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Michael B. Gerrard
Columbia Law School, michael.gerrard@law.columbia.edu

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ARTICLES

WASTE AND CHEMICAL MANAGEMENT IN A 4°C WORLD

by Michael B. Gerrard

Michael B. Gerrard is Professor and Faculty Director of the Sabin Center for Climate Change Law at Columbia Law School. The third edition of his book Global Climate Change and U.S. Law (co-edited with Jody Freeman and Michael Burger) is being published in 2023 by the American Bar Association.

SUMMARY

Many chemicals and hazardous substances are kept in places that can withstand ordinary rain, but not severe storms or floods. If these events occur and the chemicals are released, people and the environment may be endangered. This Article discusses the hazards posed to chemical and waste disposal facilities by extreme weather events that would be worsened as a result of climate change, and how U.S. laws do (or do not) deal with these hazards; and considers how the law would need to change to cope with what would happen to these facilities in a potentially 4°C world. It is adapted from a new book by the Environmental Law Collaborative (Katrina Kuh & Shannon Roesler eds., ELI Press forthcoming 2023).

Many chemicals and hazardous substances are kept in places that can withstand ordinary rain, but not severe storms or floods. If these events occur and the chemicals are released, people and the environment may be endangered. The law has a long way to go—using existing tools and developing new ones—in protecting against these hazards and coping with the damage when they do occur. This becomes even more urgent if, as Profs. J.B. Ruhl and Robin Kundis Craig have suggested in their seminal article,1 we need to begin preparing for the possibility of a world that is up to 4°C (7.2°F) warmer.

U.S. sea levels today are about nine inches higher than a century ago.2 By the end of the century, they could be another six feet or even higher (or lower).3 Just how high depends mostly on the levels of greenhouse gases (GHGs) we are still emitting, and on the rate of melting in Greenland and Antarctica. Moreover, flood risks are hardly limited to the coasts. Over the past century, annual precipitation and also extreme precipitation events have increased across most of the northern and eastern United States (and decreased across much of the southern and western states), due mostly to GHG emissions.4 Each 1°F increase in temperature leads to more evaporation and 4% more water vapor in the atmosphere, meaning more rain.5 This affects inland areas as well as the coasts; flooding across the Midwest and South during 2019 affected nearly 14 million people.6

Hurricanes have been getting more frequent and intense since at least the 1970s, and that will continue.7 While climate change is making hurricanes stronger, it can also slow their lateral movement along the coast and even make them almost stand still, continuously drawing water from the ocean like a massive pump and, as they rotate, dumping torrents of rain on a location for days on end.8 That is what happened with Hurricane Harvey over the Houston

area in 2017, Hurricane Dorian over the Bahamas in 2019, and Hurricane Ian over Florida in 2022. This article discusses the hazards posed to chemical and waste disposal facilities by extreme weather events that would be worsened as a result of climate change, and how U.S. laws do (or do not) deal with these hazards. It then considers how the law would need to change to cope with what would happen to these facilities in a 4°C world.

I. Current Law

Threats realized. According to the U.S. Government Accountability Office (GAO), “Over 11,000 facilities across the nation make, use, or store extremely hazardous chemicals in amounts that could harm people, the environment or property if accidentally released.” Large concentrations of these facilities are in the areas of New Orleans (hit by Hurricanes Katrina and Rita in 2005, Laura in 2020, and Ida in 2021) and Houston (hit by Hurricane Harvey in 2017). The high winds and rushing waters from these storms caused multiple releases of chemicals into the air or water. Storage tanks buckled, toppled over, or were washed away; the floating roofs atop several tanks sank or were dislodged; pipelines burst.

A 14-inch pipeline owned by Williams Companies spewed anhydrous hydrogen chloride for several hours at La Porte, Texas, mixing with moisture in the air to form hydrochloric acid and requiring neighboring residents to shelter in place. At ExxonMobil’s Olefins Plant in Baytown, Texas, some 457 million gallons of stormwater mixed with untreated wastewater, including oil and grease, and surged into an adjacent creek. Hurricane Ida led to 55 reported oil spills, many of them from abandoned pipelines and offshore oil platforms near the Texas and Louisiana coastlines.

