



July 2020

CRUMBLING FOUNDATIONS

Extent of Homes with Defective Concrete Is Not Fully Known and Federal Options to Aid Homeowners Are Limited

Accessible Version

GAO Highlights

Highlights of [GAO-20-649](#), a report to congressional committees

Why GAO Did This Study

Certain homes built in northeastern Connecticut and central Massachusetts between 1983 and 2015 have concrete foundations containing the mineral pyrrhotite. Pyrrhotite expands when it is exposed to water and oxygen and, over time, concrete foundations containing pyrrhotite may crack and crumble.

The Explanatory Statement accompanying the Consolidated Appropriations Act, 2019 included a provision for GAO to study the financial impact of pyrrhotite. This report describes (1) what is known about the number of homes affected by pyrrhotite in the region; (2) the financial impact of pyrrhotite on homeowners; (3) the financial effects on towns, local housing markets, and the federal government; and (4) federal options to mitigate pyrrhotite's financial impact on affected homeowners.

GAO analyzed data from state, local, and private entities about the extent of pyrrhotite in foundations and associated costs, and federal actions taken in response to pyrrhotite. GAO also interviewed federal, state, and local officials; homeowners; and other stakeholders such as banks and real estate agents.

View [GAO-20-649](#). For more information, contact John Pendleton at (202) 512-8678 or pendletonj@gao.gov.

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Extent of Homes with Defective Concrete Is Not Fully Known and Federal Options to Aid Homeowners Are Limited

What GAO Found

As of December 2019, at least 1,600 homes in Connecticut had confirmed pyrrhotite but the total number of affected homes is likely higher. According to one estimate, 4,000–6,000 more homes in Connecticut could develop crumbling foundations due to pyrrhotite.

Affected homeowners may face total remediation costs of \$150,000 or more and drops in property values of 25 percent or more. Connecticut established funding to provide homeowners with up to \$175,000 towards the cost of foundation replacement, but affected homeowners are typically responsible for about one-third of total repair costs (which can include costs for replacing driveways and porches damaged during foundation replacement). Current funding is expected to assist 1,034 homeowners.

Pyrrhotite Damage to a Basement and a Home Being Repaired Due to Pyrrhotite Damage



Source: GAO. | GAO-20-649

GAO found that highly affected towns lost more than \$1.6 million in tax revenue in 2018 due to lost assessment value of the houses affected by pyrrhotite, but town officials told us the losses have not yet significantly affected their budgets. However, officials were concerned that pyrrhotite could have long-term effects on their towns if the number of affected homes increased or homes were not remediated. GAO also found that homes located in highly affected towns and built when pyrrhotite-containing concrete was used sold for significantly less, on average, than similar homes in less-affected towns. Stakeholders told GAO that defaults and foreclosures related to pyrrhotite have been limited to date.

Some federal funds have already been used for pyrrhotite testing and GAO identified eight additional federal programs that could be used to help mitigate financial impacts on homeowners. However, most of these programs have eligibility or funding restrictions that limit their potential for this purpose. Stakeholders with whom GAO spoke suggested other federal responses—in particular, declaring pyrrhotite damage a major disaster or establishing a federally backed insurance product. However, the Federal Emergency Management Agency determined that pyrrhotite damage did not qualify as a natural catastrophe, and a federally backed insurance program may not be feasible since it would serve a small population with high expected costs.

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Abbreviations

AMI	area median income
CDBG	Community Development Block Grant
CFSIC	Connecticut Foundation Solutions Indemnity Company, Inc.
FEMA	Federal Emergency Management Agency

FHA	Federal Housing Administration
HUD	Department of Housing and Urban Development
IRS	Internal Revenue Service
LMI	low- and moderate-income
USDA	Department of Agriculture

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July 29, 2020

The Honorable John N. Kennedy
Chairman
The Honorable Chris Coons
Ranking Member
Subcommittee on Financial Services and General Government
Committee on Appropriations
United States Senate

The Honorable Mike Quigley
Chairman
The Honorable Tom Graves
Ranking Member
Subcommittee on Financial Services and General Government
Committee on Appropriations
House of Representatives

In recent years, the mineral pyrrhotite has caused damage to home foundations in northeastern Connecticut and central Massachusetts. Pyrrhotite expands when exposed to water and oxygen and, over time, may cause concrete foundations to crack and crumble (also known as “crumbling foundations”). Remediating pyrrhotite damage typically involves costly replacement of the entire foundation, which homeowners insurance generally does not cover.

The Explanatory Statement accompanying the Consolidated Appropriations Act, 2019 included a provision for us to study the financial impact of pyrrhotite.¹ This report describes (1) what is known about the number of homes affected by pyrrhotite in Connecticut and Massachusetts; (2) the financial impact of pyrrhotite on homeowners; (3) the financial effects on towns, local housing markets, banks, and the federal government; and (4) federal options to mitigate pyrrhotite’s financial impact on affected homeowners.²

¹H.R. Rep. No. 116-9, at 661 (2019).

²For the purposes of this report, “homeowners” includes the owners of single-family houses, condominium units, and homes in planned unit developments.

To address our first objective, we analyzed data on homes confirmed to have pyrrhotite from the Connecticut Foundation Solutions Indemnity Company, Inc. (CFSIC)—the captive insurer Connecticut established to provide remediation assistance to affected homeowners—as well as from Connecticut’s pyrrhotite testing programs and selected town assessors.³ We also interviewed representatives from CFSIC and state and local governments regarding projections of the number of homes that could be affected.

To address our second objective, we reviewed information on costs to homeowners, available financial assistance, and out-of-pocket costs. Specifically, to assess costs to homeowners, we analyzed CFSIC data to determine the average amount of assistance per recipient and reviewed its guidance on covered and uncovered remediation costs. To assess pyrrhotite’s impact on home values, we used real estate listing aggregators such as Zillow and Redfin to find the sales histories of a nongeneralizable sample of recently sold homes that appeared to have pyrrhotite damage (such as mentions of positive pyrrhotite test results or descriptions of crumbling foundations). We also visited northeastern Connecticut to view damaged properties and hold discussion groups with affected homeowners. We supplemented the discussion groups with additional interviews with other affected homeowners in Connecticut and Massachusetts.

To address our third objective, we used different methodologies to assess pyrrhotite’s financial effects on towns, local housing markets, banks, and the federal government. For towns, we analyzed data from 22 towns with at least one pyrrhotite-related reassessment to determine their lost assessment value and related tax revenues due to pyrrhotite.⁴ To assess pyrrhotite’s effects on local housing markets, we conducted a regression analysis using data from a Connecticut multiple listing service on home sales during January 2012–March 2020 in the two most affected

³For our analysis, we considered a home to have a confirmed case of pyrrhotite if it had a positive core or visual test or received the property tax reduction that requires homeowners to submit confirmation of pyrrhotite. A captive insurance company is established by a single company or group of companies to self-insure their own risks.

⁴We requested assessment data from the 30 towns with at least one confirmed case of pyrrhotite, according to data from CFSIC or pyrrhotite testing programs. One town assessor confirmed that the town had pyrrhotite-related reassessments but did not provide us with data, and seven said no one in their towns had requested a reassessment due to pyrrhotite.

counties—Tolland and Hartford Counties.⁵ Our regression analysis tested whether the average sales prices of single-family houses built during the years pyrrhotite-containing concrete was used or in highly affected towns were significantly lower than average sales prices of houses built earlier or in less-affected towns.⁶ To assess pyrrhotite's effects on banks and the federal government, we interviewed representatives from the Connecticut and Massachusetts state banking associations, two banks in the affected region, Fannie Mae, Freddie Mac, and the Federal Housing Administration (FHA). We also analyzed data from Fannie Mae, Freddie Mac, and FHA on their mortgage portfolios in the affected region for homes built in 1983–2015.

We took various steps to assess the reliability of the data analyzed in the first three objectives, including interviewing knowledgeable officials, reviewing related documentation, and analyzing the data for outliers or errors. Based on this assessment, we determined the data were sufficiently reliable to report on the number of homes affected by pyrrhotite and pyrrhotite's financial effects on homeowners, towns, local housing markets, banks, and the federal government.

To address our fourth objective, we reviewed the Catalog of Federal Domestic Assistance and agency reports to identify federal programs that could potentially provide home remediation assistance to homeowners or localities.⁷ For programs we identified, we reviewed agency documentation to determine program requirements, eligibility criteria, and other information. We also interviewed officials at the Department of Housing and Urban Development (HUD) and Department of Agriculture (USDA) to confirm the extent to which these programs could be used to assist pyrrhotite-affected homeowners.

⁵A multiple listing service is a database that cooperating real estate brokers establish to provide data about properties for sale.

⁶We defined a highly affected town as one with 1.5 or more affected houses per 100 houses and a less-affected town as one with less than 0.5 affected houses per 100 houses. We used data from CFSIC, Connecticut testing program, and town assessors to determine the number of affected houses per town, and the Census Bureau's American Community Survey data to determine the total number of houses per town. We also used American Community Survey data to control for demographic variables.

⁷Office of Management and Budget and General Services Administration, *2019 Catalog of Federal Domestic Assistance* (Washington, D.C.: October 2019). For an example of another publication we reviewed, see Federal Deposit Insurance Corporation, *Affordable Mortgage Lending Guide, Part I: Federal Agencies and Government Sponsored Enterprises* (Washington, D.C.: November 2018).

We also reviewed GAO and agency reports to assess the extent to which federal responses to defective drywall and the 2007–2011 housing crisis could help pyrrhotite-affected homeowners. In addition, we interviewed officials at the Federal Emergency Management Agency (FEMA) and Connecticut Insurance Department to assess two federal options that homeowners and other stakeholders commonly suggested—a federal disaster declaration and federally backed insurance. Finally, we reviewed Canada’s and Ireland’s responses to similar damage in residential structures. For more information on our scope and methodology, see appendix I.

We conducted this performance audit from June 2019 to July 2020 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

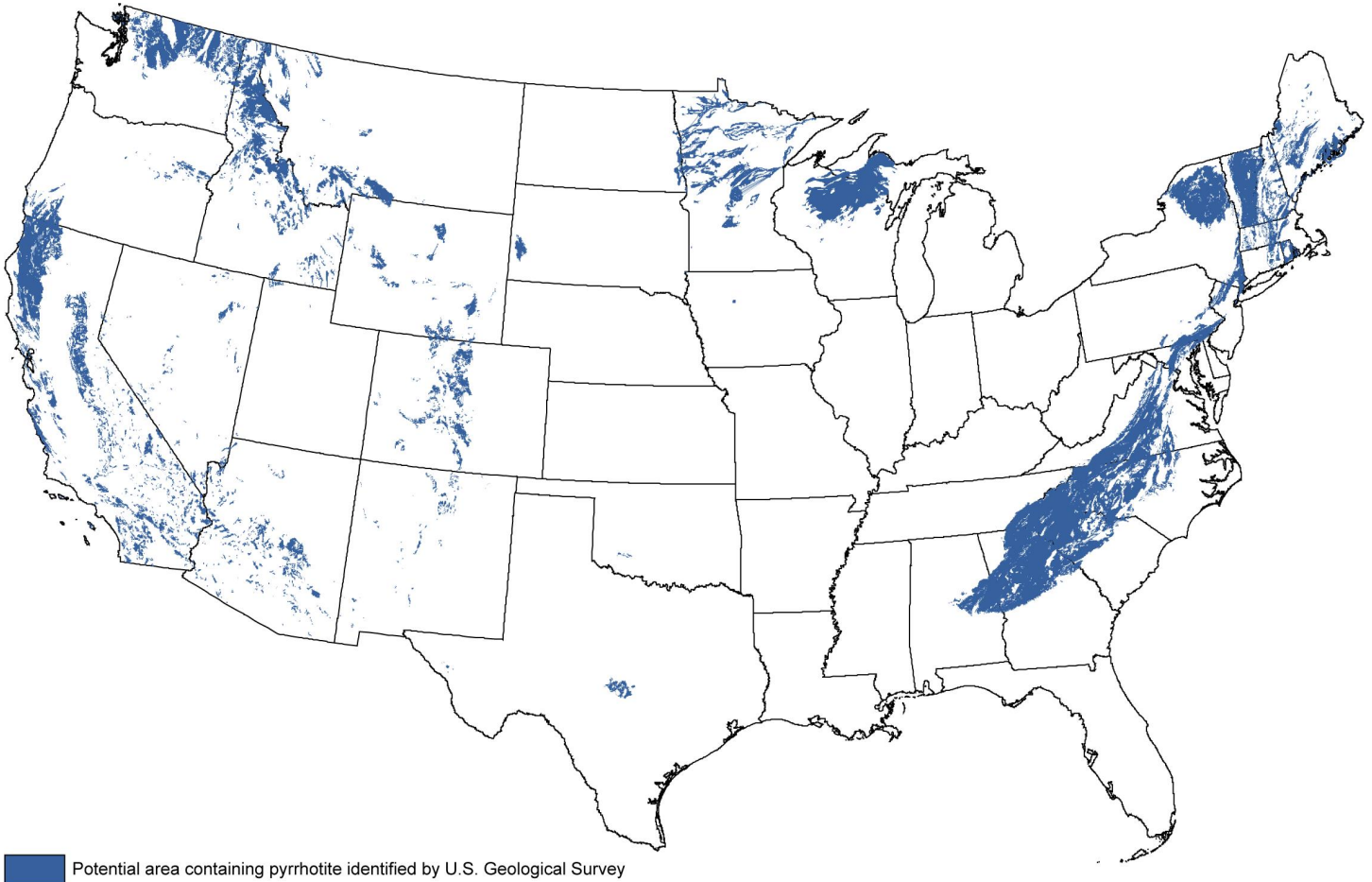
Background

Pyrrhotite

Pyrrhotite is a naturally occurring iron sulfide mineral. While there are no maps showing the exact distribution of pyrrhotite in the United States, the U.S. Geological Survey reports that it may occur across the continental United States, including a vein of pyrrhotite in New England (see fig. 1). Concrete-containing pyrrhotite generally occurs when the concrete’s aggregate comes from a quarry with pyrrhotite.⁸ To date, in the United States, only northeast Connecticut and central Massachusetts have reported structural damage to residences caused by concrete containing pyrrhotite.

⁸Concrete consists of three basic components: water, aggregate (rock, sand, or gravel), and cement. Cement acts as a binding agent when mixed with water and aggregates. Aggregates add volume and strength to the mixture.

