

A Toxic Relationship

Extreme Coastal Flooding and Superfund Sites

HIGHLIGHTS

About 2,000 official and potential Superfund sites—sites contaminated by extremely hazardous chemicals—are located within 25 miles of the East or Gulf Coast. As sea levels rise, many of these toxic sites are at risk of flooding. Millions of people live near these sites, and flooding could bring them into contact with these chemicals.

The areas near these sites are disproportionately populated by communities of color and low-income communities. If leaders continue to sideline science when making decisions about climate change and about these sites, millions of the country's most vulnerable people's health will be at risk. We recommend steps that decisionmakers could take to ensure the resiliency of Superfund sites to extreme floods.

Less than two weeks before Hurricane Harvey caused extreme flooding in Texas, the Trump administration rescinded a science-based executive order intended to make infrastructure more resilient to future flooding events (Relman 2017). This included infrastructure for Superfund sites, which contain some of the most harmful chemicals known to humankind. Hurricane Harvey's floodwaters compromised the containment of hazardous chemicals at the San Jacinto Waste Pits Superfund site in Houston, Texas (Gebelhoff 2019). The breach of this site potentially exposed nearby communities to dioxins, highly toxic chemical compounds that can cause reproductive and developmental problems, damage the immune system, interfere with hormones, and cause cancer.

This is not the only example of flooding at a Superfund site that has left the health of nearby communities at risk. For example, in 2011 Hurricane Irene's floodwaters led to the release of benzene (a cancer-causing agent) beyond the protective barriers of the American Cyanamid Superfund site located in New Jersey (Murray 2011). In response, the site's owners raised protective infrastructure several feet above previous flood high-water lines and reinforced two berms surrounding chemical impoundments (Battipaglia 2014). They also implemented a remedy that would be able to withstand a "1-in-500-year" flood (an event with a 0.2 percent chance of occurring in any given year). These flood risk reduction measures prove that making these sites more resilient to future extreme floods is possible. However, without government action like the executive order that the Trump administration rescinded, it is unlikely that Superfund sites' responsible



AP Photo/Jason Dearen

The flooding of Superfund sites—such as this one in Texas, inundated by Hurricane Harvey in 2017—is likely to happen more frequently as sea levels rise along the East and Gulf Coasts, increasing the risk that hazardous chemicals could be transported in floodwaters and harm nearby communities.

parties will improve their sites' resilience such that they can withstand more extreme flooding and other impacts that will occur as climate change progresses.

Superfund Sites Disproportionately Affect Vulnerable Communities

When natural disasters compromise Superfund sites, the impacts are not equally shared. Compared with other communities, communities of color and low-income communities experience worse health impacts due to the proximity of these communities to Superfund sites (Crawford 1994; Johnson 2020). Indeed, the blossoming environmental justice movement's concerns were brought to national attention as long ago as 1987, when the Commission for Racial Justice of the United Church of Christ issued a report on the racial and socioeconomic characteristics of communities located near hazardous facilities (CRJ 1987). One of the report's most significant findings was that race was the "most significant among variables tested in association with the location of commercial hazardous facilities (CRJ 1987)." In other words, the strongest predictor of where hazardous facilities are located is the racial composition of residential communities.

Unfortunately, vulnerable communities are still disproportionately negatively affected by the siting of hazardous facilities, including Superfund sites. A higher proportion of communities of color and low-income communities are located in areas that have higher numbers of Superfund sites, and these areas tend to have heightened rates of cancer (Amin, Nelson, and McDougall 2018). Research has shown that it is more difficult for communities of color and low-income communities to get hazardous sites listed under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA),¹ and the government is slower to respond to demands from communities of color than to White communities' demands (Bullard 2012).

Communities of color and low-income communities are also likely to be disproportionately affected as climate change and its consequences, particularly extreme flooding, put Superfund sites at risk (Kramar et al. 2018; USGAO 2019). However, these risks, where and when they will occur, and to whom specifically they apply are incompletely known. These unknowns are linked to uncertainty regarding future heat-trapping emissions scenarios, resulting sea level rise projections, and future demographic changes in coastal communities. The Trump administration's attacks on and politicization of science-based decisionmaking, especially regarding climate change and environmental justice, have halted relevant research both inside and outside the government that could reduce this uncertainty (Friedman 2020).

A higher proportion of low-income communities and communities of color are located in areas that have higher numbers of Superfund sites.