During Harvey, chemical spills contributed to unhealthy levels of air pollution, and a chemical plant owned by Arkema Inc. exploded after the failure of an essential cooling system. More than a dozen emergency responders were injured, and carcinogens were released into the air. The company and two executives were indicted on criminal charges for reckless release of toxic chemicals, but the court found prosecutorial misconduct and incompetence and dismissed the charges; several civil lawsuits continue.

Bio-Lab, a plant near New Orleans, burned to the ground during Hurricane Laura and released chlorine that it was producing for swimming pools, leading to another shelter-in-place order. Other hurricanes have caused severe damage to refineries and other petrochemical plants. One 2022 headline was especially vivid: “Florida County Sees Spike in Deadly Infections Caused by ‘Flesh-Eating’ Bacteria After Hurricane Ian.”

Clean Air Act. As part of a comprehensive amendment to the Clean Air Act (CAA) in 1990, the U.S. Congress adopted a new program on prevention of accidental releases of hazardous chemicals from stationary sources, called the §112(r) program. It provided that owners and operators of these sources “have a general duty . . . to identify hazards which may result from such releases using appropriate hazard assessment techniques, to design and maintain a safe facility taking such steps as are necessary to prevent releases, and to minimize the consequences of accidental releases.”

17. 42 U.S.C. §7412(r).
releases which do occur.” Congress told the U.S. Environmental Protection Agency (EPA) to adopt regulations and to require facility owners and operators to prepare and implement “risk management plans.” These plans came to include “off-site consequences analyses,” but in 1999 Congress, two years before the 9/11 attacks but already concerned that terrorists might use this information to find targets, amended the law to make it much more difficult for the public to obtain these analyses.22

Then, in 2013, the explosion of a fertilizer plant in the town of West, Texas, killed 15 people, and President Barack Obama directed EPA to strengthen the chemical safety rules. EPA issued stronger regulations in January 2017, one week before President Obama left office. The Donald Trump Administration rescinded the stronger rules.23 In February 2022, GAO found that about 3,200 facilities covered by the program are in locations that may be at risk from the effects of climate change—flooding, storm surge, wildfire, and sea-level rise.24 In August 2022, EPA proposed a new rule that followed GAO’s recommendation to explicitly require consideration of climate change in preparing their risk management plans.25 Under existing regulations, the risk management plans must be updated every five years.26

Similar to the risk management plans required by EPA, which are designed to protect the environment and the community, the Occupational Safety and Health Administration (OSHA) requires “process safety management plans” to protect workers.27 The plans required by EPA must consider the effects of a chemical release on the nearby community; the plans required by OSHA must consider the effects of a chemical release on the nearby community, the Occupational Safety and Health Administration (OSHA) requires “process safety management plans” to protect workers.27 The plans required by EPA must consider the effects of a chemical release on the nearby community; the plans required by OSHA generally look only at the effects in the workplace, and there is no explicit requirement to consider climate change. Both EPA and OSHA require companies, in carrying out these plans, to follow “recognized and generally accepted good engineering practices” (RAGAGEP).

The RAGAGEP practices are established by such non-profit organizations as the American Society of Mechanical Engineers, the American National Standards Institute, and the National Fire Protection Association.28 Some of these practices implicitly consider various effects of climate change (such as flooding and wildfires), but few if any explicitly discuss climate change or the conditions it will cause in the future.29 Changes to these practices could have a significant impact on industrial practices, as several consulting firms have gone into the business of auditing companies for their compliance with the RAGAGEP.