Figure 1: U.S. Geological Survey Map of Potential Pyrrhotite Distribution in the United States



Source: GAO analysis of United States Geological Survey data. | GAO-20-649

Concrete foundations containing pyrrhotite may develop problems and degrade over time. Pyrrhotite reacts with water and air, creating new materials that may expand and weaken the concrete over time. Concrete foundations with pyrrhotite damage typically exhibit cracking (see fig. 2).

Figure 2: Basement with Severe Pyrrhotite Damage



Source: GAO. | GAO-20-649

Continued cracking can cause serious structural damage to the home. Walls may become misaligned and the home eventually may become uninhabitable (see fig. 3).

Figure 3: Basement and Exterior of a Home Condemned Due to Pyrrhotite Damage



Source: GAO. | GAO-20-649

Typically, remediating a foundation with pyrrhotite-related damage requires completely replacing it by lifting the entire home to remove the crumbling foundation and pour a new concrete foundation (see fig. 4).⁹ The cost to replace a foundation depends on factors such as the size of the home and repair method, but typically is between \$150,000 and \$250,000.

⁹One homeowner we interviewed had his foundation remediated using the composite method. He and a local contractor explained that in this method, contractors remove one foundation wall at a time and replace them with fiberglass panels. This method is less expensive because it does not require lifting the house.

Figure 4: Homes Elevated to Replace Pyrrhotite-Damaged Foundations

Source: GAO. | GAO-20-649

Scientists we interviewed reported that the rate at which concrete containing pyrrhotite deteriorates is variable and depends on various factors, which may include the level of water and oxygen exposure. However, the extent to which these factors contribute to the rate of pyrrhotite-related damage is unknown and damage may take decades to appear. For example, some scientists we interviewed reported that there are instances of homes that tested positive for high levels of pyrrhotite with no signs of deterioration.

There are two ways to test for the presence of pyrrhotite in a concrete foundation: visual inspections and core tests. Qualified engineers perform visual inspections to confirm that visible damage is associated with pyrrhotite and to determine the extent of any structural damage. In a core test, a laboratory analyzes samples of concrete removed from the foundation to determine the presence and levels of pyrrhotite.

Currently, there are no industry specifications on the safe level of pyrrhotite (that is, a level that will not result in crumbling foundations). According to a Connecticut report, two large standards development organizations—ASTM International and the American Concrete Institute—do not reference pyrrhotite in their concrete aggregate

standards.¹⁰ Among countries that have faced similar iron sulfide issues, Ireland adopted building standards limiting the presence of sulfur to 1 percent of concrete and Canada has funded research to develop its own pyrrhotite standard. (For more information on the related issues in Canada and Ireland, see appendix II).

Pyrrhotite Damage to Homes in Connecticut and Massachusetts

In recent years, homes in northeastern Connecticut and central Massachusetts built in 1983–2015 have begun to exhibit pyrrhotite-related damage.¹¹ A 2016 Connecticut Attorney General and Department of Consumer Protection investigation identified J.J. Mottes Concrete Company in northeastern Connecticut as the only concrete company connected to crumbling foundations.¹² The company procured its aggregate from nearby Becker’s Quarry, which is located on a vein of rock that contains significant amounts of pyrrhotite. Because concrete should not be transported for long periods of time, it is likely that this company’s product was widely used only in the region. However, the company did not have records of the homes for which it supplied concrete. In 2016, Connecticut obtained a written agreement from the concrete company and quarry operator to cease selling products containing aggregate from Becker’s Quarry for use in residential concrete foundations. As of June 2019, Becker’s Quarry remained operational, but the concrete company was no longer in business. As of December 2019, Massachusetts did not have similar restrictions on the quarry, but state officials told us they were not aware of any construction companies still sourcing materials from this quarry.

¹⁰Julia Singer Bansal, *State Building Code: Pyrrhotite in Concrete Aggregate* (Hartford, Conn.: Office of Legislative Research, Sept. 20, 2019). The United States has a voluntary, consensus-based standards system, whereby most documentary standards (standards that can describe the performance or design of a product, process, or test) are developed collaboratively by producers and users through private-sector standards development organizations.

¹¹A Connecticut official noted that recent pyrrhotite testing identified affected houses that were built in 2016. However, we limited our analysis to 1983–2015, as 2015 was the last full year the pyrrhotite-containing concrete was sold for residential construction.

¹²Connecticut Department of Consumer Protection, *Report on Deteriorating Concrete in Residential Foundations* (Hartford, Conn.: Dec. 30, 2016).

Insurance companies have largely denied claims for pyrrhotite-related crumbling foundations. According to a Connecticut report, standard homeowners insurance policies generally cover losses involving a home's sudden collapse.¹³ Foundations containing pyrrhotite degrade over time and thus insurance companies have concluded that the damage does not meet the policy's definition of collapse.¹⁴ Over the years, homeowners have filed numerous law suits against their insurance companies, challenging the denial of their claims. In November 2019, the Supreme Court of Connecticut ruled favorably for insurance companies in three key cases, further limiting homeowners' ability to recover costs of replacing foundations with pyrrhotite damage in the future.¹⁵

State Actions to Help Homeowners

Connecticut took multiple actions to provide financial assistance to affected homeowners, including funding assistance for foundation replacement, requiring town assessors to conduct property tax reassessments of affected homes upon homeowner request, establishing pyrrhotite testing programs, and creating a supplemental loan program. Massachusetts took fewer actions but established a program to reimburse homeowners for pyrrhotite testing.

- **Captive insurance company.** In 2017, Connecticut established CFSIC, a not-for-profit captive insurance company, to provide remediation assistance to homeowners with concrete foundations that

¹³Alex Reger, *Insurance Coverage for Crumbling Concrete Foundations: A Summary of the Issues* (Hartford, Conn.: Office of Legislative Research, Nov. 21, 2018). For example, see Insurance Services Office, Inc. (ISO) Homeowners-3 Special Form (HO 00 03 10 00), last accessed on June 24, 2020, at https://www.iii.org/sites/default/files/docs/pdf/HO3_sample.pdf (ISO HO-3). ISO HO-3 provides additional coverage for losses involving a collapse caused by certain specified perils. The policy defines collapse as an abrupt falling down or caving in of a building, such that the building cannot be occupied for its intended purpose. The policy specifies that a building (or part thereof) is not considered to be in a state of collapse if it is still standing, despite showing evidence of cracking or expanding. Section I, paragraph E.8.

¹⁴Depending on the language of the policy in question, insurance companies also may deny claims for other reasons, such as the use of defective construction materials or decay that was previously known to the insured.

¹⁵See *Karas v. Liberty Ins. Corp.*, No. SC 20149, 2019 WL 5955947 (Conn. 2019), *Vera v. Liberty Mut. Fire Ins. Co.*, No. SC 20178, 2019 WL 5955936 (Conn. 2019), and *Jemiola v. Hartford Cas. Ins. Co.*, No. SC 19978, 2019 WL 5955904 (Conn. 2019).

have deteriorated due to pyrrhotite.¹⁶ The state funded CFSIC with \$100 million in state bonds and a \$12 surcharge on new homeowners' insurance policies starting in 2019.¹⁷ CFSIC anticipates receiving an additional \$37.5 million from this surcharge.¹⁸ CFSIC began accepting applications in January 2019. The enabling legislation provided for CFSIC to continue until June 30 2022, at which point CFSIC is currently scheduled to stop accepting applications.¹⁹

- **Property tax reductions.** In 2016, Connecticut passed legislation that requires town assessors to inspect and reassess homes with defective concrete foundations at the request of the homeowner.²⁰ These reassessments remain in effect for 5 years, or until an earlier remediation.²¹
- **Pyrrhotite testing programs.** Connecticut has three programs to help homeowners finance pyrrhotite testing (both visual inspections and core testing). Connecticut allocated \$5 million for a testing reimbursement program administered by the Connecticut Capitol Region Council of Governments (a regional organization). This program is open to all homeowners whose houses meet certain requirements and provides full reimbursement for visual tests (up to \$400) and partial reimbursement for core tests (up to \$2,000).

Connecticut also established two other testing programs that cover a total of 10 towns, funded with \$673,000 from its HUD Community Development Block Grant (CDBG) for Small Cities, which cover all testing costs upfront. HUD officials told us that these grants were awarded as part of CDBG's objective to principally benefit low- and

¹⁶See Conn. Pub. Act No. 17-2, § 336, 2017 Conn. Acts 17-2 (June Spec. Sess.) (codified at Conn. Gen. Stat. § 38a-91vv).

¹⁷The \$12 surcharge is added to each homeowners insurance policy issued or renewed (effective January 2019 through December 2029). Eighty-five percent of the revenue raised by the surcharge is made available to CFSIC for use in providing assistance.

¹⁸CFSIC also must use some of its funding to cover administrative costs and capital reserves; thus, unless it receives additional funding, the total amount it spends on remediation likely will be less than \$137.5 million.

¹⁹See Conn. Gen. Stat. § 38a-91vv(i).

²⁰According to state officials, towns in Massachusetts are not required to reassess the value of pyrrhotite-affected properties, but several affected Massachusetts homeowners told us they requested and received reassessments.

²¹The homeowner is required to notify the assessor if the concrete foundation is remediated during the 5-year period, and the assessor will reassess the property based on its current value. Conn. Pub. Act No. 16-45, §§ 1-2, 2016 Conn. Acts 16-45 (codified at CGS § 29-265d).

moderate-income (LMI) persons. In general, HUD defines an activity to be principally benefitting LMI persons if at least 51 percent of the population of the activity's service area or the project's beneficiaries meet HUD's LMI definition. In addition, Massachusetts established a pyrrhotite testing reimbursement program that fully reimburses visual tests and partially reimburses core tests.

- **Supplemental loan program.** In 2019, the Connecticut Housing Finance Authority established a guaranteed loan program to help homeowners obtain loans for remediation expenses not covered by CFSIC. The program launched in November 2019 with three participating banks.

Federal Actions

Some federal agencies also took actions in response to pyrrhotite damage, including:

- **Internal Revenue Service (IRS).** A 2017 IRS revenue procedure allowed homeowners to deduct unreimbursed amounts paid to repair damage caused by deteriorating concrete foundations containing the mineral pyrrhotite as a casualty loss.²²
- **HUD.** As previously discussed, Connecticut used CDBG grant funds for two pyrrhotite testing programs.
- **FEMA.** In 2016–2018, FEMA coordinated an interagency response to identify federal resources that could help affected homeowners.²³
- **National Institute of Standards and Technology.** The joint explanatory statement related to the Consolidated Appropriations Act, 2020 included a provision for the National Institute of Standards and Technology to use at least \$1.5 million to study the effects of

²²The deduction is available for concrete foundations damaged as a result of pyrrhotite in the concrete mixture used before January 1, 2018, to pour the foundation. The amount of the deduction is subject to certain limitations. See Rev. Proc. 2017-60, 2017-50 I.R.B. 559, as amended by Rev. Proc. 2018-14, 2018-9 I.R.B. 378. In addition, a homeowner who previously claimed a deduction for payments that were later reimbursed by CFSIC must include the payments in income to the extent that the earlier deduction resulted in a tax benefit. If the deduction did not result in a tax benefit, payments from the CFSIC will not be taxable. See Announcement 2020-5, 2020-19 I.R.B. 796. A revenue procedure is a statement of procedure that affects the rights and duties of taxpayers.

²³Federal Emergency Management Agency, *Connecticut's Crumbling Concrete: Coordinating Federal Resources for a Non-Declared Event* (Washington, D.C.: 2018).

pyrrhotite on concrete and develop a cost-effective standard for testing for the presence of pyrrhotite.²⁴

At Least 1,600 Connecticut Homes Have Confirmed Pyrrhotite but Total Number of Affected Homes Is Likely Higher

Thirty Connecticut Towns Have Confirmed Cases of Pyrrhotite

The total number of homes with confirmed pyrrhotite is unknown, but using data from three sources, we determined that, as of December 2019, there were at least 1,600 affected homes in Connecticut (see app. III for more information about the number of confirmed cases). We reviewed data from CFSIC, Connecticut testing programs, and town assessors but did not obtain personally identifying information from these data sources so we were unable to determine the extent to which these data overlapped. Instead, we considered the highest number of cases across the three sources to be the minimum for each town, and summed these across all the towns to arrive at the minimum number of confirmed cases in Connecticut. There may be some homeowners who did not use the type of assistance with the highest count, but did use at least one of the other two types of assistance; therefore, the total number of unique homes in these data sources is likely to be higher. In addition, these sources likely do not capture all known cases of pyrrhotite in Connecticut—some homeowners may have replaced their foundations without any of these three types of assistance.²⁵

As of December 2019, 21 homeowners in Massachusetts had applied for the state's testing reimbursement program but it is unknown how many of these homes tested positive for pyrrhotite. As of June 2020, there were no other official data sources related to known pyrrhotite cases in Massachusetts.

