Health Consultation

Final Release

Public Health Implications of Exposures to Foundry Waste

SOUTHSIDE CHATTANOOGA LEAD SITE
National Priorities List

CHATTANOOGA, HAMILTON COUNTY, TENNESSEE

EPA FACILITY ID: TNN000410686

Prepared by the

Tennessee Department of Health

MAY 17, 2023

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Office of Capacity Development and Applied Prevention Science
Atlanta, Georgia, 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

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The Tennessee Department of Health (TDH) prepared this Health Consultation for the Southside Chattanooga Lead (SSCL) site in Chattanooga, Hamilton County, Tennessee under a cooperative agreement (program #TS20-2001) with the federal Agency for Toxic Substances and Disease Registry (ATSDR). The health consultation is in accordance with the approved agency methods, policies, and procedures existing at the date of publication. ATSDR reviewed this document and concurs with its findings based on information presented by TDH.

If you have questions about this report, we encourage you to contact the TDH at (615) 741-7247, or (800) 404-3006, or email at eep.health@tn.gov.

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Summary

Introduction

Congress mandates the Agency for Toxic Substances and Disease Registry (ATSDR) conduct public health activities at Superfund sites that U.S. Environmental Protection Agency (EPA) proposes to its National Priorities List (NPL). The purpose of this health consultation is to document the potential health impact of exposures to contamination found in soil in the neighborhoods within the boundaries of the Southside Chattanooga Lead (SSCL) site.

The Tennessee Department of Health's (TDH) Environmental Epidemiology Program (EEP) evaluated possible environmental exposures at the SSCL site. The SSCL site is characterized by soil contaminated with lead because of the historical use of foundry waste material as fill material or topsoil in the downtown area of Chattanooga. Foundry waste material is typically composed of spent foundry sand, baghouse dust, coke, and slag. The SSCL site consists of residential properties and communal areas (i.e., playgrounds, schools, childcare centers, and churches) where soils were potentially contaminated by these foundry waste materials. Activities to fully evaluate the SSCL site are ongoing [EPA 2018a].

The EPA proposed adding the SSCL site to the Superfund Program's National Priorities List (NPL) of hazardous waste sites on January 18, 2018. The NPL is part of EPA's Superfund clean-up process intended to identify the sites of national priority among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories. Although EPA's site cleanup actions have reduced the levels of lead and levels of associated metals cadmium and arsenic in community soils, the potential for harmful exposures to contaminants still remains in the Southside neighborhoods of Chattanooga. As of May 18, 2018, EPA collected soil samples from approximately 300 properties in the community. EPA's preliminary clean-up goal for lead at the SSCL site was 360 milligrams per kilogram (mg/kg). EPA evaluated the data and estimated that 30% of the 3,600 properties within the neighborhoods contain lead-bearing material with concentrations above the site-specific clean-up goal of 360 mg/kg. This means that an estimated 1,100 properties will require remediation. The SSCL site was officially added to the NPL on September 13, 2018 [83 Federal Register 46408]. As of February 2021, 117 properties with soil lead concentrations of 1,200 mg/kg or greater had been remediated as part of a time critical project. As of February 27, 2023, 577 properties within the SSCL area with soil lead concentrations of 1,200 mg/kg or greater have been remediated as part of a time critical project. An additional 146 properties still need to be addressed as part of the time critical project. The remaining properties will be addressed under an ongoing, long-term remedial action.

A draft of this health consultation was prepared and posted for public comment on December 16, 2022. The public comment period ended on February 16, 2023. No comments were received from the public on the health consultation during the comment period.

Overview

The Tennessee Department of Health's (TDH) Environmental Epidemiology Program reached three conclusions about the Southside Chattanooga Lead (SSCL) site.

Conclusions

Conclusion 1

Residents, and in particular young children, at some residential properties inside the boundaries of the SSCL site are exposed to lead, copper, and polycyclic aromatic hydrocarbons (PAHs) in the soil at levels that could harm their health.

In particular, young children, pregnant women, and developing babies are at greatest risk for harmful health effects from lead exposure.

