

CBO

Expected Costs of Damage From Hurricane Winds and Storm-Related Flooding



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At a Glance

Strong winds from hurricanes and tropical storms, and flooding from storm surges and heavy rain, inflict losses on various sectors of the economy. They also impose costs on the federal budget. In this report, the Congressional Budget Office estimates expected values of those economic and budgetary costs. Expected costs represent average annual costs over the long run based on current conditions for climate, sea levels, and property development in places at risk of such storms. Estimates of expected costs are inherently uncertain.

- **Total Expected Economic Losses.** For most types of losses to the U.S. economy caused by hurricane winds and storm-related flooding, expected annual costs total \$54 billion, CBO estimates, equivalent to 0.3 percent of the nation's current gross domestic product. That total consists of \$34 billion in expected annual economic losses to the residential sector, \$9 billion to commercial businesses, and \$12 billion to the public sector.
- **Compensation for Losses.** CBO estimates that a combination of private insurance coverage for wind damage, federal flood insurance, and federal disaster assistance would cover roughly 50 percent of losses to the residential sector and 40 percent of losses to the commercial sector.
- **Effects on the Federal Budget.** Under current conditions and policies, the expected annual cost to the federal government—and thus to taxpayers—of damage from hurricane winds and storm-related flooding is \$17 billion for the major categories of spending that CBO analyzed.
- **Options for Policymakers.** Approaches that would reduce expected storm losses and their effects on the federal budget include limiting greenhouse gas emissions, increasing federal funding to assess flood risks or to lessen damage if storms occur, expanding purchase requirements for flood insurance, and increasing the share of disaster assistance paid for by state and local governments. Without policy changes, storm-related costs are likely to rise in the future because of climate change and increases in development in risky areas.



Contents

Summary	1
What Is CBO's Estimate of Expected Economic Losses?	1
Who Would Pay for Expected Economic Losses to the Residential Sector?	2
Who Would Pay for Expected Economic Losses to the Commercial Sector?	4
How Are Storms Expected to Affect the Federal Budget?	4
What Policies Might Reduce Expected Losses and Federal Costs?	4
Current Federal Programs That Address Damage From Hurricane Winds and Storm-Related Flooding	6
Federal Mitigation Efforts	6
The National Flood Insurance Program	7
Federal Disaster Assistance Programs	8
Estimates of Expected Economic Losses From Hurricane Winds and Storm-Related Flooding	8
Expected Losses to the Residential Sector	9
Expected Losses to the Commercial Sector	10
Expected Losses to the Public Sector	10
Expected Losses That CBO Could Not Estimate	13
Compensation for Expected Losses to the Residential and Commercial Sectors	13
Compensation for Flood Losses to Households	13
Compensation for Wind Losses to Households	15
Compensation for Flood and Wind Losses to Commercial Businesses	16
Expected Federal Spending in Response to Damage From Hurricane Winds and Storm-Related Flooding	17
Federal Spending to Address Losses	17
Federal Spending Implied by the Gap Between the NFIP's Premiums and Expected Costs	18
Expected Federal Costs That CBO Could Not Estimate	18
Basis for CBO's Estimates	19
Policy Approaches for Reducing Expected Storm Losses	19
Limit Greenhouse Gas Emissions	19
Increase Federal Funding to Assess Flood Risks	21
Expand Purchase Requirements for Flood Insurance and Better Align Premiums With Risks	22
Expand the Federal Role in Risk Mitigation	25
Increase State and Local Governments' Share of the Cost of Postdisaster Assistance	27

Appendix A: Federal Spending to Address the Public-Sector Costs of Damage From Hurricane Winds and Storm-Related Flooding, 2005 to 2016	31
Appendix B: How CBO Constructed Ratios of Federal Spending to Residential Flood Losses	37
List of Tables and Figures	43
About This Document	44

Notes

Unless otherwise specified, all years referred to in this report are calendar years, and all monetary values are expressed in calendar year 2017 dollars. Those values were adjusted to remove the effects of inflation using estimates of the gross domestic product price index contained in CBO’s August 2018 baseline projections.

Unless otherwise noted, amounts of federal spending indicate estimated outlays rather than budget authority.

Numbers in the text, tables, and figures may not add up to totals because of rounding.

Supplemental data for this analysis are available on CBO’s website (www.cbo.gov/publication/55019).



Expected Costs of Damage From Hurricane Winds and Storm-Related Flooding

Summary

Damage from hurricane winds, storm surges, and heavy rain impose costs on private entities, such as households and businesses, and on all levels of government. Such damage affects the federal budget in at least two ways:

- If the President declares a disaster in response to a severe storm, that declaration can lead to significant federal spending for repairs and assistance.
- When claims on the federally administered National Flood Insurance Program (NFIP) exceed the program's receipts from insurance premiums, net federal outlays rise.

In this analysis, the Congressional Budget Office estimates the expected annual economic losses to three sectors of the economy (residential, commercial, and public) and the expected annual costs to the federal government from hurricane winds and storm-related flooding. Those expected economic and budgetary costs represent average one-year costs based on current conditions for climate, sea levels, and property development in places at risk of severe storms. The estimates are based in part on large-scale commercial models that simulate damage from hundreds of thousands of potential storms that might occur under current conditions, along with their probability of occurring. Because expected costs account for potential damage from infrequently occurring catastrophic storms, they will be higher than actual costs in most years—but much lower than actual costs in a year when a catastrophic storm occurs.

In this analysis, CBO also estimates the shares of expected residential and commercial losses that would be covered by insurance claims or by federal aid and the shares that would be uncompensated. Finally, CBO examines five policy approaches that could reduce the magnitude of storm losses and their budgetary costs. Without policy changes, storm-related costs are likely to

rise in the future because of climate change and increases in development in risky areas.

Estimates of expected costs are inherently uncertain: They are limited by available data and computing technology and by evolving knowledge about the causes of storms and the resulting damage. In addition, estimates of the shares of expected losses that would be covered by insurance policies or federal assistance are uncertain. CBO's estimates are based on existing insurance coverage and past patterns of federal aid after disasters.

What Is CBO's Estimate of Expected Economic Losses?

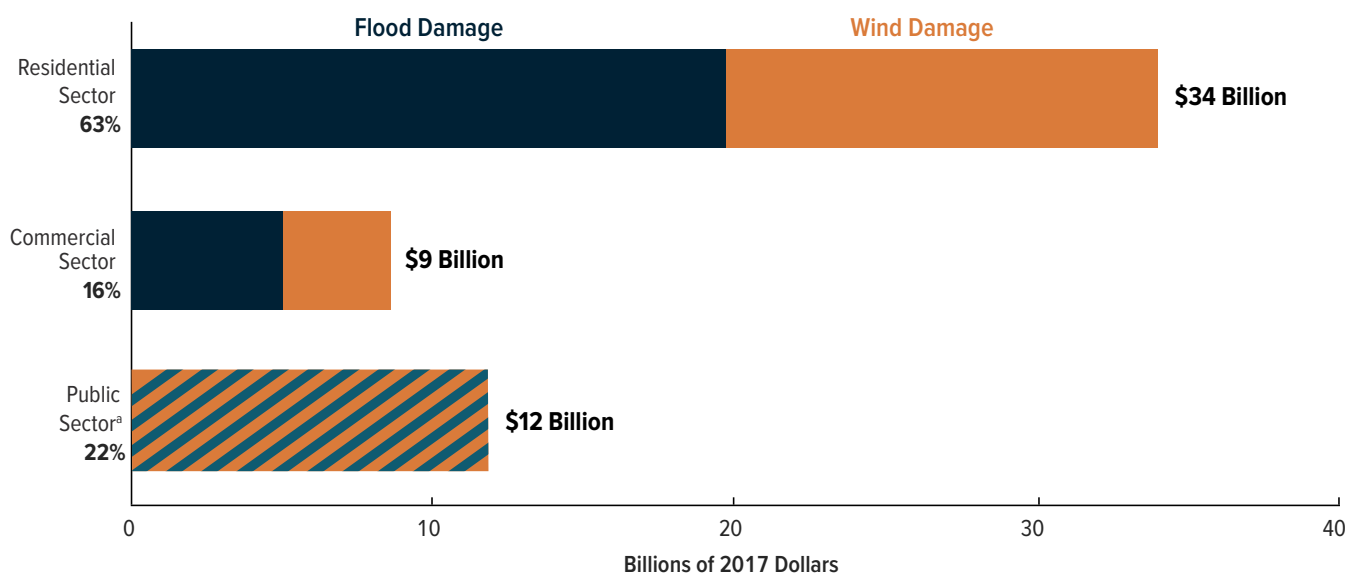
Hurricane winds and storm-related flooding are responsible for the bulk of damage from disasters in the United States.¹ For most types of damage caused by storm surges, heavy precipitation, or high winds from hurricanes or tropical storms, expected annual economic losses total \$54 billion, CBO estimates, which is equivalent to 0.3 percent of the nation's current gross domestic product (GDP). Before compensation from insurance payments or federal assistance, those losses consist of the following (see Figure 1):

- Expected annual losses of \$34 billion to the residential sector, including the costs of repairing homes and obtaining temporary housing;
- Expected annual losses of \$9 billion to the commercial sector, including the costs of repairing buildings and finding temporary space as well as

1. In the National Oceanic and Atmospheric Administration's database of disasters that have caused at least \$1 billion in damage, the categories "tropical cyclone" and "flooding" account for more than 60 percent of losses since 1980. See National Oceanic and Atmospheric Administration, "Billion-Dollar Weather and Climate Disasters: Summary Stats" (accessed February 1, 2019), www.ncdc.noaa.gov/billions/summary-stats.

Figure 1.

Expected Annual Economic Losses From Hurricane Winds and Storm-Related Flooding Under Current Conditions, by Sector and Source of Damage



Source: Congressional Budget Office, using data from Risk Management Solutions, the Federal Emergency Management Agency, the Department of Housing and Urban Development, the Small Business Administration, the Department of Transportation, the Government Accountability Office, and the Congressional Research Service.

The expected economic losses shown here are one-year costs (before compensation by insurance companies or federal programs) estimated on the basis of current conditions for such factors as climate, sea levels, and development in areas at risk of hurricane winds or storm-related flooding. The estimates are based on large-scale commercial models that simulate damage from hundreds of thousands of potential storms that might occur under current conditions. Because expected losses account for the potential damage from infrequently occurring catastrophic storms, they will be higher than actual losses in most years—but much lower than actual losses in a year when a catastrophic storm occurs.

Because of data limitations, these estimates exclude some types of expected losses, including some losses incurred by federal, state, and local governments (such as losses associated with damaged buildings or infrastructure that is not repaired); expected losses to businesses outside the commercial sector (such as farms or energy producers); and nonmonetary costs (such as the emotional cost of losing a home).

a. CBO could not determine the extent to which expected losses to the public sector would result from flood damage or wind damage.

revenue losses because of disruption to businesses; and

- Expected annual losses of \$12 billion to the public sector, including damage to public property and spending on recovery activities, such as removing debris.

CBO's \$54 billion total excludes some costs related to damage from hurricane winds and storm-related flooding because of data limitations. For example, that estimate does not include losses to assets that the federal government would not fully repair; expected losses to parts of the private sector other than commercial businesses, such as the energy, agricultural, and industrial sectors; and

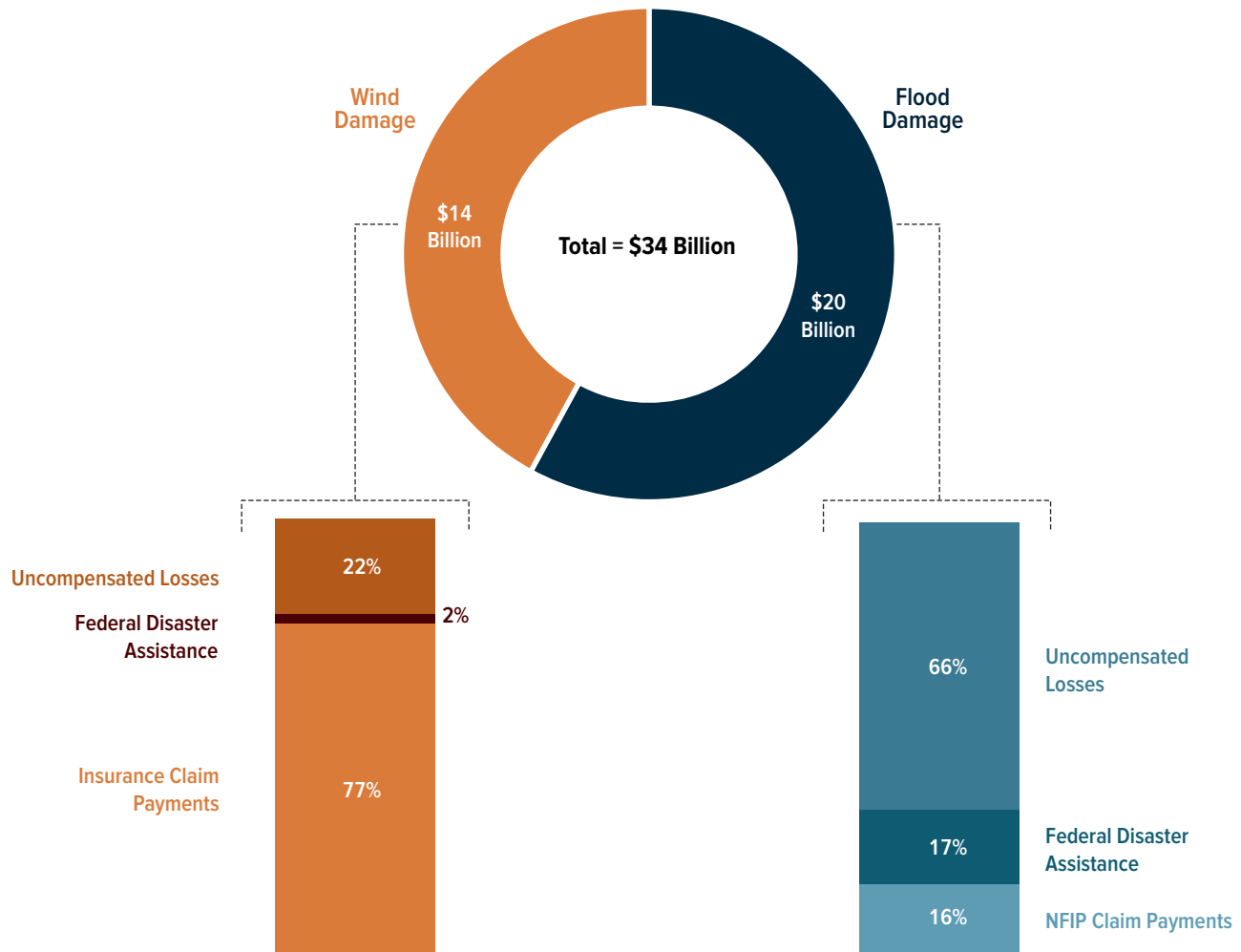
nonmonetary losses, such as the emotional cost of losing a home. In addition, CBO's estimate does not cover other types of storms that sometimes result in federal costs, such as blizzards and tornados, or other types of natural disasters, such as droughts and wildfires.

Who Would Pay for Expected Economic Losses to the Residential Sector?

Households can expect to receive compensation for roughly half of their economic losses from hurricane winds and storm-related flooding (for the types of losses included in CBO's analysis). However, the extent of compensation would differ greatly for wind-related losses and for losses from flooding, CBO estimates. That difference occurs mainly because homeowner's insurance

Figure 2.

Expected Annual Economic Losses to the Residential Sector Under Current Conditions, by Sources of Damage and Compensation



Source: Congressional Budget Office, using data from Risk Management Solutions, the Federal Emergency Management Agency, the Department of Housing and Urban Development, the Small Business Administration, and the Office of Management and Budget.

The expected economic losses shown here are one-year costs estimated on the basis of current conditions for such factors as climate, sea levels, and development in areas at risk of hurricane winds or storm-related flooding.

Dollar amounts are expressed in calendar year 2017 dollars.

NFIP = National Flood Insurance Program.

typically covers wind-related losses, whereas coverage for flood losses generally requires a separate policy—usually from the NFIP, which accounts for about 95 percent of residential flood insurance.

CBO estimates that insurance, provided largely by the private sector, would cover about three-quarters of households’ \$14 billion of expected annual wind losses

(see Figure 2). By contrast, federally provided flood insurance and federal disaster assistance would cover approximately one-third of households’ \$20 billion of expected annual flood losses.

Compensation for flood losses would differ significantly for households with and without NFIP policies. Claim payments would cover roughly 85 percent of losses for

NFIP-insured households, whereas federal assistance would cover about 20 percent of flood losses for uninsured households.

Who Would Pay for Expected Economic Losses to the Commercial Sector?

Commercial businesses—including those involved in wholesale or retail trade, transportation, health care, professional services, and hospitality—can expect to receive compensation for some of their losses from hurricane winds and flooding. CBO estimates that insurance claim payments would cover about 40 percent of the sector's \$9 billion of expected annual losses, including \$3 billion of expected wind losses and at least \$0.3 billion of expected flood losses. The amount of expected flood losses covered by insurance might be larger than \$0.3 billion depending on the degree to which private flood insurance would cover losses not paid for by the NFIP. (CBO could not determine the extent of private flood insurance coverage in the commercial sector.)

How Are Storms Expected to Affect the Federal Budget?

CBO estimates that under current conditions and policies, the expected cost to the federal government—and thus to taxpayers—because of damage from hurricane winds and storm-related flooding is \$17 billion per year for the major categories of related spending that CBO analyzed (see the bottom of Figure 3). That estimate is not comprehensive because it excludes some federal costs, such as those covered by regular annual appropriations. The \$17 billion figure includes the following:

- \$11 billion to address losses to the public sector (the estimated \$12 billion in such losses, net of required contributions by state and local governments),
- \$4 billion to provide individual assistance to households,
- \$1 billion to cover administrative costs associated with providing federal disaster relief, and
- \$1.4 billion in implicit federal subsidies for the National Flood Insurance Program.

CBO estimates a subsidy cost for the NFIP because the program's expected costs exceed its premiums, creating an expected annual shortfall of \$1.4 billion under current conditions. Raising NFIP premiums by \$1.4 billion would eliminate the expected shortfall.

The estimate of \$17 billion in *expected* federal spending is different from the estimates of spending on disaster assistance that CBO produces as part of its baseline budget projections, which do not rely on models that calculate expected costs.²

What Policies Might Reduce Expected Losses and Federal Costs?