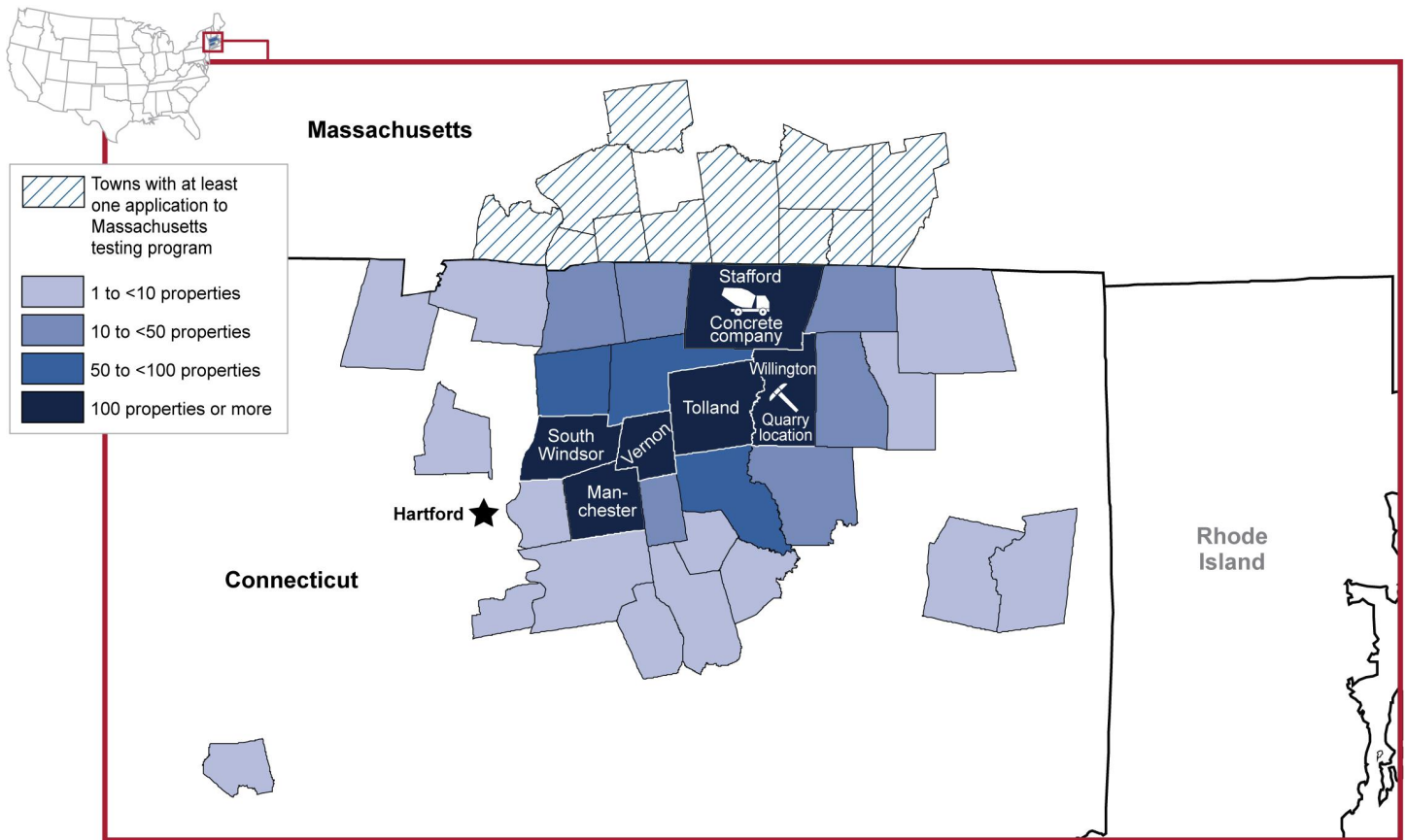
²⁴See 165 Cong. Rec. H10613, H10961-62 (daily ed. Dec. 17, 2019) and S. Rep. No. 116-127, at 25 (2019).

²⁵A Connecticut official told us that in some cases, homeowners' insurance companies paid for pyrrhotite testing but these results are not reported to the state.

These confirmed cases of pyrrhotite have been concentrated in a small geographic area. Based on data from the three Connecticut sources, affected homes were located in 30 towns generally in the northeastern region of the state, with 15 towns having 10 or more confirmed cases (see fig. 5). Almost all confirmed cases were located in Tolland and Hartford Counties, with Tolland County having the most cases. In addition, homes that utilized Massachusetts' testing reimbursement program were located in 11 towns near the Connecticut border. These towns are generally in close proximity to the company that produced the pyrrhotite-contaminated concrete.²⁶

²⁶A Connecticut official told us that while affected homes presumably would be located within 20 miles of the concrete company, the farthest home with a crumbling foundation was roughly 45 miles away.

Figure 5: Towns in Connecticut and Massachusetts with Confirmed Cases of Pyrrhotite and Their Number of Affected Properties



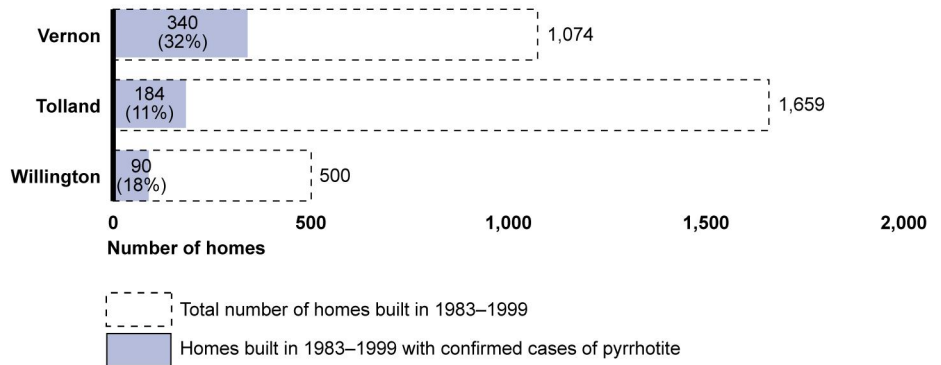
Source: GAO analysis of data provided by CFSIC, Connecticut town assessors, and Connecticut and Massachusetts testing programs. | GAO-20-649

Notes: “Confirmed cases of pyrrhotite” is the higher number from either the Connecticut Foundation Solutions Indemnity Company, Inc. (CFSIC), town assessors, or the Connecticut testing programs’ data. The identification of the Massachusetts towns is based on information from testing applications.

Our analysis showed that in some highly affected Connecticut towns, pyrrhotite-affected homes can constitute a significant percentage of the homes built during the period when the defective concrete was used. Using state testing results, CFSIC applications, and property data, we found that as of December 2019, in three highly affected towns, 11 percent, 18 percent, and 32 percent of homes built in 1983–1999 had confirmed pyrrhotite (see fig. 6).²⁷

²⁷For this analysis, we looked at homes built in 1983–1999 because pyrrhotite damage can take 10 or more years to appear.

Figure 6: Number of Homes Built in 1983–1999 with Confirmed Cases of Pyrrhotite in Three Highly Affected Connecticut Towns (as of December 2019)



Source: GAO analysis of data provided by town assessors, CFSIC, and testing programs. | GAO-20-649

Data table for Figure 6: Number of Homes Built in 1983–1999 with Confirmed Cases of Pyrrhotite in Three Highly Affected Connecticut Towns (as of December 2019)

Town	Total number of homes built	Number of confirmed cases of pyrrhotite ^a	Percent of housing stock affected by pyrrhotite
Vernon	1074	340	32
Tolland	1659	184	11
Willington	500	90	18

Notes: Town assessors provided data on the number of residential structures and years built. Confirmed cases of pyrrhotite for homes built in 1983-1999 is the higher number from either the Connecticut Foundation Solutions Indemnity Company, Inc. (CFSIC) or the Connecticut testing programs' data (reassessment data did not include year built).

Thousands of Additional Homes in Connecticut May Eventually Exhibit Pyrrhotite Damage

Estimating precisely the total number of Connecticut homes that will eventually exhibit pyrrhotite damage is difficult for multiple reasons. First, there are no records of how many and which structures contain the defective concrete. Additionally, homeowners may be reluctant to apply for the assistance programs out of concern that a confirmed case of pyrrhotite could have negative consequences, such as a decline in their home values. Finally, since pyrrhotite damage can take more than 10 years to appear and because the defective concrete was used until 2015, it is likely that a number of homes have not yet begun to exhibit damage.

CFSIC estimated that about 4,000–6,000 additional homes will exhibit pyrrhotite damage based on data from existing claims and the likelihood in certain neighborhoods that homes near already-confirmed homes were also built with defective concrete.²⁸ Additionally, the number of affected homes in Massachusetts is not known. One source estimated that up to 2,000 foundations in Massachusetts could have been built with concrete containing pyrrhotite.²⁹

Pyrrhotite Has Had Significant Financial Impacts on Some Homeowners

Homeowners with pyrrhotite can face repair costs of more than \$150,000 and potential losses in home value of 25 percent or more. Connecticut homeowners who receive assistance from CFSIC can have all or most of the foundation replacement costs covered, but some may still incur substantial out-of-pocket expenses. Furthermore, it is likely that not all affected homeowners will have access to state repair assistance.

Pyrrhotite Damage Can Result in High Repair Costs and Losses in Home Value

The cost to remediate a foundation with pyrrhotite damage depends on the size of the home, but stakeholders report that for houses in Connecticut, it typically ranges from about \$150,000 to \$250,000. The remediation costs can be a significant portion of a home's value: the National Association of Realtors estimated that the median home in Tolland County (the most affected county) was worth about \$274,400 in

²⁸In 2016, the Office of the Governor of Connecticut estimated that over 34,000 homes may have been built with concrete containing pyrrhotite based on the number of homes built in 1983–2000 for homes within a 20-mile radius of the affected quarry. However, because not every foundation built with concrete containing pyrrhotite will deteriorate, CFSIC and others believe the actual number of affected homes will be less than 34,000.

²⁹Commonwealth of Massachusetts, *Final Report of the Special Commission to Study the Financial and Economic Impacts of Crumbling Concrete Foundations due to the Presence of Pyrrhotite* (Boston, Mass.: December 2019). A construction industry representative in Massachusetts developed this estimate based on the estimated market share of foundation contractors who sourced their aggregate from the affected quarry during the time defective homes were built.

2019. Thus, for the median home, a remediation cost of \$150,000 would be about 55 percent of the home value.

Once a home is confirmed to have pyrrhotite, it can lose significant value. For illustrative purposes, we judgmentally selected and reviewed 13 real estate listings for Connecticut homes that sold from 2016 to 2019 and appeared to have pyrrhotite (such as mentions of positive pyrrhotite test results or descriptions of crumbling foundations). These homes saw decreases in their sales price of 25–73 percent since the last sale before pyrrhotite was discovered. For example, an affected condominium sold for \$121,000 in 2011 and next sold for \$68,000 in 2019 (a 44 percent reduction).³⁰ An affected house sold for about \$286,000 in 2002 and next sold for \$100,000 in 2018 (a 65 percent reduction). In three cases, the home sold for less than it had in the 1990s. For example, a house that sold for \$270,000 in 1991 next sold for \$85,000 in 2018 (about a 70 percent reduction). However, real estate agents we interviewed told us that homes generally recovered their value relative to other homes in the area once they were remediated.

In addition to the financial impacts, most homeowners with whom we spoke—both those who had and had not remediated their homes—said that dealing with pyrrhotite damage took an emotional toll on them. Homeowners described themselves as depressed or stressed and some who remediated their homes or sold them said that the feelings continued even after resolving the issue.

Available Assistance Generally Covers Foundation Replacement but Homeowners Can Incur Additional Costs

CFSIC provides Connecticut homeowners with financial assistance for costs directly associated with replacing the foundation, up to \$175,000 for a single-family house and \$70,000 for a condominium unit. As of December 2019, 331 homeowners had entered into agreements for CFSIC remediation assistance.³¹ These homeowners included 265 who received direct financing and 65 who self-financed remediating their

³⁰These numbers are not adjusted for inflation.

³¹CFSIC officials told us that, as of June 2020, this number had increased to 379.

homes and subsequently were reimbursed. In June 2020, CFSIC reported that 150 homes had completed remediation.

Many homeowners still have out-of-pocket remediation expenses, such as replacing septic tanks, porches, or other components of the home that might have been removed during construction. In August 2019, CFSIC told us that, on average, it reimbursed 68 percent of the total remediation cost and homeowners were responsible for the other 32 percent. Using CFSIC data from December 2019, we calculated its average assistance to single-family homeowners was \$144,635, which means the average CFSIC recipient would have had to pay about \$68,000 out of pocket. CFSIC also does not cover other related expenses, such as temporary housing during construction.

We spoke with eight Connecticut homeowners who remediated their homes with financial assistance from CFSIC, six of whom had out-of-pocket expenses. These six homeowners paid for the additional costs with retirement savings or loans. For example, one homeowner paid an additional \$112,830 out-of-pocket to repair his driveway, landscaping, and septic tank, among other things. He told us he paid for these expenses with retirement savings. Another homeowner had about \$72,000 in out-of-pocket costs, which included replacing or repairing the home's deck, septic tank, and finished basement.

In November 2019, Connecticut launched a low-interest loan program to help homeowners cover these out-of-pocket repair costs. One homeowner we interviewed used the program but some others said they did not want to take on additional loans and would prefer to cover the expenses through retirement funds. As of June 2020, the program had loaned a total of \$537,664, with another \$45,000 in the pipeline. Two other homeowners received money from their homeowners insurance companies to help cover out-of-pocket repair costs through a program set up between the state and three insurance companies.³²

³²In December 2018 and January 2019, Connecticut entered into separate agreements with three homeowners insurance companies to help provide supplemental remediation funds to affected homeowners who are current or former policyholders. The companies agreed to make a total of \$15.5 million available in exchange for the state releasing them from any pyrrhotite-related claims. The maximum amount of assistance per home is \$25,000 for current policyholders and \$10,000 for former policyholders. To receive these funds, homeowners must have received CFSIC assistance and agree to waive any pyrrhotite-related claims against the insurance company.

As discussed earlier, homeowners with unreimbursed repair expenses can deduct them from their federal taxes through IRS's casualty loss deduction. Four of the 27 homeowners we interviewed used this deduction, and another was planning to once his repairs were complete.³³ Three of these four homeowners noted that the deduction significantly reduced their taxes for the year in which it was claimed. Two homeowners noted that the deduction helped to offset some of the increased income taxes they incurred from withdrawing from their retirement savings to finance repairs. Two additional homeowners stated that they believed claiming the casualty loss deduction would not be helpful in their specific circumstances because they had limited out-of-pocket expenses.³⁴ We also interviewed representatives of a local accounting firm who told us the firm had helped three taxpayers claim the casualty loss deduction, and about 20 had expressed interest in advance of the 2020 tax season. However, Public Law No. 115-97 (commonly known as the Tax Cuts and Jobs Act) restricted casualty loss deductions to federally declared disasters for tax years 2018–2025.³⁵ IRS officials told us that they issued another revenue procedure giving homeowners additional time to pay for repairs, in order to take a deduction for the homeowner's 2017 taxable year. Specifically, the revenue procedure allows homeowners to deduct payments made prior to the last day for filing a timely amended return for the 2017 taxable year.³⁶ For instance, a taxpayer who filed their original 2017 tax return—together with payment of taxes owed—in April 2018 would have until April 2021 to amend the 2017 tax return. Payments made after this point in time are not deductible under the new revenue procedure.

Some condominiums also have concrete foundations containing pyrrhotite, and their owners may face additional challenges in accessing state assistance because multiple units share the foundation. As previously mentioned, CFSIC will provide condominiums with \$70,000 per unit in a shared foundation (for example, a four-unit condominium could receive \$280,000 in total from CFSIC). CFSIC only accepts applications from condominium associations on behalf of owners of affected units and

³³IRS officials told us that the agency did not have records of how many homeowners claimed the casualty loss deduction specifically for pyrrhotite-related repairs.