Basis for Decision

Concentrations of lead and copper measured in the soil of some properties inside the boundaries of the SSCL site exceeded health-based comparison values and required further evaluation to understand the health implications of contacting contaminated soil. As soil sampling continues at this site, the extent of contamination and potential exposure will become more well defined.

EPA assessed the ability of the body to take up the type of lead found in soil within the boundaries of the SSCL site and used the Integrated Exposure Uptake and Biokinetic (IEUBK) model to evaluate lead in the soil. EPA used version 1 of the IEUBK model incorporating the exposure unit values proposed for use in the IEUBK model version 2 to calculate the site-specific values for SSCL. More information about blood lead models and the IEUBK model can be found in Appendix F.

The Centers for Disease Control and Prevention (CDC) has not identified a safe blood lead level (BLL) in humans. CDC's blood lead reference value of 3.5 micrograms per deciliter (µg/dL) is used to identify children with BLLs that are higher than most children's levels. This value is based on the U.S. population of children ages 1-5 years who are in the highest 2.5 percent of children when tested for lead in their blood. Based on the evaluation of SSCL site soil data, it is possible that BLLs would exceed 3.5 µg/dL in young children who live at certain properties because of lead contamination in soil.

When people, particularly children, purposely eat dirt they have pica behavior. Based on the gastrointestinal effects (abdominal pain, nausea, vomiting) small children would experience from eating about a teaspoon of soil, it was determined that copper could pose a hazard when soil levels exceed 53 mg/kg. These effects are not usually persistent [ATSDR 2004b]. A total of 52 properties had soil copper levels that exceeded 53 mg/kg with a lead concentration that did not exceed EPA's established clean up level of 360 mg/kg to be

	remediated as part of the NPL project. Note: the evaluation of copper hazards for acute and pica exposure may be underestimated based on the use of incremental sampling methodology (ISM) [EPA 2018f]. In addition, the estimated cancer risk from PAHs found at two locations in soil samples from the Jefferson Heights neighborhood were considered moderate for children. PAHs at these two locations could pose a health concern.
Conclusion 2	The percentage of children with elevated blood lead levels in the SSCL area was greater than in the surrounding area of Hamilton County and the state of Tennessee for 9 out of the previous 10 years.
Basis for Decision	TDH reviewed blood lead level (BLL) data from the Tennessee Department of Health from 2012-2021. For 9 out of the past 10 years, the percent of SSCL site children ages 6 to 72 months, whose tests showed elevated BLLs (greater than or equal to 3.5 µg/dL) was higher than the percent of children tested with elevated BLLs in the rest of Hamilton County (excluding the SSCL site area). In addition, the percent of SSCL site children with elevated BLLs was higher than the percent of children in the state whose tests also indicated elevated BLLs. TDH identified multiple factors that could be associated with the higher BLLs in the SSCL site community. The factors include age of housing, contaminated soil, poverty, and race.
Conclusion 3	Data gaps limit TDH's ability to determine whether some residents may have been exposed to harmful levels of lead and other contaminants in the soil from their yards. TDH cannot determine whether health effects may occur from soil at properties that were not sampled, or that had samples that were not analyzed for the full list of metals or PAHs. We were unable to evaluate the risk for children with soil-pica behavior on some properties where only composite incremental sampling methodology (ISM) was conducted.
Basis for Decision	EPA has not sampled and analyzed soil from all properties within the boundaries of the SSCL site. Access agreements giving EPA permission to conduct soil sampling activities were not signed by some property owners. Without soil samples from these yards, it is not possible to determine the potential for exposure to harmful levels of lead or other chemicals of concern for those residents. In addition, soil sampling activities were limited to testing for lead in many areas within the boundaries of the SSCL site after 2018. Without lab results for other contaminants, TDH cannot determine whether other contaminants are present or pose a potential hazard through exposure.

There are limitations to using ISM to evaluate acute and pica exposures. Soil contamination may be underestimated based on the use of composite ISM, and TDH is unable to evaluate the possible health effects from potential hot spots with full confidence.

Next Steps

TDH continues to be involved with the Southside Chattanooga Lead NPL Site. Next steps to be taken include the following:

1. TDH will continue outreach and education activities to the SSCL site communities and surrounding area about the existing lead contamination and lead poisoning prevention.