The Trump administration has also sidelined environmental justice work (Desikan et al. 2019). The environmental justice office at the Environmental Protection Agency (EPA) is severely understaffed, and the funding provided by this office's small grants program to allow grassroots organizations to conduct environmental justice work in their communities has been drastically cut. The Trump administration also has abruptly rescinded science-based policies that were informed by environmental justice and Indigenous groups' concerns without any consultation. For example, the administration rescinded Executive Order 13754, which established a plan for maintaining the resilience of the Bering Sea in light of the foreseeable effects of climate change (WHOoPS 2016). The executive order had been heavily influenced by Alaskan Native groups, particularly the Bering Sea Elders group. The Trump administration rescinded the order without so much as contacting the Alaskan Native groups, the people on whose participation it was based and whose welfare it was designed to protect (Oliver 2017).

The Effects of Climate Change on Superfund Sites

The Trump administration has shown a consistent pattern of sidelining federal scientists and their work, especially in regard to climate change (Carter et al. 2019; Davenport and Landler 2019; Friedman 2020). The administration has targeted climate change scientists and reassigned them to positions for which they do not have expertise, forcing them to resign. Grant proposals designed to produce scientific evidence that could inform agency decisions about climate change and its impacts have been thrown out of consideration simply for mentioning "the double-C word" (Eilperin 2017). Scientific papers on climate change written by federal scientists have been stopped and suppressed—all to the detriment of the public, which deserves access to federal information about the risks of climate change and how to prepare for them.

The Trump administration's attacks on climate science are unfortunate and dangerous because coastal floods are

increasing in both height and frequency around the world (Buchanan, Oppenheimer, and Kopp 2017; Vitousek et al. 2017). With trillions of dollars in assets located along the US coasts and millions of people calling US coasts home, extreme floods are projected to be the most damaging climate change impact for many coastal areas (Hallegatte et al. 2013; Hauer, Evans, and Mishra 2016). Additionally, sea level rise rates along the US East Coast are higher than the average for the rest of the country (Krasting et al. 2016; Sallenger, Doran, and Howd 2012), and accelerated rates of sea level rise have been linked with higher flood frequencies across multiple studies (Woodruff, Irish, and Camargo 2013).

Extreme coastal flooding will be a health hazard for the millions of people living along the US coasts (Lane et al. 2013; Patz 2001). Tidal flooding is already affecting the lives of many who live along the coasts (Dahl et al. 2018). With continued sea level rise, and no additional protective measures, coastal flooding would increase the number of industrial accidents that leave floodwaters mixed with hazardous chemicals that could come into contact with nearby communities (Marcantonio, Field, and Regan 2019). Floodwaters also are likely to combine with sewage and failing septic systems, increasing chances that communities are exposed to fecal bacteria and other microbial pathogens (ten Veldhuis et al. 2010). The physical health effects on communities exposed to such floodwaters are numerous, and individuals affected by flooding also experience mental health effects from the hardships and losses they endure (Goldstein 2020; Stanke et al. 2012).

Science-Based Policies Are Needed for Superfund Site Resilience

As sea levels continue to rise, multiple types of industrial facilities, and the contaminants they store, could be in the paths of extreme coastal floods—but the flooding of Superfund sites is particularly worrisome. These sites include manufacturing facilities, processing plants, landfills, and mining sites. And they are contaminated with some of the most hazardous chemicals known to humankind.

In order to protect human health from the chemicals these sites contain, Congress enacted CERCLA in 1980. The law allows the EPA the authority to manage and clean up Superfund sites (i.e., remediate the sites) and also allows the agency to identify parties responsible for paying for cleanup

costs. When no responsible party can be identified, taxpayers bear the burden of paying for the costs of Superfund site remediation.

The containment of hazardous chemicals as well as ongoing remediation activities at Superfund sites are likely to be affected by climate change (USGAO 2019). The EPA fully recognizes these threats to Superfund sites. In 2011, the Office of Solid Waste and Emergency Response (now the Office of Land and Emergency Management) published a climate change adaptation plan that identified climate change impacts likely to affect the programs it manages, including Superfund programs (EPA 2014). The climate change impacts include: increased extreme temperatures, sustained changes in average temperatures, sea level rise, decreased permafrost, decreased precipitation, increased drought, increased heavy precipitation events, increased flood risk, increased frequency and intensity of wildfires, and increased intensity of hurricanes.

Policies aimed at rectifying Superfund site vulnerabilities to climate change have been written. For example, the Obama administration issued Executive Order 13690 in 2015 requiring any new federal infrastructure designs to incorporate climate change into planning for future flood risks,² and this order's scope included Superfund sites. The order could have resulted in agencies providing Superfund site managers with information about future flood risks to their sites, allowing them to ensure that sites are more resilient to future flooding events. The Trump administration eliminated this science-based order less than two weeks before the floods of Hurricane Harvey damaged the city of Houston, Texas, including the San Jacinto Waste Pits Superfund site (Relman 2017). Also, the Government Accountability Office (GAO) presented the Trump administration with an analysis showing that 60 percent of Superfund sites are at risk of harmful climate change impacts; however, the EPA's response ignored most of the GAO's recommendations, claiming that the status quo is working. One of the authors of this fact sheet, Dr. Jacob Carter, conducted a similar analysis while working as a post-doctoral fellow with the EPA, but the agency has failed to finalize and publish the results.