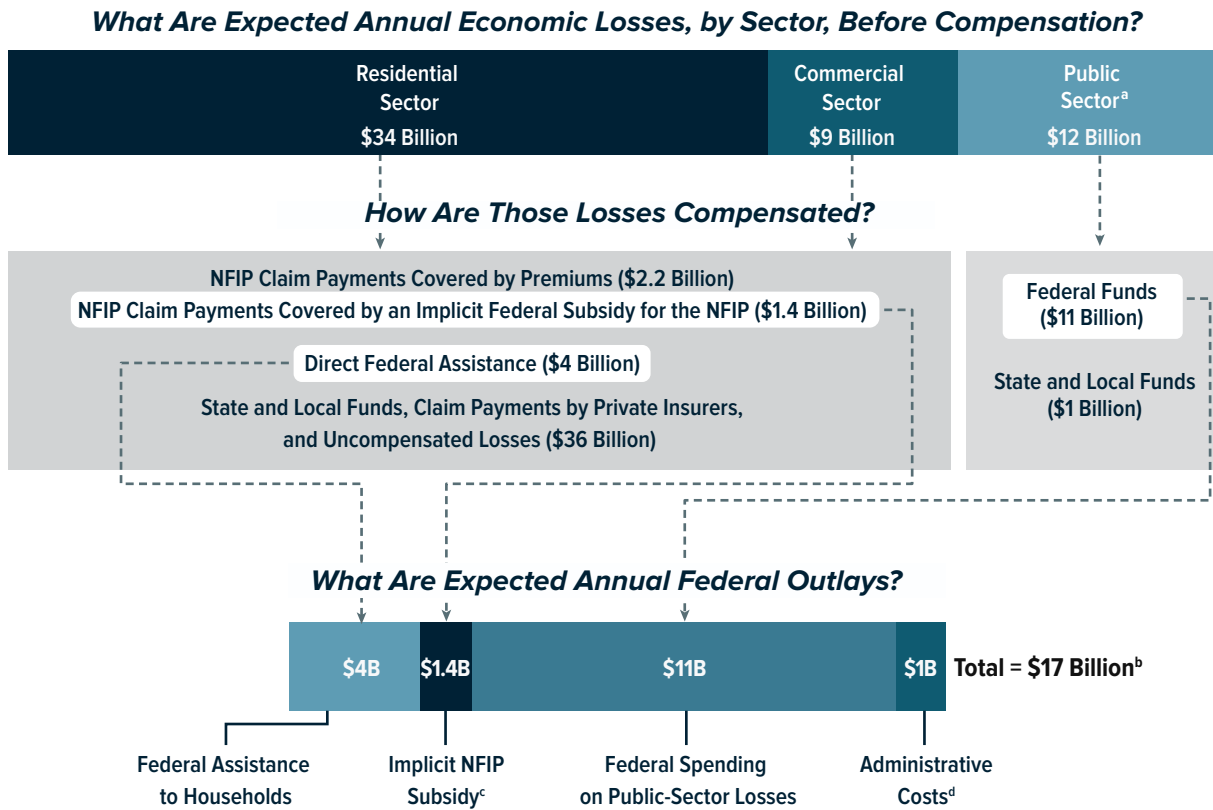
Lawmakers could pursue various approaches to decrease expected losses from hurricane winds and storm-related flooding and to limit the effect of those losses on the federal budget. CBO examined five approaches:

- **Limit greenhouse gas emissions**, which would reduce projected increases in sea levels and could lessen the severity of future storms, thus reducing the likelihood that storm damage will worsen in coming decades.
- **Increase federal funding to assess flood risks**, because up-to-date information about current and future risks could help people make more informed decisions about where to locate homes and businesses.
- **Expand purchase requirements for flood insurance and better align premiums with risks**, which would increase the number of households with flood coverage and improve the financial sustainability of the NFIP.
- **Expand the federal role in risk mitigation**, for example by spending more on predisaster activities that would reduce damage if storms occurred or by encouraging greater use of risk-reducing measures in new construction.
- **Increase the share of postdisaster assistance paid for by state and local governments**, which would give them more incentive to discourage development in vulnerable areas, thereby lowering expected costs from future storms.

2. As directed by the Balanced Budget and Emergency Deficit Control Act of 1985, CBO's baseline projections of disaster assistance and other discretionary spending reflect the most recent amounts appropriated, projected inflation rates, and the caps on discretionary spending in effect through 2021 under the Budget Control Act of 2011. See Congressional Budget Office, *How CBO Prepares Baseline Budget Projections* (February 2018), pp. 9–10, www.cbo.gov/publication/53532.

Figure 3.

Relationship Between Expected Economic Losses and Expected Federal Spending in Response to Damage From Hurricane Winds and Storm-Related Flooding Under Current Conditions



Source: Congressional Budget Office, using data from Risk Management Solutions, the Federal Emergency Management Agency, the Department of Housing and Urban Development, the Small Business Administration, the Department of Transportation, the Congressional Research Service, the Office of Management and Budget, and the Government Accountability Office.

The expected economic losses shown here are one-year costs estimated on the basis of current conditions for such factors as climate, sea levels, and development in areas at risk of hurricane winds or storm-related flooding. Because of data limitations, these estimates exclude some types of expected losses, including some losses incurred by federal, state, and local governments (such as losses associated with damaged buildings or infrastructure that is not repaired); expected losses to businesses outside the commercial sector (such as farms or energy producers); and nonmonetary costs (such as the emotional cost of losing a home).

Estimates of federal spending are based on obligations or allocations made by agencies or, in some cases, on supplemental appropriations provided to agencies. The amounts of federal spending are outlays estimated in calendar year 2017 dollars. These estimates are not comprehensive because they exclude some costs, such as those covered by regular annual appropriations.

FEMA = Federal Emergency Management Agency; HUD = Department of Housing and Urban Development; NFIP = National Flood Insurance Program; SBA = Small Business Administration.

- a. Includes public-sector losses addressed through federal spending from FEMA’s Disaster Relief Fund (DRF) programs, from the state and local cost sharing associated with the DRF Public Assistance Program, from HUD’s Community Development Block Grant Disaster Recovery program, and from supplemental appropriations to other federal agencies and departments.
- b. Includes \$40 million in expected federal compensation to the commercial sector through the SBA’s Disaster Loan Program. That amount represents the estimated subsidy cost of the loans (a budgetary measure of the federal government’s net cost).
- c. CBO estimated in 2017 that the NFIP has a one-year expected shortfall of \$1.4 billion. See Congressional Budget Office, *The National Flood Insurance Program: Financial Soundness and Affordability* (September 2017), www.cbo.gov/publication/53028.
- d. Consists of expected administrative costs associated with all of FEMA’s Disaster Relief Fund programs, HUD’s Community Development Block Grant Disaster Recovery program, and the SBA’s Disaster Loan Program. CBO could not determine administrative costs associated with other sources of federal compensation for disasters.

Current Federal Programs That Address Damage From Hurricane Winds and Storm-Related Flooding

Federal programs and policies directly affect both the size of economic losses from storms in the United States and the way in which postcompensation losses are distributed among the federal government, state and local governments, and private entities. Those federal programs and policies can be grouped into three categories:

- Federal mitigation efforts, which involve investments and policies aimed at reducing the magnitude of losses if a storm occurs;
- The National Flood Insurance Program, which provides insurance that some homeowners in flood-prone areas are required to purchase; and
- Federal disaster assistance, which comprises an array of policies and programs of several federal agencies that provide assistance to state and local governments, households, and businesses after a storm that results in a Presidential disaster declaration.

This section summarizes the aims and potential unintended effects of major federal policies and programs in each category. When discussing the size of storm-related losses, CBO is generally referring to their expected magnitude. Expected losses are based on the full range of potential storm events and the estimated losses for each type of event, weighted by the annual probability of that type of event. Expected losses are an appropriate measure to use when setting actuarially sound insurance rates or when weighing the costs and benefits of investments in mitigation measures. They can be much larger or smaller than actual losses in any given year.

Federal Mitigation Efforts

Since the early 20th century, the federal government has taken steps to reduce potential losses from storms. Today, the government has a range of programs and policies that influence the magnitude of expected losses, particularly from flooding.³ Those efforts include the following:

- Building large-scale infrastructure (such as levees, dams, and shoreline barriers) to try to protect areas from flooding.
- Building “green” infrastructure as well as undertaking nonstructural mitigation measures, such as preserving or restoring wetlands, dunes, and shoreline vegetation to help absorb storm surges and rainfall, or placing oyster beds along coastlines to reduce erosion.
- Funding efforts to restrict land use (such as by purchasing floodplain easements) or to reduce the flood risk to individual buildings (such as by elevating them or buying them out).

Federal mitigation programs are funded mainly from regular annual appropriations, particularly to the Army Corps of Engineers, the National Oceanic and Atmospheric Administration, the Department of Agriculture, and the Federal Emergency Management Agency (FEMA). In fiscal year 2018, annual appropriations that primarily targeted mitigation, coupled with income from NFIP premiums used for mitigation, totaled \$1.5 billion. (By contrast, federal disaster assistance is provided largely through supplemental appropriations, which furnish additional funding to a federal agency for a fiscal year already in progress.)

In the case of flooding, although federal mitigation policies are intended to reduce the magnitude of losses, they can sometimes have unintended harmful effects. That potential is greatest with large-scale mitigation projects, such as dams and levees. If such structures fail because of construction flaws, insufficient maintenance, or flood levels that exceed the conditions for which the structures were designed, damage can be catastrophic. (A vivid example of that occurred in August 2005 when Hurricane Katrina made landfall near New Orleans.) The amount of damage can be amplified by the fact that building dams and levees facilitates development in low-lying areas and can create a sense of safety that undermines incentives for local governments and individuals to take risk-reducing measures.⁴

Federal efforts can be complemented or counteracted by state and local governments’ decisions about local

3. For more details, see Nicole T. Carter and others, *Flood Resilience and Risk Reduction: Federal Assistance and Programs*, Report for Congress R45017 (Congressional Research Service, July 25, 2018), <https://crsreports.congress.gov/product/pdf/R/R45017> (PDF, 2.2 MB).

4. See Raymond J. Burby, “Hurricane Katrina and the Paradoxes of Government Disaster Policy: Bringing About Wise Governmental Decisions for Hazardous Areas,” *Annals of the American Academy of Political and Social Science*, vol. 604 (March 2006), pp. 171–191, www.jstor.org/stable/25097787.

development, which affect the size of expected losses from storms. For example, state and local governments determine zoning rules, which may permit or restrict development in areas known to be at risk.

The National Flood Insurance Program

The NFIP was established in 1968 in response to concerns that flood losses, and subsequent federal disaster relief, “placed an increasing burden on the Nation’s resources.”⁵ The program, which is administered by FEMA, was designed to promote “sound land use by minimizing exposure of property to flood losses” and to offer insurance that had proved difficult for the private sector to provide at affordable rates.⁶

The program directly affects both the magnitude of flood losses and the distribution of those losses among NFIP policyholders, U.S. taxpayers, and uninsured entities. To the extent that its flood insurance rate maps and premium rates underestimate flood risks, the program subsidizes households and commercial businesses that locate in flood-prone areas and decreases their incentives to take actions to reduce their risk.

Effects on the Scale of Expected Flood Losses. The NFIP aims to reduce expected flood losses in several ways. First, it uses premium revenue to award grants to state, local, and private entities to reduce flood risks through FEMA’s Flood Mitigation Assistance Program. Second, FEMA develops a flood insurance rate map for each community that participates in the NFIP (which enables the community’s residents to purchase NFIP policies). Those maps delineate areas of varying flood risks, including identifying “special flood hazard areas” (SFHAs), which face at least a 1 percent annual probability of flooding.

Third, the program requires participating communities to undertake a variety of mitigation activities. For example, all new residential buildings in an SFHA must meet specified elevation requirements and use certain construction materials and methods that help minimize flood damage.

Finally, to the extent that the NFIP charges higher premium rates for higher risks, those premiums can serve as an incentive to reduce flood risks. For instance, the program’s rates, combined with its flood maps, can inform communities, businesses, and households about the relative risks of buying or building structures in various locations. Maps and insurance rates may also influence policyholders’ decisions about what risk-reducing mitigation measures would be cost-effective to undertake, thereby directly affecting the nation’s expected flood losses. For example, policyholders might reduce their premium rate by elevating their home.

Effects on the Distribution of Flood Losses. The NFIP affects the extent to which the costs of flood losses are borne by policyholders, taxpayers, and uninsured entities in at least two ways. First, the program increases the purchase of flood insurance by requiring that owners of properties located in an SFHA have flood insurance as a condition of obtaining a federally backed mortgage. Increasing the prevalence of flood insurance decreases the amount of flood costs that are covered by taxpayers in the form of postdisaster assistance or that are borne by uninsured households.

Second, the structure and pricing of flood insurance determine whether the NFIP is self-sustaining and thus whether policyholders will bear all of the costs of paying claims for insured properties. FEMA sets NFIP premiums on the basis of flood insurance rate maps, and those premiums determine the program’s ability to pay claims. The NFIP is allowed to cover shortfalls by borrowing from the Treasury (up to a cap set by lawmakers). In 2017, CBO estimated that the program’s one-year expected shortfall was \$1.4 billion because the NFIP’s expected rate-based receipts and fees do not fully cover the expected costs of the program.⁷

The Congress can increase the borrowing authority available to the NFIP by raising the cap on borrowing or by forgiving some of the program’s outstanding debt. In October 2017, lawmakers enacted legislation forgiving \$16 billion of the NFIP’s accumulated debt, thus transferring that cost from policyholders to the

5. See 82 Stat. 573 for text in the original statute (section 1302(a) of Public Law 90-448). This language remains in statute (see 42 U.S.C. §4001(a)).

6. See 82 Stat. 573 for text in the original statute (section 1302(c) of P.L. 90-448). This language remains in statute (see 42 U.S.C. §4001(c)).

7. See Congressional Budget Office, *The National Flood Insurance Program: Financial Soundness and Affordability* (September 2017), www.cbo.gov/publication/53028.

federal government. The program's remaining debt totals \$20.5 billion.⁸

Federal Disaster Assistance Programs

When a large-scale storm or other disaster overwhelms the capacity of state and local resources to provide relief, the President may declare the event to be a major disaster. That declaration authorizes certain federal agencies, such as FEMA, to provide financial and technical assistance to state and local governments, individuals, and businesses in affected areas. The amounts and types of such assistance—which largely result from choices made by policymakers on a case-by-case basis—directly affect how the cost of storms is distributed among various levels of government as well as between the federal government and the private sector (including households and businesses).

Postdisaster assistance helps address immediate needs, such as removing debris, providing temporary shelter, and ensuring safety, as well as longer-term needs, such as repairing damaged homes, businesses, public buildings, and local infrastructure. (For more details about the types of disaster assistance provided by the federal government and past spending on them, see Appendix A.)

Like federal flood-mitigation efforts, federal assistance after storms has the potential to create undesired effects. For example, by lowering the costs that communities and individuals bear as a result of flooding and hurricane winds, postdisaster aid may unintentionally encourage development in vulnerable areas, undermine households' and businesses' incentives to buy flood insurance, and reduce the willingness to take actions that decrease the risk of incurring damage from floods and wind.

Estimates of Expected Economic Losses From Hurricane Winds and Storm-Related Flooding

Expected economic losses to the United States from hurricane winds, storm surges, and heavy precipitation total \$54 billion annually for most types of losses under current conditions, CBO estimates. (As discussed below, that total excludes some types of losses.) Estimates of expected losses represent the average annual losses that result from simulating many thousands of storms

that could potentially occur under current conditions, weighted by the probability of their occurring. Current conditions include the existing average global temperature, sea levels, sea-surface temperatures, and property development.

Before factoring in compensation from insurance payments or federal assistance, 63 percent of those expected losses would fall on the residential sector, 16 percent on the commercial sector, and the other 22 percent on the public sector, CBO estimates (see Figure 1 on page 2). (Public-sector losses are different from federal spending in response to disasters, as explained below.) Because of a lack of data, CBO could not estimate expected losses to other sectors of the economy, such as the industrial, energy, or agricultural sectors.

CBO's estimates are uncertain. They rely on commercially available models developed by Risk Management Solutions (RMS) that simulate thousands of potential storm events that could occur and the damage that would result from those storms. The number of each type of storm event modeled (such as a Category 3 hurricane hitting Miami) is based on its probability of occurring. Estimating those probabilities is difficult because storm events are infrequent and occur in no particular temporal pattern. Commercial models address that problem by simulating a very large number of storms. For example, RMS models thousands of hurricanes with physically realistic pathways and determines the frequency of landfall for hurricanes of a particular strength (such as a Category 4 storm) in a given area (such as a 100 kilometer stretch of the Florida coast) on the basis of events over the past 100 years. That approach seeks to develop a set of events that are physically realistic and that span the range of all possible storms that could occur in a given year.⁹

Those models' predictions of damage are uncertain. For example, in the case of coastal storms, sea levels and specific features of a storm, such as whether it occurs at high or low tide, can have a large effect on the severity of flooding that results. In addition, the location of a storm, the existence of flood barriers, and the number and type of buildings present will affect the amount of damage

8. See Federal Emergency Management Agency, "The Watermark: Fiscal Year 2018, Fourth Quarter" (December 20, 2018), www.fema.gov/media-library/assets/documents/161889.

9. See Michael Delgado and others, "Technical Appendix: Detailed Sectoral Models," in Trevor Houser and others, *American Climate Prospectus: Economic Risks in the United States* (Rhodium Group and Risk Management Solutions, October 2014), p. C-6, www.impactlab.org/research/american-climate-prospectus.

that occurs from a given type of event. According to a 2017 report by the American Academy of Actuaries, the modeling tools available for estimating catastrophic risk in general—and flood risk in particular—have improved in recent years, partly because of general improvements in computer technology that allow for more sophisticated simulation modeling and partly because of increases in the amount of data about property and hazard characteristics.¹⁰ Despite those recent improvements, the estimates derived from commercial models—the types used in CBO’s analysis—remain uncertain.

CBO’s estimates of expected annual costs are based on current conditions, including the extent of development in vulnerable areas, climatic conditions (such as sea levels and atmospheric and sea-surface temperatures), and government policies (such as zoning, building codes, insurance rates, and the extent of federal assistance). Expected costs will change as those conditions change. For example, in 2016, CBO projected that expected costs associated with hurricane-induced storm surges and wind (a subset of the expected costs included in this report) would grow by 40 percent by 2075 as a percentage of GDP.¹¹ That increase is projected to result from the combined forces of climate change, which raises sea levels and sea-surface temperatures (among other things), and coastal development, which increases the amount of property exposed to storm surges and hurricane winds.

Expected Losses to the Residential Sector

CBO estimates that, under current conditions, expected economic losses caused by hurricane winds and flooding from storm surges and heavy precipitation total \$34 billion per year. That estimate includes most, but not all, types of losses that households might experience. It consists of the costs of repairing homes to make them functional, renting furniture, obtaining temporary lodging in a hotel or rental property, and replacing possessions (such as clothing, furnishings, and appliances). The estimate covers precompensation losses incurred by households that are insured against losses from wind and flood damage as well as households that are not insured.

10. See American Academy of Actuaries, Flood Insurance Work Group, *The National Flood Insurance Program: Challenges and Solutions* (April 2017), p. 38, <https://tinyurl.com/y9hf9vuz> (PDF, 2.2 MB).

11. See Congressional Budget Office, *Potential Increases in Hurricane Damage in the United States: Implications for the Federal Budget* (June 2016), www.cbo.gov/publication/51518.

Table 1.

Expected Annual Economic Losses to the Residential Sector Under Current Conditions, by Insurance Status of Households

Billions of 2017 Dollars

	Insured Households	Uninsured Households	All Households
Losses From Flooding	4	16	20
Losses From Wind	12	2	14
Total Losses	16	18	34

Source: Congressional Budget Office, using data from Risk Management Solutions and the Federal Emergency Management Agency.