2. TDH recommends that EPA

- Consider re-evaluating the cleanup level using a lower blood lead level in the IEUBK model and updating/revising the plan to remove lead- contaminated soil.
- Remove lead-contaminated soil based on an updated and revised plan.
- Take measures to reduce exposures to copper, and PAHs where concentrations were elevated, and lead levels did not warrant removal action under current plans. Consider additional sampling in yards with no remediation to evaluate hot spots where children may be likely to play.
- Continue efforts to obtain access agreements to sample soil on neighborhood properties.

3. TDH recommends that residents around the SSCL site engage in testing:

- Have children's blood tested for lead, preferably by using a venous blood sample.
- Allow EPA access to conduct soil sampling and removal activities, as needed.
- If eating produce from a home garden, consider having the soil tested, if it has not already been tested and using raised-bed gardening with uncontaminated soil.

4. TDH recommends that residents around the SSCL site become informed about pica behavior and how to reduce potential exposures in children with this behavior.

5. TDH recommends that residents around the SSCL site, with children or pets, take the following steps to reduce exposure to contaminants in soil:

- Regularly wash children's hands, especially before eating.

- Watch children to identify any hand-to-mouth behavior or excessive intentional dirt eating – these behaviors should be modified or eliminated.
- Make sure your child does not have access to peeling paint or chewable surfaces painted with lead-based paint.
- Pregnant women and preschool children should not be present in housing built before 1978 that is undergoing renovation.
- Create safe play areas for children with appropriate and clean ground covers. If you have children who like to dig in dirt around your home, consider having a sand box with a cover for your child to use for digging.
- Frequently bathe your pets since they can also track contaminated soil into your home.

6. TDH recommends that all residents around the SSCL site take the following steps to reduce exposure to contaminants in soil:

- Regularly use a damp mop or damp duster to clean surfaces.
- Vacuum with a properly maintained high-efficiency particulate air (HEPA) filter. Non HEPA-filter vacuums may suspend the particles during the vacuuming process making the contaminated particles breathable. In addition, frequent filter changes may be necessary.
- Remove shoes before going in the house and ask others to do the same.
- Use walk-off mats at exterior doorways.
- Cover bare, contaminated soil with mulch or vegetation (grass, etc.).
- Create a raised garden bed and fill with clean soil to reduce exposures from gardening and digging.
- Rinse produce well to remove garden soil.

TDH will continue to partner with the Tennessee Childhood Lead Poisoning Prevention Program, the University of Tennessee Agricultural Extension Program, and the Hamilton County Health Department on a Lead Education Station. The Lead Education Station has been operational since October 2019 and is housed in the Chattanooga Public Library, South Chattanooga Branch, 925 West 39th Street, Chattanooga, TN 37410, near the SSCL site neighborhoods. One priority of this station is to encourage physicians and parents to increase blood-lead testing in the vicinity of the NPL boundaries and other areas of the county. More information about the station, including the schedule for the on-site staff person, can be found at leadedu.tennessee.edu.

TDH can answer questions community members have about their current exposures. TDH will continue outreach and education activities about the existing lead contamination and lead poisoning prevention for the SSCL site and surrounding area.

TDH will continue to work with EPA to continue public availability sessions that educate the community about the importance of providing access to their property for soil sampling. TDH will also organize an additional soilSHOP event to educate surrounding communities on the importance of testing their soil for lead and use soilSHOP screening results to update EPA about lead patterns in the community.

For More Information

If you have any questions or concerns about your health, contact your healthcare provider. For more information on the Southside Chattanooga Lead site, call TDEC toll free at 1-888-891-8332. For more information on this report, please call TDH at 615-741- 7247 or 1-800-404-3006 during normal business hours. You can also email TDH at eep.health@tn.gov.