As part of the same 1990 amendments to the CAA, Congress created the Chemical Safety and Hazard Investigation Board, modeled after the National Transportation Safety Board, to investigate accidents at chemical plants and recommend corrective measures.30 However, it did not begin operations until Congress finally funded it in 1998, and the Trump Administration tried without success to dismantle it. It has conducted useful investigations, but with a very limited staff it has never been able to look into more than a small fraction of chemical plant incidents.31 In 2020, the Board issued a short guidance document for how chemical plants should deal with extreme weather events, acknowledging an increase in flooding in recent years, but not mentioning climate change.32 An October 2022 report from EPA’s Office of Inspector General found that the Board is still severely understaffed, and has only two of five authorized members.33

Resource Conservation and Recovery Act. EPA has issued detailed regulations under the Resource Conservation and Recovery Act (RCRA)34 for the storage of certain chemicals,35 but they apply only to hazardous wastes, not to useful products or to materials that will be used. Moreover, RCRA regulates the units that are most vulnerable to storms—above-ground storage tanks—only if they are holding oil or its products like gasoline. A law enacted after the chemical disaster in Bhopal, India, in 1984, the Emergency Planning and Community Right-to-Know Act of 1986 (EPCRA),36 requires companies storing large quantities of certain hazardous substances (not only wastes) to report their inventories and make some other disclosures, but it does not impose substantive requirements that would help make sure the tanks do not leak or burst.37

This gaping regulatory gap was on display in January 2014 in Charleston, West Virginia, when a large leak developed at a tank holding a chemical used as a cleansing agent in the coal mining industry. The liquid poured into the Elk

26. 40 C.F.R. §68.36.
27. 29 C.F.R. §1910.119.
29. GAO Report, supra note 10, at 33.
35. 40 C.F.R. pr. 264.
36. Id. pt. 112.
River and rendered the water supply for 300,000 people undrinkable for weeks. The spill occurred during a spell of record low temperatures caused by a “polar vortex” (a phenomenon that some link to climate change), causing “frost heaving” that deformed the ground surface on which the tank was sitting.

Though the tank was corroded, it was not subject to EPA’s tank regulations because it contained a useful product—neither waste nor oil. The company and some of its managers were prosecuted criminally and fined, not because the tank was substandard, but because the company did not have a permit under the Clean Water Act (CWA) to discharge into the river and had not taken adequate precautions to prevent a spill. After this incident, West Virginia adopted legislation regulating above-ground storage tanks.

EPA has promulgated very detailed regulations under RCRA for hazardous waste disposal facilities. These include special precautions for facilities sited in a 100-year floodplain. Since rising seas and more intense storms mean that many more areas will have that level of flood risk, those areas will encompass many more facilities. Based on past experience, it is not clear that their operators will be taking the necessary precautions.

Clean Water Act. As enacted in 1972, the CWA requires EPA to “establish procedures, methods, and equipment and other requirements for equipment to prevent discharges of oil and hazardous substances.” In 1973, EPA issued standards for the storage of oil. The current regulations require oil storage facilities to have spill prevention control and countermeasure (SPCC) plans. These plans are very elaborate and no doubt have greatly reduced the amount of oil that gets into the environment, but they are required only for oil. In 2015, several environmental groups sued EPA to compel it to issue similar regulations for hazardous substances, as the CWA requires. EPA agreed in a 2016 consent decree to begin a rulemaking to correct this gap, but the Trump Administration then concluded that new rules were not necessary. The Joe Biden Administration has not indicated whether it will take a different position.

In 2019, the Natural Resources Defense Council and others sued EPA under a related provision of the CWA (added by the Oil Pollution Act of 1990 (OPA)) that required the president to issue regulations requiring owners or operators of certain onshore facilities to prepare plans “for responding, to the maximum extent practicable, to a worst case discharge, and to a substantial threat of such a discharge, of oil or a hazardous substance.” The parties entered into a consent decree in March 2020 requiring EPA to propose regulations complying with this requirement within two years, and in March 2022, EPA issued its proposed rule on “Clean Water Act Hazardous Substance Worst Case Discharge Planning.” EPA indicated that climate change could cause or worsen these worst-case events, and should be considered in the plans.