The following analyses demonstrate the real-life harm caused by sidelining science and rescinding science-based legislation. We developed a flooding model that incorporates climate change effects (i.e., sea level rise) to identify Superfund sites along the East and Gulf Coasts that may be vulnerable

Superfund sites are contaminated with some of the most hazardous chemicals known to humankind.

to future extreme floods. The EPA Facility Registry Service (FRS) has made the location of about 10,000 sites regulated under the Superfund Enterprise Management System (SEMS) publicly available (EPA 2020). This list contains the location of sites that are being actively remediated as Superfund sites (i.e., they are listed on the national priority list) or are proposed to be listed. The SEMS also contains the location of sites that are in the screening and assessment phases for possible inclusion on the list. While we acknowledge that not all sites in the SEMS list will ultimately be designated as Superfund sites, it is important to note the potential long-term risks for these facilities, all of which contain harmful chemicals. From here on we refer to all these SEMS-listed sites as “Superfund sites.”

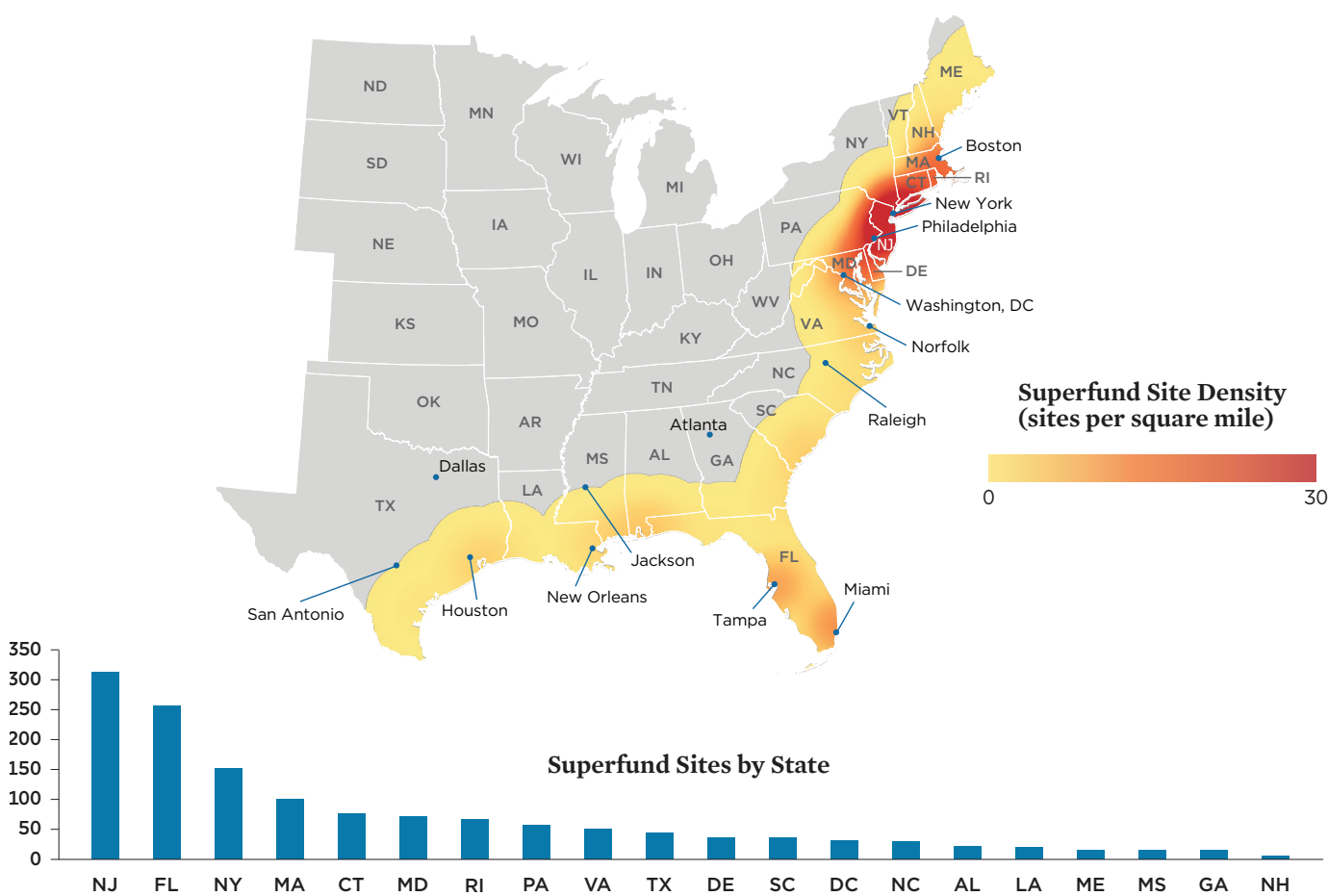
We identify SEMS-listed sites that would be vulnerable under four sea level rise scenarios for 2040, 2060, 2080, and