Background and Statement of Issues

The Tennessee Department of Health's (TDH) Environmental Epidemiology Program evaluated possible environmental exposures at the Southside Chattanooga Lead (SSCL) Superfund site (the site). This site has also been identified as the Former Chattanooga Foundries site. The U.S. Environmental Protection Agency (EPA) proposed the SSCL site to its National Priorities List (NPL) of hazardous waste sites on January 18, 2018. The NPL is part of EPA's Superfund clean-up process intended to identify the sites of national priority among the known releases or threatened releases of hazardous substances, pollutants, or contaminants throughout the United States and its territories. The SSCL site was officially listed on the NPL on September 13, 2018 [83 Federal Register 46408]. Congress mandates the Agency for Toxic Substances and Disease Registry (ATSDR) conduct public health activities at Superfund sites that EPA proposes to its NPL. In response, TDH prepared this public health consultation under a cooperative agreement with ATSDR.

A draft of this health consultation was prepared and posted for public comment on December 16, 2022. The public comment period ended on February 16, 2023. TDH's EEP prepared a press release notifying stakeholders on the availability of the draft for review and public comment during the week of December 18, 2022. The health consultation was also provided to EPA's Remedial Project Manager for the SSCL site, TDEC's Chattanooga Field Office, and the University of Tennessee-Chattanooga's Master of Public Health Program. EPA's Community Outreach Coordinator for the SSCL site also sent out a notice to stakeholders about the availability of the health consultation for public comment. No comments were received from the public on the health consultation during the comment period.

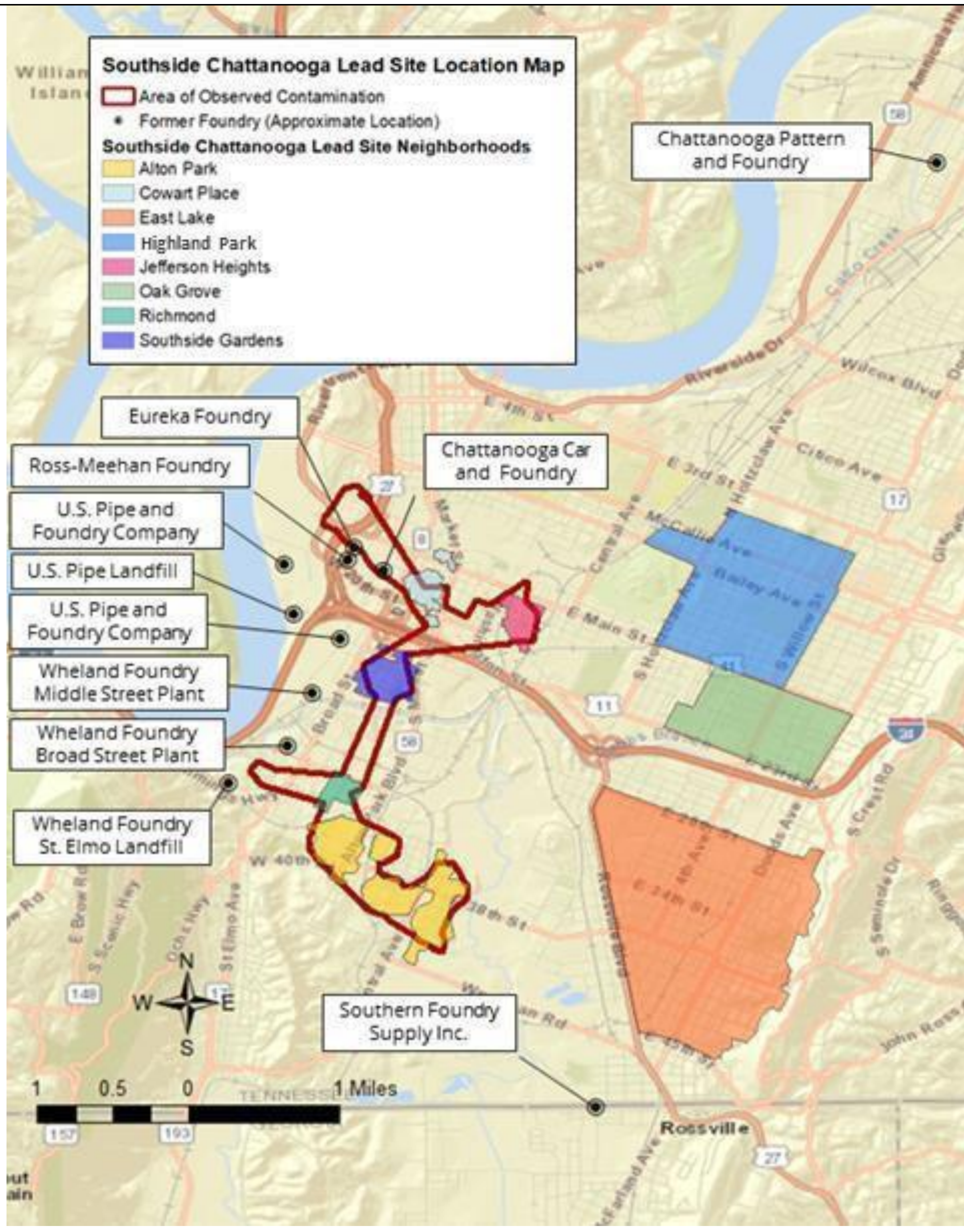
The SSCL site has soil contaminated with lead as a result of the historical use of foundry waste material as fill material or topsoil in the downtown area of Chattanooga. Foundry waste material is typically composed of spent foundry sand, baghouse dust, coke, and slag. The SSCL site consists of residential properties and communal areas (i.e., playgrounds, schools, childcare centers, and churches) where soils were potentially contaminated by these foundry waste materials. Activities to fully evaluate the SSCL site are ongoing [EPA 2018a]. The SSCL site consists of residential properties where soils were contaminated by these foundry waste materials. EPA has set a clean-up goal for lead in soil at 360 mg/kg for this project [EPA 2018c].