Even when SPCC plans are required, they often ignore the perils that climate change poses to tanks that hold large amounts of oil. In 2016, the Conservation Law Foundation sued ExxonMobil, alleging that its oil tank farm on the Mystic River near Boston is not prepared for storm surge or other possible impacts of climate change, in violation of the CWA and RCRA. The same group followed with similar suits against Gulf Oil and Shell Oil concerning different tank farms. These cases are in active litigation.

Another kind of litigation—that under tort law—does little to induce greater care in protecting chemical facilities from climate risks. A damaging hurricane like Katrina or Harvey can cause multiple spills, leading to the intermingling of chemicals in a toxic soup and making it impossible to prove what facility caused what injury. Unless stronger standards are imposed, in many cases, plaintiffs will also have difficulty proving that the companies were negligent, which would be necessary for most of these suits to succeed.

Comprehensive Environmental Response, Compensation, and Liability Act. The best-known program for contaminated sites that are no longer active (as opposed to operating factories) is under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). EPA places the worst sites on its National Priorities List; these are commonly called Superfund sites. These sites are

42. 40 C.F.R. §264.18(b).
46. 33 C.F.R. §112.3.
53. See generally Sachs, supra note 47.
disproportionately located in or near communities of color. After listing, each site undergoes an elaborate process called the remedial investigation and feasibility study, leading to EPA's selection of a way to address the contamination, called a "remedy."

Some common remedies include digging up the material and hauling it to a licensed disposal site; leaving it in place and placing an imperious cover over it; or pumping out contaminated groundwater, treating it, and putting it back in the ground. Of the Superfund sites not on federal property, at least 60% (945 of 1,571) are in locations that under current conditions are vulnerable to flooding, storm surge, wildfires, or sea-level rise. Even more sites will be at risk as climate conditions worsen.

Extreme storms do not necessarily release contaminants from Superfund sites. An EPA study of three 2017 hurricanes (Harvey, Irma, and Maria) found that 252 Superfund or similar sites were exposed to tropical force winds or higher and 63 experienced flooding, but only 16 reported minor damage. One that was affected was the San Jacinto River Waste Pits, where Hurricane Harvey damaged a temporary protective cap on a pit of toxic sludge, exposing waste with high levels of dioxins and washing some of it downhill. Hurricane Maria stirred up already high levels of polychlorinated biphenyls (PCBs) in Guánica Bay, Puerto Rico.

EPA has identified many ways that a changing climate can worsen the already toxic conditions at contaminated sites. For example, it can transport pollution offsite; mobilize formerly stable contaminants, especially those in sediments at the bottom of bodies of water; damage the often thin caps that cover contaminants that are left in place; and make contaminants more volatile with higher temperatures. Climate change can also increase erosion, raise or lower groundwater levels, flood drainage systems beyond their design conditions, and force soil vapor to migrate, further complicating Superfund remedies.

In 2021, EPA suggested that its officials implementing CERCLA “should assess the vulnerability of a remedial action’s components, including its associated site infrastructure and evaluate whether the long-term integrity of a selected remedy may be impaired by adverse effects of climate change,” and that “intensities and frequencies of extreme weather events over a timeframe corresponding to a remedy’s anticipated duration” should be considered. The remedies recently chosen for some sites do include protections against extreme flooding.

EPA has legal options if it finds that climate change has rendered a site remedy inadequate. CERCLA provides that if any contaminants remain at the site, EPA must review the remedial action at least every five years “to assure that human health and the environment are being protected,” and if they are not, EPA must take action. Most cleanups of Superfund sites are carried out through consent decrees with the potentially responsible parties, and EPA’s model consent decree allows the Agency to compel further action at closed sites if required by the circumstances. Therefore, if EPA concludes that the remedy at a Superfund site is vulnerable to climate change, it has considerable authority to require a change, though in practice it has seldom done so. EPA could also go further and amend the regulation that governs the CERCLA cleanup process, called the National Contingency Plan, to require more systematic consideration of climate change when identifying sites to be listed as Superfund sites, selecting the remedy, and monitoring its effectiveness.