The expected economic losses shown here are one-year costs (before compensation by insurance companies or federal programs) estimated on the basis of current conditions for such factors as climate, sea levels, and development in areas at risk of hurricane winds or storm-related flooding.

Composition of Losses. Coastal storms, such as hurricanes and tropical storms, tend to be less frequent but far more costly than inland storms. The main reason is that the damage from coastal storms can include not only flooding caused by heavy precipitation but also flooding caused by storm surges and damage from hurricane-force winds.¹² As a whole for most types of damage, 75 percent of households’ expected annual losses are attributable to coastal storms and the other 25 percent to inland storms, CBO estimates.

Of households’ \$34 billion in expected economic losses, \$20 billion result from flooding and \$14 billion from wind, CBO estimates. Only about 20 percent of flood-related losses (\$4 billion) are expected to be incurred by households with insurance, whereas roughly 85 percent of wind-related losses (\$12 billion) are expected to be incurred by insured households (see Table 1).

Basis for CBO’s Estimates. The estimate of households’ expected losses from flooding was produced for CBO by RMS using commercially available models (one that

12. In this analysis, coastal storms consist of hurricanes and tropical storms, which create damage through high winds, storm surges, and heavy precipitation. CBO classifies all heavy-precipitation events that are not hurricanes or tropical storms as “inland storms.” However, precipitation from hurricanes can cause flooding in inland areas, and “inland” storms can cause flooding in coastal areas.

estimates damage from storm surges and one that estimates damage from heavy precipitation). Those models simulate tens of thousands of potential flood events that could occur throughout the United States in a given year and their probabilities. The estimate can be thought of as the amount of annual losses averaged over hundreds of years of flooding under current conditions. As such, actual flood losses in any particular year could be substantially higher or lower than one-year expected losses.

CBO's estimate of expected flood losses incurred by NFIP-insured households was based on three factors: an estimate of expected NFIP claims for policies in place in 2016 that CBO produced for a 2017 analysis of the program, the historical gap between the total flood damage that insured households report to the NFIP and the claim payments they receive, and an adjustment for expenses (such as the cost of obtaining temporary living quarters) that are considered economic losses but are not covered by NFIP policies.¹³

CBO's estimate of households' expected losses from hurricane winds was based on a report that CBO published in 2016.¹⁴ That estimate was developed using the same model used to estimate storm-surge damage described above. Specifically, the model accounted for the full range of potential hurricane events that could occur, along with their probabilities, given the current state of the climate and coastal development.

Expected Losses to the Commercial Sector

CBO estimates that, under current conditions, hurricane winds and storm-related flooding in the United States can be expected to cause annual economic losses of \$9 billion to the commercial sector, for most types of both insured and uninsured losses combined. Expected

losses consist of the costs of repairing buildings to make them functional; renting temporary space; and repairing and replacing equipment, inventory, and supplies. Those costs also include revenue losses from interruptions to business. The model on which CBO's estimate is based broadly defines the commercial sector as encompassing businesses and institutions associated with a variety of goods and services, including wholesale and retail trade, finance, insurance, education, the arts, and recreation.¹⁵

Composition of Losses. Of the commercial sector's \$9 billion in expected economic losses, 72 percent are attributable to coastal storms and 28 percent to inland storms, CBO estimates. Those losses consist of \$5 billion in expected losses from flooding and \$4 billion from wind damage. CBO could not estimate the share of commercial-sector flood losses covered by insurance. However, in the case of commercial-sector wind losses, information provided by RMS suggests that nearly all such losses are covered by insurance.

Basis for CBO's Estimates. CBO's estimate of expected annual flood losses to the commercial sector was determined by the same kind of commercially available model used to estimate expected flood losses to households. That estimate was produced by RMS. The estimate of expected losses from wind was based on the report about potential hurricane damage that CBO published in 2016.¹⁶

Expected Losses to the Public Sector

Besides imposing economic losses on households and commercial businesses, hurricane winds and storm-related flooding can cause losses to federal, state, and local governments. Those public-sector losses include damage to public buildings and infrastructure and the expenses associated with meeting emergency needs in

13. CBO's estimate of expected claim payments is based on an analysis of 5 million NFIP policies in effect on August 31, 2016, which approximate the policies currently in place in the contiguous United States. See Congressional Budget Office, *The National Flood Insurance Program: Financial Soundness and Affordability* (September 2017), www.cbo.gov/publication/53028. CBO determined the gap between NFIP-reported damage and NFIP claims on the basis of storm-specific data provided by FEMA. The adjustment for expenses such as temporary living costs was determined as a percentage of NFIP-reported damage from an estimate provided by RMS.

14. See Congressional Budget Office, *Potential Increases in Hurricane Damage in the United States: Implications for the Federal Budget* (June 2016), www.cbo.gov/publication/51518.

15. Specifically, the commercial sector consists of wholesale trade; retail trade; transportation and warehousing; information; finance and insurance; real estate and rentals and leasing; professional, scientific, and technical services; management of companies and enterprises; administration and support of waste management and remediation services; education services; health care and social assistance; arts, entertainment, and recreation; and accommodation and food services. This analysis does not include expected costs to parts of the economy other than the residential, commercial, and public sectors.

16. See Congressional Budget Office, *Potential Increases in Hurricane Damage in the United States: Implications for the Federal Budget* (June 2016), www.cbo.gov/publication/51518.

affected communities (for example, by removing debris and ensuring safety). CBO estimates the expected one-year losses to the public sector at \$12 billion.

The commercial models used to estimate expected losses to the residential and commercial sectors do not cover the public sector. Instead, CBO based its estimate of expected public-sector losses on actual public-sector losses from recent storms—specifically, on the ratio of public-sector losses to total residential flood losses from major storms that occurred between 2005 and 2016. (See Appendix A for details about public-sector losses from those storms and Appendix B for a discussion of how CBO constructed the relevant ratios.)

Composition of Losses. The ratio of public-sector losses to residential flood losses during the 2005–2016 period was higher, on average, for coastal storms than for inland storms. Thus, CBO calculated separate ratios for coastal and inland storms. For the coastal storms, public-sector losses include damage caused by storm surges and hurricane winds as well as by heavy precipitation, whereas for the inland storms, public-sector losses consist only of damage caused by heavy precipitation.

Of the public sector’s \$12 billion in expected losses, 80 percent are attributable to coastal storms and 20 percent to inland storms, CBO estimates. However, the data set of major storms during the 2005–2016 period does not allow CBO to determine the shares of expected public-sector losses resulting from flooding and from wind.

Basis for CBO’s Estimates. CBO estimated expected losses to the public sector in two steps. First, the agency assessed the ratios of public-sector losses to residential flood losses for a set of 46 inland storms and 12 coastal storms occurring between January 1, 2005, and December 31, 2016, that triggered Presidential disaster declarations. Next, CBO applied those ratios to its estimates of expected flood losses to the residential sector from inland storms and from coastal storms. In essence, CBO used total residential flood losses as a proxy for the severity of inland and coastal storms and as an indicator of the magnitude of public-sector losses. Although the relationship between public-sector losses and residential flood losses is likely to vary substantially from storm to storm, CBO’s estimate is based on its assessment that the relationship would be similar when averaged over large numbers of storms.

For the 46 historical inland storms, CBO estimated that public-sector losses totaled \$14 billion and that residential flood losses totaled \$52 billion, implying a ratio of 0.28. For the 12 coastal storms, public-sector losses totaled \$134 billion and residential flood losses totaled \$158 billion, implying a ratio of 0.85.

The historical public-sector losses used for those estimates include estimated federal outlays to repair damaged government (federal, state, and local) buildings and infrastructure, remove debris, provide emergency shelter, help communities recover from the storms, and control future flooding.¹⁷ The outlays came from an array of federal agencies and programs, with the largest share (35 percent) coming from FEMA’s Disaster Relief Fund (DRF) Public Assistance Program (see Table 2). Historical public-sector economic losses also include state and local spending that is required as part of some federally funded repair efforts. For example, disaster relief activities funded by the DRF typically require that state and local governments cover between 10 percent and 25 percent of the activities’ costs, with smaller required cost shares for larger disasters.¹⁸

The historical residential flood losses used for those estimates were calculated by multiplying CBO’s estimates of NFIP claims for past storms by the ratio of expected residential losses to expected NFIP claims for similar storms (coastal or inland). CBO estimated separate losses for the 12 coastal and 46 inland storms because the ratio of expected residential losses to NFIP claims is smaller for coastal storms, which occur in regions where

17. In this report, CBO’s estimates of federal outlays are based on agencies’ obligations or allocations or, in some cases, on supplemental appropriations to agencies. CBO did not have data on actual outlays that could be linked to storms. For more details, see Appendix B.

18. Under the 1988 Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law 100-707), the federal share of costs for relief activities funded by the DRF Public Assistance Program is at least 75 percent, with state and local governments funding the other 25 percent. However, the federal share can increase if damage reaches certain thresholds. See Bruce R. Lindsay, *FEMA’s Disaster Relief Fund: Overview and Selected Issues*, Report for Congress R43537 (Congressional Research Service, May 7, 2014), p. 20. The average federal share for the DRF Public Assistance Program was at least 90 percent for 5 of the 58 historical storms in CBO’s analysis, including a group of major hurricanes in 2005 (Katrina, Rita, Wilma, and Ophelia, which are counted as a single storm) and floods in Baton Rouge, Louisiana, in 2016.

Table 2.

Estimated Spending to Address the Public-Sector Costs of Damage From Hurricane Winds and Storm-Related Flooding That Occurred Between 2005 and 2016, by Agency and Program

	Outlays in Billions of 2017 Dollars	Percentage of Total Outlays
Federal Spending		
Federal Emergency Management Agency		
DRF Public Assistance Program	52	35
DRF mission assignment ^a	8	5
DRF Hazard Mitigation Grant Program	3	2
Army Corps of Engineers ^b	21	14
Department of Transportation ^c	19	13
Department of Housing and Urban Development—Community Development Block Grant Disaster Recovery Program	16	11
Department of Defense ^b	10	7
Department of Health and Human Services ^b	5	3
Other Agencies ^d	9	6
Subtotal	143	96
State and Local Cost Sharing ^e		
FEMA's DRF Public Assistance Program	5	3
FEMA's DRF Hazard Mitigation Grant Program ^f	1	*
Subtotal	5	3
Total	149	100

Source: Congressional Budget Office, using data from the Federal Emergency Management Agency, the Department of Housing and Urban Development, the Department of Transportation, and the Congressional Research Service.

The estimated spending shown here occurred in response to 58 major storms during the 2005–2016 period that were declared disasters by the President, thus triggering eligibility for federal disaster relief.

Estimates of federal spending are based on obligations or allocations made by agencies or, in some cases, on supplemental appropriations provided to agencies.

DRF = Disaster Relief Fund; FEMA = Federal Emergency Management Agency; * = between zero and 0.5 percent.

- Mission assignment consists of activities carried out by other federal departments and agencies that are funded by FEMA's Disaster Relief Fund. Roughly 85 percent of the estimated mission-assignment spending included here was provided in response to Hurricanes Katrina, Rita, and Wilma in 2005. The majority of such spending went to the Department of Defense and the Army Corps of Engineers.
- Estimated spending resulting from supplemental appropriations enacted in response to one or more of the 58 storms that CBO analyzed.
- Estimated spending resulting from allocations made by the Federal Highway Administration's Emergency Relief Program and supplemental appropriations enacted in response to one or more of the 58 storms that CBO analyzed. All supplemental appropriations provided to the Emergency Relief Program were excluded to avoid double counting.
- Estimated spending resulting from supplemental appropriations to the Departments of Education, Agriculture, Veterans Affairs, the Interior, and Commerce and to the Environmental Protection Agency.
- Because of data limitations, CBO could not estimate other state and local spending in response to the 58 storms that it analyzed.
- Includes only the state and local cost-sharing requirement associated with the program's public-sector projects.

more homeowners are insured, than the ratio for inland storms. (CBO estimates that NFIP claim payments for the 58 storms totaled \$39 billion: \$34 billion for coastal storms and \$5 billion for inland storms.)

Expected Losses That CBO Could Not Estimate

CBO's figure of \$54 billion in expected annual economic losses from hurricane winds and storm-related flooding covers most types of economic losses. However, because of a lack of data, the estimate omits several categories of such losses:

- CBO could not include projected federal disaster-related spending resulting from annual (rather than supplemental) appropriations, except spending by the DRF and the Federal Highway Administration's Emergency Relief Program, which have been funded by both annual and supplemental appropriations. However, in CBO's assessment, the omitted costs associated with annual appropriations are likely to be small.
- CBO's estimate of expected losses does not include the value of damage to public-sector property that governments might choose not to repair.
- Except for state and local cost sharing under the DRF Public Assistance Program and Hazard Mitigation Grant Program, CBO could not estimate expected public-sector losses to state and local governments for which they would not receive federal compensation. Assessing the potential size of omitted state spending is difficult because states do not typically track their spending on natural disasters.¹⁹
- The estimate does not include expected losses to the industrial sector (such as the damage to oil rigs and ensuing loss of business that the petroleum industry experienced from Hurricane Katrina in 2005).
- The estimate does not include less tangible costs of hurricane winds and storm-related flooding, such as disruptions to households and work schedules, school closings, and emotional distress.

19. See Ingrid Schroeder and others, *What We Don't Know About State Spending on Natural Disasters Could Cost Us: Data Limitations and Their Implications for Policymaking and Strategies for Improvement* (Pew Charitable Trust, June 2018), <https://tinyurl.com/yazezp57>.

Compensation for Expected Losses to the Residential and Commercial Sectors

CBO estimates that households would receive compensation from insurance payments and federal aid for roughly half of the residential sector's \$34 billion of expected annual losses from hurricane winds and storm-related flooding (for the types of losses included in CBO's analysis). The share of expected losses for which households would be reimbursed would be much smaller for flood losses than for wind losses, CBO estimates.

The commercial sector would receive compensation for at least 40 percent of its \$9 billion of expected losses, CBO estimates. Insurance payments would cover most losses from wind, and the NFIP would cover a small share of losses from flooding. However, CBO could not determine the extent to which private insurance would cover flood losses to commercial businesses.

State and local governments would also receive compensation from the federal government for some of their expected losses from hurricane winds and storm-related flooding. That compensation is discussed in the next section, which focuses on expected costs to the federal government from such disasters.

Compensation for Flood Losses to Households

Expected flood losses to the residential sector would generally be covered in one of three ways: by claim payments from the National Flood Insurance Program, by disaster assistance payments from the federal government, or by the affected households themselves. The NFIP and federal disaster assistance programs would each cover about one-sixth of households' expected flood losses, in CBO's estimation; households would be responsible for bearing the other two-thirds of those losses (see Figure 2 on page 3).

Amount of Flood Losses Covered by NFIP Claim Payments. CBO estimates that \$3.2 billion, or 16 percent, of the \$20 billion in expected residential flood losses would be covered by claim payments from the NFIP.²⁰ With NFIP-insured households expected to account for \$3.9 billion of flood costs to the residential sector, CBO's estimate implies that NFIP claim

20. See Congressional Budget Office, *The National Flood Insurance Program: Financial Soundness and Affordability* (September 2017), www.cbo.gov/publication/53028. That \$3.2 billion figure excludes \$0.5 billion in expected claim payments by the NFIP to commercial policyholders and claims adjusters.

payments would cover 83 percent of flood losses to insured households.²¹

The NFIP would pay for only a small percentage of expected flood losses to the residential sector as a whole because relatively few homeowners have flood insurance.²² Although homeowners with federally insured mortgages who live in special flood hazard areas are required to buy flood insurance, analysts estimate that only about 50 percent of homeowners in such areas have flood policies.²³ Moreover, substantial flooding can occur outside SFHAs. The combination of those factors can lead to large amounts of uninsured damage. For example, the City of New York estimates that less than 20 percent of the residential buildings inundated because of Hurricane Sandy in 2012 were covered by the NFIP.²⁴

Amount of Flood Losses Covered by Federal Disaster Assistance to Households. Catastrophic events that trigger a disaster declaration by the President may enable households to receive federal aid. That assistance can take many forms, including grants to repair homes, to address storm-related medical needs, and to obtain temporary housing, as well as access to federal loans.

CBO estimates that \$3.4 billion, or 17 percent, of expected residential flood losses would be paid for with federal disaster assistance, if the share of flood losses covered by such aid after future storms was similar to

21. Two factors contribute to that 83 percent figure. First, NFIP claim data indicate that claim payments cover 88 percent of insurable NFIP losses. Second, temporary living expenses, which RMS reports as accounting for about 6 percent of total residential flood losses, are not insurable under the NFIP. As a result, expected NFIP claim payments cover 88 percent of the 94 percent of total expected flood losses that are potentially insurable under the NFIP.

22. Private insurers provide some flood insurance coverage in the United States, but mainly through policies that complement rather than substitute for NFIP coverage. CBO could not estimate the amount of expected residential losses that would be paid for by private flood insurers, but that amount is likely to be small because available estimates indicate that private insurance accounts for only about 5 percent of residential flood coverage.

23. See Carolyn Kousky, *Financing Flood Losses: A Discussion of the National Flood Insurance Program*, Discussion Paper 17-03 (Resources for the Future, February 2017), p. 8, <https://tinyurl.com/y8prstgq>.

24. See City of New York, *A Stronger, More Resilient New York* (2013), p. 97, www.nycfedc.com/resource/stronger-more-resilient-new-york.

the average share covered after storms during the 2005–2016 period. If all of that assistance was targeted toward uninsured households (because NFIP-insured households would have the bulk of their losses reimbursed), federal aid would cover 22 percent of the total expected flood losses of uninsured households, CBO estimates.

The amount of expected federal disaster assistance is higher for coastal flooding than for inland flooding: Coastal storms account for 56 percent of expected residential flood losses but 70 percent (\$2.4 billion) of expected federal compensation for those losses. Inland floods, by contrast, account for 44 percent of expected losses but 30 percent (\$1.0 billion) of expected federal compensation for residential flood losses.

Basis for CBO's Estimates. CBO estimated the amount of expected federal disaster assistance that households would receive for flood losses by calculating the amount of actual assistance relative to residential flood losses that occurred during the 2005–2016 period for the 12 coastal storms and 46 inland storms that CBO examined.²⁵ For the coastal storms, CBO estimated that federal assistance to households totaled \$34 billion and that residential flood losses totaled \$158 billion, implying a ratio of 0.22. For the inland storms, CBO estimated that federal aid to households totaled \$6 billion and that residential flood losses totaled \$52 billion, implying a ratio of 0.12. The agency then applied those ratios to its estimates of expected residential flood losses from coastal and inland storms (see Appendix B).

Estimated Federal Assistance to Households After Past Storms. For each of the 58 major storms in its 2005–2016 data set, CBO assessed the amount of individual assistance that households received through four federal programs:

- FEMA's Disaster Relief Fund Individual Assistance Program provided \$14 billion to households (\$11 billion in response to coastal storms and \$3 billion in response to inland storms) to use for repairing damaged homes, obtaining temporary

25. For each of the coastal storms, CBO estimated the amount of federal assistance aimed at compensating households for flood-related damage by prorating that assistance on the basis of the share of households with wind and flood insurance (see Appendix B for details).

housing, and replacing damaged property.²⁶ Because of the cost-sharing requirement associated with part of the program, CBO estimates that \$0.3 billion of that total was paid for by state and local governments.