³⁴The deduction can only be claimed to the extent a taxpayer's total net casualty losses exceed 10 percent of the taxpayer's adjusted gross income for the year. See Rev. Proc. 2017-60, § 2.09. 2017-50 I.R.B. 559, and 26 U.S.C. § 165(h)(2).

³⁵Section 11044(a), 131 Stat. 2054, 2087-2088 (2017) (codified at 26 U.S.C. § 165(h)(5)).

³⁶See Rev. Proc. 2018-14, § 2.01, 2018-9 I.R.B. 378.

not from owners of individual units. Therefore, if individual owners who share a foundation differ in their decisions on whether to pursue remediation, those who wish to remediate would not be able to apply for CFSIC assistance on their own. Additionally, condominiums with more than four units initially were excluded from the program under the enabling legislation, and could not apply to CFSIC until July 2019 (6 months after it started accepting applications). We calculated that, as of December 2019, CFSIC had allocated over \$21.2 million for the remediation of 303 individual condominium units. Condominium owners also may incur out-of-pocket repair costs. One representative of an affected condominium association told us she calculated almost \$9,000 in supplemental repair costs per unit to cover decks, landscaping, and refinishing basements, among other items. As of June 2020, condominium unit owners and associations could not apply for the supplemental loan program, but program representatives stated they were designing a component for condominiums.

Some Connecticut homeowners may not apply for CFSIC assistance because of the out-of-pocket repair costs. As previously discussed, on average, these costs are about \$68,000 and in some instances have exceeded \$100,000. We spoke with two Connecticut homeowners who said they will not remediate their foundations, even with CFSIC assistance, for this reason. These homeowners told us they were planning to eventually abandon their homes and default on their mortgages. Similarly, a real estate attorney in the region told us she has worked with homeowners who would prefer to undergo foreclosure instead of paying for repairs. As of May 2020, she had discussed foreclosure with about 40 affected homeowners and she had eight pyrrhotite-affected clients in the process of foreclosure.

Some homeowners without access to assistance have paid for remediation out-of-pocket or sold their homes at discounted prices. As previously discussed, Massachusetts does not have a remediation assistance program. We interviewed three homeowners in Massachusetts who remediated their foundations entirely out-of-pocket. One financed it through savings, donations, and a repayment plan with the contractor; another obtained a loan; and the third obtained a loan and second mortgage. In Connecticut, we spoke with two homeowners whose foundations needed repairs before CFSIC was established who sold their homes to contractors at heavily discounted prices.

Homeowners Who Discover Pyrrhotite in the Future May Not Have Access to State Assistance

We found that as of December 2019, CFSIC had allocated about \$132 million to assist 1,034 homeowners with confirmed pyrrhotite. The \$132 million likely represents approximately the total funding CFSIC expects to receive before it is scheduled to end in 2022.³⁷ However, CFSIC estimates that 4,000–6,000 more homes will need new foundations, which we estimate would cost between about \$579 million and \$868 million in additional funding (see table 1). Using CFSIC’s average homeowner out-of-pocket costs to remediate their foundations, the total out-of-pocket costs would be between about \$272 million and \$408 million.

Table 1: Illustrations of Projected Costs to Remediate Pyrrhotite-Affected Foundations in Connecticut

	Number of additional homes needing remediation	CFSIC remediation cost (millions of dollars) ^a	Homeowner out-of-pocket cost (millions of dollars) ^b	Total projected remediation costs (millions of dollars)
CFSIC low estimate	4,000	579	272	851
CFSIC high estimate	6,000	868	408	1,276

Legend: CFSIC = Connecticut Foundation Solutions Indemnity Company, Inc.

Source: GAO analysis of CFSIC data. | GAO-20-649

^aWe calculated these estimates using CFSIC’s average payment to single-family homeowners of \$144,635.

^bWe calculated the estimated homeowner out-of-pocket cost using CFSIC’s estimate that, on average, homeowners pay 32 percent of remediation costs out of pocket, which would be \$68,064 based on the average CFSIC payment of \$144,635.

CFSIC’s enabling legislation provides for it to continue until June 2022, so homeowners who discover pyrrhotite damage after this date may not have access to CFSIC’s remediation assistance. Because pyrrhotite damage may take 10 or more years to appear and the defective concrete was used until 2015, there may be a cohort of homes that exhibit damage and need financial assistance after current CFSIC authorities and funding end.

³⁷As previously discussed, CFSIC anticipates receiving about \$137.5 million in state funding financed through bonds and a surcharge on new homeowners’ insurance policies. However, some of CFSIC’s funding must go toward administrative costs and capital reserves and thus the \$132 million represents most, if not all, of the available funding for foundation remediation.

Pyrrhotite Has Had Some Financial Effects on Towns, Local Housing Markets, Banks, and the Federal Government

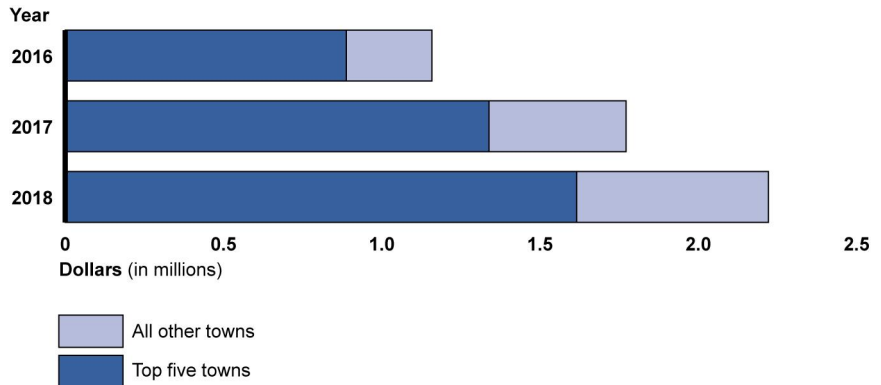
To date, pyrrhotite has caused heavily affected towns to lose tax revenue and potentially affected homes to have lower sales prices. However, it has had less effect on banks and the federal government.

Most Affected Towns Have Lost Revenue Due to Pyrrhotite

We found that from 2016 through 2018, 18 Connecticut towns lost a total of \$5.2 million in tax revenue due to pyrrhotite-related property tax reductions, but town officials reported that these tax losses had not had large effects on towns' budgets.³⁸ The tax losses were largely concentrated in the most affected towns—in 2016, five of the most affected towns lost more than \$888,000 in tax revenue due to pyrrhotite-related reassessments, and this loss almost doubled by 2018 to \$1.6 million (see fig. 7). In 2018, lost tax revenue per town ranged from \$7,891 to \$380,445 for towns whose data we reviewed. However, officials from five of the most affected towns told us that they had not yet had to cut services or expenditures to compensate for lost tax revenue. For example, in its 2019 budget, a town that lost \$380,445 in tax revenue due to pyrrhotite had estimated total revenues that year of \$56,772,735; thus, the lost tax revenue amounted to about 0.7 percent of total revenue.

³⁸We received pyrrhotite-related tax assessment information from 22 towns. All of the towns provided data for properties reassessed through 2018, but not all towns had completed their 2019 reassessments at the time of our request. One town with at least 80 affected properties did not provide us with assessment data. We limited our analysis of tax revenue loss to towns with five or more properties reassessed due to pyrrhotite.

Figure 7: Pyrrhotite-Related Tax Revenue Loss in Connecticut Towns, 2016–2018



Source: GAO analysis of town assessor data. | GAO-20-649

Data table for Figure 7: Pyrrhotite-Related Tax Revenue Loss in Connecticut Towns, 2016–2018

Town	2016	2017	2018
Top 5 Towns	888,295	1,338,930	1,615,852
All other towns	270,063	432,987	605,816

Notes: Included towns each had five or more reassessed properties as of 2018. The top five towns include the five with the most lost property tax revenue due to pyrrhotite. Some towns had reassessments in 2015 that are included in the 2016 numbers. One town with at least 80 affected properties did not provide us with data.

While pyrrhotite has not yet significantly affected towns’ budgets, officials we interviewed were concerned about the potential for it to do so in the future. Some town officials told us that if the number of affected properties increased or if homeowners could not afford to repair their homes, then they might have to reduce services, delay necessary projects, or further increase taxes on unaffected properties.³⁹ Town officials were concerned that such actions could cause residents to leave or discourage new residents from moving to their towns.

In addition, costs to towns could increase if public infrastructure, such as municipal buildings, exhibited pyrrhotite damage. For example, in February 2020, officials from one town told us it had three affected municipal buildings, including an elementary school. Town officials told us that the school is being replaced, which is being funded with \$46 million

³⁹While reassessments are in effect for 5 years or until an earlier remediation, officials were concerned about new homeowners discovering pyrrhotite damage and seeking a reassessment.

from state and local governments. Officials from six other towns with a number of affected homes told us they had not yet identified any affected public infrastructure.⁴⁰

Recent Home Sales Prices in Highly Affected Towns Have Been Lower Than in Less-Affected Towns

Our analysis of Connecticut real estate market data indicated that the presence of pyrrhotite-damaged houses reduced the average sales price of all houses in highly affected towns, especially for homes built in 1983–2015 (when pyrrhotite-containing concrete was used). We conducted a regression analysis using multiple listing service data on sales from January 2015 to March 2020 to analyze the effect of location and year built (indicating a house might have pyrrhotite-containing concrete) on the sales prices of single-family houses in Tolland and Hartford Counties, while controlling for factors that would affect sales price (such as square footage and number of bedroom and bathrooms). For Tolland County, we estimated that:

- Houses built in 1983–2015 and in highly affected towns had average sales prices of \$12,187 less than houses built in the same time period in moderately affected towns, and \$16,085 less than houses built in the same time period in less-affected towns (see table 2).
- In contrast, houses built in 1970–1982 (before pyrrhotite-containing concrete was used) and located in highly affected towns sold for \$10,646 more on average than houses in moderately affected towns, and there was no significant price difference between highly and less-affected towns.

For sales completed in 2012–2014—before the issue of pyrrhotite in concrete foundations was widely known—there were no significant price differences between highly affected and less-affected towns regardless of year built. Together, these findings indicate that significantly lower prices between highly, moderately, and less-affected towns are only present for houses built when pyrrhotite-containing concrete was used and only after

⁴⁰Officials from one town told us it has two commercial buildings with confirmed pyrrhotite. Commercial buildings are not eligible for CFSIC or other assistance programs. We did not include commercial buildings in the scope of this report.

pyrrhotite damage became widely known.⁴¹ See appendix IV for more information on our analysis of pyrrhotite’s effects on house sales prices, including results for Hartford County.

Table 2: Average Price Differences for Houses Built in 1970–1982 and 1983–2015 in Towns with Different Levels of Pyrrhotite Damage, for Sales in Tolland County from January 2015 to March 2020 (in dollars)

	Year built: 1970–1982	Year built: 1983–2015
Difference between highly and less-affected ZIP codes	4,145	-16,085***
Difference between highly and moderately affected ZIP codes	10,646**	-12,187***
Difference between moderately and less-affected ZIP codes	-6,501	-3,898

Legend: *** = significance at the 1 percent level and ** = significance at the 5 percent level.

Source: GAO analysis of Smart MLS data. | GAO-20-649

Notes: We defined a highly affected town to have 1.5 affected homes per 100 homes, a moderately affected town to have 0.5–1.49 affected homes per 100 homes, and a less-affected town to have less than 0.5 affected homes per 100 homes. All homes that have exhibited pyrrhotite damage to date were built in 1983–2015. We used data from the Census Bureau’s American Community Survey on the number of houses per ZIP code (each town in our analysis is typically associated with one ZIP code).

Pyrrhotite Has Had Limited Financial Impacts on Banks and the Federal Government to Date

As of September 2019, Fannie Mae, Freddie Mac, and FHA guaranteed or insured 13,900 mortgages on homes built during 1983–2015 in the affected region of Connecticut, with an unpaid principal balance of more than \$2.4 billion, but delinquency rates for these mortgages did not differ significantly from comparable averages.⁴² For example, for Fannie Mae, 1.4 percent of such mortgages were 30–89 days delinquent, as of September 2019. According to the National Mortgage Database, 2.2 percent of mortgages in Connecticut were 30–89 days delinquent. Among FHA mortgages, as of September 2019, 5.7 percent of such mortgages

⁴¹Our analysis showed that in highly affected towns, houses built in 1983–2015 had significantly lower average sales prices than houses built in 1970–1982. However, we found this pattern in sales both before and after 2015, so it is unclear whether these differences can be statistically related to pyrrhotite.

⁴²These data reflect outstanding mortgages as of September 30, 2019. The comparable mortgage delinquency rates are also from September 2019. We included mortgages in towns with five or more confirmed cases of pyrrhotite.

were 30–89 days delinquent, compared to 7.0 percent of all FHA mortgages in the United States.

Similarly, representatives from the Connecticut and Massachusetts state banking associations told us their members have not observed changes in delinquency or default rates due to pyrrhotite, in part because they sold their mortgages in the secondary market. Additionally, representatives of two banks in the affected area told us pyrrhotite had not affected their mortgage portfolios. Finally, representatives for Fannie Mae, Freddie Mac, FHA, and local financial institutions told us they have not observed any changes in the number of foreclosed properties due to pyrrhotite.

However, foreclosure rates could increase if homeowners believe they are better off defaulting on their mortgages, which could negatively affect the entities that hold or guarantee these mortgages. In March 2019, Fannie Mae said it had identified seven foreclosed properties and two short sales with pyrrhotite. From December 2019 to March 2020, we identified nine foreclosed Fannie Mae, Freddie Mac, and FHA properties with confirmed pyrrhotite, and an additional 17 potentially affected based on the year built and location.⁴³ A representative of a Connecticut bank in the affected region told us that before CFSIC, the local banking industry had been concerned that many affected homeowners would default on their mortgages, and that he believes remediation assistance reduced the likelihood of default. He and another local stakeholder stated that foreclosure rates could increase if CFSIC assistance was no longer available.

⁴³We considered a property to have a confirmed case of pyrrhotite if it was mentioned in the listing or if the property received a pyrrhotite-related tax reassessment.