Site Location and Details

The SSCL site is located at 1705 Read Avenue, Chattanooga, Tennessee 37408. Chattanooga is part of Hamilton County. The SSCL site consists of residential properties within eight neighborhoods (Figure 1) where foundry waste was distributed as fill and/or topsoil to be used by homeowners in their yards. The eight neighborhoods are Alton Park, Cowart Place, East Lake, Highland Park, Jefferson Heights, Oak Grove, Richmond, and Southside Gardens.

Since the mid-nineteenth century about 60 foundries, typically iron and brass foundries, have operated in the City of Chattanooga. Ferrous (iron and steel) foundries specialize in melting and casting metal into desired shapes. The casting process involves pouring molten metal into molds. Sand is the most common molding material used. Foundry sand can be reused; however, sand fines are removed from the process. The approximate locations of a few of these foundries can be seen in Figure 1. The three most prominent foundries were U.S. Pipe and Foundry (circa 1882), Wheland Foundry (circa 1873), and Ross-Meehan Foundry (circa 1889). Each of these foundries was located between Broad Street and the Tennessee River. Foundry waste can contain elevated concentrations of lead and other metals. Personal accounts from local residents indicate that it was common practice in the early 1900s for foundries to give local residents excess foundry waste to use as fill material [EPA 2018b].

Figure 1. Southside Chattanooga Lead Site Location Map



Sources: EPA Hazard Ranking System (HRS) Documentation Record, Southside Chattanooga Lead Site, January 2018 and EPA Interim Remedial Investigation Report, Southside Chattanooga Lead Site, July 2018 (EPA 2018)

Summary of Early Site Investigations

Foundry waste has been found throughout Southside Chattanooga neighborhoods. The results of soil analyses indicate the presence of lead, arsenic, PAHs, cadmium, and copper contamination.

In 2011, TDH became aware of a property in the Southside Gardens neighborhood of Chattanooga where the homeowner was reported to have an elevated blood lead level. The home was being renovated due to the presence of lead-based paint. However, lead was found in areas of soil away from the home, which is not typical for lead paint residue. Concerns were raised by those renovating the home that paint was not the only source of the lead in the soil. As a result, the Tennessee Department of Environment and Conservation (TDEC) conducted initial soil screenings using a handheld X-ray fluorescence (XRF) analyzer and reported lead concentrations as high as 8,200 mg/kg. EPA became involved and conducted composite sampling where the highest composite concentration was measured at 2,500 mg/kg.