- FEMA's DRF Hazard Mitigation Grant Program provided \$2.3 billion to households (\$1.8 billion in response to coastal storms and \$0.5 billion in response to inland storms) to use for measures aimed at reducing future flood damage, such as elevating homes. CBO's \$2.3 billion estimate includes \$0.4 billion that was paid for by state and local governments as a result of a cost-sharing requirement.
- The Community Development Block Grant Disaster Recovery (CDBG-DR) program of the Department of Housing and Urban Development (HUD) provides grants to help states recover from Presidentially declared disasters. States directed \$22 billion of the grant money they received after the 58 storms to households (\$20 billion for coastal storms and \$2 billion for inland storms) to use for repairing or rebuilding homes. In some cases, CDBG-DR funds were used to buy out homes in areas at high risk of flooding.
- The Disaster Loan Program of the Small Business Administration (SBA) made \$8 billion of direct loans to individuals (\$6 billion in response to the 12 coastal storms and \$2 billion in response to the 46 inland storms) to help them repair their homes. The subsidy cost of those loans—which serves as the budgetary measure of the federal government's net cost—totaled \$1.4 billion (\$1.2 billion for coastal storms and \$0.2 billion for inland storms).

For the 58 storms that CBO examined, those programs provided a total of \$40 billion in compensation for households' flood losses. The CDBG-DR accounted for 55 percent of that total, although its share of compensation for residential flood losses varied widely among the

26. What this report refers to as the DRF Individual Assistance Program consists of several programs: the Individuals and Households Program (including Other Needs Assistance), Mass Care and Emergency Assistance, the Crisis Counseling Assistance and Training Program, Disaster Unemployment Assistance, Disaster Legal Services, and Disaster Case Management. This analysis included only assistance provided by the Individuals and Households Program, which accounted for almost all of the combined spending by those programs.

specific storms (from 80 percent for Hurricane Sandy in 2012 to 5 percent for Hurricane Irene in 2011).

On the basis of those four programs' shares of past federal assistance to households, CBO estimates that the CDBG-DR would provide \$1.8 billion of the \$3.4 billion in compensation for expected residential flood losses (see Figure 4). FEMA's Disaster Relief Fund, through the Individual Assistance Program and the Hazard Mitigation Grant Program, would provide \$1.5 billion of the expected compensation (including \$0.1 billion of state and local cost sharing).

Amount of Flood Losses Borne by Households.

Approximately \$13 billion, or two-thirds, of expected flood losses to the residential sector would not be reimbursed, CBO estimates, and thus would probably be borne by households. (That figure represents expected residential flood losses of \$20 billion, minus \$3.2 billion in expected NFIP claim payments and \$3.4 billion in expected federal aid to households.) Some of those losses might be covered by private insurance, but the amount would probably be small given that the NFIP accounts for roughly 95 percent of residential flood insurance.²⁷

Compensation for Wind Losses to Households

Unlike their losses from flooding, the vast majority of households' expected losses from hurricane winds would be reimbursed, CBO estimates. In the parts of the country that are considered prone to wind damage from hurricanes (21 states and the District of Columbia), 87 percent of households are insured against wind losses, CBO estimates, generally through their homeowner's insurance.²⁸ CBO did not have information about the coverage details of wind policies, so it estimated that the percentage of insurable residential losses covered by claims would be the same for wind losses as for

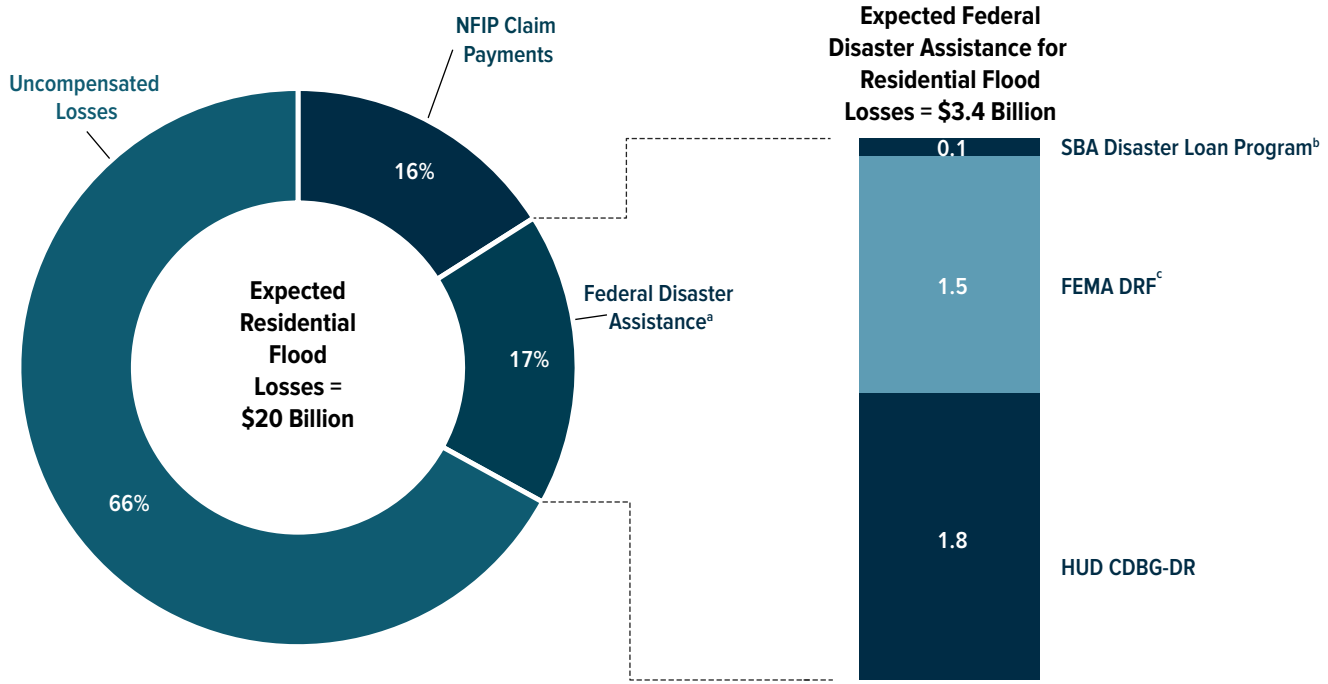
27. See Government Accountability Office, *Flood Insurance: Potential Barriers Cited to Increased Use of Private Insurance*, GAO-16-611 (July 2016), p. 18, www.gao.gov/products/GAO-16-611; and Carolyn Kousky and others, *The Emerging Private Residential Flood Insurance Market in the United States* (University of Pennsylvania, Wharton Risk Management and Decision Processes Center, July 2018), <https://tinyurl.com/yaxfzapi>.

28. In data provided by Risk Management Solutions, actual coverage varied among states from 85 percent to 89 percent. CBO's 87 percent average is based on each state's share of households with insurance, weighted by that state's share of expected wind damage.

Figure 4.

Sources of Compensation for Expected Annual Flood Losses to Households Under Current Conditions

Billions of 2017 Dollars



Source: Congressional Budget Office, using data from Risk Management Solutions, the Federal Emergency Management Agency, the Department of Housing and Urban Development, the Small Business Administration, and the Office of Management and Budget.

The expected economic losses shown here are one-year costs estimated on the basis of current conditions for such factors as climate, sea levels, and development in areas at risk of storm-related flooding.

CDBG-DR = Community Development Block Grant Disaster Recovery program; DRF = Disaster Relief Fund; FEMA = Federal Emergency Management Agency; HUD = Department of Housing and Urban Development; NFIP = National Flood Insurance Program; SBA = Small Business Administration.

- a. Includes expected compensation for residential flood losses paid through FEMA’s Disaster Relief Fund (including from the Individual Assistance Program and the Hazard Mitigation Grant Program), HUD’s Community Development Block Grant Disaster Recovery program, and the SBA’s Disaster Loan Program. The estimates of expected federal assistance are based on CBO’s estimates of federal spending following 58 major storms during the 2005–2016 period that were declared disasters by the President, thus triggering eligibility for federal disaster relief.
- b. Includes only the estimated subsidy cost of the loans (a budgetary measure of the federal government’s net cost).
- c. Includes a combined \$0.1 billion in expected assistance from state and local governments to fulfill their cost-sharing requirements under parts of FEMA’s DRF Individual Assistance Program and Hazard Mitigation Grant Program.

flood losses, 88 percent.²⁹ As a result, CBO estimates that insurance claim payments would cover 77 percent (88 percent x 87 percent) of the total expected economic losses (including losses to both insured and uninsured households) stemming from damage from hurricane winds. Thus, insurance would cover \$11 billion out of

\$14 billion in total expected wind losses, CBO estimates. In addition, households would receive federal assistance for a small amount (\$0.2 billion) of their uninsured wind losses through the four programs listed above, in CBO’s estimation.

Compensation for Flood and Wind Losses to Commercial Businesses

Of the commercial sector’s \$9 billion of expected losses from flooding and wind damage, at least 40 percent

29. See Footnote 21. Unlike NFIP policies, homeowner’s insurance policies typically cover temporary living expenses, a cost that is included in CBO’s estimate of residential losses; therefore, CBO did not have to adjust for those expenses.

would be compensated through insurance claim payments or federal assistance, CBO estimates. Specifically:

- Private insurance would cover most of the \$3.6 billion of expected wind losses,
- NFIP claim payments would cover roughly \$0.3 billion of the \$5.0 billion of expected flood losses, and
- The federal government, through the SBA's Disaster Loan Program, would provide low-interest loans with a subsidy value (federal cost) of \$0.04 billion.

Of the remaining \$5 billion of commercial-sector losses, CBO could not estimate how much would be covered by claim payments from private flood insurance and how much would be unreimbursed, because the agency did not have enough information to determine the extent to which commercial businesses have private flood insurance coverage.

In the case of wind losses, CBO had an industry estimate (from Risk Management Solutions) that virtually all commercial businesses in states at risk of hurricane winds are insured against such losses. As with residential wind insurance, CBO did not have information about coverage details for commercial wind policies, so it estimated that the percentage of insurable commercial wind losses covered by claims would be the same as the percentage of insurable commercial flood losses covered by claims, 86 percent. Thus, CBO estimates that \$3.1 billion of the commercial sector's \$3.6 billion of expected wind losses would be covered by claim payments.

The estimate that \$0.3 billion of expected flood losses to the commercial sector would be covered by NFIP claim payments was based on CBO's 2017 analysis of the program.³⁰

CBO's estimate of the expected subsidy value of SBA disaster loans for commercial businesses was based on

the ratios of SBA loan subsidies to residential flood losses seen for the 12 coastal storms and 46 inland storms from the 2005–2016 period that CBO analyzed. In response to those storms, the SBA's Disaster Loan Program made an estimated \$2.7 billion in direct loans to commercial businesses (\$2.3 billion for coastal storms and \$0.5 billion for inland storms) to help them repair their businesses and meet their expenses following the storms. Those loans had a total estimated subsidy cost of \$0.5 billion—which is a budgetary measure of the loans' net cost to the federal government.

Expected Federal Spending in Response to Damage From Hurricane Winds and Storm-Related Flooding

Disasters such as hurricanes and inland floods affect the federal budget in numerous ways. The expected economic losses from such disasters—in the form of damage to the residential, commercial, and public sectors—would result in federal spending of \$17 billion annually for the major categories of related spending, CBO estimates. That figure includes \$16 billion in expected federal outlays to address losses to the public sector, provide direct assistance to households and commercial businesses, and cover the administrative costs of providing that spending. CBO's estimate also includes an implicit \$1.4 billion expected annual subsidy of the National Flood Insurance Program. However, the \$17 billion total excludes some federal spending that CBO could not estimate, such as most disaster relief provided through regular appropriations rather than supplemental appropriations and federal spending on mitigation efforts that are not tied to any particular disaster.

Estimates of expected economic losses from heavy precipitation, storm surges, and hurricane winds take into account the potential damage from infrequently occurring catastrophic storms. As a result, expected losses will be higher than actual losses in most years—but much lower than actual losses in a year when a catastrophic storm occurs. The same is true for expected federal spending in response to such losses.

Federal Spending to Address Losses

CBO's \$16 billion estimate of expected federal spending to address losses from hurricane winds and storm-related flooding is the amount that would result if such spending, measured as a share of residential flood losses, was the same in the future as it was, on average, for major storms during the 2005–2016 period (see Appendix B

30. See Congressional Budget Office, *The National Flood Insurance Program: Financial Soundness and Affordability* (September 2017), www.cbo.gov/publication/53028. Total expected claim payments for storm-related flooding, including payments to residential and commercial policyholders and to claims adjusters, amount to \$3.7 billion. Payments to residential policyholders and claims adjusters are excluded from the \$0.3 billion estimate for the commercial sector.

for details). That estimate consists of four types of expected federal spending:

- **The amount spent on public-sector losses.** The federal government's one-year expected cost to address losses to the public sector from heavy precipitation, storm surges, and hurricane winds is \$11 billion, CBO estimates. That estimate consists of the \$12 billion in expected public-sector losses net of state and local cost sharing. The \$11 billion expected annual cost consists of federal outlays to repair federal, state, and local government property and to furnish community-level assistance (as opposed to assistance to households or businesses), such as removing debris and providing emergency shelters. Such outlays account for 65 percent of the estimated \$17 billion of expected federal spending in response to damage from hurricane winds and storm-related flooding (see the bottom of Figure 3 on page 5).
- **The amount spent on residential-sector losses.** The one-year expected cost of providing federal disaster assistance to households after hurricanes and inland floods is \$4 billion, CBO estimates, or about 20 percent of expected federal spending in response to such disasters. That amount consists of expected compensation that households would receive for losses from flooding and hurricane winds through FEMA's DRF Individual Assistance and Hazard Mitigation Grant programs, HUD's CDBG-DR program, and the SBA's Disaster Loan Program.
- **The amount spent on commercial-sector losses.** The one-year expected subsidy cost of federal loans to small businesses is \$0.04 billion, CBO estimates. Those low-interest loans from the Disaster Loan Program aim to help companies repair their business and meet expenses after a disaster.
- **The amount spent on federal administrative costs.** The expected cost of administering federal spending to address public-sector losses and provide assistance to households and commercial businesses is at least \$1 billion, CBO estimates.³¹

31. Expected administrative costs could be somewhat higher than \$1 billion because CBO could not distinguish between spending on addressing public-sector losses and spending on administrative costs for some activities funded by supplemental appropriations. Therefore, a small share of the amount of expected public-sector losses probably consists of administrative costs. CBO's \$1 billion

Federal Spending Implied by the Gap Between the NFIP's Premiums and Expected Costs

CBO's estimate of \$17 billion in expected annual federal spending in response to damage from hurricane winds and storm-related flooding includes a \$1.4 billion expected net cost for the NFIP—the amount by which the program's expected annual payments (to residential and commercial policyholders and to claims adjusters) exceed its expected income from premiums. CBO assumes that the shortfall would be financed by borrowing from the Treasury.³²

The program currently has a remaining accumulated debt of \$20.5 billion, and its borrowing is capped at \$30.4 billion.³³ If the NFIP does not generate sufficient income to repay such debt, and losses continue to accumulate, lawmakers can choose to forgive some or all of the debt or increase the program's cap on borrowing. (If the cap is reached, the NFIP's ability to pay claims and other expenses is limited to the amount of premiums it collects.) For example, in October 2017, Public Law 115-72 canceled \$16 billion of the NFIP's debt.

Expected Federal Costs That CBO Could Not Estimate

CBO's \$17 billion figure covers the major categories of annual federal outlays expected to result from losses caused by heavy precipitation, storm surges, and hurricane winds. Because of insufficient data, CBO could not estimate several other types of such costs:

- Some government spending on disaster relief that is funded through regular annual appropriations;
- Federal spending on mitigation efforts that are aimed at reducing the effects of future storms but that are not tied to any particular disaster;
- Federal spending on compensation to businesses outside the commercial sector, such as farms, energy producers, and industrial enterprises;

estimate is based on the administrative costs associated with the DRF programs, the CDBG-DR program, and the Disaster Loan Program.

32. For more information about the gap between the NFIP's premiums and expected costs, see Congressional Budget Office, *The National Flood Insurance Program: Financial Soundness and Affordability* (September 2017), www.cbo.gov/publication/53028.

33. See Federal Emergency Management Agency, "The Watermark: Fiscal Year 2018, Fourth Quarter" (December 20, 2018), www.fema.gov/media-library/assets/documents/161889.

- Reductions in federal tax revenues because of increased tax deductions associated with investments made to replace storm-damaged equipment or buildings; and
- Increases in spending when storm-related losses cause additional households to qualify for federal benefit programs, such as the Supplemental Nutrition Assistance Program.

Moreover, federal spending in response to damage from hurricane winds and storm-related flooding may not fully account for the government's losses. For example, storms may cause damage to government property that is not subsequently repaired. Such damage, if it is to federal property, is a cost to the federal government even though it does not result in federal spending.

Basis for CBO's Estimates

CBO based its estimate of expected federal spending to address losses to the public, residential, and commercial sectors on estimates of the amount of such spending after past storms relative to the amount of flood losses from those storms (see Appendix B). CBO's estimate of expected federal spending is uncertain and would change with shifts in future policies. If, for example, modifications to federal policy altered flood insurance coverage, the scale of uninsured losses would change, as would the demand for federal aid to households and commercial businesses.

In addition, the extent to which the federal government assists communities, households, and businesses can change over time and could be different in the future than it was during the 12-year historical period that CBO examined. That period captured the ratio of federal spending to residential storm losses from 2005 (the year of Hurricanes Katrina, Rita, and Wilma) through 2016. The ratio of federal spending to storm losses tended to be higher in that period than it was before Hurricane Katrina.³⁴

A further breakdown of estimated federal spending in response to 58 major coastal and inland storms during the 2005–2016 period reveals that 44 percent of that

spending was directed to repairing or replacing homes, government buildings, and infrastructure. Eighteen percent went to mitigation efforts, such as building flood-control structures and relocating or buying out homes in high-risk areas, and 18 percent went to emergency services. The remaining federal spending covered administrative expenses, health-related services, and various other recovery costs (see Table 3).

Policy Approaches for Reducing Expected Storm Losses

Federal lawmakers could take a variety of steps to decrease the size of expected losses from heavy precipitation, storm surges, and hurricane winds and to limit the effect of those losses on the federal budget. In this analysis, CBO examines five broad policy approaches:

- Limiting greenhouse gas emissions,
- Increasing federal funding to assess flood risks,
- Pursuing policy changes that would increase the prevalence of NFIP coverage and better align premiums with expected costs,
- Expanding the federal role in mitigating storm losses, and
- Increasing the shares of disaster assistance paid for by state and local governments to give them a greater incentive to account for expected storm-related costs when planning new development.

Limit Greenhouse Gas Emissions

Climate change, driven by greenhouse gas emissions, is expected to increase flooding in two ways: by causing sea levels to rise (which increases damage from storm surges in coastal areas) and by increasing the likelihood of extreme precipitation from hurricanes and other storms. Of those two mechanisms, the first is more certain—warmer oceans have higher sea levels because water expands as it warms and because warming melts land-locked ice masses, which release their water into the oceans.