Federal Options to Assist Homeowners Affected by Pyrrhotite Are Limited

CDBG Funds Have Helped Some Connecticut Homeowners but Have Some Limitations

As previously discussed, Connecticut established two pyrrhotite testing programs with \$673,000 of its CDBG grant for nonentitlement areas. These programs cover the full cost of testing for participants, provided that at least 51 percent of participants are LMI. Program representatives told us one program used its \$250,000 grant to provide 42 households with testing over a 2-year period, and the other program served 23 households from September 2019 to July 2020. However, a state representative told us that the program's LMI requirement could be a challenge to fully utilizing CDBG funds for this purpose. One program reported that it was able to meet the LMI requirements and fully utilize available funds. The other program reported serving 13 LMI and 17 non-LMI households, but had another 17 non-LMI households waiting to receive testing until the program had a sufficient number of LMI participants.⁴⁴

HUD officials stated that CDBG funds may be used for pyrrhotite-related repairs as an eligible housing rehabilitation activity and must generally be limited to LMI households. Additionally, such funds would only be available to homeowners if the grant recipients chose to use the funds in this way. However, the relatively limited amount of funding CDBG provides, coupled with the high cost of foundation replacement, may restrict the number of households that could be fully assisted. For example, the highly affected town of Manchester received a \$562,699 CDBG Entitlement Grant for fiscal year 2019—assuming a cost of \$150,000 per foundation, the full grant would have funded fewer than four foundation replacements.⁴⁵ The entirety of the \$13.38 million Connecticut

⁴⁴Program officials told us that the 13 LMI households included 28 LMI individuals, while the 17 non-LMI households included 24 non-LMI individuals.

⁴⁵East Hartford, which received a CDBG-Entitlement Grant allocation of \$564,561 for 2019, also has identified a few pyrrhotite-affected properties. HUD officials told us in 2019 that East Hartford had not allocated any of its CDBG-Entitlement Grant toward pyrrhotite-related costs.

received in 2019 for its Small Cities grant would have fully funded roughly 89 foundation replacements.

A Few Additional Federal Loan and Grant Programs Could Offer Limited Financial Assistance for Foundation Remediation

We identified eight additional federal programs that agency officials confirmed could provide assistance to certain affected homeowners but had not been widely used for this purpose. Of these eight programs, three are grant programs and five are loan programs. We found that these grants and loans might contribute towards the financial needs of certain affected homeowners, but not all affected homeowners would qualify for all programs. In addition, no single grant or loan program is likely to fully cover the cost of foundation replacement. However, they might contribute towards the financial needs of certain homeowners, such as low-income and rural seniors.

Six of these programs have eligibility restrictions such as income limits, which could reduce their applicability to homeowners with pyrrhotite. For all three of the grant programs we identified, program requirements restrict eligibility to very low- or low-income households, defined as a percentage of the area median income (AMI) for the region (see table 3).⁴⁶ In addition, three of the five available loan programs restrict eligibility to households with very low-, low- or moderate-incomes (see app. V for additional program details).

⁴⁶Very low-income is defined as below 50 percent of AMI (below \$51,300 for Tolland County, the most affected county to date); low-income is 50–80 percent of AMI (from \$51,300 to \$78,500); and moderate income is below 115 percent of AMI (below \$116,300). Available data did not include information on the income level of affected homeowners.

Table 3: Federal Grant and Loan Programs Potentially Available to Assist Homeowners Affected by Pyrrhotite

Program	Type of program	Income limit	Rural requirement	Age restriction	Maximum benefit, in dollars ^a
Rural Housing Preservation Grant (USDA)	Grant	eligibility restriction	eligibility restriction	—	Limit determined by sponsoring organization ^b
Section 504 Home Repair Program Grant (USDA)	Grant	eligibility restriction	eligibility restriction	eligibility restriction	7,500
Section 504 Home Repair Program Loan (USDA)	Loan	eligibility restriction	eligibility restriction	—	20,000
Section 502 Direct Loan Program (USDA)	Loan	eligibility restriction	eligibility restriction	—	Loan combined with existing mortgage cannot exceed the value of the home
HOME Investment Partnerships Program (HUD)	Grant	eligibility restriction	—	—	Funding distribution determined by local and state governments ^b
Community Development Block Grant Section 108 Loan Guarantee Program (HUD)	Loan	eligibility restriction	—	—	Funding distribution determined by local and state governments ^b
203(k) Rehab Mortgage Insurance (HUD)	Loan	—	—	—	Loan combined with existing mortgage cannot exceed FHA loan limit (353,050 in Tolland County in 2020)
Property Improvement Loan Insurance (HUD)	Loan	—	—	—	25,000

Legend: HUD = Department of Housing and Urban Development; USDA = Department of Agriculture; ✓ = program has this eligibility restriction

Source: GAO analysis of federal agency documents. | GAO-20-649

^aThe maximum benefit may be subject to other restrictions under applicable federal laws and regulations.

^bIndividuals cannot apply directly to the federal agency, and instead receive funding through intermediaries such as state and local governments.

In addition, four of the eight programs only serve residents of rural areas. Based on USDA program documentation, 21 of the 30 towns affected by pyrrhotite, including Tolland and Willington, would qualify as rural. However, two of the most affected towns—Manchester and Vernon—would not. In addition, the USDA Section 504 grant limits recipients to those who are age 62 or older.⁴⁷

⁴⁷None of the data sources we reviewed on homes with pyrrhotite had information on homeowner age.

Each federal grant and loan program we identified likely limits the amount of financial assistance it can provide to less than the average foundation replacement cost. For two of the five loan programs, the maximum loan amount is a fixed amount significantly below the average cost of foundation replacement. For example, USDA's Section 504 Home Repair Program has a maximum loan amount of \$20,000, and HUD's Property Improvement Loan Insurance has a maximum loan amount of \$25,000. For other available loan programs, the 203(k) Rehab Mortgage Insurance Program limits the combined amount of the loan and any existing mortgage to FHA's mortgage limit, which was \$353,050 for the affected region of Connecticut as of January 2020. However, FHA officials noted it is unlikely that an affected homeowner could obtain a 203(k) loan large enough to finance the entire cost of foundation remediation due to an affected home's decrease in value, particularly if the homeowner had an existing mortgage on the home. Under the Section 502 Direct Loan Program, the total of the loan and any existing mortgage cannot exceed the value of the home. In both cases, the outstanding balance of an existing mortgage could limit the amount that a homeowner could borrow. As previously discussed, the cost to replace a foundation can exceed \$150,000. Individually, these programs are unlikely to cover the full amount of remediation costs, but they could supplement other repair funds such as CFSIC assistance. However, FHA officials noted that it could be difficult to coordinate CFSIC assistance with a 203(k) loan per the 203(k) program guidelines.

While homeowners can apply directly for funding from five of the eight programs, entities such as states, counties, or cities must apply for or receive allocations from the USDA Rural Housing Preservation Program, CDBG Section 108 Loan Guarantee, and HOME Investment Partnerships Programs. HUD requires that recipients of its CDBG grants submit annual plans on how funds will be spent, so recipients must decide to use these funds for pyrrhotite-related purposes before they would become accessible to homeowners. HUD officials told us that they discussed using the CDBG Section 108 Loan Guarantee Program with Connecticut officials to create a foundation remediation loan pool primarily for LMI homeowners, but state officials declined because the expected pyrrhotite repair costs were unknown and could be high. A state official also noted that the complexity of creating and administering a loan pool at the local level could be administratively burdensome, but the Connecticut Department of Housing would be willing to review applications from any interested towns.

HUD and USDA officials told us that they believed very few homeowners had used these eight programs for pyrrhotite-related expenses. USDA officials told us that no affected homeowners had applied to the Section 502 or 504 programs for remediation assistance. However, one affected homeowner, who was in the foreclosure process, received a reamortization of an existing Section 502 direct loan. USDA officials told us they promoted these assistance programs to affected homeowners by publishing a letter in June 2019 that encouraged affected homeowners with existing USDA-backed mortgages to contact them to discuss possible servicing options. HUD officials told us they were not aware of any homeowners seeking loans through the 203(k) Rehab Mortgage Insurance or Property Improvement Loan Insurance.

Federal Responses to Other Situations Not Well-Suited to Meet Needs of Pyrrhotite-Affected Homeowners

We reviewed the federal response to defective drywall contaminated with high levels of hydrogen sulfides that was installed in approximately 11,000 new homes from 2004 to 2008. As with pyrrhotite, affected homeowners incurred high repair costs that were not covered by homeowners insurance. The federal response to defective drywall was similar to its response to pyrrhotite. IRS allowed a casualty loss deduction for repair costs to assist affected homeowners.⁴⁸ Fannie Mae, Freddie Mac, and FHA requested that their servicers offer mortgage payment flexibilities to affected homeowners and these entities have stated that these flexibilities are also available to pyrrhotite-affected homeowners, as discussed below. HUD allowed states to use their CDBG allocations to fund defective drywall repair, although in 2013, we reported that a HUD official told us no communities chose to use their CDBG allocation for this purpose.⁴⁹ At the state level, Florida and Virginia both allowed their localities to decrease property tax liability for some affected homeowners.

⁴⁸This deduction is allowed for certain imported drywall installed in homes between 2001 and 2009. See IRS Pub. 547, 4 (Feb. 19, 2020).

⁴⁹GAO, *Information on Defective Drywall*, [GAO-13-735R](#) (Washington, D.C.: July 31, 2013). Louisiana allowed the use of \$5 million of its CDBG-Disaster Recovery funds towards defective drywall assistance. Only affected homeowners who previously received assistance from another Louisiana CDBG program for hurricane recovery assistance qualified for this defective drywall program. These funds paid for testing in 32 homes and provided 35 families with temporary housing assistance.

In contrast to pyrrhotite-affected homeowners, homeowners with defective drywall obtained large settlements with drywall manufacturers and other industry participants, including one which has been estimated at \$1.1 billion.⁵⁰ In the case of pyrrhotite, the Connecticut Department of Consumer Protection and the Connecticut Attorney General determined there was insufficient evidence to bring action under the Connecticut Unfair Trade Practices Act against the companies involved.⁵¹

Furthermore, given the length of time pyrrhotite damage takes to appear, some homeowners' claims have been barred by Connecticut's statute of limitations.⁵² In addition, as previously discussed, Connecticut courts have ruled favorably for insurance companies in key pyrrhotite-related lawsuits.

Because homeowners with pyrrhotite damage may incur significant losses in home value, we also reviewed the federal programs to assist homeowners during the 2007–2011 housing crisis. Specifically, housing assistance programs established under the Troubled Asset Relief Program included options for homeowners to refinance their mortgages, adjust monthly payments, or reduce the principal balance owed on a mortgage. These efforts generally served to make the monthly payment more affordable to homeowners and thus reduced the likelihood of foreclosure. In response to pyrrhotite, Fannie Mae, Freddie Mac, and FHA told us that their standard mortgage assistance options for borrowers facing financial hardship—such as repayment plans and loan modifications—are available to pyrrhotite-affected homeowners. In March 2019, Fannie Mae released a memorandum clarifying to its servicers that these options are available to homeowners experiencing financial hardship due to pyrrhotite. While the options are not as expansive as those provided under the Troubled Asset Relief Program, they can reduce an affected homeowner's monthly mortgage payment. However, homeowners with whom we spoke generally did not express a desire for mortgage payment assistance and most had not contacted their mortgage servicer to discuss payment flexibilities. Additionally, as previously discussed, representatives from Fannie Mae, Freddie Mac, and local

⁵⁰In *Re: Chinese-Manufactured Drywall Prods. Liab. Litig.*, 424 F.Supp.3d 456, 469 (E.D. La. 2020) (No. 09-4115).

⁵¹Connecticut Department of Consumer Protection, *Report on Deteriorating Concrete in Residential Foundations* (Hartford, Conn.: Dec. 30, 2016). Conn. Gen. Stat., § 42-110a, et. seq.

⁵²See, e.g., *Tofolowsky v. Bilow*, No. CV97 006375, 2003 WL 1475141, at *8-9 (Conn. Super. Ct. March 17, 2003).

banks told us that pyrrhotite has not yet affected foreclosure rates in the affected region.

Federally Backed Disaster Assistance and Insurance Programs Are Unlikely to Be Suitable to Address Pyrrhotite Damage

Homeowners, stakeholders, and local officials with whom we spoke suggested that the federal government help mitigate the financial effects of pyrrhotite by declaring pyrrhotite damage a major disaster or by establishing a federally backed insurance program.⁵³ We found that these responses would have statutory barriers or implementation challenges that would limit their suitability for addressing pyrrhotite damage.

Federal Disaster Assistance

Some homeowners, state officials, and local officials we interviewed suggested that the President declare pyrrhotite damage a major disaster to provide homeowners with funding through disaster programs. FEMA's Individuals and Households Program provides up to \$34,900 in assistance for disaster-related expenses. In addition, recipients may be eligible for low-interest disaster loans from the Small Business Administration or Congress could choose to appropriate supplemental funding to the CDBG program to provide assistance to affected homeowners.⁵⁴

In 2016, Connecticut requested that the federal government declare pyrrhotite damage a disaster, but FEMA determined that pyrrhotite damage does not qualify as a natural catastrophe under the Robert T.

⁵³The parties we interviewed most commonly suggested these two federal responses.

⁵⁴We have previously reported that these appropriations often provide HUD the authority to waive or modify many of the statutory and regulatory provisions governing the CDBG program, thus providing states with greater flexibility and discretion to address recovery needs. For example, in consecutive notices for disasters that occurred from 2001–2016, HUD waived the requirement that 70 percent of CDBG funds received by the state during a 1–to 3–year period be for activities that benefit persons of low and moderate income. See GAO, *Disaster Recovery: Better Monitoring of Block Grant Funds Is Needed*, [GAO-19-232](#) (Washington, D.C.: Mar. 25, 2019).

Stafford Disaster Relief and Emergency Assistance Act.⁵⁵ In January 2020, FEMA officials told us that even if pyrrhotite damage were declared a major disaster, the amount of support that FEMA can provide is dependent on what the President authorizes. Furthermore, officials stated that their programs would not be well-suited to meet the needs of affected homeowners.

Federally Backed Supplemental Insurance

Stakeholders, including real estate agents and financial industry representatives, with whom we spoke proposed a federally backed supplemental insurance program to protect homeowners who purchase potentially affected homes from the expense of foundation replacement should pyrrhotite damage occur. Two stakeholders suggested that such a program would help local housing markets because potential homebuyers are reluctant to buy homes with any amount of pyrrhotite. Real estate agents told us that buyers in the region have asked for core or visual tests for potentially affected homes and that some buyers are reluctant to look at homes in towns affected by pyrrhotite. Real estate agents told us that because there is no standard for acceptable levels of pyrrhotite in concrete, even homes with seemingly low levels of pyrrhotite could have difficulty selling because homeowners fear they might need to pay for costly repairs.

