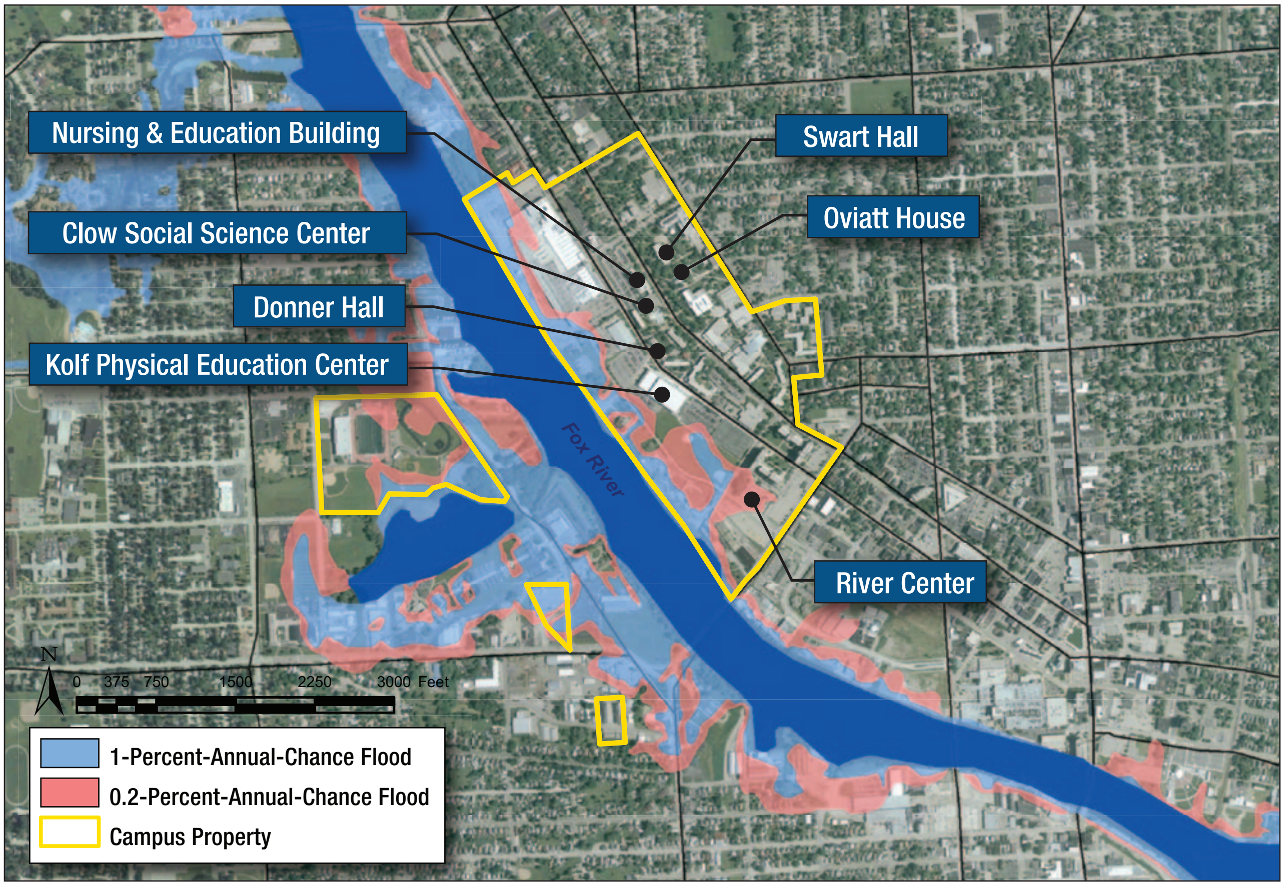

Figure 4-42.
Flood zones for the University of Wisconsin at Oshkosh and buildings visited by the MAT (Oshkosh, Wisconsin)

Figure 4-43.
City-owned storm drains contributed to flooding at UW Oshkosh, but this vulnerability was not considered prior to the 2008 floods (Oshkosh, Wisconsin).

UW Oshkosh had previously experienced flooding, and, as a result, had implemented mitigation measures such as installing check valves on sewer lines (at Donner Hall and others) and raising curbs and entrances (at the Kolf Physical Education and Sports Center) (Figure 4-44). These measures helped to avoid damages at certain buildings, and, as of September 2008, the school plans to continue mitigation efforts. After the flood, the staff refurbished damaged academic buildings with flood damage-resistant materials (Figure 4-45). The Institute for Business and Home Safety (IBHS) publication *Water Damage Prevention for Commercial Buildings* includes more information about the effects of grounds maintenance and landscaping on flood vulnerability.

Figure 4-44.
The curb and sidewalk along the entrance to the Kolf Center had been raised as part of a previous mitigation project to prevent water that collected in the parking lot from entering the building and, thus, to provide positive drainage per local building codes (Oshkosh, Wisconsin).