Without limits on emissions, the rise in sea levels is predicted to accelerate in the second half of this century, followed by potentially large increases in sea levels

34. See Congressional Budget Office, *Potential Increases in Hurricane Damage in the United States: Implications for the Federal Budget* (June 2016), www.cbo.gov/publication/51518.

Table 3.

Estimated Federal Spending in Response to Damage From Hurricane Winds and Storm-Related Flooding That Occurred Between 2005 and 2016, by Use of Funds and Sector of the Economy

Category of Spending	Outlays in Billions of 2017 Dollars	Percentage of Total Outlays	Examples of How Funds Were Spent
Repairs and Replacement			
Public sector	58	28	Repair or replacement of federal, state, and local government buildings and infrastructure
Residential sector	31	15	Repair or replacement of damaged residential properties
Commercial sector	*	**	Loans to repair or replace businesses' structures and equipment ^a
Subtotal	90	44	
Mitigation, Relocation, and Buyouts			
Public sector	33	16	Repair or replacement of dams, seawalls, and other flood-control measures
Residential sector	4	2	Efforts to elevate, relocate, or buy out residences in high-risk areas
Subtotal	37	18	
Emergency Services			
Public sector	28	14	Debris removal, temporary shelter, and security services
Residential sector	8	4	Transient accommodations, transportation, and furniture rental
Subtotal	36	18	
Recovery			
Public sector	10	5	Economic development, tourism, and affordable rental units
Commercial sector	*	**	Loans to cover businesses' expenses following storms ^a
Subtotal	10	5	
Health Facilities and Services			
Public sector	5	2	Repair of medical facilities and states' shares of CHIP and Medicaid payments
Residential sector	*	**	Medical, dental, and funeral expenses
Subtotal	5	2	
Administrative Costs ^b	16	8	
Other Spending ^c	10	5	
Total	203	100	

Source: Congressional Budget Office, using data from the Federal Emergency Management Agency, the Department of Housing and Urban Development, the Small Business Administration, the Department of Transportation, the Congressional Research Service, the Office of Management and Budget, and the Government Accountability Office.

The estimated federal spending shown here occurred in response to 58 major storms during the 2005–2016 period that were declared disasters by the President, thus triggering eligibility for federal disaster relief.

The amounts and sector designations of spending in this table are not directly comparable with similar totals shown elsewhere in this report, which were designed for different purposes. For example, the amount of spending identified here as benefiting the residential sector is a more comprehensive measure than the figure given earlier in this report of \$40 billion in disaster assistance provided for households after the 58 historical storms. That \$40 billion consists only of federal spending that directly offset losses accounted for in Risk Management Solutions' measure of expected insurable losses from flooding. This table includes additional spending that aimed to help households recover from storms but that did not directly compensate them for insurable flood losses. Such additional spending included, for example, funds to repair damage caused by wind or funds to build affordable rental housing to help low-income households in affected communities recover from the storms.

Estimates of federal spending are based on obligations or allocations made by agencies or, in some cases, on supplemental appropriations provided to agencies.

* = between zero and \$500 million; ** = between zero and 0.5 percent; CHIP = Children's Health Insurance Program; SBA = Small Business Administration.

a. Includes only the estimated subsidy cost of loans provided by the SBA's Disaster Loan Program (the subsidy cost is a budgetary measure of the loans' net cost to the federal government).

b. Consists of estimated administrative costs associated with all of the Federal Emergency Management Agency's Disaster Relief Fund programs, the Department of Housing and Urban Development's Community Development Block Grant Disaster Recovery program, and the SBA's Disaster Loan Program. CBO could not determine administrative costs associated with other sources of federal compensation for disasters.

c. Includes estimated spending by six other agencies funded through supplemental appropriations. Spending by those agencies, which amounted to \$0.5 billion to \$2.5 billion per agency, largely addressed public-sector losses, but CBO could not divide it by purpose.

in coming centuries.³⁵ Those increases, along with other changes caused by warming (such as increases in droughts and the spread of certain invasive species), will adversely affect economic output in the future and have other negative effects that are not captured by changes in GDP (such as decreases in biodiversity).

A coordinated effort to significantly reduce global emissions of greenhouse gases—the most abundant of which is carbon dioxide—could lessen the potential for increased flooding in the future. The impact would be greatest in the latter part of this century and beyond.³⁶ Consequently, limiting emissions would not reduce the expected losses discussed in this report, which represent near-term losses under current conditions. But limiting emissions would slow the increase in expected losses in future years.

Lawmakers could consider a variety of policies that would reduce U.S. emissions of greenhouse gases. Policies that would put a price on emissions would best motivate cost-effective reductions. Such policies would provide an incentive for all U.S. households and businesses to undertake emission-reducing measures, up to the point where the cost of such measures was equal to the price on emissions. Lawmakers could put a price on emissions by taxing them or by capping them and distributing tradable rights to the emissions allowed under the cap (referred to as a cap-and-trade program).

Although putting a price on emissions would encourage cost-effective reductions and help limit future changes in the climate—thereby reducing the potential for adverse effects in the future—it would also affect the economy and the federal budget in several ways in the near term. For example, such a policy could reduce the nation's economic output and would raise the relative prices of emission-intensive goods and services, shift employment among sectors of the economy, and impose costs on the

federal government (either by raising prices of the goods and services that the government uses or by reducing the tax revenues collected on various sources of income).³⁷

Policies to reduce U.S. emissions would be most successful in limiting climate-induced increases in flooding in the United States if they were part of a coordinated global effort. One reason is that greenhouse gas emissions are global pollutants; their effects on warming are independent of where they are emitted. In addition, the United States' share of global carbon dioxide emissions has been shrinking: From 23 percent in 2000, it is projected to fall to 12 percent by 2050.³⁸

Finally, in the absence of comparable efforts by other major emitters, reductions in U.S. emissions would be partly offset by increases in emissions elsewhere. Such “leakage” can occur if emission-intensive industries relocate from the United States to countries with less stringent policies or if putting a price on U.S. emissions reduces domestic demand for oil, whose price is determined in a world market. In the latter case, the reduction in U.S. oil consumption would tend to depress the global price and thus lead to higher foreign demand.

Increase Federal Funding to Assess Flood Risks

Understanding and managing the risk of flooding requires accurately assessing and mapping that risk and keeping such maps up to date. Flood risk changes over time because of factors such as sea-level rise and land subsidence. In addition, increases in the amount of property development reduce the share of permeable land surface and may decrease the number of wetlands and mangroves, all of which help minimize damage from flooding.

Lawmakers could improve FEMA's ability to accurately assess and map the nation's current and future flood risks

35. See Robert E. Kopp and others, “Evolving Understanding of Antarctic Ice-Sheet Physics and Ambiguity in Probabilistic Sea-Level Projections,” *Earth's Future*, vol. 5, no. 12 (December 2017), pp. 1217–1233, <https://doi.org/10.1002/2017EF000663>; and Intergovernmental Panel on Climate Change, *Global Warming of 1.5°C: Summary for Policymakers* (October 2018), p. 9, www.ipcc.ch/sr15/chapter/summary-for-policy-makers.

36. See Stefan Rahmstorf, “Sea Level in the 5th IPCC Report,” *Real Climate* (blog entry, October 15, 2013), <https://tinyurl.com/mvy3h7j>.

37. See Congressional Budget Office, *The Economic Effects of Legislation to Reduce Greenhouse Gas Emissions* (September 2009), www.cbo.gov/publication/41266, cost estimate for H.R. 2454, the American Clean Energy and Security Act of 2009 (June 5, 2009), www.cbo.gov/publication/41189, and *Policy Options for Reducing CO₂ Emissions* (February 2008), www.cbo.gov/publication/41663.

38. See World Bank, “CO₂ Emissions (kt)” (accessed March 11, 2019), <https://data.worldbank.org/indicator/EN.ATM.CO2E.KT>; and Energy Information Administration, *International Energy Outlook 2017*, DOE/EIA-0484 (September 2017), Appendix A, Table A10, p. 11, www.eia.gov/outlooks/archive/ieo17/ieo_tables.php.

by increasing funding for agencies that analyze how climate change affects the potential for catastrophic storms and the extent of sea-level rise (such as the National Oceanic and Atmospheric Administration and the National Aeronautics and Space Administration, respectively). Lawmakers could also boost funding for FEMA's flood-mapping efforts, which totaled \$452 million in fiscal year 2018.³⁹

Improved flood maps would better inform communities about their flood risks and could also increase FEMA's ability to set premium rates for flood insurance that reflect policyholders' risks. Such rates could improve the financial soundness of the NFIP and provide greater incentives for households and businesses to undertake cost-effective measures to reduce their risk. (The benefits and drawbacks of adjusting NFIP premiums for risk are discussed in more detail in the next section.) Moreover, better assessments of future flood risks would enhance the ability of communities, households, and businesses to take those future risks into account when making decisions about where to allow development, where to live, or where to locate their business. Better incorporating future risks into current decisionmaking would in turn reduce the need for postdisaster assistance.

The benefits of improved mapping of flood risks might be limited by constraints on FEMA's ability to raise premium rates for NFIP policies. Such constraints include caps on the size of rate increases and "grandfathering" provisions that allow some policyholders to pay rates based on earlier flood maps even when the maps have been updated.

Previous Congresses have directed FEMA to improve its flood mapping. Specifically, the Biggert-Waters Flood Insurance Reform Act of 2012 mandated the creation of the Technical Mapping Advisory Council. In 2016, the council reported that although FEMA had fully or partially addressed most of its recommendations, the continued use of a paper-based, cartography-driven process for constructing flood insurance rate maps was time consuming and expensive, and the lengthy study process jeopardized technical credibility.⁴⁰ More recently, the council

39. That total comprises \$263 million in annual appropriations for FEMA's Flood Risk and Mapping program and the authority to spend up to \$190 million of the NFIP's premium income on floodplain mapping.

40. See Technical Mapping Advisory Council, *National Flood Mapping Program Review* (June 2016), pp. 15–16, <https://tinyurl.com/jcoasw> (PDF, 50.6 MB).

recommended that FEMA incorporate uncertainty into its mapping of the boundaries of special flood hazard areas, which trigger requirements for homeowners with federally insured mortgages to purchase NFIP policies.⁴¹

In November 2017, CBO examined the age of FEMA's flood insurance rate maps in the 166 U.S. counties with one-year expected NFIP claims of more than \$2 million. Those counties accounted for 89 percent of total expected NFIP claims estimated for all U.S. counties; 34 percent of total expected claims came from the subset of those 166 counties whose maps were no more than 5 years old, 29 percent came from the subset whose maps were 6 to 10 years old, and 26 percent came from the subset whose maps were at least 11 years old.⁴² The fact that the largest share of expected claims came from counties with the most recently updated flood maps probably indicates that FEMA prioritizes updating maps in areas where flood risk is relatively high.

Expand Purchase Requirements for Flood Insurance and Better Align Premiums With Risks

Lawmakers could reduce expected losses from flooding and the need for postdisaster assistance by expanding participation in the National Flood Insurance Program and by better aligning premium rates with expected costs. In making changes to premiums, lawmakers would have to weigh competing goals of the NFIP, including the desire to keep premiums low so homeowners would not decide to forgo flood insurance coverage.

Increase Participation in the NFIP. Owners of properties that are located in special flood hazard areas are required to buy either NFIP policies or qualifying private flood insurance as a condition of receiving a federally backed mortgage. (Federally insured mortgages account for roughly 70 percent of new loans on single-family homes nationwide.) However, many households that are required to buy flood insurance do not do so, and many households that buy policies do not keep them. One estimate is that roughly 25 percent of the households and businesses that buy flood insurance policies

41. See Technical Mapping Advisory Council, *2018 Annual Report Summary* (2018), <https://tinyurl.com/y8xk6p5r> (PDF, 2.8 MB).

42. See Congressional Budget Office, "Age of Flood Maps in Selected Counties That Account for Most of the Expected Claims in the National Flood Insurance Program" (supplemental material for *The National Flood Insurance Program: Financial Soundness and Affordability*, November 2017), www.cbo.gov/system/files/115th-congress-2017-2018/reports/53028-supplementalmaterial.pdf (61 KB).

drop them within a year of purchase.⁴³ Some researchers suggest that households' failure to buy or maintain flood insurance results in part from mortgage lenders' failure to enforce the requirement.⁴⁴

Lawmakers could consider several approaches for expanding participation in the NFIP. First, the government could improve compliance with the existing purchase requirement, perhaps by raising financial penalties on mortgage lenders that do not enforce the requirement or by imposing penalties on home and business owners who do not comply with it.⁴⁵ In either case, it would be important to ensure that the penalties were collected.

Second, lawmakers could expand purchase requirements to cover households and businesses that are located in areas mapped as having lower flood risks (outside a special flood hazard area). Analyses conducted after Hurricanes Harvey and Sandy indicate that the share of flooded homes located outside an SFHA was 68 percent in Harris County, Texas, and the share of flooded buildings outside an SFHA was more than 50 percent in New York City.⁴⁶ In addition, a FEMA report estimated that 40 percent of properties exposed

to storm-surge risk in coastal states are not located within an SFHA.⁴⁷

Third, the federal government could revise NFIP contracts so that they span multiple years and are automatically transferred to the new owner when a property is sold. Longer-term contracts could increase the voluntary purchase of flood insurance by covering a time period that better corresponds to more intuitive presentations of risk. For example, researchers conclude that some people have difficulty understanding probabilities and may dismiss risks that fall below a subjective cutoff. However, a 1 percent annual chance of flooding implies a roughly 10 percent chance of flooding over a 10-year period and a 26 percent chance of flooding over the life of a 30-year mortgage—descriptions of risk that may be more meaningful to potential buyers of insurance.⁴⁸ In addition, automatically transferring an NFIP contract to the new owner when a property was sold would help ensure continuous coverage.

Fourth, the federal government could make NFIP insurance a default option when certain households or businesses obtain a mortgage. To forgo flood insurance, those borrowers would have to opt out of it when they got the mortgage. That approach is based on findings from behavioral economics that consumers are more likely to keep a default option than to opt out in favor of some alternative.⁴⁹

More Closely Match Policyholders' Premiums With Their Risks. Lawmakers could reduce the extent to which the costs of the NFIP are borne by taxpayers by

43. See Erwann Michel-Kerjan, Sabine Lemoine de Forges, and Howard Kunreuther, "Policy Tenure Under the U.S. National Flood Insurance Program (NFIP)," *Risk Analysis*, vol. 32, no. 4 (April 2012), pp. 644–658, <http://dx.doi.org/10.1111/j.1539-6924.2011.01671.x>.

44. See Adelle Thomas and Robin Leichenko, "Adaptation Through Insurance: Lessons From the NFIP," *International Journal of Climate Change Strategies and Management*, vol. 3, no. 3 (2011), pp. 250–263, <https://doi.org/10.1108/17568691111153401>; and Erwann Michel-Kerjan, Sabine Lemoine de Forges, and Howard Kunreuther, "Policy Tenure Under the U.S. National Flood Insurance Program (NFIP)," *Risk Analysis*, vol. 32, no. 4 (April 2012), pp. 644–658, <http://dx.doi.org/10.1111/j.1539-6924.2011.01671.x>. The authors of the second article suggest that the short time that people keep policies might be compounded by the transfer of mortgages among financial institutions.

45. Compliance with the mandatory purchase requirement is currently enforced with civil penalties on lending institutions; see 42 USC 4012a(f). The federal government collects roughly \$250,000 to \$500,000 in penalty fees each year.

46. See Jeff Lindner and Steve Fitzgerald, *Hurricane Harvey—Storm and Flood Information* (Harris County Flood Control District, June 4, 2018), www.hcfd.org/hurricane-harvey/countywide-impacts; and City of New York, *A Stronger, More Resilient New York* (2013), p. 15, www.nycfedc.com/resource/stronger-more-resilient-new-york.

47. See Federal Emergency Management Agency, *National Flood Insurance Program: Report to Congress on Reinsuring NFIP Insurance Risk and Options for Privatizing the NFIP* (August 13, 2015), p. 27, <https://tinyurl.com/y6vfupzu> (PDF, 6.2 MB).

48. For further discussion, see Erwann Michel-Kerjan, Sabine Lemoine de Forges, and Howard Kunreuther, "Policy Tenure Under the U.S. National Flood Insurance Program (NFIP)," *Risk Analysis*, vol. 32, no. 4 (April 2012), pp. 644–658, <http://dx.doi.org/10.1111/j.1539-6924.2011.01671.x>; and Howard Kunreuther, "The Role of Insurance in Reducing Losses From Extreme Events: The Need for Public-Private Partnerships," *Geneva Papers on Risk and Insurance—Issues and Practice*, vol. 40, no. 4 (October 2015), pp. 741–762, <https://link.springer.com/article/10.1057/gpp.2015.14>.

49. See Howard Kunreuther, "The Role of Insurance in Reducing Losses From Extreme Events: The Need for Public-Private Partnerships," *Geneva Papers on Risk and Insurance—Issues and Practice*, vol. 40, no. 4 (October 2015), pp. 741–762, <https://link.springer.com/article/10.1057/gpp.2015.14>.

requiring that premiums more accurately reflect the program's expected costs. Such a change would help ensure the financial sustainability of the NFIP by reducing its expected shortfall and the likelihood that taxpayers, rather than policyholders, would bear some of the program's costs.

In addition, requiring that insurance premiums more accurately reflect the expected costs from flooding could reduce the size of flood losses in two ways. First, if higher premiums indicated higher risk, they could help homeowners understand the risk associated with living in a particular location. Second, such premiums could encourage homeowners to take risk-reducing actions, such as relocating heating and cooling equipment. By contrast, insurance rates that fall short of policyholders' expected claims can implicitly subsidize the choice to live in a flood-prone area and fail to provide adequate incentives for homeowners to make risk-reducing changes to their homes.

In a 2017 analysis of the NFIP, CBO found that premiums fell short of the program's expected costs and that many policyholders' rates may not reflect their actual flood risk.⁵⁰ In particular, CBO's analysis reached the following conclusions about the program:

- Considering all expenditures (including the cost of paying expected claims) and all premium income, the NFIP had a one-year expected shortfall of \$1.4 billion.
- Roughly 20 percent of NFIP policyholders pay discounted rates (premiums that are lower than what FEMA considers to be full risk). The discounts are mainly for properties built before flood insurance rate maps were developed.
- FEMA's full-risk rates are based on an estimate of expected annual claims that is roughly \$1 billion less than the expected claims from flooding estimated with commercially available models (\$2.7 billion based on FEMA's models and methods versus \$3.7 billion based on the commercial models that CBO used).

50. See Congressional Budget Office, *The National Flood Insurance Program: Financial Soundness and Affordability* (September 2017), www.cbo.gov/publication/53028.

- Under the NFIP, some groups of policyholders subsidize others. For example, the total premiums charged to policyholders in coastal counties are \$1.5 billion lower than their expected costs, whereas the total premiums charged to policyholders in inland counties exceed their expected costs by \$0.2 billion.

Better aligning premiums with flood risks would involve several challenges, such as improving assessments of flood risk through better mapping (as discussed above) and balancing competing goals of the NFIP. Those goals include keeping premiums low to prevent homeowners from facing large new costs or rate increases that could impose financial hardship and depress property values, potentially causing some people to forgo coverage.