In certain cases, federal and state governments have established insurance programs to insure homeowners against risks that the private insurance market does not cover. In particular, one stakeholder suggested the National Flood Insurance Program—a federally backed program that insures properties across the country from flood damage—as the type of program that could help homeowners affected by pyrrhotite. Certain states also established supplemental insurance programs for risks that are generally not covered by the private insurance market, which could serve as a potential model for insuring against pyrrhotite-related risks. For example, Florida established an insurance corporation

⁵⁵42 U.S.C. §§ 5121, et seq. (commonly referred to as the Stafford Act). The Stafford Act provides for two types of disaster declarations: major disasters and emergencies. Major disasters are defined as natural catastrophes or, regardless of cause, fires, floods, or explosions and which causes damage of sufficient severity and magnitude. § 5122(2). Emergencies are more broadly defined than major disasters but require a determination that Federal assistance is needed to save lives and to protect property and public health and safety, or to lessen or avert the threat of a catastrophe. § 5122(1). The assistance available under an emergency declaration is immediate and short-term in nature. 44 C.F.R. § 206.63.

in 2002 to provide property insurance to residents who could not obtain it through the private market. As of 2019, the program covered more than 400,000 buildings and is funded by the premiums it collected as well as the reinsurance it purchased.

However, a federally backed insurance program for homes potentially affected by pyrrhotite may not be feasible because it would serve a small population and potentially have high expected claims, making it difficult to effectively spread the risk of loss across policyholders. We previously identified that when federal and state governments have stepped in to offer coverage that is either unaffordable or unavailable from private insurers, taxpayers may face a significant expense.⁵⁶ For example, we have recommended comprehensive reform of the National Flood Insurance Program, which was \$20.5 billion in debt to the Department of the Treasury as of September 2018.⁵⁷

Agency Comments

We provided a draft of this report to HUD, the Federal Housing Finance Agency, IRS, FEMA, and USDA for review and comment. We received technical comments from HUD and IRS, which we incorporated as appropriate. We also provided relevant excerpts of the draft for technical review to selected stakeholders cited in our report, and included their technical comments as appropriate.

⁵⁶GAO, *Homeowners Insurance: Multiple Challenges Make Expanding Private Coverage Difficult*, [GAO-14-179](#) (Washington, D.C.: Jan. 30, 2014).

⁵⁷In 2006, we designated the National Flood Insurance Program as one of our high-risk areas in need of transformation to address economy, efficiency, or effectiveness challenges. GAO, *High-Risk Series: Substantial Efforts Needed to Achieve Greater Progress on High-Risk Areas*, [GAO-19-157SP](#) (Washington, D.C.: Mar. 6, 2019).

We are sending copies of this report to the appropriate congressional committees, the Secretary of Housing and Urban Development, the Director of the Federal Housing Finance Agency, the Commissioner of the Internal Revenue Service, the Director of the Federal Emergency Management Agency, and the Secretary of Agriculture. In addition, the report is available at no charge on the GAO website at <https://www.gao.gov>.

If you or your staff have any questions about this report, please contact me at 202-512-8678 or pendletonj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix VI.



John H. Pendleton
Director, Financial Markets
and Community Investment

Our objectives in this report were to describe (1) what is known about the number of homes affected by pyrrhotite in Connecticut and Massachusetts; (2) the financial impact of pyrrhotite on homeowners; (3)

Appendix I: Objectives, Scope, and Methodology

the financial effects on towns, local housing markets, banks, and the federal government; and (4) federal options to mitigate pyrrhotite's financial impact on affected homeowners.¹

To address our first objective, we analyzed data on homes confirmed to have pyrrhotite from the Connecticut Foundation Solutions Indemnity Company, Inc. (CFSIC)—the captive insurer Connecticut established to provide remediation assistance to affected homeowners, Connecticut's pyrrhotite testing programs, and Connecticut town assessors. We did not obtain information on homeowner names or addresses and therefore could not determine the extent to which individual homeowners applied for multiple types of assistance. However, because each data source included the town in which positive cases were located, we identified the highest number of confirmed cases for each town across all three sources and summed each town's highest value to determine the minimum number of known cases in Connecticut (see app. III). We also interviewed representatives from CFSIC, state and local governments, and the Capitol Region Council of Governments (a regional organization) regarding projections on the number of homes that could be affected.

To address our second objective we reviewed information on costs to homeowners, available financial assistance, and out-of-pocket costs. Specifically, to assess costs to homeowners, we analyzed CFSIC data to determine the average amount of assistance per recipient. We also reviewed CFSIC guidance and interviewed officials to understand covered and uncovered remediation costs. To assess pyrrhotite's impact on home values, we searched publicly available real estate listings using aggregators such as Zillow and Redfin to identify a non-generalizable sample of recent sales listings in the affected area for homes built 1983–2015. We then reviewed the listings for information on whether the home

¹For the purposes of this report, "homeowners" includes the owners of single-family houses, condominium units, and planned unit development homes. We did not include commercial buildings in the scope of this report.

appeared to have pyrrhotite (such as mentions of positive pyrrhotite test results or descriptions of crumbling foundations) and to identify recent sales prices and dates. We also interviewed Internal Revenue Service officials, local accountants, and homeowners to determine the extent to which homeowners claimed the federal casualty loss deduction for pyrrhotite damage and their experiences doing so.

We also visited northeastern Connecticut to view damaged properties and hold discussion groups with affected homeowners. We held two discussion groups with a total of 13 households. To solicit homeowners for our discussion groups, Connecticut's Homeowner Advocate randomly selected homeowners with whom she had been in contact (including condominium owners) to receive an invitation to participate. We interviewed these homeowners about their experiences with pyrrhotite damage and accessing federal and state programs. We supplemented these discussion groups with a teleconference with six affected Massachusetts homeowners, additional interviews with Connecticut homeowners who wanted to participate but could not attend the discussion groups, and homeowner advocates. In total, we spoke with representatives of 27 affected families. Although the information we obtained from affected homeowners allowed us to provide anecdotal perspectives, it is not generalizable to all affected homeowners.

To address our third objective, we applied different methodologies to assess pyrrhotite's financial effects on towns, local housing markets, banks, and the federal government:

- **Towns.** We requested data on pyrrhotite-related reassessments from the assessors of 30 Connecticut towns that CFSIC or testing program data indicated had at least one home with confirmed pyrrhotite. We received responses from all 30 towns: 22 confirmed that their towns had at least one pyrrhotite-related reassessment and provided us with related data, one assessor confirmed that the town had pyrrhotite-related reassessments but did not provide us with data, and the other seven said no one in their towns had requested a reassessment due to pyrrhotite.² We subsequently compiled the data we received to analyze trends in property tax reassessments and calculate related tax revenue losses per town. In addition, we interviewed officials from seven affected towns regarding pyrrhotite's effects on their budgets, operations, and municipal buildings. We selected these towns

²In the data sources we reviewed to identify potentially affected towns, these seven towns all had one or two affected properties.

because they all had more than 50 properties reassessed due to pyrrhotite.

- **Housing markets.** To assess pyrrhotite’s effect on local housing markets, we obtained data from SmartMLS—a multiple listing service in Connecticut—on home sales from January 2012 to March 2020 in Tolland and Hartford Counties (the two most affected counties).³ We conducted a regression analysis to test whether single-family homes built in 1983–2015 or in highly affected towns had a significantly lower average sales price than single-family homes built in 1970–1982 or in less-affected towns.⁴ We also included data from the Census Bureau’s American Community Survey to control for demographic variables. See appendix IV for more information about the regression analysis methodology. In addition, we interviewed the then-president of the Connecticut Association of Realtors and local real estate agents to learn more about how pyrrhotite affected home sales in the region.
- **Banks and the federal government.** To assess pyrrhotite’s effects on banks, we interviewed representatives from the Connecticut and Massachusetts state banking associations, as well as representatives of two banks in the affected region (one in Connecticut and one in Massachusetts). To assess pyrrhotite’s effects on the federal government, we obtained and analyzed data from Fannie Mae, Freddie Mac, and the Federal Housing Administration on the characteristics of mortgages they hold in the affected region on homes built in 1983–2015. We also interviewed representatives of these entities regarding the extent to which pyrrhotite has affected their mortgage portfolios.

We took various steps to assess the reliability of the data analyzed in the first three objectives, including interviewing knowledgeable officials, reviewing related documentation, and analyzing the data for outliers or errors. In the few instances in which we identified potential outliers or errors, we followed up with the data provider to confirm or receive a correction. Based on these actions, we determined the data were

³A multiple listing service is a database that cooperating real estate brokers establish to provide data about properties for sale.

⁴We defined a highly affected town as one with 1.5 or more affected houses per 100 houses and a less-affected town as one with less than 0.5 affected houses per 100 houses. In this area, each town typically has one ZIP code, so we use towns and ZIP codes interchangeably in our report. Data on affected houses per town came from CFSIC, Connecticut testing programs, and town assessors. Data on houses per town came from the Census Bureau’s American Community Survey data.

sufficiently reliable to report on the number of homes affected by pyrrhotite and pyrrhotite's financial effects on homeowners, towns, local housing markets, banks, and the federal government.

To address our fourth objective, we reviewed the Catalog of Federal Domestic Assistance and agency reports to identify federal programs that could potentially provide home remediation assistance to homeowners or localities.⁵ We did not include federal programs that only provide remediation assistance for health hazards, such as lead-based paint. For programs we identified, we reviewed agency documentation to determine program requirements, eligibility criteria, and other information. We also interviewed officials at the Department of Housing and Urban Development and Department of Agriculture to confirm the extent to which these programs could be used to assist pyrrhotite-affected homeowners.

We assessed potential federal responses to pyrrhotite by reviewing federal actions in similar situations, stakeholders' suggestions for federal actions, and responses to similar situations in other countries.

- **Similar situations in the United States.** We reviewed the federal response in other situations in which homeowners incurred substantial uninsured repair costs or losses in home value: defective drywall and underwater mortgages during the 2007–2011 housing crisis. We reviewed GAO and agency reports to identify relevant federal and state responses, the extent to which these responses helped affected homeowners, and their applicability to pyrrhotite damage.
- **Stakeholder suggestions.** In our interviews with local stakeholders—including real estate agents, banks, and town officials—and homeowners, we asked for their suggestions on additional federal actions to help affected homeowners. We then conducted additional research into two of the most common suggestions: that the federal government declare pyrrhotite damage a major disaster and establish a federally backed insurance program for potentially affected houses. To assess the feasibility of these responses and the extent to which they would mitigate the financial impact of pyrrhotite damage on affected homeowners, we interviewed officials at the Federal

⁵Office of Management and Budget and General Services Administration, *2019 Catalog of Federal Domestic Assistance* (Washington, D.C.: October 2019). For an example of another agency publication reviewed, see Federal Deposit Insurance Corporation, *Affordable Mortgage Lending Guide, Part I: Federal Agencies and Government Sponsored Enterprises* (Washington, D.C.: November 2018).

Emergency Management Agency and the Connecticut Insurance Department and reviewed relevant reports.

- **Other countries.** Pyrrhotite is an iron sulfide mineral and we identified two other countries that recently experienced iron sulfide damage in residential structures: Canada and Ireland. We reviewed documentation and interviewed officials from these countries to learn about their responses and the extent to which these responses mitigated the financial impact on homeowners. See appendix II for more information on responses in Canada and Ireland.

We conducted this performance audit from June 2019 to July 2020 in accordance with generally accepted government auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Pyrrhotite and another iron sulfide (pyrite) have caused damage to homes in Canada and Ireland.¹ We examined the extent of the problem in each country and the actions that each government has taken in response. In

Appendix II: Responses of Canada and Ireland to Iron Sulfide Damage in Homes

both cases, the federal or provincial government established a program to provide at least partial financial assistance to all affected homeowners.

Canada's Response to Pyrrhotite

Beginning in 2009, some homeowners in the Mauricie region of Quebec learned that their homes built between 1996 and 2008 had concrete foundations with pyrrhotite damage.² A homeowner advocacy group estimates that there could be as many as 4,000 affected homes.

The Warranty Plan for New Residential Buildings—a mandatory warranty plan for all new homes in Quebec run by an independent company—covered all costs directly associated with foundation replacement for homeowners who discovered pyrrhotite damage within 5 years of their home's construction. As of 2014, the warranty plan had covered the foundation replacement of more than 700 homes, totaling nearly \$100 million Canadian dollars (CAD).³ As a result, the warranty administrator incurred significant financial losses and in 2013, was placed under new management. Homeowners, businesses, and the warranty plan administrator brought a lawsuit against various parties, including the engineering firm that determined the concrete aggregate was sound, concrete mixers, and the quarry. In 2014, a Canadian Superior Court judge decided in favor of the plaintiffs and awarded them a large settlement. The Court awarded payment to properties with a

¹Pyrrhotite and pyrite have different chemical structures but both minerals contain iron and sulfur and swell in concrete when exposed to oxygen and water.

²Our summary of the response to pyrrhotite damage in Quebec is based on our review of reports from the Quebec Housing Corporation and other stakeholders, and interviews with the Quebec Housing Corporation.

³As of June 2020, 1 Canadian dollar was worth about 0.74 U.S. dollars.

concentration of pyrrhotite at or above 0.23 percent; however, Quebec officials we interviewed explained that these standards were determined by the Court. In 2019, the National Research Council of Canada announced that it would devote CAD\$4.9 million to research to develop pyrrhotite standards for new construction.

In 2011, the Quebec government established a grant program to assist homeowners whose homes were no longer under warranty. The program covers 75 percent of foundation replacement expenses, up to CAD\$75,000. Homeowners who received assistance from the warranty plan are also eligible for up to CAD\$15,000 from the government grant program to cover additional related expenses such as refinishing basements.

Quebec government officials told us that as of 2019, the program had assisted 1,121 homes. The Quebec government directly funds the program but the national government of Canada supplemented program funding with CAD\$30 million from 2016 through 2019. Quebec government officials told us that the Quebec government had committed funding to the program through 2022, and that by that point, it expects it will have spent CAD\$54 million on pyrrhotite remediation.