Figure 4-45.
Carpeting was replaced with flood damage-resistant vinyl flooring throughout the damaged academic buildings (Oshkosh, Wisconsin).

Summary of Damages: Temporary changes in grading for construction allowed surface water to collect behind Oviatt House. The flooding in the academic buildings resulted from surface storm water entering the steam tunnels behind Oviatt House (Figures 4-46 and 4-47). The tunnels, which connect to several buildings including those mentioned above, allowed floodwater to enter academic and mechanical areas in several basements. In one case, staff attempted to contain water in a mechanical room by placing a wooden plank in the doorway. As water flowed in through the tunnel, it was stopped from entering into the hallway and academic area.

Figure 4-46.
Water entered steam conduits through above-ground openings like these. Construction near these openings contributed to the volume of water entering the conduits (Oshkosh, Wisconsin).

Damages incurred in the academic buildings included loss of carpeting, electrical floor outlets, drywall, and wall finishes. Following the floods, damaged basement finishes were replaced with flood damage-resistant materials:

- Carpeting and damaged tile were replaced with vinyl sheet flooring.
- Drywall was removed to 4 feet above the ground and replaced with mold-resistant cement board.
- Rather than installing floor-to-ceiling drywall, staff installed a strip of pressure treated lumber at floor level, left an air gap above it, and then installed cement board in order to prevent wicking in future flood events (similar to the technique shown in Figure 4-48).

Functional Loss: Because the flooding occurred in June, the school was able to clean affected buildings and make all necessary repairs before classes started in the fall.

Figure 4-47.
Water entered academic buildings through steam conduits, like the one in the background (Oshkosh, Wisconsin).

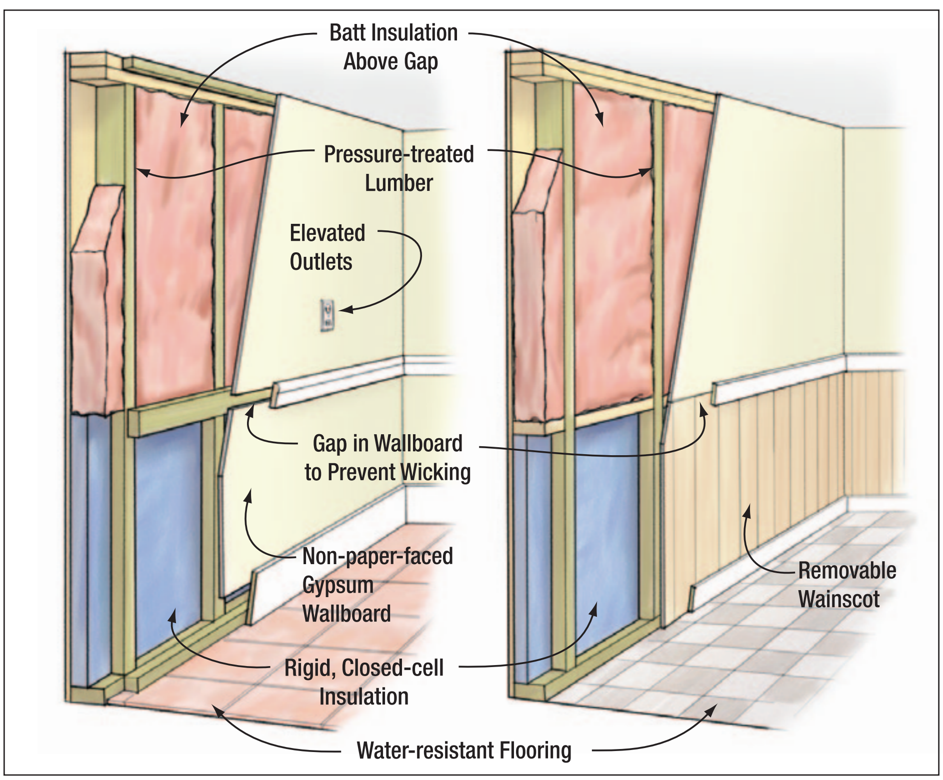

Figure 4-48.
Air gap in drywall to prevent wicking

4.4.4 River Center, University of Wisconsin at Oshkosh, Oshkosh, Wisconsin

Key Issues: Massive flooding at the UW at Oshkosh River Center caused the loss of a transformer, which led to a campus-wide power outage.

Overview: The River Center is a two-story structure that served as a cafeteria prior to the flood (see Figure 4-42). Storm sewer backup allowed water to flow from street level down a steep driveway into the River Center's loading dock, and led to 8 feet of standing water in the basement (Figure 4-49). Loss of a transformer at the River Center triggered a campus-wide power loss. Though campus power was restored within hours, the River Center was not restored before the 2008–2009 academic year; it was without power for at least two months after the flood.

Figure 4-49.
The steep driveway leads from street level to the loading dock at River Center's basement (Oshkosh, Wisconsin).

As of September 2008, UW Oshkosh staff was considering several mitigation options.