In addition to the unusual location of the lead-contaminated soil, the soil did not have the same appearance as the surrounding native soil and did not contain visible lead paint chips. Because of these differences, paint was ruled out as the likely source of the lead contamination. Home vegetable gardens were common in the neighborhood; and a public playground was in very close proximity to the original home tested in 2011. These factors increased concern about widespread lead contamination during the site investigation.

EPA expanded the investigation by testing the soil of other properties in the surrounding neighborhood for lead. During the week of May 2, 2011, EPA collected composite soil samples from 0 to 6 inches below ground surface (bgs) at 10 locations within three residential properties and a neighborhood park. These samples were analyzed for arsenic and lead [EPA 2018b].

Many yards in the community contained similar non-native-looking soil and were screened for lead using an XRF analyzer. Laboratory tests confirmed these soils contained high levels of lead. EPA initiated an expediated clean-up action. From September 24, 2012 through December 5, 2013, 115 yards were investigated, and soil cleanup was conducted at a total of 84 properties within the Southside Gardens neighborhood. Soil with elevated lead was removed from several properties located on Read Avenue, Mitchell Avenue, Underwood Street (formerly Carr Street), and intersecting streets. Properties were chosen for expedited action based on which property had the highest levels of soil lead and the potential exposure to children. Excavated areas were tested to confirm the successful removal of contaminated soil, the sites were backfilled with clean soil, and the yards were restored.

In 2016, EPA and TDEC initiated a soil investigation in other Southside Chattanooga areas. The purpose of the soil investigation was to outline the boundaries of the area impacted by lead from foundry waste and to determine whether any actions (e.g., covering soil, removing soil, or further testing) were needed to protect people. In October 2016 and January 2017, EPA collected more than 200 soil samples from residential yards. Using incremental sampling methods (ISM), EPA collected 30-point incremental soil samples, from 0 to 4 inches bgs [EPA 2018f]. The number of samples per property varied based on the size of the property. Often, one 30-point ISM sample was collected from the entire property. In some cases, a property was divided into two or more units. The unit divisions were based on visual observations of the size and layout of the yard and whether a vegetable garden or playground was present. A 30-point ISM sample was collected from each unit.

In October 2016, the study started with the Cowart Place, Jefferson Heights, and Southside Gardens neighborhoods. The EPA Region 4 Science and Ecosystem Support Division laboratory used 33 samples to calculate the ability of the body to take up the type of lead in soil. The results of this analysis provided the bioavailability of 36% for soil lead in the area [EPA 2018b]. Following the bioavailability analysis, the EPA used their IEUBK model, version 1 with exposure unit values proposed for use in the IEUBK model version 2 to determine the clean-up level of 360 mg/kg of lead in soil. EPA established 360 mg/kg as the site-specific clean-up goal for the SSCL site [EPA 2017]. Nineteen residential properties in Jefferson Heights and Southside Gardens were cleaned up as part of an initial project that prioritized removal of lead from residential properties that had soil lead concentrations greater than 1,200 mg/kg.

In January 2017, EPA tested the soil in Mountain View Court, College Hill Courts, the Richmond neighborhood, and parts of Alton Park. EPA determined that the soil at Mountain View Court and College Hill Courts contained concentrations of lead as high as 240 mg/kg and 280 mg/kg, respectively. Consequently, these neighborhoods required no further action. However, the other neighborhoods had concentrations above the EPA Removal Management Level (RML) [EPA 2018b] and needed further investigation. At the time of the SSCL investigation, the RML was 400 mg/kg.

In 2017, EPA removed lead-contaminated soil from 15 additional properties within the Jefferson Heights neighborhood. Again, properties with the highest levels of lead in the soil and with children living at or near the contaminated properties were chosen [EPA 2018c]. The excavated areas were tested to confirm the successful removal of contaminated soil, they were also filled with clean soil, and the yards were restored.

2016 Background Soil Investigation

To identify the levels of selected metals and polycyclic aromatic hydrocarbons (PAHs) that could be expected outside of the SSCL site in Chattanooga, 64 soil samples were collected in September 2016. Concentrations of a contaminant that occurs widely or even naturally in an urban area is known as the urban background level.