Irish Response to Pyrite

Beginning in 2005, homeowners in Ireland discovered that the hardcores (infill materials that support a building's foundation) under concrete slab floors in recently built homes in and around Dublin were developing cracks due to pyrite (an iron sulfide similar to pyrrhotite).⁴ In response, the Irish government established the Pyrite Remediation Scheme for affected homes and adopted building standards limiting the presence of sulfur to 1 percent of concrete. The Pyrite Remediation Scheme pays for pyrite testing expenses and funds the home remediation as well as rental housing costs while the home is under repair. Representatives from Pyrite Remediation Board (which runs the Scheme) told us that the Irish government funds the Scheme through an annual appropriation through the Department of Housing, Planning, and Local Government.

⁴Concrete slab floors are poured across the ground floor of a home and flooring such as hardwood or tile is installed above. Affected slab floors crack and buckle, causing the flooring to bulge.

**Appendix II: Responses of Canada and Ireland
to Iron Sulfide Damage in Homes**

Representatives from the Pyrite Remediation Board told us that in 2019, the Scheme provided an average of €65,000 per affected home.⁵ They added that because the damage in Ireland was not to the foundation, the house does not have to be lifted to be remediated and thus costs in Ireland tend to be less than those in the United States and Canada.

Officials told us that as of December 2019, the Scheme had received 2,592 applications and had remediated 1,890 homes, with an additional 220 homes in progress. The program has expended more than €125 million.

⁵As of June 2020, 1 Euro was worth about 1.12 U.S. dollars.

We assessed data from three Connecticut sources that collect information on homes with confirmed pyrrhotite and the towns in which they are located. We determined that, as of December 2019, at least 1,600

Appendix III: Number of Connecticut Homes with Confirmed Cases of Pyrrhotite by Town

residential units have confirmed pyrrhotite.¹ Because we did not obtain personally identifiable information, we could not determine the extent to which the data sources overlapped due to homeowners utilizing more than one assistance program. Therefore, we could not determine the exact number of unique homes included in these sources. Instead, we considered the highest number of cases across the three sources to be the minimum for each town, and we summed these across all of the towns to arrive at the minimum number of confirmed cases in Connecticut (see table 4). However, there may be some homeowners who did not use the type of assistance with the highest count, but did use at least one of the other two types of assistance; therefore, the total number of unique homes in these data sources may be higher.

¹Each of the three sources counts cases among both single-family houses and condominium units. For example, if a 10-unit condominium had confirmed pyrrhotite, then each source would identify this as 10 unique cases of pyrrhotite.

**Appendix III: Number of Connecticut Homes
with Confirmed Cases of Pyrrhotite by Town**

Table 4: Minimum Number of Connecticut Homes with Confirmed Cases of Pyrrhotite by Town (as of December 2019)

Town	CFSIC^a	Connecticut testing programs	Properties with a pyrrhotite-related reassessment^b	Highest count
Vernon	340	103	230	340
Manchester	109	249	160	249
Tolland	139	213	217	217
Stafford	86	173	129	173
South Windsor	93	101	112	112
Willington	89	97	100	100
Ellington	61	83	- ^c	83
East Windsor	72	6	11	72
Coventry	48	54	54	54
All other towns ^d	127	197	144	207 ^e
Total	1,164	1,276	1,157	1,607

Source: GAO analysis of data from the Connecticut Foundation Solutions Indemnity Company, Inc. (CFSIC), Connecticut testing programs, and town assessors. | GAO-20-649

Note: Counts include single-family houses and condominium units.

^aCFSIC applications included in the table include all applicants with a positive visual or core test. Not included are 22 applicants who had been denied for eligibility reasons, and 17 additional applicants who had not yet provided CFSIC with proof of pyrrhotite.

^bTwenty-two towns provided us with data on their pyrrhotite-related reassessments through 2018. In addition, 16 of those 22 towns provided us with data for some or all of their pyrrhotite-related reassessment for 2019.

^cDid not provide us with assessment data.

^dIncludes 21 towns each with less than 50 confirmed cases of pyrrhotite in any dataset. Not every town is represented in each dataset.

^eWe calculated the highest count for each town in this row individually. For a few towns, the highest number of pyrrhotite cases came from CFSIC or town assessor data; thus, the number highest count for "all other towns" is greater than 197.

We developed a multivariate regression model to estimate the extent to which the presence of pyrrhotite-damaged houses in selected Connecticut ZIP codes affected average sales prices of houses sold in

Appendix IV: Description of and Results for GAO's Econometric Model of Pyrrhotite's Potential Effect on House Prices

these ZIP codes in 2015–2020. To date, concrete containing pyrrhotite has been identified in houses built in 1983–2015, and certain ZIP codes have more houses reported as affected than others. Because pyrrhotite damage occurs gradually and it is difficult to observe which houses do or do not have pyrrhotite, we hypothesized that there might be a general downward pressure on average sales prices of houses in affected ZIP codes built during this time.

To test this hypothesis, we estimated a regression model, where we controlled for other factors that also may affect house price (such as house size and age, town demographics, and time of year) to determine:

1. whether houses in highly affected ZIP codes sold for significantly less than those in the same county but in other ZIP codes (“moderately affected” and “less-affected” ZIP codes), and if these differences varied based on when the house was built; and
2. whether houses built in 1983–2015 sold at lower prices on average than houses built earlier (1970–1982) and if this difference varied based on the extent to which the ZIP code is affected by pyrrhotite.¹

¹In this area, each town typically has one ZIP code, so we use towns and ZIP codes interchangeably in our report. Six towns in our sample had two ZIP codes and one town did not have its own ZIP code.

Estimation Model

We used a hedonic regression model, which typically is used to estimate the relationship between prices of houses and their characteristics.² Our model also uses fixed effects as explained below with robust errors. We analyzed the effect of location and year built (indicating a potential pyrrhotite problem) on the sales prices of single-family houses in Tolland and Hartford Counties, while controlling for other factors that affect house prices. Our model is represented below:

$$P_{izt} = \alpha + \beta * X_z + \gamma * A_i + \mu * X_i * A_i + \lambda * Z_i + \delta * S_z + \eta * T_i + \varepsilon$$

The dependent variable “P” represents the sales price at closing, where “i” identifies each house sale, “z” represents the ZIP code in which the house is located, and “t” identifies the year (t= 2015–2020), the house was sold. We trimmed the sales prices by dropping the top 1 percent and bottom 1 percent to avoid potential outliers.³

X_z represents a set of indicator variables for location (whether the house is in a highly or moderately affected ZIP code). The coefficients for these variables, parameter β s, would show the average price difference between a house in a highly or moderately affected ZIP code and one in a less-affected ZIP code. A negative value indicates a lower price for houses located in the highly or moderately affected ZIP codes.

A_i is a set of indicator variables for period built (whether the house was built in 1983–2015 when concrete containing pyrrhotite was used). A value of “1” would indicate the house was built in this period and a value of “0” would indicate it was built in 1970–1982. A negative value for this

²For example, one paper using a hedonic model showed how the number of days a house has been on the market affects its average sales price while controlling for house characteristics. See Catherine Tucker, Juanjuan Zhang, and Ting Zhu, “Days on market and home sales,” *The RAND Journal of Economics*, vol. 44, no. 2 (Summer 2013). Another paper used this kind of approach to estimate the spillover effects of foreclosures in an area on sales price of other houses located there. See John Y. Campbell, Stefano Giglio, and Parag Pathak, “Forced Sales and House Prices,” *The American Economic Review*, vol. 101, no. 5 (August 2011).

³Our analysis did not match individual houses over time.

parameter would indicate that the sales price of a house built in 1983–2015 was lower than one built in 1970–1982.⁴

$X_i * A_i$ are a set of variables that represent the interaction between a house's ZIP code and the period in which it was built. For example, the coefficients for these variables show the effect on sales price for a house built in 1983–2015 and located in a highly affected ZIP code, compared to others built in the same years but not in the same ZIP code or located in the same ZIP code but built in a different period.

Z_i represents other house characteristics that can affect the sales price such as number of bedrooms, number of bathrooms, square footage, acreage, and age. We calculated age using an individual house's year built and included it in addition to the indicator variables for the period during which the house was built, as described above.

S_z controls for various socioeconomic and demographic characteristics of ZIP codes. We used data from Census Bureau (specific variables are described below).

T_i represents a set of fixed time effects for the year in which a house sold during 2015–2020 and also includes dummy variables for each month to control for seasonality. The idiosyncratic error terms—unobserved factors that affect the dependent variable are represented by ϵ .

To reduce the impact of any model misspecifications or heteroscedasticity, we used a robust estimator.⁵ We also performed sensitivity analyses (described in detail later) and our findings were robust. See tables 5 to 8 for a summary of our regression results.

⁴Our dataset only included houses built in 1970 and later, so we did not have sales of houses built before 1970. The dataset also included houses built after 2015, which we included in our analyses but did not report the results because they were not reliable enough given the limited number of observations.

⁵Specifically, we used the Huber-White sandwich estimator, which helps to forgo model-based variance estimates in favor of more model-agnostic “robust” variances. Robust variances give more accurate assessments of the sample-to-sample variability of parameter estimates even when the model is misspecified.

Data Sources

We used the following data sources in our analysis:

- **SmartMLS.** We used transaction-level data from SmartMLS—a multiple listing service—on all house sales from January 2015 to March 2020 in Connecticut's Tolland and Hartford Counties (the two most heavily affected counties) and for houses built in 1970–2020.⁶ For each sale, these data include information on the sales price, the year built, location (ZIP code and county), and time of sale (year and month). The data also include house characteristics, such as number of bedrooms, number of bathrooms, square footage, and acreage.
- **Census Bureau.** We used data from the Census Bureau's American Community Survey (obtained through Integrated Public Use Microdata Series) on socioeconomic characteristics to control for variation across ZIP codes.⁷ Specifically, we included (1) population size, (2) per capita income, (3) percent of population employed, (4) percent of population below age 40, (5) percent of population above age 65, (6) percent white, (7) percent male, (8) percent of population with a bachelor's degree, and (9) percent of population with a master's degree or higher. We also used American Community Survey data on the number of houses per ZIP code to develop our system to categorize ZIP codes by their level of pyrrhotite damage (as we explain below).
- **Confirmed cases of pyrrhotite per ZIP code.** We obtained data on the number of houses with confirmed pyrrhotite per ZIP code from the Connecticut Foundation Solutions Indemnity Company, Inc., Connecticut pyrrhotite testing programs, and town assessors. For more information on these data sources, see appendix I.

⁶We assessed the reliability of these data by checking for errors, inconsistencies, and outliers and resolving them with the vendor.

⁷Steven Manson, Jonathan Schroeder, David Van Riper, and Steven Ruggles. IPUMS National Historical Geographic Information System: Version 14.0 [Database]. Minneapolis, MN: IPUMS. 2019

Scope and Town Classification Methodology

We defined the geographic and time period scope of our analysis in the following ways:

- **Year built.** We requested and obtained data for sales of houses built after 1970 so that we could divide them in three groups for our analysis: those built in 1970–1982 and those built in 1983–2015 and those built in 2016–2020. As previously discussed, pyrrhotite-containing concrete has only been identified in homes built in 1983–2015.⁸
- **Year of sale.** We focused our analysis on sales from January 2015 to March 2020 because pyrrhotite damage became widely known in Connecticut beginning in 2015. We also examined average sales prices in 2012–2014 to compare those trends with sales starting in 2015.
- **Location.** We limited our analysis to Tolland and Hartford Counties (where almost all known cases of pyrrhotite are located) and estimated the regression model for the two counties separately.
- **Type of property.** We focused our analysis on single-family houses and separated them from condominiums and other residential structures.⁹

We also developed a classification system to determine a ZIP code's level of pyrrhotite damage. Specifically, we used Census Bureau's American Community Survey data on the number of houses per ZIP code to develop a measure of the proportion of pyrrhotite-affected houses per

⁸We also obtained data on sales for houses built after 2015 (in 2016–2020), but there were only about 149 such sales across all categories of ZIP codes in Tolland and 299 in Hartford. We ran our analysis with an indicator variable for these newer houses but did not report the results because they may not be reliable due to the limited number of observations.

⁹We analyzed the sales prices of condominiums as a part of sensitivity tests to see if they supported our findings for single-family houses.

100 houses.¹⁰ We subsequently used these to group ZIP codes into categories of highly affected, moderately affected, and less-affected (see below). We used this measure to normalize the size (in terms of number of houses) across ZIP codes. The number of houses in each ZIP code varied widely, so it would not have been reasonable to categorize them based on the absolute number of affected houses in a ZIP code.¹¹

Our categories were as follows:¹²

- **Highly affected.** We categorized ZIP codes with 1.5 or more affected houses per 100 houses as highly affected. There were seven ZIP codes in this category.
- **Moderately affected.** We categorized ZIP codes with 0.5–1.49 affected houses per 100 houses as moderately affected. There were seven ZIP codes in this category.
- **Less-affected.** We categorized ZIP codes with less than 0.5 affected houses per 100 houses as less-affected. There were 15 ZIP codes in this category.¹³

¹⁰We used the number of all types of residences (and not just single-family houses) in our denominator as most types of housing can be considered as alternatives to each other. However, we tried alternative calculations where the denominator was restricted to only attached and detached one-unit houses and another where the denominator only included houses built in 1980–2013. All these yielded similar classifications and our classifications also match what is generally known to be highly affected towns.

¹¹For example, South Windsor had 112 affected houses out of a total of more than 10,000 houses and was categorized as moderately affected. On the other hand, East Windsor had 72 affected houses out of a total of just over 2,000 houses. Therefore in our analysis, it was categorized as highly affected.

¹²For Tolland County, the highly affected category represented 37 percent of sales in 2015–2020, the moderately affected represented 21 percent, and the less-affected represented 42 percent. For Hartford County, the highly affected category represented 16 percent of sales in 2015–2020, the moderately affected represented 14 percent, and the less-affected represented 69 percent.

¹³In our analysis, we used these groups of ZIP codes as our reference category.

Estimation Results

Tolland County

Our model estimated the sales prices of single-family houses using indicator variables for year built and location, among other factors.¹⁴ We first compared houses across different categories of ZIP codes based on the period in which they were built. We found that houses located in a highly affected ZIP code and built in 1983–2015 sold at significantly lower prices than those in less-affected ZIP codes and built in the same period (see table 5). Specifically, for sales in 2015–2020, houses in highly affected ZIP codes built in 1983–2015 sold for about \$16,000 less on average than houses built in the same period in less-affected ZIP codes. In contrast, there was no significant price difference between these ZIP codes for houses built in 1970–1982 (that is, the price difference is only present for houses built when pyrrhotite-containing concrete was used). We found similar results comparing sales prices in highly affected and moderately affected ZIP codes. However, we did not see this pattern for sales in 2012–2014, before the presence of pyrrhotite became widely known. In other words, average sales price for houses in highly affected ZIP codes were not significantly different from houses in less-affected ZIP codes, irrespective of when they were built.¹⁵ These results support the hypothesis that a potential pyrrhotite problem may have created a general downward pressure on average sales price of houses in affected ZIP codes that were built in 1983–2015, all else equal.