Summary of Damages: The River Center basement housed the Department of Residence Life, including its offices, storage space, and maintenance shop. Office finishes, contents in storage, communications systems, and maintenance equipment were all severely damaged. In addition, electrical and mechanical equipment, elevator equipment, the fire alarm system, and the emergency generator were lost in the flood. Hydrostatic pressure from the floodwater caused damage to windows as well (Figure 4-50).

Figure 4-50. Water pressure in the basement courtyard caused glass windows to shatter (Oshkosh, Wisconsin).

Functional Loss: UW Oshkosh operated six pumps for three days to empty the basement. As of September 2008, the building was not operational and the Department of Residence Life had relocated to another facility.

4.4.5 University of Iowa, Iowa City, Iowa

Key Issues: Several buildings built above the BFE at the University of Iowa sustained major damages from stillwater flooding and from water intrusion through the utility tunnel system. Loss of access to the campus and, in particular, to medical facilities, hindered operations and presented a life safety hazard. Flooding also led to loss of power generation and central mechanical systems throughout campus, causing significant loss of functions and equipment. In spite of volunteer efforts in the days leading up to the event, the University sustained damage to several buildings including mechanical and electrical equipment, research equipment, and building contents.

Overview: The University of Iowa in Iowa City is a 1,900 acre campus of 119 buildings that straddles the Iowa River (Figure 4-51). The University has an enrollment of approximately 30,000 students in programs ranging from liberal arts to medicine.[2] Approximately 29 buildings and facilities sustained damages in the flood. Two months after the flood, 17 buildings and facilities remained closed, including:

- Art Building
- Art Building West
- Danforth Chapel

2 http://www.registrar.uiowa.edu/registrar/catalog/WhatIowaIsAllAbout/index.html

- Hancher Auditorium
- Hawkeye Court Apartments
- Iowa Advanced Technology Labs (IATL)
- Iowa Memorial Union (IMU)
- Museum of Art
- Power Plant
- Theatre Building
- Voxman/Clapp Music Building
- Cretzmeyer Track
- Lagoon Shelter House
- Softball Equipment Storage Building
- Softball Stadium
- Track Equipment Building
- IMU Footbridge