EPA is considering listing certain per- and polyfluoroalkyl substances chemicals as hazardous substances under

56. GAO, SUPERFUND: EPA SHOULD TAKE ADDITIONAL ACTIONS TO MANAGE RISKS FROM CLIMATE CHANGE 18 (2019).

CERCLA. If it does so, that could require a new look at the selected remedies at many Superfund sites. This could provide a good occasion for also looking at the storm vulnerability of those sites.

States could secure more stringent cleanups of CERCLA sites by amending their coastal management plans under the federal Coastal Zone Management Act (CZMA) to mandate more climate-resilient cleanups, making these requirements “applicable or relevant and appropriate requirements” that must be met in CERCLA cleanups.

II. Related Threats and Applicable Laws

Many hazardous liquids and gases are carried by pipelines. In 2022, the Pipeline and Hazardous Materials Safety Administration (PHMSA), part of the U.S. Department of Transportation, issued an advisory bulletin warning, stating:

[C]hanging weather patterns due to climate change, including increased rainfall and higher temperatures, may impact soil stability . . . [posing] a threat to the integrity of pipeline facilities if those threats are not identified and mitigated. Owners and operators should consider monitoring geological and environmental conditions, including changing weather patterns, in proximity to their facilities.

PHMSA documented numerous instances where earth movement had ruptured pipelines and caused the release of their often hazardous contents.

One seldom-recognized risk arises if a site is downstream of a dam that is holding back a large volume of water. One investigation identified 81 dams in 24 states that, if they failed, could flood a major toxic waste site and potentially spread its contamination. The design of remedies at Superfund sites does not tend to consider this risk. Moreover, many dams are themselves holding back not only water, but also piles of contaminated sediment that have accumulated over the years; failure or removal of the dam would also release this contamination downstream.

For example, in 1973, a dam on the Hudson River was intentionally removed by its owner; a large quantity of sediment, heavily contaminated with PCBs from General Electric (GE) factories upstream, was washed downstream, the Hudson River became a Superfund site, and GE has spent about $1.6 billion cleaning it up. Around 1,700 dams have been identified in 44 states and Puerto Rico that are rated in poor or unsatisfactory condition and that could cause loss of life if they failed. Moreover, these figures tend to reflect only the larger dams; there are around 2.5 million smaller “nonjurisdictional” dams, many of which may also be vulnerable to extreme weather events, and of those, an unknown number are holding back contaminated sediment.

Many dams and impoundments hold the ash that is generated in huge quantities by coal-fired power plants. About 185 pounds of coal ash are generated for each megawatt hour of electricity from a coal plant. This ash, which often contains arsenic, mercury, chromium, and other contaminants, is almost always kept in the open air without any cover. Many severe storms have washed over coal ash impoundments and swept the ash into nearby land or streams. In December 2008, the dike holding up an impoundment of ash in Kingston, Tennessee, from Tennessee Valley Authority coal plants failed (not due to severe weather), releasing 5.4 million cubic yards of coal ash sludge; this led to a massive cleanup operation, and then to multiple lawsuits by nearby property owners, by workers who became sick performing the cleanup, and others.

Partly in reaction to this incident, in 2015, the Obama Administration issued regulations strengthening rules on the disposal of coal ash, but not listing it as a hazardous waste under RCRA, which may have required the
impoundments to be lined at the bottom and covered on top. The Trump Administration attempted to weaken those rules, but those efforts were struck down in court. In August 2022, Earthjustice brought a lawsuit against EPA seeking stronger rules on coal ash. According to Earthjustice, 172 coal ash impoundments fall within Federal Emergency Management Agency 100-year floodplains.

Flooding also afflicts another subject of outdoor disposal—hog waste. Especially in North Carolina, a major locus of the U.S. hog industry with around eight million hogs, the waste from concentrated animal feeding operations (CAFOs) is flushed into uncovered and unlined lagoons (as they are called) where bacteria partially break it down. Then, it is sprayed onto cropland, causing horrific odors and serious health problems for those living nearby, who are disproportionately African American.