2100. Additionally, using demographic data provided by the US Census Bureau, we analyze the makeup of communities in the vicinity of sites our model identifies as vulnerable. These analyses allow us a better understanding of the risks to people’s health when our leaders fail to consider science in critical decisions.

Superfund Sites at Risk of Coastal Flooding

Approximately 2,000 of the sites on the SEMS list are located 25 miles or less from either the East or the Gulf Coast, with some states, such as Florida, New Jersey, and New York, having a higher number of these sites located along their coastlines (Figure 1). Extreme coastal flooding can affect facilities tens of miles inland from the coastline, as was observed when the

FIGURE 1. Superfund Site Hot Spots Along the East and Gulf Coasts



All states along the East and Gulf Coasts have Superfund sites close to the coastline. Florida, New Jersey, and New York are particular hotspots. Flooding of any of these sites could cause extensive health damage to surrounding communities.

SOURCE: EPA 2020.

American Cyanamid site flooded during Hurricane Irene: it is located approximately 20 miles inland.

METHODS

We integrated four sea level rise scenarios into our flooding model to determine which coastal Superfund sites would be at risk of extreme coastal flooding in the future. Sea level rise was locally projected for 68 tidal gauges using the low, intermediate, intermediate-high, and high sea level rise scenarios generated by the National Oceanic and Atmospheric Administration (NOAA 2017). The sea level rise scenarios are based on multiple warming scenarios, and, when projected out to 2100, they correspond to an expected range of sea level rise from 0.3 to 2.0 meters (approximately 1 to 6.5 feet).

On top of the locally projected sea level rise, we added the expected 100-year-flood height expected for the localized area, which was based on historical flood data. As described by the US Geological Survey, a 100-year flood is an extreme hydrologic event that has a 1 percent chance of occurring in any given year (USGS n.d.). Thus, the final flooding layer generated represents extreme flooding that incorporates the local effects of tides, storms, seasonal shifts in water level, and projected sea-level rise, which is

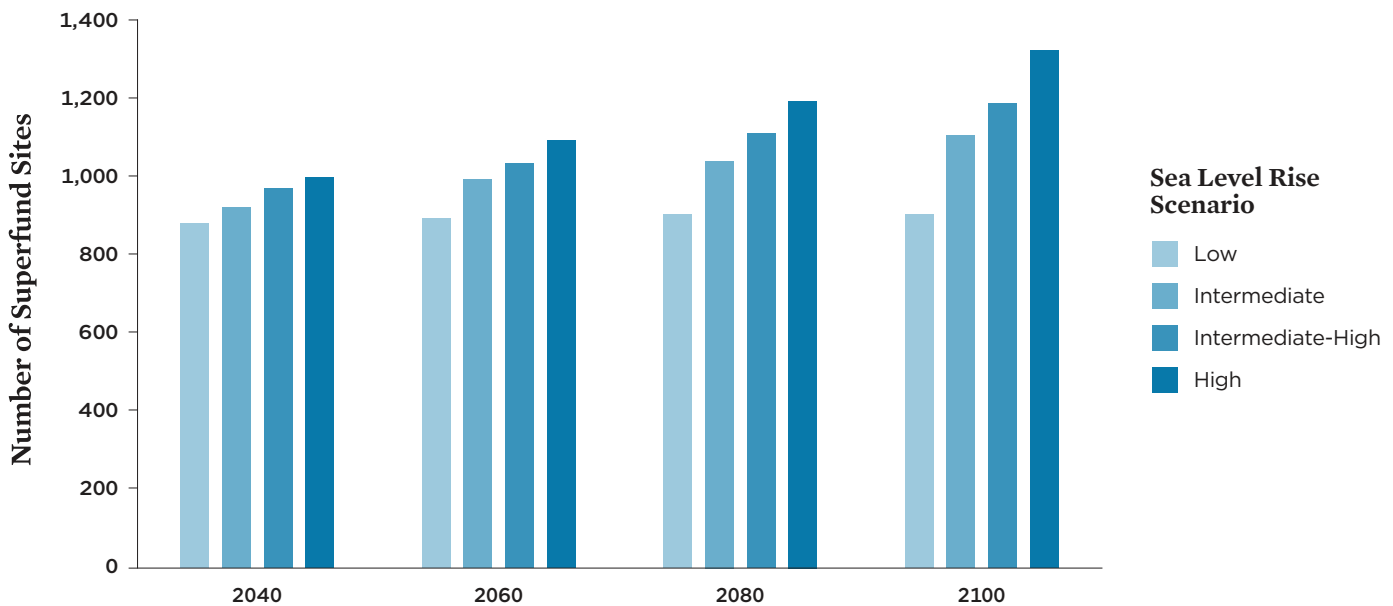
different from that expected from extreme tidal or “nuisance” flooding.