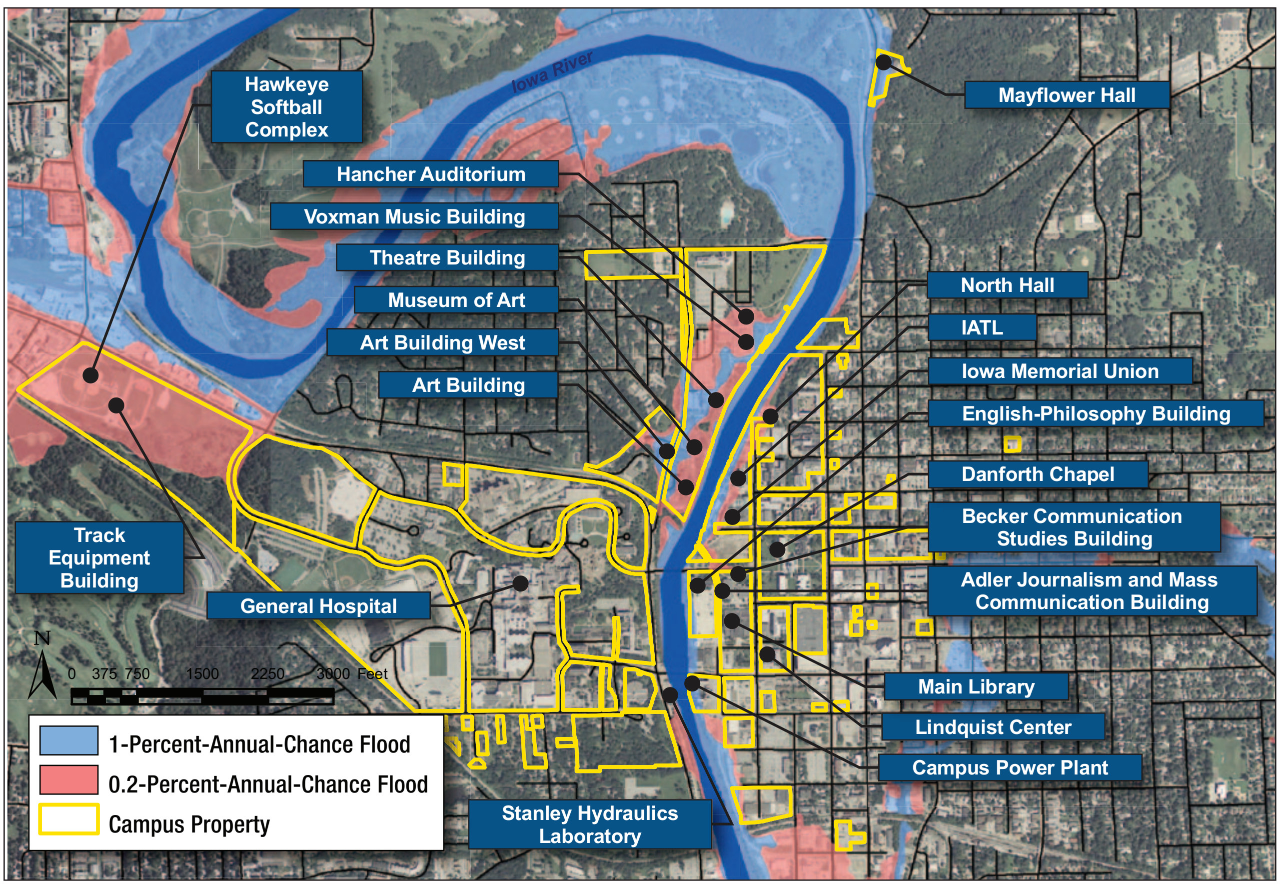

Figure 4-51. Flood zones and inundated buildings for the University of Iowa (Iowa City, Iowa)

Table 4-2 summarizes building elevation, flood depth, and floodplain information for select University of Iowa structures.

Table 4-2. Elevation Data for Facilities at the University of Iowa

Facility	Floodplain	First Floor Elevation (Basement)	Flood Elevation (Approx.)	Base Flood Elevation	0.2-Percent-Annual-Chance Flood Elevation	Recurrence Interval	Date
Mayflower Hall	SFHA	636.2	655.4	650	654.3	>500 year	Pre-FIRM
Art Building West	SFHA	635.2	653.4	648.4	652.5	>500 year	Post-FIRM
Museum of Art	SFHA	641.7	653.3	648.4	652.5	>500 year	Pre-FIRM
Voxman Music Building	0.2-Percent-Annual-Chance	644.1	653.6	649	653	>500 year	Pre-FIRM

On Friday June 13, 2008, the Iowa River levees for the Arts Campus and the IMU and IATL areas were breached (Figure 4-52). Flooding occurred at buildings on both sides of the river. A massive effort involving up to 2,000 volunteers who sandbagged buildings and removed building contents took place in the days before the flood. These emergency efforts saved valuable books from the library and the art collection from the Museum. The University estimates that approximately $750 million in contents were removed prior to the flooding.

Figure 4-52. Flooding of IATL and IMU (Source: University of Iowa Office of University Relations)

Although most of the buildings were directly flooded by river water, Adler Journalism Building, Becker Hall, and the Power Plant were significantly damaged by water entering from the utility tunnels. Access to Iowa City, the campus, and the University Hospital was severely limited. Medical personnel had to be flown in by helicopter to meet manpower needs. Power was lost throughout the campus. Temporary power generation plants were brought onto campus and restored power within three days of the flooding. The hospital, which had limited power from an operational substation on the west side of the river, had a temporary boiler system installed to provide the hot water necessary to continue emergency services.

Summary of Damages: The preliminary damages were estimated to be approximately $230 million. As of October 2008, the University, insurance companies, and FEMA were verifying those estimates. Approximate estimates of damages to some of the significant facilities' property and contents are shown in Table 4-3.

Table 4-3. Approximate Estimates of Damages to Facilities at the University of Iowa

Building	Initial Estimated Amount
IATL Flood Damages	$42,000,000
Power Plant Flood Damages	$25,100,000
IMU Flood Damages	$23,000,000
Flood Damaged Utility Tunnel System	$22,000,000
Voxman/Clapp Music Building Flood Damages	$14,000,000
Hancher Auditorium Flood Damages	$13,000,000
Art Building West Flood Damages	$13,000,000
Art Building Flood Damages	$8,000,000
Mayflower Residence Hall Flood Damages	$8,000,000
Museum of Art Flood Damages	$6,000,000
English-Philosophy Building Flood Damages	$5,500,000
Theater Building Flood Damages	$4,500,000
Adler Journalism and Mass Communication Building Flood Damages	$3,500,000
Becker Communication Studies Building Flood Damage	$3,500,000
Flood Damaged Footbridges	$1,500,000
Madison Street Services Building Flood Damages	$1,250,000
Main Library Flood Damages	$1,100,000
North Hall Flood Damages	$1,100,000
Hawkeye Court Apartments, 3 Bldgs, Units 301-376 Flood Damages	$1,100,000
Stanley Hydraulics Laboratory Flood Damages	$850,000
Lindquist Center Flood Damages	$550,000

The buildings incurred damages to the building structure and architecture, but the majority of the damage was to equipment. Several buildings lost mechanical and electrical equipment in the basement levels.

The MAT focused on five buildings located in the 1- or 0.2-percent-annual-chance floodplain and were most impacted by the floods:

- Voxman Music Building, a building with instructional and performance spaces
- Art Building West, an academic building
- Museum of Art
- Mayflower Hall, a residential building
- Campus power plant

Voxman Building: Water came through glass window walls, doors, entryways, and ventilation intakes. The interior finishes were removed to a height of 4 feet and replaced on the first floor. Most of the mechanical and electrical equipment and some of the damaged ductwork in the basement was replaced (Figure 4-53).