Hurricanes have flooded these lagoons, spreading the foul mix over large areas and drowning thousands or tens of thousands of hogs and millions of chickens, which are then landfilled or incinerated.

These lagoons are regulated at the state rather than the federal level, and North Carolina, at least, has been notoriously lax. In 2000, Smithfield Foods, the world’s leading pork producer, entered into an agreement with the North Carolina attorney general to fund a research program to find more environmentally sound methods of handling hog waste, but the results were modest. In 2018, Smithfield announced plans to cover most of its hog lagoons to protect them from rain and to capture the methane gas the waste generates for sale to generate energy (though that creates its own environmental problems).

Another important kind of waste is municipal solid waste (MSW)—household garbage. In the United States, about one-half of it—146 million tons a year—goes to landfills. There are now about 1,900 MSW landfills operating in the continental United States, and many more that are no longer operating (usually because they are full). A significant portion of these are located near a shoreline or river, or in a floodplain. One study found that in Florida, about 1,099 landfills (active or inactive) are within the present 100-year coastal flood zone, and this number will rise considerably as that zone expands.

Unlike hazardous waste landfills, MSW landfills are subject to few federal rules and are mostly under state or local control. Until the enactment of RCRA in 1976 and EPA’s adoption of its implementing regulations in 1980, there was little legal distinction between hazardous waste and MSW, and much of what we now think of as hazardous waste went to MSW landfills. That was lawful unless local public health laws provided otherwise.

These landfills were often sited in low-lying areas, and most of them lacked such modern systems as leachate collection, methane capture, and impervious liners at the bottom and caps on top. When it rained, the water seeped through, picked up contaminants from the waste, and leaked nasty liquid into the groundwater below or the nearby streams. After the enactment of CERCLA in 1980,
many of them became Superfund sites. Today, more than 250 of the landfills that received both hazardous waste and MSW are on the National Priorities List—about 23% of all sites on that list.93

These landfills were not sited or designed with sea-level rise or extreme flooding in mind, and their often primitive engineering means they are vulnerable to extreme weather. They are typically covered with soil and vegetation, and unless they are well maintained, the soil can erode or be washed away, exposing the waste. Rising groundwater—especially if salty—can eat away at whatever liners are there.94 If near the shore, some long-buried waste is uncovered and carried away by the waves; this “zombie garbage,” as it has been called, adds to the plastics in the ocean.95 Some landfills are so buoyant that if the groundwater below them rises and is not continually pumped out (into perpetuity, one presumes), they can creep upward, breaking their covers, liners, and piping.96

So far, the discussion has concerned how climate change affects waste that exists anyway. But the storms and wildfires that are worsened by climate change can themselves create very large volumes of waste: the debris left behind. The destroyed buildings, toppled trees, and everything else will block roads and cause health and safety hazards, and need to be quickly removed.

Hurricane Harvey created about 25 million cubic yards of debris, which is two-thirds of the total amount of MSW that Houston would ordinarily generate in a year.97 The usual systems could not handle that surge of waste. The state suspended many of its rules for waste handling and disposal, set up 228 temporary debris management sites, and allowed 25 landfills to exceed their permit limits, burned vegetative debris in special incinerators, and used employees and contractors to haul tens of thousands of loads in trucks.98 Hurricane Katrina generated about four times that much debris, and its removal and disposal cost $3.7 billion.99 Wildfires create similar mounds of debris (though, of course, they have been pre-incinerated),100 and depending on what they burn can spew dangerous levels of toxics into the air.101

The orderly and lawful demolition of a building involves the careful removal of asbestos-containing material, the draining of ozone-depleting substances from refrigerators, and the special handling and disposal of other hazardous materials. After a disaster, these niceties may not be possible; EPA and other agencies grant emergency exemptions or look the other way, and the landfills where the debris is taken may become laden with yet more toxic material.102 The debris often goes to old unlined landfills that had been closed but are reactivated for this purpose. In many places, these landfills are disproportionately located in disadvantaged communities.103

