

Flooding leads to devastation at personal and regional scales. Immediate impacts can include loss of life and damage to property and infrastructure. Damage to infrastructure causes disruptions to supplies of clean water, wastewater treatment, electricity, transport, education, and health care. Flooding also brings many long term challenges including environmental impacts, deterioration of human health in affected areas, and economic hardship. Water quality, air quality, and energy supply are three areas significantly impacted by Hurricane Harvey.

Water Quality

Flood waters carry enormous amounts of debris, sediments, and hazardous pollutants. Toxins and pathogens such as viruses and bacteria are transported along with contaminated sediments and floating debris. During Hurricane Harvey, tons of sediment were carried and deposited downstream in water bodies such as Spring Creek, Buffalo Bayou, the Houston Ship Channel, and Galveston Bay. Sediment accumulations in some portions of the Houston Ship Channel reduced water depths by three feet. Sediments were deposited on city streets and in residential neighborhoods and parks, causing potential health concerns related to lead, arsenic, and other pollutants stored in the sediments.

Flooding can also cause hazardous spills and toxic releases. Water from flooded refineries and superfund sites, commercial and industrial facilities, storage tanks, grounded vessels, and common household chemicals from under the kitchen sink are swept up and spread with the flood waters. Superfund sites are legacy hazardous waste sites identified by the federal government as requiring cleanup and remediation. The EPA identified 13 out of the 34 Superfund sites in the path of Hurricane Harvey as being impacted by flood waters.

Flooding can often cause sewage treatment systems to fail. Millions of gallons of untreated sewage overflows occurred throughout the region as a result of Hurricane Harvey. Intestinal bacteria such as E. coli, Salmonella, Shigella; Hepatitis A Virus; and agents of typhoid, paratyphoid and tetanus are often found in floodwaters. People exposed to these infectious agents can develop intestinal distress and debilitating disease symptoms. Other floodwater-borne pathogens such as Vibrio vulnificus (also known as flesh-eating bacteria) can cause severe forms of illness, such as necrotizing fasciitis and sepsis.

Floodwaters can also have large impacts on ecosystems. Harvey resulted in vast amounts of freshwater inflows to Galveston Bay, decreasing salinity levels to near zero (the salinity of freshwater) near Bolivar Roads, the major inlet connecting Galveston Bay to the Gulf of Mexico. While freshwater inflows are an important component of the bay system, such long-term decreases in salinity for weeks on end can kill oysters. The Texas Parks and Wildlife Department estimates that it could take more than two years for oysters to repopulate areas of Galveston Bay. A massive flood also results in changes to and loss of nesting and feeding habitat for bird, reptile and mammal species. Scientists are awaiting data that inform us about the long term impacts of Hurricane Harvey on regional fish and wildlife populations.

Air Quality

Hurricanes and related flooding also impact air quality. To limit damage to refineries and petrochemical facilities, plants are typically shut down in preparation for the storm. However, depending on the intensity of the storm, spills may still occur resulting in increased site emissions. Further, after the storm has passed, the startup and malfunctions that may happen during startup can result in the release of large amounts of pollutants. During and after Harvey, the Houston region

CDC GUIDELINES FOR CLEANING AFTER FLOODING

- Wash hands thoroughly with soap and water after contact with floodwaters.
- Don't allow children or pets in or near floodwaters.
- Don't bathe in water that may be contaminated by sewage or toxic chemicals.
- Avoid exposure to floodwaters if you have an open wound.
- Clean open wounds and cover them with waterproof bandage to reduce chances of infection.
- If a wound develops any redness, swelling, or oozing, seek immediate medical attention.
- Wear protective equipment including rubber boots, gloves and goggles during cleanup. Respirator for cleaning mold.
- To help speed up the drying process, use fans, air conditioning, and dehumidifiers after the cleanup.

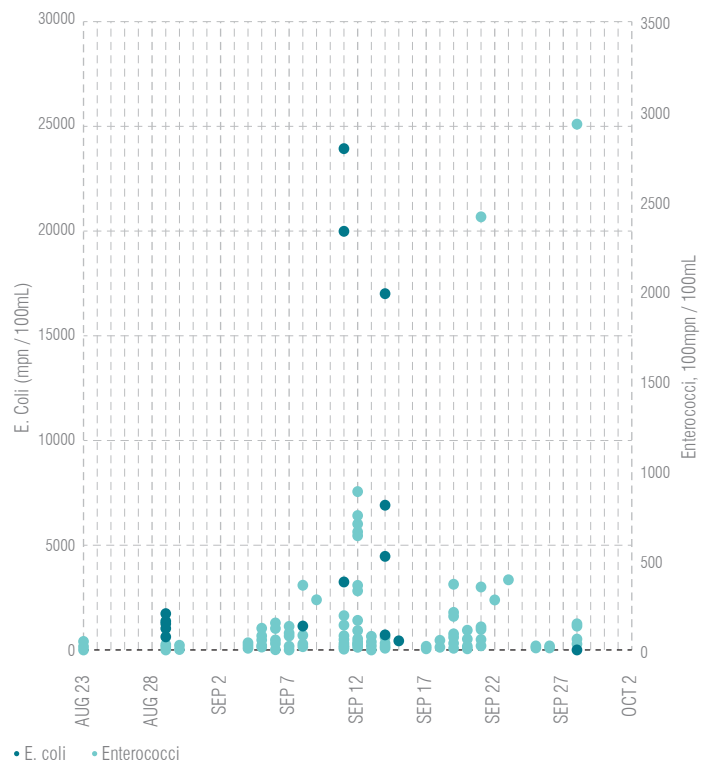


Figure 1 Modified Graph of Bacteria Sampling Results Before & After Harvey.(HARC)

KEY POLICY QUESTIONS

- What regional strategies should be employed to reduce environmental impacts of flooding?
- How can monitoring entities better coordinate to gather environmental data during & after future floods? What resources are required?
- How can information on storm-related environmental impacts & risks to health be more quickly & transparently relayed to impacted communities?

experienced many storm-related releases and spills of air pollutants including volatile organic compounds (VOCs) and sulfur dioxide.