The background sampling area can be seen in Figure 2. A grid measuring 5 miles by 5 miles was overlaid across the urban center of Chattanooga. Each cell of the grid measured approximately 0.36 mile by 0.36 mile (82.9 acres). The grid had a total of 196 cells. Fifty cells were randomly selected within the grid, and soil samples were collected and processed from the 50 chosen cells [Site Inspection Report/ EPA 2018b]. In October 2017, four additional samples were collected from a subset of the Site Inspection sampling locations used in September 2016 using a procedure that was more consistent with sampling procedures planned for future sampling events. Table 1 provides the analytical results of the background samples collected in October 2017 [EPA 2017].

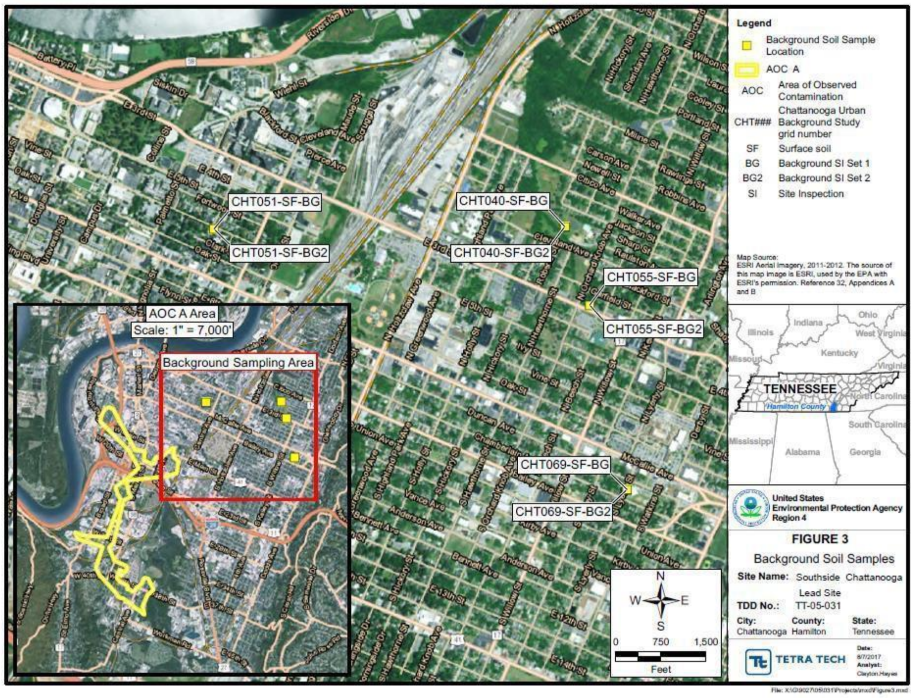
Table 1. Analytical Results for Additional October 2017 Background Samples

Analyte/ Metals (mg/kg)	Residential EPA RSL	Grid No. CHT040	Grid No. CHT051	Grid No. CHT055	Grid No. CHT069	Max. Bkg. Conc. for Comparison
		Sample No. CHT040-SF-BG2	Sample No. CHT051-SF-BG2	Sample No. CHT055-SF-BG2	Sample No. CHT069-SF-BG2	
Arsenic	0.68	5.0	6.1	5.0	13	13
Cadmium	71	0.45 UJ	0.38 U	0.59	0.47 U	0.59
Chromium	120,000	16	19	30	21	30
Copper	3,100	17	20 J	28	17	28
Lead	400*	39	43	59	57	59
Nickel	1,500	10	12	18	8.6	18
Zinc	23,000	77 J	100 J	170	110	170

Notes:

BG2	Background, Set 2
Bkg.	Background
No.	Number
CHT###	Chattanooga Urban Background Study grid number
Conc.	Concentration
EPA	U.S. Environmental Protection Agency
J	The identification of the analyte is acceptable; the reported value is an estimate.
Max.	Maximum
mg/kg	Milligrams per kilogram
RSL	June 2017 Regional Screening Levels for residential soil
SF	Surface soil
U	The analyte was not detected at or above the reporting limit.
UJ	The analyte was not detected at or above the reporting limit, which is considered approximate due to deficiencies in one or more quality control criteria.
	Shaded values exceed the June 2017 EPA RSL for residential soil.
*	EPA has not established an RSL for lead. The EPA Removal Management Level is used.