### III. How Should the Law Change to Cope With 4°C?

The environment does not care whether a chemical that has gotten into the air, water, or land is a waste or a product, or whether it was released while in storage or in transport, or accidentally or deliberately. But the law cares. The environmental statutes and regulations were written at different times and in response to different concerns or incidents, and they reflect interest group lobbying. The result is an often bewildering patchwork of requirements where the care with which a substance is handled depends on arcane regulatory distinctions that bear little relation to the actual environmental or health risk involved. Because RCRA covers only “waste,” the U.S. Court of Appeals for the District of Columbia (D.C.) Circuit famously spoke of its “mind-

numbing journey through RCRA” in determining whether a certain kind of slag was a waste.106

Because RCRA’s jurisdiction is limited to waste and oil, its regulations’ extremely detailed command-and-control rules only apply narrowly. EPCRA covers products as well as wastes, but it only requires planning and disclosure; it does not have substantive regulatory requirements. The Hazardous Materials Transportation Act covers a broad array of substances, and does have substantive requirements, but it only applies to transport-related activities. CERCLA also applies to many materials (but excludes petroleum) and imposes substantive rules, but only for the cleanup process. The Toxic Substances Control Act (TSCA),107 despite its broad-sounding name, applies mainly to chemicals that are newly introduced into commerce, with a limited look back at old ones.

The regulations in place have great complexity. EPA’s regulations under RCRA, CERCLA, EPCRA, and TSCA take up five volumes of fine print in the Code of Federal Regulations; the U.S. Department of Transportation’s regulations under the Hazardous Materials Transportation Act are another two volumes. However, the regulations were all written during a 1°C world. Some of them attempt to prepare for the sorts of extreme events that occur during a one-degree world, such as flash floods that quickly subside.

But none envisions a 3°C or 4°C world, whose day-to-day may resemble today’s extremes; and it is challenging to find even rough depictions of an extreme day in such a world (at least outside of the growing genre of “Cli-Fi”—climate fiction—and its post-apocalyptic visions). The most sophisticated of today’s engineered landfill designs will not work if the landfill is entirely under water or is engulfed in flames. Systems that depend on a continuous flow of water have problems if the rivers have run dry.

As discussed above, EPA could do more with its existing statutory authorities to reduce the spread of hazardous materials caused by extreme weather events. It could revise the National Contingency Plan under CERCLA, strengthen the regulation of coal ash under RCRA, expand the requirements for spill prevention and countermeasure plans under the CWA and the OPA, and make greater use of §112(r) of the CAA, all to explicitly require greater precautions against floods, storms, and wildfires. But this would only take us so far.

The current system with idiosyncratically different legal requirements applying to very similar activities is dysfunctional if we are heading toward a 4°C world. If the objective is to keep harmful chemicals out of the environment, it should not matter whether they are wastes or products. They should be subject to the same kinds of command-and-control rules based on their physical properties. (For some kinds of installations, technology standards may be best; for others, performance standards.) The facilities handling these chemicals should be able to withstand the conditions reasonably likely to occur (flooding, heat, etc.) at the end of their useful lives.

Flood maps that reflect the latest projections of future flooding should be utilized when siting and designing new facilities. Such maps should be used in the reviews of proposed projects that are subject to the National Environmental Policy Act (NEPA)108 or its state equivalents. EPA’s Risk Management Program Rule and OSHA’s Process Safety Management Standard both require that facility siting be considered,109 and EPA’s 2022 proposed revisions called for more care in siting facilities, though the focus was on proximity to residential communities rather than site vulnerability to extreme weather events.110

The situation for existing facilities is considerably different. It is one thing to site, design, and build a new facility to withstand future conditions; it is another thing entirely to retrofit a facility that is already in operation (or maybe closed long ago, but has left waste behind). Sometimes sensitive equipment can be raised or protective walls can be built, but often it is not physically possible or economically feasible to protect these places fully.