We collected Superfund site locations from the EPA FRS database. This database provides only a single point for a Superfund site (latitude, longitude), which represents neither the infrastructure of the facility (i.e., how much space the facility occupies) nor the location of where hazardous materials are contained or remediated at the site. Therefore, we created circular areas around these point locations with radii of 200 meters (about 126,000 square meters). This area is similar to published average Superfund site areas of 121,000 to 202,000 square meters,³ although there is likely significant variation around these averages (Sigman 2001). We considered a site to be at risk of flooding if the modeled extent of flooding intersected with the circular area we generated around this point location.

RESULTS

We find that 1,018 Superfund sites—71 percent of all Superfund sites located within 10 miles of either the East or Gulf Coast—would be at risk of flooding under the high sea level rise scenario by 2100 (Figure 2). In the next 40 years, 995 Superfund sites located along these two coasts become at risk of extreme coastal flooding under this scenario.

FIGURE 2. Superfund Sites Projected to Be at Risk of Coastal Flooding on US East and Gulf Coasts



More than 1,000 Superfund sites along the East and Gulf coasts would be at risk of extreme coastal flooding by 2100 under high rates of sea level rise, but even with low rates of sea level rise as many as 800 would be at risk of flooding within the next 20 years.

Note: Superfund sites considered at risk were those whose point location (latitude, longitude) plus a circular buffer with a 200-meter radius around that point fell within the projected flood zone using our flooding model.

We can expect Superfund sites to be vulnerable to flooding even if we take drastic measures in the near future to limit heat-trapping emissions and the corresponding effects of sea level rise. We find that extreme coastal flooding would pose a threat to at least 918 Superfund sites within the next 20 years if there is a moderate rate of sea level rise (intermediate scenario), and 876 Superfund sites would be at risk if there is a low rate of sea level rise (low scenario). Through 2060 to 2080, we find that 987 to 1,038 Superfund sites would be at risk of extreme coastal flooding if there is a moderate rate of sea level rise and 887 to 899 at risk if there is a low rate.

Extreme coastal flooding would pose a threat to more than 900 Superfund sites within the next 20 years if there is a moderate rate of sea level rise.

Communities at Risk of Toxic Floodwaters

Millions of people live within five miles of the various Superfund sites we found to be at risk of extreme coastal flooding. Communities of color and low-income communities make up high proportions of these populations surrounding the sites.

METHODS

To evaluate the impact that extreme coastal flooding of Superfund sites would have on coastal communities, we analyzed differences in the demographic makeup of communities located nearest to at-risk Superfund sites. By comparing the demographics of communities located nearest to at-risk Superfund sites with those located in coastal counties overall, we were able to study whether certain communities would be disproportionately affected by the flooding of Superfund facilities. To be clear, these risks represent potential vulnerabilities if a flooding event were to happen.

To understand the demographics of those living closest to at-risk Superfund sites, we first superimposed our modeled flooding extents for the low, intermediate, intermediate-high, and high sea level rise scenarios for the year 2040 on the Superfund site locations from the EPA's FRS database. We did not do this demographic analysis beyond 2040 as it is difficult to account for later possible migration and other demographic changes.

Once we identified at-risk Superfund sites, we identified communities within one-, three-, and five-mile circular buffers around the at-risk sites. With these buffer regions established, we were able to estimate the number of people of color and households living in poverty within these buffer zones using data from the US Census Bureau's American Community Survey at the census block group level (the smallest geographical unit for which the US Census Bureau publishes data) (USCB 2017). To account for the fact that not everyone in a census block group lives within the buffer zone, we calculated an area-weighted value to estimate the number of people at risk (see appendix, online at www.ucsusa.org/resources/toxic-relationship, for further details).

To better understand the significance of the demographics of people living in these at-risk zones, we calculated the number of people in each demographic group that we would expect to be living in the at-risk buffer zones based on the demographics of coastal counties overall. If this expected value was less than the observed value, we considered this representative of a disproportionate risk of being affected by future extreme coastal flooding of a nearby Superfund site.