Some observers have suggested that lawmakers could increase the share of NFIP policies that have actuarially sound premiums, while also addressing affordability concerns, by limiting discounted rates to households that meet certain income requirements or by providing financial assistance so low-income households could invest in measures that would reduce both their flood risk and their insurance rates.⁵¹ Either approach would entail higher administrative costs, however. Some researchers have suggested that HUD, rather than FEMA, could determine eligibility for discounted NFIP premiums because that department already administers means-tested programs.

FEMA has embarked on an effort, known as Risk Rating 2.0, to better reflect variations in flood risks for households within a given flood zone. (FEMA's flood insurance rate maps essentially have three different zones that are used for rate-setting purposes.) Although basing insurance rates on updated flood maps would help align premiums with actual flood risks, it might also cause communities to resist updates to FEMA's flood maps.

51. For further discussion on limiting discounted rates, see National Research Council, *Affordability of National Flood Insurance Program Premiums: Report 1* (National Academies Press, 2015), pp. 99–118, <http://tinyurl.com/ya4b7wzd>. For a discussion of providing financial assistance to households, see Government Accountability Office, *Flood Insurance: Comprehensive Reform Could Improve Solvency and Enhance Resilience*, GAO-17-425 (April 2017), www.gao.gov/products/GAO-17-425; and Carolyn Kousky and Howard Kunreuther, "Addressing Affordability in the National Flood Insurance Program," *Journal of Extreme Events*, vol. 1, no. 1 (2014), <https://doi.org/10.1142/S2345737614500018>.

Those updates can trigger higher insurance rates, so communities have an incentive to dispute them. Such disputes can significantly delay the adoption of a new map, thus allowing policyholders in the affected community to continue to pay lower-than-full-risk rates and setting the stage for the NFIP to have expected shortfalls.

Expand the Federal Role in Risk Mitigation

Another approach to reduce storm-related costs would be to increase the extent of predisaster activities that would decrease damage if storms occurred and to choose the most cost-effective of such risk-mitigation efforts. The federal government could help achieve those two goals in several ways, such as:

- Increasing federal funding for risk mitigation,
- Shifting federal spending on mitigation from investments made in the wake of a disaster to predisaster efforts in order to target funds toward investments that are likely to have high rates of return, and
- Increasing the stringency of building codes in areas at risk of storm damage.

Increase Funding for Risk Mitigation. The federal government could reduce expected storm damage—especially from flooding—by increasing its spending on various risk-mitigation efforts, including building physical barriers, such as seawalls; constructing or preserving green infrastructure, such as wetlands; elevating buildings; and buying out at-risk properties in low-lying areas. The federal government could also provide incentives for state and local governments, households, and businesses to make risk-reducing changes (for example, through risk-adjusted NFIP premiums, as discussed above, or through higher state and local cost sharing for federal disaster assistance, as described below).

In fiscal year 2018, federal funding from annual appropriations that primarily targeted mitigation totaled \$1.3 billion. About two-thirds of that total went to projects by the Army Corps of Engineers to reduce flood damage, and 11 percent went to watershed and flood-prevention projects by the Department of Agriculture. In addition to efforts funded by annual appropriations, NFIP premiums were expected to provide \$175 million for flood mitigation in 2018.

Investments in mitigation are beneficial if the up-front costs are outweighed by the present value of the decrease in expected costs from future flood damage.⁵² In 2007, CBO examined a subset of federal mitigation projects—those funded through FEMA's Pre-Disaster Mitigation Program—and concluded that they reduced expected future losses (measured in terms of discounted present value) by about \$3 for each \$1 spent on them.⁵³ The National Institute of Building Sciences' Multihazard Mitigation Council examined the same set of projects and estimated a \$4 reduction in expected future losses for each \$1 spent.⁵⁴ CBO's estimated rate of return was lower because CBO discounted all avoided future losses when calculating their present value and weighted mitigation projects by their dollar values when calculating averages.

In 2017, the Multihazard Mitigation Council released a follow-up report including an additional 12 years of data about mitigation projects and changing the method it used to calculate rates of return.⁵⁵ That report concluded that mitigation projects in general reduced future expected losses by \$6 for each \$1 spent on them and that projects aimed at reducing damage from river flooding reduced losses by \$7 for each \$1 spent. CBO has not reviewed the data and methods used in that analysis.

Significant uncertainty surrounds estimates of the benefits of mitigation efforts, and the information available about past projects may not reliably indicate the effectiveness of additional mitigation projects in the future. Moreover, a complete assessment would need to consider whether some mitigation measures, such as building seawalls, have unintended effects—for example, encouraging development in vulnerable areas or undermining incentives for residents to invest in their own risk-reducing measures.

52. A present value is a single number that expresses a flow of future income or payments in terms of an equivalent lump sum received or paid at a specific time.

53. See Congressional Budget Office, *Potential Cost Savings From the Pre-Disaster Mitigation Program* (September 2007), www.cbo.gov/publication/19166.

54. See Multihazard Mitigation Council, *Natural Hazard Mitigation Saves: An Independent Study to Assess the Future Savings From Mitigation Activities*, vol. 1 (2005), p. 5, <https://tinyurl.com/ybwemvxj> (PDF, 252 KB).

55. See Multihazard Mitigation Council, *Natural Hazard Mitigation Saves: 2017 Interim Report* (December 2017), www.nibs.org/page/mmc_resources.

Shift Federal Funds From Postdisaster Mitigation to Predisaster Mitigation. The federal government could increase the cost-effectiveness of its spending on risk mitigation by developing a more comprehensive and strategic approach for determining where and how to invest federal dollars in improving disaster resilience (the ability to recover from a disaster quickly and without harm to long-term economic prospects). Such an approach would target the most vulnerable areas and focus on investments likely to have high rates of returns.

In contrast to such a strategic approach, a 2015 report by the Government Accountability Office (GAO) observed that most federal spending on mitigation occurs in the wake of a disaster and is funded through supplemental appropriations rather than through regular annual appropriations.⁵⁶ Although individuals and communities may be more receptive to spending their own money on mitigation when they are recovering from a disaster, relying mainly on postdisaster funding has significant disadvantages. For example, officials may find it hard to focus on mitigation in the midst of recovery. GAO found that local officials were likely to fund multiple small mitigation projects scattered throughout the community, rather than focusing on ones that might have the largest return. In general, funding mitigation efforts through supplemental appropriations in the wake of disasters can create a reactionary and fragmented approach, in which particular disasters determine when and where the federal government invests in disaster resilience.

Increase the Stringency of Building Codes. The federal government could reduce the size of expected flood losses by enacting policies that would facilitate the use—and enforcement—of building codes that require stronger risk-reducing measures in new buildings. The particular set of building codes that would be cost-effective (by requiring changes whose additional costs would be outweighed by the resulting decrease in expected losses) would vary among communities on the basis of their exposure to flood risks. Building codes apply to new construction, so the risk-reducing measures they might require, such as elevating buildings or placing heating and cooling equipment on roofs, will typically cost less than if those measures are retrofitted to existing

structures. As a result, the measures are more likely to be cost-effective if they are included in construction projects initially.

Policymakers could increase the stringency of building codes in flood-prone areas in at least two ways:

- By revising FEMA's requirements for new buildings constructed in communities that participate in the NFIP, and
- By providing incentives for communities to update and enforce their building codes.

Revise Building Standards Under the NFIP. FEMA estimates that more than 90 percent of U.S. communities identified as having some degree of flood risk participate in the NFIP, which obligates them to comply with FEMA's minimum requirements for new buildings.⁵⁷ However, some of those requirements are less stringent than the most recent standards specified by the International Code Council (ICC), which produces some of the most widely used building safety codes.⁵⁸

Lawmakers could reduce expected losses by mandating that the NFIP's requirements be updated periodically to reflect shifting vulnerabilities to flood risk and changes in ICC standards. Because the mix of cost-effective risk-reducing measures differs by location, the program's requirements would be most cost-effective if they

56. See Government Accountability Office, *Hurricane Sandy: An Investment Strategy Could Help the Federal Government Enhance National Resilience for Future Disasters*, GAO-15-515 (July 2015), www.gao.gov/products/GAO-15-515.

57. Specifically, roughly 22,000 of the 24,000 communities that FEMA identified as having a risk of flooding participate in the NFIP. See Federal Emergency Management Agency, "The National Flood Insurance Program Community Status Book" (accessed February 23, 2018), <https://tinyurl.com/y7rn84ee>.

58. For example, the NFIP requires that the top of the lowest floor surface of a single-family home built in a special flood hazard area be at or above the base flood elevation (the level to which floodwater is expected to rise in a flood that has a 1 percent annual chance of occurring). See Flood Plain Management Criteria for Flood-Prone Areas, 44 C.F.R. §§60.3(c)(2) and 60.3(e)(4) (2017). In contrast, since 2015, the ICC's residential code has required that the lowest floor surface of a single-family home exceed the base flood elevation by at least one foot. See International Code Council and Federal Emergency Management Agency, *Reducing Flood Losses Through the International Codes: Coordinating Building Codes and Floodplain Management Regulations*, 4th ed. (September 2014), pp. 3–6 and 22, www.fema.gov/media-library/assets/documents/96634; and Federal Emergency Management Agency, "2018 I-Codes: Summary of Changes to Flood Provisions" (January 17, 2018), www.fema.gov/media-library/assets/documents/156934.

varied among communities. For example, a 2017 study found that the most efficient elevation to require when constructing buildings in coastal areas at risk of significant wave damage varied among states, from 6 feet to 10 feet.⁵⁹

Some research indicates that a relative lack of stringency in the NFIP's requirements may have led to increased losses from hurricanes. A 2013 study concluded that properties built after those requirements went into effect sustained more damage from Hurricane Charley, which made landfall in Florida in 2004, than similarly located properties that were built before the program's requirements took effect.⁶⁰ The authors attributed those results to the NFIP's elevation requirements being lower, and foundation requirements being less stringent, than the standards that had been in place previously.

Provide Incentives to Update and Enforce Building Codes. Lawmakers could also reduce expected losses by providing incentives for states to adopt and enforce updated construction standards. For example, the Safe Building Code Incentive Act of 2015, which was introduced in the 114th Congress, would have increased the amount of assistance that a state received after a major disaster if, when the disaster occurred, the state had in place—and was enforcing—a nationally recognized model building code (such as the ICC code) that had been updated in the previous six years.⁶¹

In 2013, FEMA estimated that 70 percent of participating NFIP communities had building codes that were based on some edition of the ICC standards.⁶² (The other participating communities had to comply, at a minimum, with the NFIP's requirements.) However, in the communities with ICC-based building codes,

those codes might be less stringent than the most recent ICC standards, for at least three reasons. First, although ICC standards are updated every three years, states differ in how frequently they adopt the new editions. In 2013, FEMA found that only 3 states and the District of Columbia had standards that were based on the 2012 edition of the ICC standards (the most recent at that time), 30 states had standards based on the 2009 edition, 15 states had standards based on the 2006 edition, and 2 states had standards based on the 2003 edition.⁶³ Second, states may choose to modify the ICC standards that they adopt. Third, some states allow local governments to set standards that differ from the state's building codes.

In addition, states may not enforce their codes. For example, according to a 2018 study by the Insurance Institute for Business and Home Safety, states vary widely in the adoption and enforcement of residential building codes designed to reduce wind damage.⁶⁴

Increase State and Local Governments' Share of the Cost of Postdisaster Assistance

Providing federal assistance in the aftermath of disasters that involve hurricane winds or storm-related flooding helps hard-hit communities, but it also reduces incentives for people to take into account how their decisions about where to live and locate businesses will affect their expected losses. In essence, federal assistance subsidizes growth in areas that are vulnerable to storm damage by shielding households, businesses, and state and local governments in those areas from the financial consequences of such decisions.

Increasing the share of postdisaster aid provided by state and local governments could encourage them to more fully account for the effects of their policies on expected losses from hurricane winds and storm-related flooding. As a result, they might choose to reduce the pace of development in areas at high risk of storm damage. Approaches for the federal government could include the following:

- Raising the minimum amount of statewide damage per capita that FEMA uses as the main criterion for determining whether to recommend that the

59. The efficient elevation is the point at which the marginal cost of elevating a building is equal to the marginal benefit. See Multihazard Mitigation Council, *Natural Hazard Mitigation Saves: 2017 Interim Report* (December 2017), www.nibs.org/page/mmc_resources.

60. See Carolyn A. Dehring and Martin Halek, "Coastal Building Codes and Hurricane Damage," *Land Economics*, vol. 89, no. 4 (November 2013), pp. 597–613, <http://le.uwpress.org/content/89/4/597.short>.

61. Safe Building Code Incentive Act of 2015, H.R. 1748, 114th Cong. (2015).

62. See Federal Emergency Management Agency, *Including Building Codes in the National Flood Insurance Program* (November 2013), pp. 9–10, www.fema.gov/media-library/assets/documents/85960.

63. *Ibid.*, p. 22.

64. See Insurance Institute for Business and Home Safety, *Rating the States: 2018* (March 2018), <https://tinyurl.com/yagt74uy>.

President declare a major disaster and provide federal assistance; and

- Reducing the minimum share of costs that the federal government is required to cover for assistance provided through FEMA's Disaster Relief Fund, thus raising the share borne by state and local governments.

Set a Higher Minimum Threshold for Disaster Declarations. Most federal postdisaster aid (including spending from the Disaster Relief Fund and the Community Development Block Grant Disaster Recovery program) is authorized only when the President declares a major disaster in response to a request by a governor or tribal leader. Some analysts and policymakers maintain that such declarations have been made for incidents that could have been handled by the affected states.

Since 1986, FEMA has used the estimated amount of statewide damage relative to a state's population as an indicator of the burden of a disaster. It has generally relied on that indicator as a threshold in deciding whether to recommend that the President declare an event a major disaster and thereby trigger federal aid. Although current law prohibits FEMA from making disaster determinations solely on the basis of population- or income-based formulas, statewide damage per capita is the principal criterion that FEMA uses to determine whether damage is severe enough to warrant recommending a major disaster declaration.⁶⁵

That indicator, however, may underestimate a state's resources compared with what the indicator signaled several decades ago. GAO reported in 2012 that the threshold for declaring a disaster is artificially low because it does not reflect the increase in individual income per capita that has occurred since the indicator was introduced in 1986 and because it has only been adjusted upward for inflation since 1999.⁶⁶ As a result, FEMA's

65. Section 320 of the 1988 Robert T. Stafford Disaster Relief and Emergency Assistance Act (P.L. 100-707) prohibits FEMA from denying assistance under that law to an area solely on the basis of a mathematical formula or sliding scale that is based on income or population. See Bruce R. Lindsay, *FEMA's Disaster Relief Fund: Overview and Selected Issues*, Report for Congress R43537 (Congressional Research Service, May 7, 2014), p. 16.

66. Originally set at \$1.00 per person in 1986, FEMA's statewide per capita indicator rose to \$1.35 by 2012 and \$1.46 by

indicator understates the amount of economic resources that states can draw on to fund their own disaster response efforts. Raising that indicator—or setting some other, more stringent requirement for measuring a state's need and capacity—could lessen the number of disaster declarations and thus reduce federal spending on disaster assistance.

Another proposal that has been considered would require states to have their own disaster contingency funds in place in order to be eligible for federal assistance. Such a requirement might increase states' capacity to handle emergencies without federal aid.⁶⁷

Reduce the Federal Share of Aid for Declared Disasters. For some relief activities funded through FEMA's Disaster Relief Fund, the federal share of costs is set by law at a minimum of 75 percent, with state and local governments paying the rest. The federal share can increase, however, if total damage reaches certain thresholds.⁶⁸ For the 58 major storms of the 2005–2016 period that CBO analyzed, the federal government covered 92 percent of the total cost of projects approved through the DRF Public Assistance Program, mainly because of high federal cost shares for large storms such as Hurricane Katrina.

Some analysts and policymakers have proposed that the statutory minimum federal share be reduced—to

2018 because of periodic adjustments for inflation since 1999. GAO estimated in 2012 that the indicator would have been \$3.57 in 2011 if it had been adjusted for increases in per capita income since 1986 and would have been \$2.07 in 2012 if it had been adjusted only for inflation since 1986. Of disaster declarations made between fiscal years 2004 and 2011, 44 percent would not have met the threshold to qualify for assistance if the statewide indicator had been adjusted for increases in per capita income, and 25 percent would not have qualified if the indicator had been adjusted for inflation since 1986, GAO estimated. See Government Accountability Office, *Federal Disaster Assistance: Improved Criteria Needed to Assess a Jurisdiction's Capability to Respond and Recover on Its Own*, GAO-12-838 (September 2012), www.gao.gov/products/GAO-12-838.

67. For a more detailed discussion of such options, see Bruce R. Lindsay and Justin Murray, *Supplemental Appropriations for Disaster Assistance: Summary Data and Analysis*, Report for Congress R43665 (Congressional Research Service, October 1, 2014).

68. See Bruce R. Lindsay, *FEMA's Disaster Relief Fund: Overview and Selected Issues*, Report for Congress R43537 (Congressional Research Service, May 7, 2014), p. 20.

50 percent, for example. Others argue that such a change might place too great a burden on state and local governments.

Another approach that has been discussed would be to convert some of the federal disaster aid provided to states into low-interest or no-interest loans. Those loans could be structured in such a way as to encourage states to plan for disasters. For instance, the government could offer lower interest rates, or a larger share of assistance in the form of grants rather than loans, for states that have taken steps to prepare for disasters.

Setting limits on the circumstances for providing federal assistance—or on the share of costs borne by the federal

government when a major disaster is declared—could reduce the amount of expected storm damage in at least two ways. First, such a change would give state and local governments more incentive to limit development in areas at relatively high risk of flooding, such as through zoning restrictions or stricter building code requirements. Second, such a change could encourage state and local governments to invest more in infrastructure that is designed to reduce storm damage, such as wetlands, sand dunes, and seawalls. However, reducing federal disaster assistance would increase the burden on state and local governments and could slow the recovery of affected communities.

Federal Spending to Address the Public-Sector Costs of Damage From Hurricane Winds and Storm-Related Flooding, 2005 to 2016

The Congressional Budget Office estimates that the federal government spent \$153 billion (including administrative costs) on addressing economic losses to the public sector from 58 major coastal and inland storms that occurred between January 1, 2005, and December 31, 2016. (For details about why CBO chose those storms to analyze and how it estimated federal spending on them, see Appendix B.) That federal postdisaster spending was aimed at assisting communities and repairing damaged property belonging to the federal, state, or local governments. It did not include federal postdisaster assistance to households and commercial businesses (which is discussed in Appendix B).

CBO's estimate of \$153 billion in federal outlays consists of \$71 billion for financial assistance to state and local governments, \$72 billion spent by federal agencies for disaster recovery efforts led by the federal government, and \$10 billion in administrative costs (see Figure A-1).

Outlays for Efforts Led by State and Local Governments

The \$71 billion for financial assistance to states and localities was allocated through three federal programs (which also spent \$9 billion on administrative costs associated with furnishing that assistance):

- The Disaster Relief Fund (DRF) Public Assistance Program of the Federal Emergency Management Agency (FEMA) provided \$52 billion to state and local governments to use for activities such as removing debris, protecting property, providing emergency shelter, and repairing public buildings and infrastructure. Including an estimated \$8 billion for administrative costs, the program spent \$59 billion on those activities in response to the 58 storms that CBO analyzed. More than half of that spending was used to repair or rebuild public buildings, roads, bridges, utilities, and other infrastructure (see Figure A-2).