Figure 4-53.
Interior damage at Voxman Building (Iowa City, Iowa)

Art Building West: Although the first floor was designed to be 1 foot above the BFE, Art Building West has a below-grade basement that is well below the BFE. The building had 3 to 4 feet of standing water on the first floor in addition to complete flooding of the basement. The basement housed all the electrical and mechanical systems as well as two elevators, which were completely under water and required extensive repairs or replacement. The first floor sustained damage to drywall partitions, electrical wiring and devices, mechanical ductwork, and floor finishes. The glass panels of the exterior wall on the north side filled with water and had to be cleaned (Figure 4-54). Mold intrusion was a concern, and appropriate mitigation was underway in October 2008.

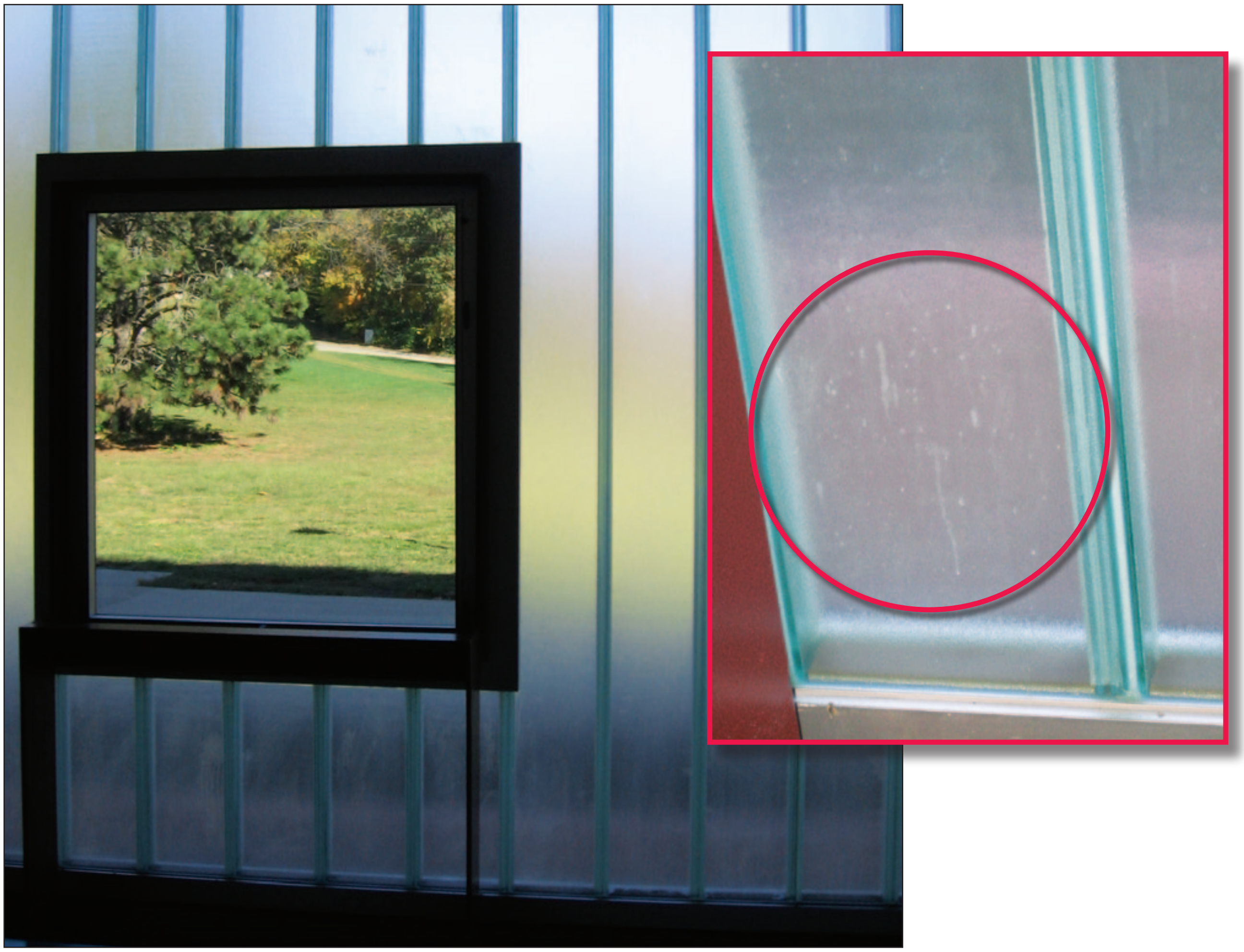

Figure 4-54.
Double glass panels trapped river water between panes in structural glass walls at the Art Building West (Iowa City, Iowa).

Museum of Art: This building had 2 to 6 inches of water on the first floor and several feet of water in the basement. The basement housed all the electrical and mechanical systems, which were completely under water and required extensive repairs or replacement. The first floor sustained damage to drywall partitions, electrical wiring and devices, mechanical ductwork, and floor finishes (Figure 4-55). The art collection was removed prior to flooding and will not be returned; as of October 2008, the University was evaluating the structure for other possible uses.