¹⁴In a regression model the effect of an indicator variable on the dependent variable is interpreted as a difference from a reference case. In this model, the reference case represents the sales price of a typical house located in a less-affected ZIP code and built in 1970–1982. We used the coefficient values on the location and year-built indicators, as well as interactions between them, to examine the magnitude and statistical significance of differences in the sales price of this typical house if it had another combination of year-built and location.

¹⁵Among houses built in 1970–1982 and for sales before 2015, those in moderately affected ZIP codes had significantly lower average prices than those in less-affected ZIP codes. However, for sales after 2015, sales prices in moderately affected ZIP codes were not significantly different than those in less-affected ZIP codes.

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Table 5: Regression Results on Average Differences in House Sales Prices in Tolland County, in Dollars

	Sales: 2015–2020		Sales: 2012–2014	
	Year built: 1970–1982	Year built: 1983–2015	Year built: 1970–1982	Year built: 1983–2015
Difference between highly and less-affected ZIP codes	4,145	-16,085***	1,036	-6,565
Difference between highly and moderately affected ZIP codes	10,646**	-12,187***	20,279***	-769
Difference between moderately and less-affected ZIP codes	-6,501	-3,898	-19,243**	-5,796

	Sales: 2015–2020	Sales: 2012–2014
Number of observations	4051	1,865
R-square (percent)	67	76

- Other explanatory variables**
1. Square footage, acreage, and number of bedrooms and bathrooms all had positive and significant effects on price.
 2. Age of the house had a negative and significant effect on the price.
 3. Sales in all spring and summer months generally showed significantly higher prices than sales in December.

Legend: *** = significance at the 1 percent level; ** = significance at the 5 percent level

Source: GAO analysis of SmartMLS data. | GAO-20-649

Notes: We categorized the ZIP codes as highly, moderately, and less-affected based on the proportion of all houses affected in a particular ZIP code. We defined the highly affected group as the set of ZIP codes that had 1.5 or more affected houses per 100 houses, moderately affected as 0.5–1.49 affected houses per 100 houses, and less-affected as less than 0.5 affected houses per 100 houses.

We also estimated average prices for houses built in 1970–1982 and those built in 1983–2015 within the same category of ZIP codes using results from our regression model to see if the differences between them were significant. As shown in table 6, the average sales price across all three categories of ZIP codes in Tolland County was significantly lower for houses built in 1983–2015 than for those built in 1970–1982 (after controlling for other factors that affect sales price). This could signal potential concerns about pyrrhotite: typically, all else equal, newer houses would be expected to have higher average sales prices than older

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houses.¹⁶ However, sales prices for the newer houses were significantly lower, even for sales in 2012–2014. Therefore, it is unclear whether these differences can be statistically related to pyrrhotite.

Table 6: Estimated Average House Sales Prices in Tolland County by Year Built, in Dollars

	Sales: 2015–2020			Sales: 2012–2014		
	Year built: 1970–1982	Year built: 1983–2015	Difference between periods	Year built: 1970–1982	Year built: 1983–2015	Difference between periods
Highly affected ZIP codes	234,145	193,019	-41,126***	217,036	184,541	-32,495***
Moderately affected ZIP codes	223,499	205,206	-18,293***	196,757	185,310	-11,447*
Less-affected ZIP codes	230,000	209,104	-20,896***	216,000	191,106	-24,894***

Legend: *** = significance at the 1 percent level; ** = significance at the 5 percent level

Source: GAO analysis of SmartMLS data. | GAO-20-649

Notes: We categorized ZIP codes as highly, moderately, and less-affected based on the proportion of all houses affected in a particular ZIP code. We defined the highly affected group as the set of ZIP codes that had 1.5 or more affected houses per 100 houses, moderately affected as 0.5–1.49 affected houses per 100 houses, and less-affected as less than 0.5 affected houses per 100 houses.

Hartford County

In Hartford County, for sales in 2015–2020, houses in highly affected ZIP codes sold at significantly lower prices on average than houses in less-affected ZIP codes and this difference was significantly greater for houses built in 1983–2015 than those built in 1970–1982 (see table 7).¹⁷ For example, if houses in highly affected ZIP codes were built in 1970–1982, they sold for \$33,000 less on average than houses in less-affected ZIP codes. But these houses sold for almost \$53,000 less if they were built in 1983–2015. The same pattern held when comparing highly affected ZIP codes with moderately affected ones and moderately affected ZIP codes with less-affected ZIP ones. For sales in 2012–2014, the price difference between houses built in 1983–2015 in highly affected ZIP codes and less-affected ZIP was \$45,000 less on average than sales after 2015. The

¹⁶In our model, the age of the house had a significant and negative effect on sales price after we controlled for the period in which it was built. Although houses built in 1983–2015 as a group sold at a lower price on average than those built in 1970–1982, within each of these periods, the older the house, the lower the price.

¹⁷As of June 2020, many ZIP codes in Hartford County did not have any pyrrhotite-affected properties. In general, these unaffected ZIP codes were furthest from the concrete company that supplied the defective concrete. Because of their distance from the epicenter and lack of any affected properties, we removed them from our scope.

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same is true when we look at the price differences between houses in moderately affected and less-affected ZIP codes in sales before and after 2015.¹⁸ These results could be consistent with a potential adverse effect of pyrrhotite on average house prices in Hartford County for homes built during 1983–2015, all else equal.

Table 7: Regression Results on Average Differences in House Sales Prices in Hartford County, in Dollars

	Sales: 2015–2020		Sales: 2012–2014	
	Year built: 1970–1982	Year built: 1983–2015	Year built: 1970–1982	Year built: 1983–2015
Difference between highly and less-affected ZIP codes	-33,021***	-52,610***	-31,601***	-44,941***
Difference between highly and moderately affected ZIP codes	-22,473***	-34,304***	-10,014	-36,472***
Difference between moderately and less-affected ZIP codes	-10,548***	-18,306***	-21,587***	-8469

	Sales: 2015–2020	Sales: 2012–2014
Number of observations	5388	2594
R-square (percent)	81	81

- Other explanatory variables**
4. Square footage, acreage, and number of bedrooms and bathrooms all had positive and significant effects on price.
 5. Age of the house had a negative and significant effect on the price.
 6. Sales in all spring and summer months generally showed significantly higher prices than sales in December.

Legend: *** = significance at the 1 percent level; ** = significance at the 5 percent level
Source: GAO analysis of SmartMLS data. | GAO-20-649

Notes: We categorized ZIP codes as highly, moderately, and less-affected based on the proportion of all houses affected in a particular ZIP code. We defined the highly affected group as the set of ZIP codes that had 1.5 or more affected houses per 100 houses, moderately affected as 0.5–1.49 affected houses per 100 houses, and less-affected as less than 0.5 affected houses per 100 houses.

Similar to Tolland County, in Hartford County, all houses built in 1983–2015 sold at significantly lower prices than houses built in 1970–1982 in all categories of ZIP codes (see table 8). This is true for sales before and

¹⁸The price differences between houses in highly affected ZIP codes and moderately affected ZIP were almost the same in sales before and after 2015.

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after 2015, so it is unclear whether these differences can be statistically related to pyrrhotite.

Table 8: Estimated Average Home Sales Prices in Hartford County by Year Built, in Dollars

	Sales: 2015–2020			Sales: 2012–2014		
	Year built: 1970–1982	Year built: 1983–2015	Difference between periods	Year built: 1970–1982	Year built: 1983–2015	Difference between periods
Highly affected ZIP codes	226,979	184,488	-42,491***	218,399	177,812	-40,587***
Moderately affected ZIP codes	249,452	218,792	-30,660***	228,413	214,284	-14,129**
Less-affected ZIP codes	260,000	237,098	-22902***	250,000	222,753	-27,247***

Legend: *** = significance at the 1 percent level; ** = significance at the 5 percent level

Source: GAO analysis of SmartMLS data. | GAO-20-649

Notes: We categorized ZIP codes as highly, moderately, and less-affected based on the proportion of all houses affected in a particular ZIP code. We defined the highly affected group as the set of ZIP codes that had 1.5 or more affected houses per 100 houses, moderately affected as 0.5–1.49 affected houses per 100 homes, and less-affected as less than 0.5 affected houses per 100 houses.

Sensitivity Analyses and Potential Limitations

Sensitivity Analyses

To check the robustness of our findings, we performed several sensitivity analyses by using alternative specifications of our model and by changing the scope of our data as described below. All of these resulted in similar findings to our original model.

1. We used data on all prices instead of trimming the prices to exclude the top 1 percent and bottom 1 percent of prices. We also used a log transformation of price as our dependent variable.
2. We used different mathematical transformations of square footage and acreage. For example, we tried the square root of square footage but not acreage and then another model with the square root of square footage and acreage.
3. Instead of categorizing ZIP codes according to the proportion of houses affected, we used the actual proportion of affected houses per ZIP code.
4. We estimated all sales in 2012–2020 together instead of before and after 2015.

5. We estimated the same model for condominiums instead of single-family houses and categorized towns as being affected based on whether there were affected condos in a particular ZIP code or not.

Potential Limitations

As described above, we tried several alternative specifications of our model; however, the linear model we used may still have some of the usual shortcomings. That is, it may be subject to specification bias to the extent the relationship between price and some of the independent variables is not linear. It also may be subject to omission bias to the extent there are other variables that affect average sales prices for which we could not account. It also does not account for qualitative and other differences between ZIP codes not captured in the Census Bureau data. Our model also does not account for changes in socioeconomic and demographic profiles across time. Finally, our sources likely do not capture all known cases of pyrrhotite in Connecticut—some homeowners may have replaced their foundations without any of the three types of assistance and therefore will not show up in our count of affected houses.¹⁹

¹⁹In some cases, homeowners' insurance companies paid for pyrrhotite testing but these results are not reported to the state.

Appendix V: Federal Assistance Programs That Could Provide Financial Assistance to Homes Affected by Pyrrhotite

We identified three federal grant programs and five federal loan programs that agency officials confirmed could potentially be used toward pyrrhotite remediation expenses.¹

Of the three grant programs, two limit eligibility to homes located in rural areas and all three limit eligibility to applicants below a specific income threshold (see table 9).

Table 9: Federal Grant Programs Potentially Available to Assist Homeowners Affected by Pyrrhotite

Program and description	Agency	Key eligibility requirements	Maximum benefit, in dollars ^a	Total program funding, in dollars (fiscal year 2019)
Section 504 Home Repair Program Grant: Provides grants to elderly very low-income homeowners to remove health and safety hazards.	USDA	<ul style="list-style-type: none"> The property must be located in an eligible rural area. Applicants must have very low incomes (for instance, up to \$51,300 in Tolland County, Connecticut). Applicants must be age 62 or over. 	7,500	30 million
Rural Housing Preservation Grant: Provides grants to communities for use in assisting very low- and low-income rural homeowners to repair, rehabilitate, or replace their dwellings.	USDA	<ul style="list-style-type: none"> The property must be located in an eligible rural area. Applicants must have very low- or low-incomes. 	Limit determined by sponsoring organization	15 million

¹Certain funds under the Department of Housing and Urban Development's Community Block Grant Program can also be used for pyrrhotite remediation. These grants are discussed elsewhere in this report.

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HOME Investment Partnerships Program: Recipients can distribute grant funds as grants, loans, or in other forms to be used for affordable housing to benefit low-income households. Relevant eligible uses include home rehabilitation.	HUD	<ul style="list-style-type: none"> Applicants must have very low or low-incomes. 	Funding distribution determined by local and state governments	Connecticut awarded 9 million
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Legend: HUD = Department of Housing and Urban Development; USDA = Department of Agriculture
Source: GAO analysis of federal agency documents. | GAO-20-649

^aThe maximum benefit may be subject to other restrictions under applicable federal laws and regulations.

In addition, we identified five loan programs that are available to affected homeowners (see table 10).

Table 10: Federal Loan Programs Potentially Available to Assist Homeowners Affected by Pyrrhotite

Program and description	Agency	Key eligibility requirements	Maximum benefit, in dollars ^a
Section 502 Direct Loan Program: Assists very low- to low-income households to obtain adequate housing for use as a permanent residence in rural areas. Borrowers may qualify for a subsidized interest rate as low as 1 percent and a loan term up to 38 years.	USDA	<ul style="list-style-type: none"> The property must be located in an eligible rural area. Applicants must have very low or low incomes (for instance, up to \$78,500 in Tolland County, Connecticut). 	Loan combined with existing mortgage cannot exceed the value of the home
Section 504 Home Repair Program Loan: Provides loans to very low-income homeowners to repair or improve their homes to remove health and safety hazards. Loans can have a term of up to 20 years; loan interest rate is fixed at 1 percent.	USDA	<ul style="list-style-type: none"> The property must be located in an eligible rural area. Applicants must have very low incomes (below \$51,300 in Tolland County). 	20,000
Community Development Block Grant Section 108 Loan Guarantee Program: Allows communities to borrow against their current and future Community Development Block Grant allocations to fund larger-scale housing and community and economic development projects.	HUD	<ul style="list-style-type: none"> Projects and activities must benefit low- and moderate-income persons, aid in the elimination or prevention of slums and blight, or meet urgent needs of the community 	Funding distribution determined by local and state governments
203(k) Rehab Mortgage Insurance: Enables homeowners to finance the rehabilitation of a newly purchased or existing home.	HUD	<ul style="list-style-type: none"> None with respect to income, age, or geography^a 	Loan combined with existing mortgage cannot exceed FHA loan limit (353,050 in Tolland County in 2020)
Property Improvement Loan Insurance: Provides mortgage insurance to protect lenders against the risk of default on mortgages to qualified buyers to finance improvements to homes.	HUD	<ul style="list-style-type: none"> None with respect to income, age, or geography^a 	25,000

Legend: HUD = Department of Housing and Urban Development; USDA = Department of Agriculture
Source: GAO analysis of federal agency documents. | GAO-20-649

^aThe maximum benefit may be subject to additional restrictions under applicable federal laws and regulations.

Appendix VI: GAO Contact and Staff Acknowledgments

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Staff Acknowledgments

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