Two air pollutants were significantly elevated after Harvey, ozone and BTEX. Ozone is a respiratory irritant that can lead to coughing, breathing difficulty and shortness of breath, asthma attacks, throat irritation, and lung infections. The Houston region experienced four consecutive ozone action days after the storm (August 30 – September 2).

BTEX is an air pollutant whose primary sources are refineries, petrochemical plants, vehicle emissions, and evaporative losses from fuel storage tanks. Exposure can lead to headaches, eye and nose irritation, and nervous system, liver, and kidney damage. Benzene, a component of BTEX, is a known carcinogen (cancer causing). Elevated levels of these hazardous air pollutants were seen after Hurricane Harvey, and are likely due to storm-related spills and releases at industrial facilities, shutdowns and startups at refineries and petrochemical facilities, as well as increased numbers of small, gasoline-powered engines in portable generators, chainsaws, and leaf blowers operating in the region after the hurricane.

Electricity & Energy

Power outages are common during hurricanes and large flooding events. Due to wind and flooding, a hurricane is capable of damaging multiple components of the electric power system, from power generation to the distribution system. Hurricane Harvey cut the power to over 2 million customers across the Gulf Coast. Upon landfall much of the power outages were from wind damage to transmission and distribution lines. In utility territories that had implemented smart grid technologies, power was quickly restored. As Harvey moved up the Gulf Coast, power outages were due more to flooding of substations and transformers and less from wind. Because of the long duration of Harvey, it took several weeks to gain access to and repair damaged equipment. Fortunately, lessons learned from Tropical Storm Allison resulted in flood resilient infrastructure in parts of the region. The Grant Substation that feeds a portion of the Texas Medical Center was elevated after Allison and was not affected by Harvey.

Large central power stations were also impacted by Harvey. Heavy rains saturated the coal piles at the W.A. Parish Power Plant, one of the largest power plants in the region, forcing it to curtail operations and switch to natural gas. To improve resilience of our power generation system, the deployment of distributed generation systems, particularly combined heat and power (CHP), has increased across the region. At UTMB-Galveston during Harvey, two electrical feeders that provide power to the campus went down. However, the CHP system that was implemented after Ike maintained power, as well as continued to provide cooling for the hospital campus during and after the storm.

Planning & Monitoring

The environmental impacts of flooding can be wide-ranging. The Greater Houston region has a large transportation infrastructure and a long history of industrial activity that sits alongside ecologically diverse landscapes and coastal ecosystems. Many of these ecosystems are the subject of regular monitoring programs by federal, state and local agencies that provide information regarding their health and function. However, information gaps exist, especially relating to pollutants released into air and water. Storm events such as Harvey exacerbate existing environmental issues and call attention to the need for additional monitoring resources. Coordination of storm-related

monitoring and data acquisition efforts should be a topic of regional planners in preparation for the next storm event.

Flood mitigation planning should also incorporate activities to avoid impacts to the greatest extent possible. For instance, the removal of fuel tanks and attention to hazardous wastes prior to landfall would eliminate some of the contaminated pollutant problems. Development of outreach material on the hazards of wading, playing or swimming in floodwaters would reduce direct contact.

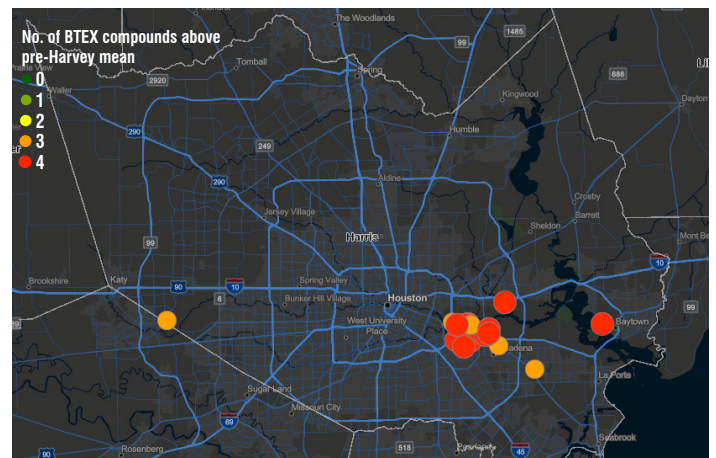


Figure 2 BTEX levels in Harris County on September 5, 2017. (HARC)



Figure 3 Hurricane Ike at UTMB-Galveston. Image from Affiliated Engineers presentation.

For More Information Visit

HARC Summarizing Hurricane Harvey’s Environmental Impact
harveyimpacts.harcresearch.org

Greater Houston Flood Mitigation Consortium
HoustonConsortium.com