Mayflower Residence Hall: Built in 1968 and acquired by the University in 1983, this building is a medium rise, eight-story dormitory. It is located upstream of the main campus and in the SFHA. The building, which sits on top of a two-story, below-grade parking structure, had 2 inches of water on the first floor. The parking structure, which housed electrical and mechanical systems, was completely flooded (Figure 4-56). Although the parking structure had not been used for parking in several years, the electrical and mechanical equipment were severely damaged. The first floor sustained damage to wooden doors and frames, drywall partitions, appliances, casework, electrical wiring and devices, mechanical ductwork, and floor finishes in the housing areas. The Food Services area sustained major damage to interior architectural finishes and food service equipment. The building was repaired and reoccupied in time for the 2008–2009 academic year.

Figure 4-55. Drywall damage on first floor of Art Museum (Iowa City, Iowa)

Figure 4-56. Entrance to the parking garage beneath the Mayflower Residence Hall (Iowa City, Iowa)

Power Plant: A portion of the Power Plant is located in the 0.2-percent-annual-chance floodplain along the Iowa River. This building had major flooding in the basement, which housed the power, processing, pumping, and controls of the steam generation equipment for the entire campus. The controls were completely submerged, and, as a result, they needed extensive repairs. In October 2008, the building was under evaluation for structural damage; the basement floor was estimated to have incurred damage of over $25 million, primarily to the main steam generation equipment (Figure 4-57).

Figure 4-57. Power plant site repairs (Iowa City, Iowa)

Utility Tunnels: Water entered campus utility tunnels through access hatches and tunnel vents, and through tunnel openings in the Power Plant. The utility tunnels, which run from the Power Plant carrying steam and water piping and communication lines throughout the campus, were flooded in the following locations:

- On the west side of the river, flooding occurred in:
  - The Art tunnel from the Voxman/Clapp Music Building to the Art Building.
  - Dam tunnel across the river and into the Grand Avenue tunnel.
  - International Center tunnel from Art Building to the International Center.
- On the east side of the river, flooding occurred in:
  - The IMU tunnel from north of the IATL to the Power Plant.
  - The Old Capitol tunnel from the Power Plant to the Seamans Center.

The tunnels incurred damages to steam pipe insulation, valves, pipe penetrations, ductwork, and building entrances (Figures 4-58 and 4-59).