- The Department of Housing and Urban Development's Community Development Block Grant Disaster Recovery Program provided states with \$16 billion of public-sector assistance for the 58 storms that CBO examined. Including an estimated \$1 billion for administrative costs, the program spent \$17 billion in response to those storms.¹ That assistance was used to repair or replace public buildings and infrastructure, provide public housing and affordable rental properties, and encourage economic recovery (see Figure A-3).
- FEMA's DRF Hazard Mitigation Grant Program provided \$3 billion to states to use for activities such as elevating or relocating public structures; upgrading, repairing, or providing protective measures for public facilities or infrastructure; implementing flood-control measures, such as dams, diversions, and retention ponds; or stabilizing shorelines. In addition, the program spent an estimated \$0.5 billion on administrative costs for public-sector assistance activities.

Outlays for Efforts Led by the Federal Government

Of the \$72 billion in estimated spending on federally led efforts to provide assistance and repair storm-damaged infrastructure, the bulk was provided through supplemental appropriations for four agencies:

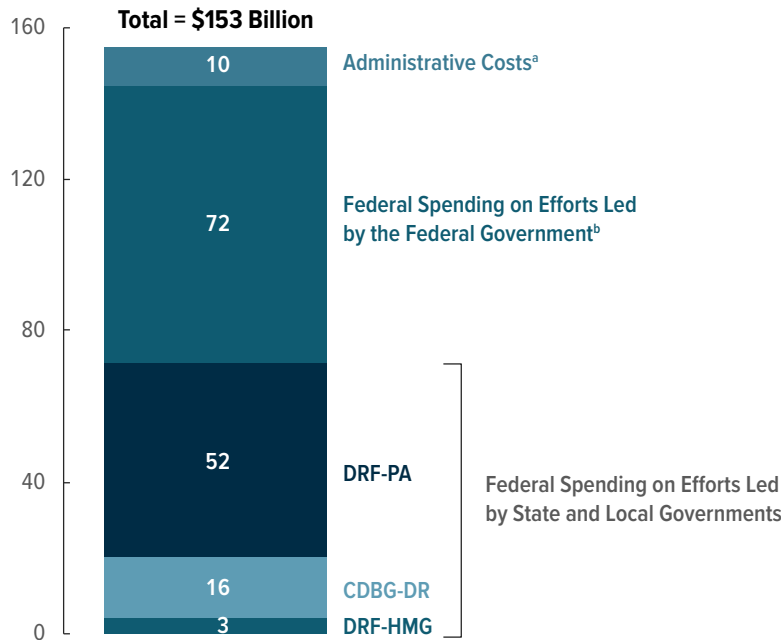
- The Army Corps of Engineers accounted for 29 percent (\$21 billion) of the total and used those funds mainly to repair and replace flood-control infrastructure (see Figure A-4);

1. States received an additional \$24 billion from the program for assistance to households to help them repair, rebuild, or relocate, for which the program spent \$0.8 billion on administrative expenses.

Figure A-1.

Estimated Federal Spending to Address the Public-Sector Costs of Damage From Hurricane Winds and Storm-Related Flooding That Occurred Between 2005 and 2016

Billions of 2017 Dollars



Source: Congressional Budget Office, using data from the Federal Emergency Management Agency, the Department of Housing and Urban Development, the Department of Transportation, the Congressional Research Service, and the Government Accountability Office.

The estimated federal spending shown here occurred in response to 58 major storms during the 2005–2016 period that were declared disasters by the President, thus triggering eligibility for federal disaster relief.

Estimates of federal spending are based on obligations or allocations made by agencies or, in some cases, on supplemental appropriations provided to agencies. The amounts of federal spending are outlays estimated in calendar year 2017 dollars.

CDBG-DR = Community Development Block Grant Disaster Recovery program; DRF-HMG = Disaster Relief Fund Hazard Mitigation Grant program; DRF-PA = Disaster Relief Fund Public Assistance program; FEMA = Federal Emergency Management Agency; HUD = Department of Housing and Urban Development.

a. Consists of administrative costs associated with federal spending on public-sector losses by all of FEMA’s Disaster Relief Fund programs and by HUD’s CDBG-DR program. CBO could not determine administrative costs associated with other sources of federal compensation for disasters.

b. Estimated outlays were based on obligations from FEMA’s Disaster Relief Fund to other federal agencies for “mission assignment” (work orders issued by FEMA that provide funds for other agencies to assist state and local governments with disaster recovery) as well as on supplemental appropriations enacted in response to one or more of the 58 storms that CBO analyzed. CBO included spending from supplemental appropriations to the Army Corps of Engineers; the Departments of Transportation, Defense, Health and Human Services, Education, Veterans Affairs, Commerce, Agriculture, and the Interior; and the Environmental Protection Agency.

■ The Department of Transportation accounted for 27 percent (\$19 billion) and primarily used those funds to repair highways and other transportation infrastructure;²

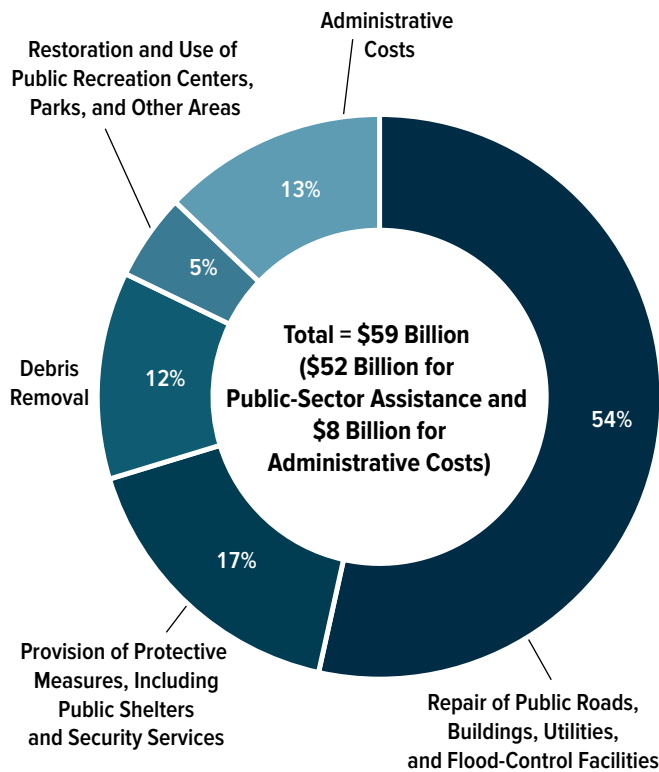
■ The Department of Defense accounted for 14 percent (\$10 billion), which it used mainly to cover the costs of deploying military personnel to help provide

2. That \$19 billion figure includes spending by the Federal Highway Administration’s Emergency Relief Program, which received about \$10 billion in supplemental appropriations during the 2005–2016 period in addition to its regular appropriations

of \$0.1 billion per year. See Robert S. Kirk and William J. Mallett, *Emergency Relief for Disaster-Damaged Roads and Public Transportation Systems*, Report for Congress R45298 (Congressional Research Service, August 29, 2018), <https://crsreports.congress.gov/product/pdf/R/R45298> (PDF, 1.2 MB).

Figure A-2.

Estimated Spending From FEMA’s Disaster Relief Fund Public Assistance Program to Address Damage From Hurricane Winds and Storm-Related Flooding That Occurred Between 2005 and 2016



Source: Congressional Budget Office, using data from the Federal Emergency Management Agency and the Government Accountability Office.

The estimated federal spending shown here occurred in response to 58 major storms during the 2005–2016 period that were declared disasters by the President, thus triggering eligibility for federal disaster relief.

Estimates of spending are based on obligations made by the Disaster Relief Fund Public Assistance Program. The amounts of spending are outlays estimated in calendar year 2017 dollars.

FEMA = Federal Emergency Management Agency.

emergency services and the costs of repairing damaged military structures and ships; and

- The Department of Health and Human Services accounted for 6 percent (\$5 billion), which went primarily to cover some of the affected states’ shares of payments to Medicaid and the Children’s Health Insurance Program and to restore medical facilities.

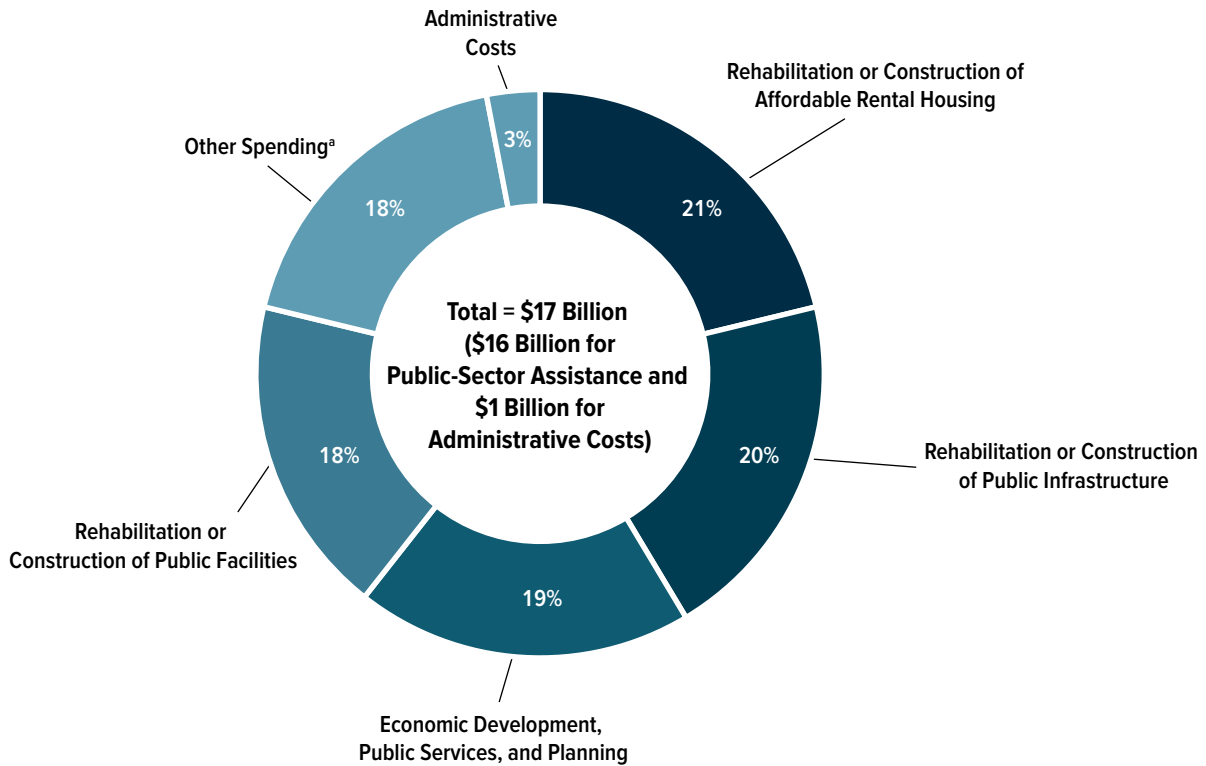
Estimated spending by six other federal agencies that received relatively small supplemental appropriations together accounted for 13 percent (\$9 billion) of the \$72 billion total. Those six entities were the Departments of Education, Agriculture, Veterans Affairs, the Interior, and Commerce, as well as the Environmental Protection Agency. In all, those six agencies and the four listed above accounted for \$64 billion of the \$72 billion total. Because of data limitations, CBO could not identify the share of that \$64 billion that went to administrative costs.

The remaining 11 percent of that total (\$8 billion) consisted of funds that FEMA’s Disaster Relief Fund directed to other federal agencies through “mission assignment”—work orders issued by FEMA that provide funds for other agencies to assist state and local governments with disaster recovery. Most of that spending was carried out by the Department of Defense and the Army Corps of Engineers, and roughly 85 percent of it was used to address damage from Hurricanes Katrina, Rita, and Wilma in 2005. FEMA spent an additional \$1 billion on administrative costs related to mission assignment, CBO estimates.

The composition of estimated federal spending varied substantially among the 58 storms that CBO examined. For example, most of the spending by the Army Corps of Engineers came in response to three hurricanes in 2005 (Katrina, Rita, and Wilma), whereas the bulk of the spending by the Department of Transportation came in response to Hurricane Sandy in 2012.

Figure A-3.

Estimated Spending on Public-Sector Assistance From HUD’s Community Development Block Grant Disaster Recovery Program to Address Damage From Hurricane Winds and Storm-Related Flooding That Occurred Between 2005 and 2016



Source: Congressional Budget Office, using data from the Department of Housing and Urban Development.

Funds from HUD’s Community Development Block Grant Disaster Recovery program can be used for a Presidentially declared disaster with the goal of assisting in long-term recovery efforts. The estimated federal spending shown here occurred in response to 58 major storms during the 2005–2016 period that were declared disasters by the President, thus triggering eligibility for federal disaster relief. Both individuals and communities can apply for grants from the program. This figure excludes spending used to compensate households, which accounted for about 60 percent of the program’s spending in response to those 58 storms.

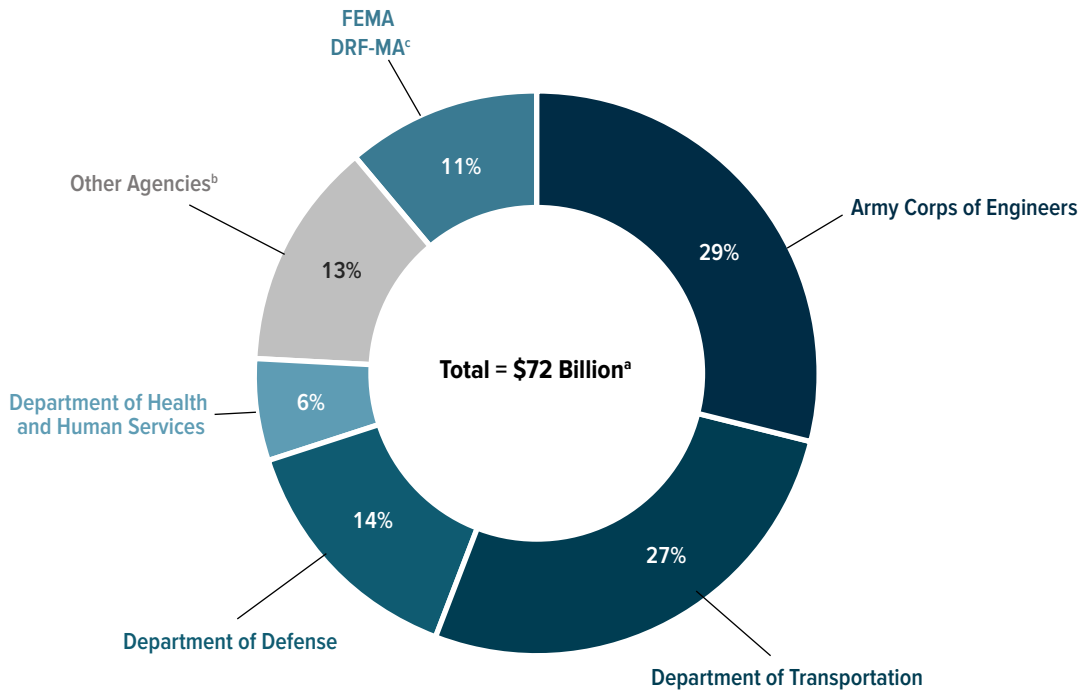
Estimates of spending are based on obligations made by the Community Development Block Grant Disaster Recovery program. The amounts of spending are outlays estimated in calendar year 2017 dollars.

HUD = Department of Housing and Urban Development.

a. Consists of \$3 billion in spending on miscellaneous activities that received relatively small amounts of funding from the program. Of that \$3 billion, roughly 20 percent was for the acquisition and disposal of property, 15 percent was for emergency services (such as clearance and demolition), 10 percent was for mitigation activities (such as restoration of dams and riverbanks), and 10 percent was for construction of new or replacement housing.

Figure A-4.

Estimated Spending on Efforts Led by the Federal Government to Address the Public-Sector Costs of Damage From Hurricane Winds and Storm-Related Flooding That Occurred Between 2005 and 2016



Source: Congressional Budget Office, using data from the Federal Emergency Management Agency, the Department of Transportation, and the Congressional Research Service.

The estimated federal spending shown here occurred in response to 58 major storms during the 2005–2016 period that were declared disasters by the President, thus triggering eligibility for federal disaster relief.

Estimates of federal spending are based on obligations or allocations made by agencies or, in some cases, on supplemental appropriations provided to agencies. The amounts of federal spending are outlays estimated in calendar year 2017 dollars.

FEMA DRF-MA = Federal Emergency Management Agency’s Disaster Relief Fund mission assignment.

- a. Because of data limitations, CBO could not identify how much of that spending was for administrative costs. Excludes federal spending by FEMA and the Department of Housing and Urban Development on disaster relief efforts led by state and local governments.
- b. Consists of estimated spending resulting from supplemental appropriations to the Departments of Education, Agriculture, Veterans Affairs, the Interior, and Commerce and to the Environmental Protection Agency.
- c. Mission assignment includes activities carried out by other federal departments and agencies that are funded by FEMA’s Disaster Relief Fund. Roughly 85 percent of the estimated mission-assignment spending included here occurred in response to Hurricanes Katrina, Rita, and Wilma in 2005. The majority of such spending was carried out by the Department of Defense and the Army Corps of Engineers.

How CBO Constructed Ratios of Federal Spending to Residential Flood Losses

For this analysis, the Congressional Budget Office estimated the federal government's expected annual spending on four activities in response to damage from hurricane winds and storm-related flooding:

- Addressing losses to the public sector,
- Compensating affected households,
- Compensating affected commercial businesses, and
- Covering administrative costs associated with those categories of spending.

In each case, the estimate of expected federal spending was calculated by looking at the relationship between such spending after past storms and the amount of residential flood losses produced by those storms. That relationship was determined separately for two categories of storms—coastal storms (defined as hurricanes and tropical storms) and inland storms (defined as other storms that cause flooding through heavy precipitation)—because past public-sector losses and federal spending tended to be larger for the coastal storms that CBO examined than for the inland storms.

Specifically, CBO estimated *expected* annual federal spending for each activity (such as compensating households) using two steps. First, CBO determined the ratio of *historical* federal spending on that activity to *historical* residential flood losses for similar storms (coastal or inland) among the 58 storms from the 2005–2016 period that the agency analyzed. Second, CBO multiplied those ratios by its estimate of *expected* annual residential flood losses for such storms.

For example, the ratio of past federal spending on compensating households to past residential flood losses was 0.24 for coastal storms. Applying that ratio to CBO's estimate of \$11 billion in expected one-year residential flood losses from coastal storms produced the agency's

estimate of \$3 billion in expected federal spending on aiding households in the aftermath of coastal storms (see Table B-1, which, for brevity, omits the ratios for administrative costs).