However, for facilities subject to CAA §112(r), the plans prepared in accordance with EPA’s August 2022 proposal would go a long way toward at least requiring companies to consider climate risks in their facility operations. A particularly important measure to protect facilities that handle dangerous chemicals is enhancing the resilience of the electric power supply, coupled with emergency generators that can withstand extreme weather and have ample fuel supplies, since loss of power has become a common cause of chemical releases, and extreme weather is leading to more power outages.110

As noted above, CAA §112(r) gives facilities a “general duty” to minimize hazards. EPA has interpreted this “to generally require owners and operators to adhere to recognized industry practices and standards in addition to any applicable government regulations.”111 If the organizations that set industry standards, such as the American Institute of Chemical Engineers and the American Society of Mechanical Engineers, were to establish standards that required consideration of future sea-level rise and other climate-related events in facility siting and operations, that would have important legal and practical effect.

One important step would be to create a nationwide inventory of the existing chemical and waste facilities and contaminated sites that are vulnerable to flooding under likely future climate conditions. (Ideally, the inventory would also reflect future wildfire conditions, but for these the mapping is far less advanced.) Then, decisions need to

107. 29 C.F.R. §1910.119(e)(3)(v); 40 C.F.R. §68.67(c)(5).
109. Id. at 53570.
be made about priorities. Different facilities will have different probabilities of flooding, and different health and environmental consequences if they do flood. They also have capacities to pay for improvements ranging from considerable (for some currently operating facilities) to zero (for many and probably most closed facilities).

Difficult choices will be needed in setting priorities, beyond just the calculation of risks, hazards, and costs (complex as those may be). That is particularly the case with CERCLA, the law that imposes the most stringent cleanup requirements. A common rationale in choosing CERCLA remedies is to avoid even a small health risk to people who, some day in the future, may drink water from under the site, or to children who someday may play in the dirt there.111

But it makes little sense to spend large sums of money (especially public money) cleaning up sites for future residents of places that will become uninhabitable as a result of climate change. It is true that contaminants from these sites may leak out and cause some environmental damage, but in a 4°C world, the chemicals carried in the water from the globe’s flooded waste and industrial sites could make those from many U.S. Superfund sites seem trivial. (To be fair, I have seen no study about this.) Scarce resources should be directed to actions that would have the greatest benefit.

Some have suggested that the waste in landfills that will be flooded should be moved to other locations.112 However, digging up buried waste poses dangers to the construction workers; it can cause some of the waste to become airborne and enter nearby communities; and hauling it by trucks to new disposal locations will, statistically, cause a certain number of fatal accidents. Several studies have found that these risks can exceed, perhaps by orders of magnitude, the risks to the site neighbors of the contamination staying in place.113 Moreover, finding a new place for the material is likely to be extraordinarily difficult. It is hard enough to find disposal locations for waste that was generated nearby; persuading a community to accept someone else’s trash (or ramming it down their throats) is even harder.

The massive containment areas for coal ash are typically owned or controlled by the electric utilities that used them, and these utilities should be responsible for covering them in a way that protects them from flooding. Likewise, the lagoons with hog waste should be protected from flooding, and the large pork companies that sold the meat from these operations should pay for all of this. Unlike CERCLA, where the wastes are often underground, the coal ash and hog waste are very vulnerable to flooding that could cause considerable harm.

It would be wonderful if society stopped generating the wastes that require disposal. The phaseout of coal as a source of electricity—an essential part of any decarbonization strategy—will stop the generation of coal ash. Though recycling and composting will moderate the amount of MSW, trends do not indicate major progress in eliminating it.114 Generation of RCRA hazardous waste has been about flat for the past two decades.115 Nor is there a marked downward trend in pork consumption.116 Under any scenario, large amounts of hazardous and noxious substances will continue to be created every day. Dealing with them, and with those that already exist, will be a great challenge as we approach a 4°C (or even a 2°C) world; we are not even doing it adequately in our current 1.2°C world.