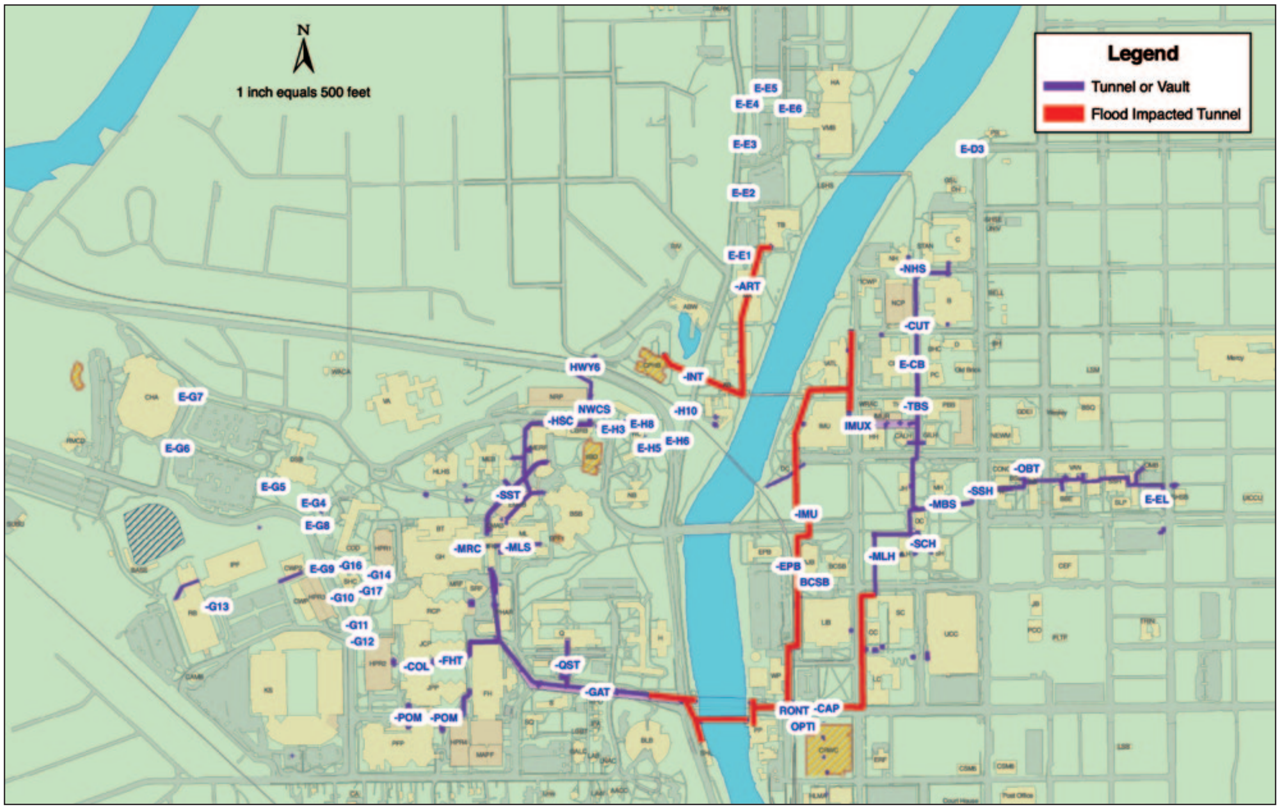

Figure 4-58. Schematic layout of campus tunnels indicating flooded areas
SOURCE: UNIVERSITY OF IOWA FACILITIES MANAGEMENT DEPARTMENT

Functional Loss: As of October 2008, the University was operational with limitations due to closed buildings, such as the Art Museum, Art Building West, Voxman Music Building, and the IATL building. The Iowa Memorial Union Bookstore was relocated to the University Capitol Centre during repairs. The Museum of Art's collection was removed and stored in Chicago. The athletic programs were relocated to available space. Major issues facing the University include expediting repairs, replacing damaged facilities, and mitigating future flooding disasters while maintaining the character of the Iowa River and the University of Iowa campus.

Figure 4-59.
Repair to tunnel entrance to Alder Journalism and Mass Communications Building (Iowa City, Iowa)

4.5 Lessons Learned

Table 4.5 lists the critical and essential facilities reviewed in Chapter 4 and presents lessons learned from the 2008 floods. Each lesson is an observation or recommendation based on observed damages and conversations with facility staff and includes a reference to one or more federal documents that can provide additional guidance. This table is recommended as a reference guideline for users prior to and during site selection, preliminary design, and building rehabilitation of an existing facility. The table is meant to illustrate the issues encountered by the MAT in flood damaged areas of Iowa and Wisconsin, to recommend strategies for mitigating those problems, and to indicate federal publications for further reference. The conclusions and recommendations presented here are discussed in detail in Chapters 6 and 7 of this report.

Table 4-4. Lessons Learned for Critical and Essential Facilities

	Critical Facilities (Category III)												Essential Facilities (Category IV)			
Lessons Learned	Cedar Rapids City Hall/Linn County Courthouse	Linn County Detention Center	Cedar Rapids Education Services Center/Annex	South School	UW Oshkosh Academic Buildings	UW Oshkosh River Center	University of Iowa	Reedsburg WWTF	Reedsburg Sewer Pump Station	Baraboo WWTF	Jefferson WWTF	Cedar Falls Utility Plant	Mercy Medical Center	Linn County Sheriff's Department	Cedar Rapids Police Department	La Valle Fire Station
General																
Critical facilities should be protected to the 0.2-percent-annual-chance flood or the ASCE 24 recommended level, whichever is greater. *Reference: FEMA 543*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
New critical facilities should be sited outside of the 0.2-percent-annual-chance floodplain. *Reference: FEMA 543*															●	
Planning and Preparedness																
Critical actions (contents and functions including public records, operations centers, and emergency equipment) should be located above the 0.2-percent-annual-chance flood elevation. *Reference: FEMA 348, E.O. 11988, FEMA 543*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Critical medical or research functions and equipment and valuable property such as art and music equipment in individual buildings should be located above the 0.2-percent-annual-chance flood elevation. *Reference: FEMA 348, FEMA 543*	●	●	●		●	●	●						●	●	●	●
Emergency plans must consider the availability of power supply for emergency equipment. Flooding caused loss of off-site natural gas supplies for generators. Anchored, on-site fuel tanks for emergency generators should be considered. *Reference: FEMA 543, FEMA 577*		●						●	●	●	●	●	●	●	●	

Table 4-4. Lessons Learned for Critical and Essential Facilities (continued)

	Critical Facilities (Category III)												Essential Facilities (Category IV)			
Lessons Learned	Cedar Rapids City Hall/Linn County Courthouse	Linn County Detention Center	Cedar Rapids Education Services Center/Annex	South School	UW Oshkosh Academic Buildings	UW Oshkosh River Center	University of Iowa	Reedsburg WWTF	Reedsburg Sewer Pump Station	Baraboo WWTF	Jefferson WWTF	Cedar Falls Utility Plant	Mercy Medical Center	Linn County Sheriff's Department	Cedar Rapids Police Department	La Valle Fire Station
Planning and Preparedness (cont.)																
Detailed emergency plans and checklists are needed for prisons' response to natural disasters, including detailed plans and preparedness for offsite evacuation of prisoners. *Reference: Critical Analysis of Emergency Preparedness, U.S. Department of Justice, National Institute of Corrections*		●														
Building Systems																
Building utilities including electrical, mechanical, and gas should be elevated to or above the 0.2-percent-annual-chance flood elevation. *Reference: FEMA 348*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Installation of elevator equipment should comply with guidance in NFIP TB 4. *Reference: NFIP TB 4*	●	●			●	●	●						●		●	
Risk and Remediation																
Flood recurrence intervals are difficult to predict given limited history for hydrological data and long-term weather patterns. *Reference: Galloway Report*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Facilities protected by levees or floodwalls should include redundant flood protection measures, including elevating critical equipment and functions. *Reference: FEMA 543*								●			●	●				