To estimate expected economic losses to the public sector, CBO took the estimate of expected federal spending on public-sector losses produced using the above method—for example, for coastal storms, applying 83 percent (131/158) to \$11 billion—and added an amount for the state and local cost sharing required under some federal disaster assistance programs. (CBO could not estimate expected public-sector losses to state and local governments that they would not receive federal compensation for or that they would not pay for through their cost sharing.)

Past Storms Used in CBO's Analysis

The 58 storms that CBO included in its analysis, 12 coastal storms and 46 inland storms, occurred between January 1, 2005, and December 31, 2016. In some cases, multiple storms were combined into a single event if federal funding was allocated to a combination of storms that occurred close together in time.¹ Each of the events was declared by the President to be a disaster under the 1988 Robert T. Stafford Disaster Relief and Emergency Assistance Act (Public Law 100-707), which triggers the provision of federal spending for disaster assistance.

CBO included all hurricanes during the 2005–2016 period that made landfall in the continental United States and that were Presidentially declared disasters. However, to ease data collection requirements, CBO treated inland storms differently depending on

1. For example, Hurricanes Katrina, Rita, Wilma, and Ophelia, which occurred within a three-month span in 2005 and affected states on the Gulf Coast (among others), were grouped together as one event. In all, the 12 coastal storms in CBO analysis consisted of 18 named hurricanes and tropical storms.

Table B-1.

Example of CBO's Method of Estimating Expected Annual Federal Spending on the Residential, Commercial, and Public Sectors

Billions of 2017 Dollars

		Coastal Storms			Inland Storms		
		Residential Sector	Commercial Sector	Public Sector	Residential Sector	Commercial Sector	Public Sector
Historical Amounts							
(1)	Federal Spending	38	0.4	131	6	0.1	13
(2)	Residential Flood Losses ^a	158			52		
(3)	Federal Spending as a Percentage of Residential Flood Losses ^b	24%	*	83%	11%	*	24%
Expected Amounts							
(4)	Residential Flood Losses	11			9		
(5)	Federal Spending ^c	3	**	9	1	**	2

Source: Congressional Budget Office, using data from the Federal Emergency Management Agency, the Department of Housing and Urban Development, the Small Business Administration, the Department of Transportation, the Congressional Research Service, and the Office of Management and Budget.

The estimated historical spending and losses shown here resulted from 58 major storms during the 2005–2016 period that were declared disasters by the President, thus triggering eligibility for federal disaster relief. The expected spending and losses shown here are estimated on the basis of current conditions for such factors as climate, sea levels, and development in areas at risk of hurricane winds or storm-related flooding.

Estimates of historical federal spending are based on obligations or allocations made by agencies or, in some cases, on supplemental appropriations provided to agencies. The amounts of federal spending are outlays estimated in calendar year 2017 dollars.

In this analysis, coastal storms are defined as hurricanes and tropical storms; inland storms are defined as other storms that cause flooding through heavy precipitation.

CBO used the same method shown here to estimate expected federal spending on administrative costs, but for brevity, the numbers underlying that calculation are not included in this table.

* = between zero and 0.5 percent; ** = between zero and \$50 million.

a. Estimated by scaling up claims on the National Flood Insurance Program (NFIP) associated with the 58 historical storms by the ratio of expected residential flood losses to expected NFIP claims for similar storms (coastal or inland). Historical residential flood losses serve as an indicator of the severity of the storm. CBO could not estimate historical flood losses for the commercial and public sectors.

b. Sector-specific historical federal spending (row 1) relative to residential flood losses (row 2) is measured as a percentage of the relevant measure of residential flood losses: \$158 billion for coastal storms and \$52 billion for inland storms.

c. Sector-specific expected federal spending (row 5) is equal to the percentage shown in row (3) multiplied by the relevant measure of expected residential flood losses: \$11 billion for coastal storms and \$9 billion for inland storms.

whether they occurred between January 1, 2005, and December 31, 2011, or between January 1, 2012, and December 31, 2016. The later inland storms were included if they were Presidentially declared disasters and if CBO could determine that most of their damage resulted from flooding. The earlier inland storms were included if, in addition to those two criteria, they had been declared by the National Oceanic and Atmospheric Administration as causing at least \$1 billion in total

damage.² That additional criterion reduced the number of storms for which data were collected for the 2005–2011 period relative to more recent years. But it captured the most costly storms, which are important determinants of federal spending on disaster assistance.

2. See National Oceanic and Atmospheric Administration, "Billion-Dollar Weather and Climate Disasters: Table of Events" (accessed August 24, 2018), www.ncdc.noaa.gov/billions/events/US/1980-2018.

Estimates of Federal Postdisaster Spending on Those Storms

CBO estimates that federal spending in response to those 58 historical storms totaled \$203 billion (in 2017 dollars):³

- \$143 billion (excluding administrative costs) on efforts led by federal, state, or local governments to address public-sector losses (see Appendix A);⁴
- \$44 billion to provide assistance to households;
- \$0.5 billion in subsidy costs for low-interest loans to commercial businesses; and
- \$16 billion in administrative costs.

Those estimates reflect spending by the Federal Emergency Management Agency's (FEMA's) Disaster Relief Fund (DRF), the Department of Housing and Urban Development's (HUD's) Community Development Block Grant Disaster Recovery (CDBG-DR) program, the Small Business Administration's (SBA's) Disaster Loan Program, and supplemental appropriations for 10 other federal agencies.

CBO did not have data on actual outlays that could be linked to storms, so for this analysis, CBO based its estimates of federal postdisaster spending on obligations or allocations for projects made by agencies or, in some

cases, on supplemental appropriations provided to those agencies. Using historical data, CBO estimated the share of an appropriated, allocated, or obligated amount that would be spent, as well as the rate at which that spending would occur. Some types of assistance, such as funds for the DRF Individual Assistance Program, are spent quickly after a disaster. Other types of assistance, such as funds for the Army Corps of Engineers, can be spent over the course of many years because of the kinds of projects that the Corps carries out. Consequently, some of the federal spending estimated for more recent storms is expected to result in outlays in the future.

CBO assigned spending from the DRF, the CDBG-DR, and the SBA to individual coastal and inland storm events using FEMA's state- and disaster-specific numbers.⁵ (For example, DR-4085 is the identifier for DRF and CDBG-DR spending in New York State that was used to address the effects of Hurricane Sandy.) CBO estimated the share of each CDBG-DR grant used for various categories of spending (such as addressing public-sector losses or providing compensation to households) on the basis of HUD data, which indicate a grant's intended uses as reported in the recipient's grant application.

In addition, CBO estimated postdisaster spending by 10 other federal agencies on the basis of supplemental appropriation laws, enacted in response to one or more of the 58 storms, whose designated purposes included responding to damage caused by those storms. The 10 departments and agencies were the Departments of Transportation, Defense, Health and Human Services, Veterans Affairs, the Interior, Commerce, Agriculture, and Education, as well as the Army Corps of Engineers and the Environmental Protection Agency.

Historical Spending to Address Public-Sector Losses

The \$143 billion in total federal spending on public-sector losses from those 58 historical storms occurred through a variety of federal agencies, CBO estimates (see Table 2 on page 12). That spending was used to provide emergency services, such as debris removal and emergency shelters, and to repair government property. It was split almost evenly between financial assistance to state and local governments and postdisaster efforts led by the federal government (see Appendix A for

3. The Government Accountability Office (GAO) estimated that the federal government obligated a total of at least \$278 billion for disaster assistance over fiscal years 2005 to 2014. That estimate is not directly comparable with CBO's estimate for several reasons. First, GAO reported obligated amounts, whereas CBO estimated outlays. Second, GAO included all spending by the National Flood Insurance Program (NFIP) and the Department of Agriculture's crop insurance program. In contrast, CBO's analysis includes only the NFIP's expected shortfall (rather than all spending by the program) because most of the program's costs are covered by premiums and fees. In addition, CBO's analysis excludes the crop insurance program. Third, GAO included obligations for types of disasters that are not included in CBO's analysis, such as wildfires. See Government Accountability Office, *Federal Disaster Assistance: Federal Departments and Agencies Obligated at Least \$277.6 Billion During Fiscal Years 2005 Through 2014*, GAO-16-797 (September 2016), www.gao.gov/products/GAO-16-797.

4. The \$153 billion total for federal spending on public-sector losses described in Appendix A includes administrative costs.

5. See the supplemental tables posted with this report on CBO's website (www.cbo.gov/publication/55019).

details). Coastal storms accounted for \$131 billion of that \$143 billion total, and inland storms accounted for just \$13 billion.

Historical Spending to Compensate Households

Of the \$44 billion that the federal government spent to provide assistance to households after those 58 storms, \$38 billion was spent in response to coastal storms and \$6 billion in response to inland storms, CBO estimates. That spending, which helped people repair homes and obtain temporary living quarters, occurred through FEMA's DRF Individual Assistance Program and DRF Hazard Mitigation Grant Program, the CDBG-DR program, and the SBA's Disaster Loan Program. Federal spending on SBA loans includes only the subsidy cost of the loans (a budgetary measure of the federal government's net cost).

For the 12 coastal storm events in the 2005–2016 data set, CBO estimated the shares of household assistance that occurred in response to flood damage and to wind damage. In the case of spending by the DRF Hazard Mitigation Grant Program, CBO could identify spending on specific projects related to wind damage. In the case of spending by other programs that provide federal assistance to households, CBO estimated the shares to address losses from wind and from flooding on the basis of the fraction of a coastal storm's damage that resulted from flooding versus wind and on the take-up rates (shares of homes with insurance) for flood insurance and wind insurance in the affected area.

For example, assume that roughly 60 percent of the damage from a particular hurricane came from wind and 40 percent from flooding. If 85 percent of homes in the affected area had wind insurance (with 15 percent uninsured) and only 30 percent of homes had flood insurance (with 70 percent uninsured), CBO would assign 76 percent of the federal assistance for households for that hurricane to compensation for flood damage. That figure represents the amount of uninsured damage from flooding as a percentage of the total amount of uninsured damage from flooding and wind, or $(0.4 \times 0.7) / [(0.6 \times 0.15) + (0.4 \times 0.7)]$.⁶

6. Risk Management Solutions (RMS) provided CBO with state-specific estimates of take-up rates for wind insurance. RMS also provided information on the relative share of wind and flood damage for six coastal events in CBO's set of historical storms. For those six events, CBO used the storm-specific wind share from RMS in its calculations; for the rest, CBO applied

Historical Spending to Compensate Commercial Businesses

In response to the 58 storms from the 2005–2016 period that CBO examined, the federal government spent a total of \$0.5 billion on compensation to small businesses, CBO estimates—\$0.4 billion for coastal storms and \$0.1 billion for inland storms. That spending consisted of the federal subsidy cost associated with \$3 billion of loans provided to commercial businesses through SBA's Disaster Loan Program.

Historical Spending on Administrative Costs

Administrative costs associated with the assistance that FEMA's DRF programs, HUD's CDBG-DR program, and SBA's Disaster Loan Program provided in response to those 58 storms totaled \$16 billion. In the case of the FEMA and SBA programs, CBO estimated the administrative costs of the agencies themselves. For FEMA's DRF programs, CBO used the average shares of administrative costs for disasters of different sizes during the fiscal year 2004–2013 period and applied those averages to the 58 storms.⁷ For the Disaster Loan Program, CBO calculated the average percentage of administrative costs for the fiscal year 2005–2014 period and applied that percentage to the loan amounts associated with the 58 storms.⁸

In the case of the CDBG-DR program, CBO included the administrative costs designated in HUD's grants to carry out the projects (those costs are capped at 5 percent of a grant's value). But CBO did not have information about the cost to HUD of administering and monitoring the grants. In addition, CBO could not determine the administrative costs associated with other forms of federal compensation included in this analysis.

an average of the six wind shares provided by RMS to all other hurricane and tropical storm events. CBO estimated take-up rates for flood insurance using data from FEMA on the location of properties covered by NFIP insurance and data from the Census Bureau on numbers of residences in various census tracts.

7. Government Accountability Office, *Federal Emergency Management Agency: Opportunities Exist to Strengthen Oversight of Administrative Costs for Major Disasters*, GAO 15-65 (December 2014), p. 16, www.gao.gov/products/GAO-15-65.
8. Government Accountability Office, *Federal Disaster Assistance: Federal Departments and Agencies Obligated at Least \$277.6 Billion During Fiscal Years 2005 Through 2014*, GAO-16-797 (September 2016), p. 168, www.gao.gov/products/GAO-16-797.

Estimates of Historical Residential Flood Losses

The other half of CBO's historical ratios—flood losses to the residential sector—totaled \$211 billion for the 58 historical storms that CBO analyzed. That figure represents the economic losses that households incurred because of flooding (before compensation by insurance companies or federal assistance programs), including the value of damage to residential structures and their contents and the costs associated with temporary lodging. Although coastal events made up only about 20 percent of the storms that CBO examined, they accounted for 75 percent of flood losses to households.

Method of Estimating Residential Flood Losses

CBO based its estimates of households' past flood losses (including losses incurred by both insured and uninsured households) on historical losses to insured households and the ratio of expected losses for all households to expected losses for insured households. Take-up rates for the National Flood Insurance Program (NFIP) are typically higher in coastal areas than in inland areas, so CBO produced separate estimates of flood losses from the coastal and inland storms in its analysis. In each case, the estimate of economic losses from flooding included damage to residential structures and their contents and temporary living expenses incurred by both insured and uninsured households.

Specifically, CBO estimated total residential flood losses from the two types of storms (coastal and inland, indexed by i) as:

$$T_i = V_i * \frac{E(T_i)}{E(C_i)}$$

where:

- T_i = estimated total amount of economic flood losses for historical storms of type i ,
- V_i = total claim payments reported for NFIP-insured households for damage from storms of type i ,
- $E(T_i)$ = expected one-year economic losses from flooding incurred by both insured and uninsured households due to storms of type i under current conditions, and

- $E(C_i)$ = expected one-year claim payments for insured households due to storms of type i under current conditions.

Data and Information Used to Estimate Residential Flood Losses

The values and parameters used to estimate total economic losses to households from flooding for the 12 coastal storms or 46 inland storms (T_i) were based on data provided by FEMA, modeling results from a commercially available model, an analysis by Risk Management Solutions, and estimates made by CBO for a 2017 report on the NFIP.⁹

FEMA provided CBO with data on all NFIP claims related to losses that occurred from the beginning of the program, in January 1969, through December 31, 2016. Those data included actual claim payments and estimates of total damage to the residential structures and contents that were the subject of the claims (including damage that was not covered by the claim payments because of deductibles or coverage caps). FEMA's data also included the census tract in which an insured property was located. CBO allocated claim-specific damage to each historical flood event on the basis of dates and locations provided in FEMA's disaster declaration for that event and the dates and location of NFIP claims. CBO then totaled the flood-specific estimates of both claims and damage to insured residences (damage to the structures and contents) for the 58 historical events, calculating subtotals for the amounts associated with coastal and inland storms. That process yielded estimates of V_i .

CBO's estimates of one-year expected flood losses, $E(T_i)$, were produced by a commercially available model that simulates tens of thousands of potential flood events that could occur in a given year along with their probabilities. That estimate was generated for CBO by Risk Management Solutions.

The commercially available catastrophic risk models used to develop the estimates of expected costs that underlie this analysis are inherently uncertain. The models' estimates are produced by simulating thousands of potential storm events in proportion to the probability

9. See Congressional Budget Office, *The National Flood Insurance Program: Financial Soundness and Affordability* (September 2017), www.cbo.gov/publication/53028.

of their occurring and by estimating the damage that would result from those storms. The reliability of the estimates depends on the quality of the information and data used in the models for various factors, including the following:

- Scientific understanding about numerous relationships, such as the effects of sea-surface temperatures and wind shear on hurricane formation;
- Data on current conditions, such as land use and existing buildings; and
- Engineering relationships, such as the amount of damage that floods of various depths would cause to different types of buildings.

Such catastrophic risk models have become more useful over time because of advances in science, increases in

computing capacity, and improvements in the available data about topographical features, land use, and development in various locations.

CBO's estimates of expected one-year claim payments, $E(C_i)$, were developed by the agency for its 2017 report on the NFIP. Those estimates were primarily based on commercial models that simulated thousands of flood events (reflecting the probability-weighted possible outcomes in a given year under current conditions) and their effects on all 5 million individual properties covered by an NFIP policy on August 31, 2016. CBO modified the estimates to account for additional expenses related to investigating and adjusting claims filed by policyholders.¹⁰

10. For more details about how CBO estimated expected claims, see Congressional Budget Office, *The National Flood Insurance Program: Financial Soundness and Affordability* (September 2017), Appendix A, www.cbo.gov/publication/53028.



List of Tables and Figures

Tables

1.	Expected Annual Economic Losses to the Residential Sector Under Current Conditions, by Insurance Status of Households	9
2.	Estimated Spending to Address the Public-Sector Costs of Damage From Hurricane Winds and Storm-Related Flooding That Occurred Between 2005 and 2016, by Agency and Program	12
3.	Estimated Federal Spending in Response to Damage From Hurricane Winds and Storm-Related Flooding That Occurred Between 2005 and 2016, by Use of Funds and Sector of the Economy	20
B-1.	Example of CBO's Method of Estimating Expected Annual Federal Spending on the Residential, Commercial, and Public Sectors	38

Figures

1.	Expected Annual Economic Losses From Hurricane Winds and Storm-Related Flooding Under Current Conditions, by Sector and Source of Damage	2
2.	Expected Annual Economic Losses to the Residential Sector Under Current Conditions, by Sources of Damage and Compensation	3
3.	Relationship Between Expected Economic Losses and Expected Federal Spending in Response to Damage From Hurricane Winds and Storm-Related Flooding Under Current Conditions	5
4.	Sources of Compensation for Expected Annual Flood Losses to Households Under Current Conditions	16
A-1.	Estimated Federal Spending to Address the Public-Sector Costs of Damage From Hurricane Winds and Storm-Related Flooding That Occurred Between 2005 and 2016	32
A-2.	Estimated Spending From FEMA's Disaster Relief Fund Public Assistance Program to Address Damage From Hurricane Winds and Storm-Related Flooding That Occurred Between 2005 and 2016	33
A-3.	Estimated Spending on Public-Sector Assistance From HUD's Community Development Block Grant Disaster Recovery Program to Address Damage From Hurricane Winds and Storm-Related Flooding That Occurred Between 2005 and 2016	34
A-4.	Estimated Spending on Efforts Led by the Federal Government to Address the Public-Sector Costs of Damage From Hurricane Winds and Storm-Related Flooding That Occurred Between 2005 and 2016	35



About This Document

This Congressional Budget Office report was prepared at the request of the Chairman of the Subcommittee on Economic Development, Public Buildings, and Emergency Management of the House Committee on Transportation and Infrastructure. In keeping with CBO's mandate to provide objective, impartial analysis, the report makes no recommendations.

The analysis was prepared by Terry Dinan and David Wylie with assistance from Jon Sperl and guidance from Joseph Kile and Chad Shirley. Perry Beider, Kim Cawley, Robert Reese, Aurora Swanson, and David Torregrosa of CBO provided valuable comments and assistance. Jordan Berne fact-checked the report.

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CBO continually seeks feedback to make its work as useful as possible. Please send any feedback to communications@cbo.gov.

Keith Hall
Director
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