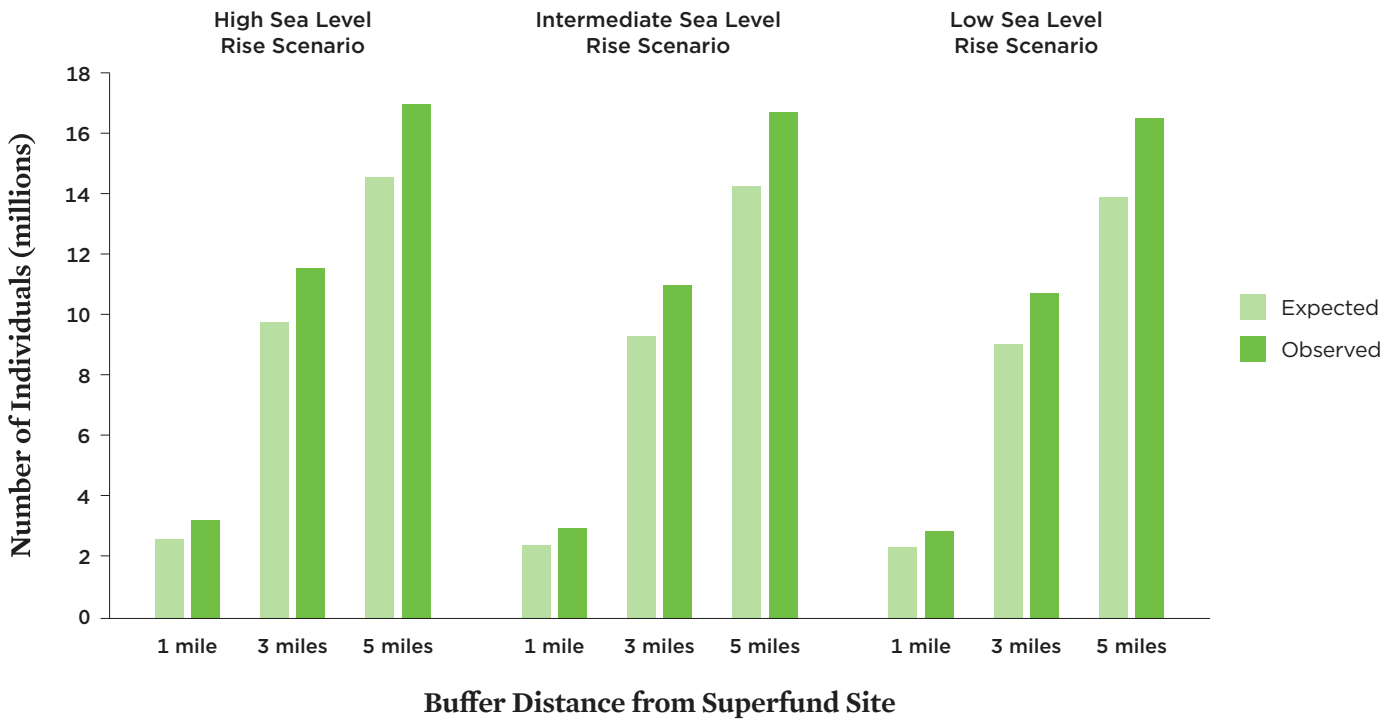
RESULTS

While results varied by state, we find overall that under all sea level rise scenarios Superfund site flooding would disproportionately affect communities of color and low-income communities within the next 20 years.

Based on demographic data for coastal counties, if communities of color and White communities were at equal risk from extreme coastal flooding of Superfund sites along the East and Gulf Coasts, we would expect between 2.3 and 14.5 million people of color to live within one, three, or five miles of at-risk sites within the next 20 years. Instead, we find that there would be between 3 and 17 million people of color (Figure 3). This number increases as the projected sea level rise accelerates. Thus, nearly 2.5 million more people of color than expected for counties along the East and Gulf Coasts live within five miles of a Superfund site at risk of flooding in the high sea level rise scenario. But the health of millions of people of color is at risk of being disproportionately affected by the flooding of Superfund sites even in the lowest projected rates of sea level rise.

Low-income households could also be disproportionately negatively affected by Superfund site flooding along the East and Gulf Coasts. We found that 300,000 more low-income households than expected for counties along the East and Gulf Coasts fall within five miles of Superfund sites that would experience extreme coastal flooding by 2040 in the low sea level rise scenario (Figure 4, p. 8). If sea level rises more quickly, such as in the intermediate or high scenarios, this would

FIGURE 3. Number of People of Color at Risk from Flooding of Superfund Sites



Communities of color disproportionately make up populations living close to coastal Superfund sites. They would therefore be disproportionately affected if these sites experience extreme coastal flooding. Millions of people in these communities are likely to suffer the consequences.