Table 4-4. Lessons Learned for Critical and Essential Facilities (continued)

	Critical Facilities (Category III)												Essential Facilities (Category IV)			
Lessons Learned	Cedar Rapids City Hall/Linn County Courthouse	Linn County Detention Center	Cedar Rapids Education Services Center/Annex	South School	UW Oshkosh Academic Buildings	UW Oshkosh River Center	University of Iowa	Reedsburg WWTF	Reedsburg Sewer Pump Station	Baraboo WWTF	Jefferson WWTF	Cedar Falls Utility Plant	Mercy Medical Center	Linn County Sheriff's Department	Cedar Rapids Police Department	La Valle Fire Station
Risk and Remediation (cont.)																
Manufactured products such as water-filled bladders, sand-filled containers, frame-supported fabrics, and others that serve as temporary barriers to hold back floodwater can be used as standalone mitigation measures or to reinforce existing, more permanent mitigation measures. Facility owners considering purchasing such manufactured products to reduce future flood damage should consider whether these products have been subjected to the testing and standards within the National Program to Test and Certify Flood Proofing and Flood Fighting Products. *Reference: National Program to Test and Certify Flood Proofing and Flood Fighting Products*							●	●		●	●	●	●			
Utility Tunnels																
Conduct a vulnerability assessment of utility tunnels to determine potential points of entry. Utility tunnels should be protected against flooding: ■ Tunnel hatches and vents should be raised to elevations that prevent floodwater entry ■ Tunnel access points to buildings should be dry floodproofed *Reference: NA*					●		●						●			

Table 4-4. Lessons Learned for Critical and Essential Facilities (continued)

	Critical Facilities (Category III)												Essential Facilities (Category IV)			
Lessons Learned	Cedar Rapids City Hall/Linn County Courthouse	Linn County Detention Center	Cedar Rapids Education Services Center/Annex	South School	UW Oshkosh Academic Buildings	UW Oshkosh River Center	University of Iowa	Reedsburg WWTF	Reedsburg Sewer Pump Station	Baraboo WWTF	Jefferson WWTF	Cedar Falls Utility Plant	Mercy Medical Center	Linn County Sheriff's Department	Cedar Rapids Police Department	La Valle Fire Station
Access																
Floodprone access routes should be elevated to no more than 1 to 2 feet below the 0.2-percent-annual-chance flood elevation, particularly for WWTFs, which tend to be in low-lying areas. *Reference: FEMA 543*		●	●				●	●	●	●	●		●			
Access ramps and underground tunnels to and from underground parking garages can provide points of entry for water and should be watertight or otherwise floodproofed. *Reference: FEMA 543 & NFIP TB 6*	●	●				●							●			
All points of entry, including stairwells, loading ramps, and courtyards, must be considered in mitigating floods. *Reference: FEMA 543*	●	●		●	●	●	●	●					●			
Sewers and Wastewater Management																
Replacing manhole covers to ensure they are watertight can protect sewers from floodwater infiltration. *Reference: FEMA 348*								●	●	●	●					
Reducing direct inflows to wastewater treatment facilities can help to avoid overwhelming equipment and should be considered as part of emergency preparedness plans. *Reference: NA*								●		●	●					
Backflow prevention valves can help to avoid sewer system backup in a facility's toilets, drains, etc. *Reference: FEMA 348*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Table 4-4. Lessons Learned for Critical and Essential Facilities (continued)

	Critical Facilities (Category III)												Essential Facilities (Category IV)			
Lessons Learned	Cedar Rapids City Hall/Linn County Courthouse	Linn County Detention Center	Cedar Rapids Education Services Center/Annex	South School	UW Oshkosh Academic Buildings	UW Oshkosh River Center	University of Iowa	Reedsburg WWTF	Reedsburg Sewer Pump Station	Baraboo WWTF	Jefferson WWTF	Cedar Falls Utility Plant	Mercy Medical Center	Linn County Sheriff's Department	Cedar Rapids Police Department	La Valle Fire Station
Flood Damage-Resistant Materials																
For facilities that cannot be elevated, staff should install flood damage-resistant materials below the 0.2-percent-annual-chance flood elevation. Using flood damage-resistant materials and construction practices can reduce losses and facilitate cleanup. *Reference: NFIP TB 2*	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
Glazing located below the design flood elevation should be designed to resist flood-related loads. *Reference: NFIP TB 2*	●			●		●	●									