SOURCE: USCB 2018.

result in similar disproportionate impacts, as the number of households that would be harmed increases from approximately 486,000 to 2.5 million. Regardless of which sea level rise projection is considered, low-income households will disproportionately bear the brunt of the damage resulting from extreme coastal flooding of nearby Superfund sites.

Conclusions and a Path Forward

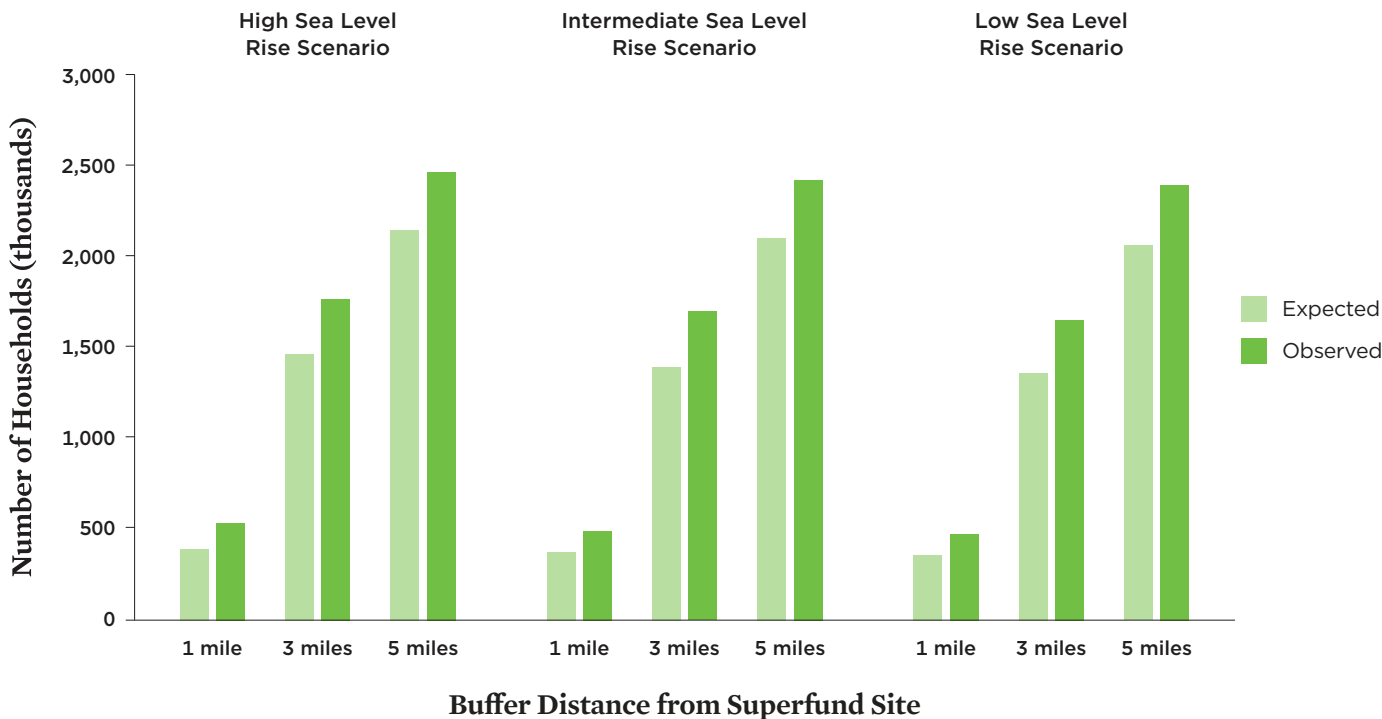
The possibility—indeed, the probability—of extreme coastal flooding of Superfund sites is a result of climate change. To limit future sea level rise and subsequent extreme coastal flooding, the United States must contribute to global efforts to constrain emissions, enacting and investing in just and equitable solutions that get the nation to net-zero carbon emissions no later than 2050. Increasing energy efficiency, ramping up renewable energy, and electrifying most energy uses in the transportation, industrial, and buildings sectors would help put the United States on this path. So, too, would reducing emissions from agriculture while investing in

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carbon-removal technologies and enhancing carbon storage in soils, forests, and vegetation.

Our results suggest that if leaders continue to sideline science when making important decisions concerning future flooding of hazardous facilities, the health of millions of the country’s most vulnerable people will be at risk. If sea levels continue to rise at rates expected in high heat-trapping emissions scenarios, we can expect the majority of coastal Superfund sites and the communities of color and low-income communities located near these sites to be at risk of extreme

FIGURE 4. Number of Low-Income Households at Risk from Flooding of Superfund Sites



More low-income households than expected for coastal counties along the East and Gulf coasts would be at risk by future extreme coastal flooding of nearby Superfund sites. Even in the low sea level rise scenario, more than 100,000 low-income households than expected for coastal counties along the East and Gulf coasts would be negatively affected by the flooding of a Superfund site located near their community.

SOURCE: USCB 2018.

floods. Our results identify the possible extent of the problem along the East and Gulf Coasts, but our study is not the first to illustrate the vulnerabilities of Superfund sites to climate change (Marcantonio, Field, and Regan 2019; USGAO 2019).

Decisionmakers must take action now to protect the health and safety of the communities located near these facilities. The EPA already has resources available to guide remediation project managers and others who manage Superfund sites regarding measures that can be put in place to adapt these facilities to withstand expected climate change effects. However, other resources are needed to help stakeholders navigate complex climate change models for their sites as well as risk analysis frameworks.

The results presented here along with those previously published paint a very clear and stark picture—Superfund sites and the vulnerable communities located nearby will be negatively affected by future extreme coastal flooding. Millions of people of color and hundreds of thousands of low-income households are at risk of being exposed to hazardous floodwaters, so why are our decisionmakers taking

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so long to take action? Resiliency measures must be put in place now.

The adaptation of Superfund sites to withstand future extreme coastal floods will take time. Here are some steps that decisionmakers could take to ensure the resiliency of Superfund sites to extreme floods:

- To protect the health of communities located near at-risk Superfund sites and to protect their ongoing remediation activities, the president should issue an executive order, similar to Executive Order 13690, requiring that all

new federal infrastructure incorporate the best available climate change science when considering the effects of future floods in order to ensure that communities can adequately prepare for climate change–induced flooding.

- The Office of Science and Technology Policy should coordinate an interagency working group to undertake the following tasks:
 - Determine best practices for implementing the above-mentioned executive order.
 - Discuss strategies for ensuring the resilience to future flood events of older infrastructure still in use.
 - Work with Congress to increase funding and capacity for agencies to undertake this work.
 - Ensure agencies develop programs to train non-climate experts in agencies on practices to identify infrastructure at risk of future flooding, as well as to provide educational opportunities for these individuals to gain a deeper understanding of these methods and the climate models that underlie them.
- The administrator of the EPA should clarify how the EPA’s actions to manage risks to human health and the environment from the potential impacts of climate change at Superfund sites align with the agency’s current goals and objectives (USGAO 2019).

- To ensure that Superfund site decisionmakers consider the best available climate science, the director of the Office of Superfund Remediation and Technology Innovation (OSRTI) should provide direction on how to integrate information on the potential impacts of climate change effects into flood risk assessments at Superfund sites (USGAO 2019). This direction should be made publicly available and published immediately.
- To improve the accuracy of determining how and where Superfund sites, and ongoing remediation activities, may be most at risk from flooding and other climate change impacts, the director of OSRTI should establish a schedule for standardizing and improving information on the boundaries of Superfund sites (USGAO 2019).
- To ensure that the EPA is fully incorporating the needs of vulnerable communities that are located near at-risk Superfund sites in resilience efforts, the director of OSRTI should expand community involvement when considering improving Superfund site resilience to future floods and other climate change impacts.

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ENDNOTES

- 1 *Comprehensive Environmental Response, Compensation, and Liability Act of 1980, Pub. L. No. 96-510, 94 Stat. 2767, codified as amended at 42 U.S.C. §§ 9601-9675 (1988 and Supp. 1m, 1991); see also Superfund Amendments and Reauthorization Act of 1986 (“SARA”), Pub. L. No. 99-499, 100 Stat. 1613 (1986) (amending CERCLA). The statute is also known as the “Superfund Act” because of the fund it created to pay for the cleanup of hazardous waste sites. See CERCLA § 111, 42 U.S.C. § 9611.*
- 2 *Exec. Order No. 13,690 of January 30, 2015, Establishing a Federal Flood Risk Management Standard and a Process for Further Soliciting and Considering Stakeholder Input, <https://obamawhitehouse.archives.gov/the-press-office/2015/01/30/executive-order-establishing-federal-flood-risk-management-standard-and->*
- 3 *Superfund Program: Hearings Before the Subcommittee on Transportation and Hazardous Materials of the Committee on Energy and Commerce, House of Representatives, 103rd Congress, First Session on Oversight of the Implementation of the Superfund Program, Volume 4, January 1, 1993, US Government Printing Office.*

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AP Photo/Chris O'Meara

Anthony Stansbury, shown here fishing along the western Florida coast in 2017, lives in a neighborhood adjacent to a Superfund site. Sea level rise and extreme precipitation are projected to worsen in the coming decades as heat-trapping emissions continue to rise, putting Superfund sites at risk of flooding and contaminating waterways with toxic chemicals—harming marine life as well as neighboring communities.

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