Figure 2. Southside Chattanooga Background Soil Sampling Location Map



Sources: EPA Hazard Ranking System (HRS) Documentation Record, Southside Chattanooga Lead Site, January 2018

2018 Site Investigation and National Priorities Listing

In January 2018, EPA reported that they had found foundry waste at 150 residential properties and that the lead levels were above urban background conditions [EPA 2018e]. The naturally occurring background level of lead in Tennessee soils is 45 mg/kg [TDEC 2001]. The measured background level of lead in Chattanooga (average = 51 mg/kg) was slightly higher than the naturally occurring background level of lead in Tennessee soils (Table 1).

EPA determined that a further site assessment was needed to identify all contaminated properties. On January 18, 2018, EPA proposed that the SSCL site be added to the Superfund Program's National Priorities List (NPL) [EPA 2018d].

The EPA investigations only focused on lead. In contrast, TDH reviewed the available environmental data for potential exposure to metals and polycyclic aromatic hydrocarbons (PAHs) in this health consultation.

In May 2018, EPA collected soil samples from properties within the Alton Park, Cowart Place, Jefferson Heights, and Southside Gardens neighborhoods. Of the samples collected (Table 3), six samples, collected from five locations, exceeded the clean-up goal of 360 mg/kg. However, none of the samples exceeded the time critical action level. That is, none of the samples exceeded 1,200 mg/kg, which is the minimum level that qualifies for an emergency response

[EPA 2018b]. More discussion about these samples and the clean-up goal can be found in the section on Lead: Interpretation and Health Significance.

On September 13, 2018, the SSCL site was added to the NPL [CFR 2018]. Eight Southside Chattanooga neighborhoods are included on the NPL: Alton Park, East Lake, Highland Park, Oak Grove, Richmond, Cowart Place, Jefferson Heights, and Southside Gardens [CFR 2018].

Discussion

Exposure Pathway Evaluation

People may come in contact with harmful substances, also called contaminants, that were released into the environment. When people experience that contact at high concentrations or very often, there is potential for harmful health effects. Contaminant releases do not always result in exposure. People can only be exposed to a contaminant if they come in contact with the contaminant—if they breathe, eat, drink, or come into skin contact with the contaminant. If there is concern that people are being exposed to environmental contaminants, then a health assessment may occur. During the health assessment process, careful consideration is given to areas that people frequently access (e.g., their yards) that may expose them to a contaminant. If people are not exposed to contaminants, then no exposure-related adverse health effects occur.

The way a contaminant moves through the environment is called an exposure pathway. An exposure pathway can involve air, surface water, groundwater, soil and airborne particles, or plants and animals.

An exposure pathway has five elements:

1. a source of contamination,
2. an environmental media,
3. a point of exposure,
4. a route of human exposure, and
5. a receptor population.

The source of contamination is the place where the contaminant was released. The environmental media (such as groundwater, soil, surface water, or air) move the contaminants through the environment. The point of exposure is the place where people come into contact with the contaminant. The route of exposure is the way the contaminant enters the body (e.g., through eating or breathing). The people who are exposed to the contaminant are called the receptor population. During the health assessment process, TDH identifies and assesses exposure pathways to understand whether they are a past, current, or future danger.

If all five elements of the exposure pathway are present and contaminant sources can be linked to a human receptor population, then a **completed exposure pathway** exists. That means that people have contact with or are likely to come in contact with contamination at a particular exposure point via an identified exposure route. As stated above, a release of a chemical into the environment does not always result in human exposure. For an exposure to occur, a completed exposure pathway must exist. Completed exposure pathways require further evaluation to determine whether exposures are sufficient in magnitude, duration, and frequency to result in harmful health effects.

If one or more of the five elements of an exposure pathway are missing or uncertain, then a **potential exposure pathway** exists. A potential exposure pathway indicates that exposure to a contaminant could have occurred in the past, could be occurring currently, or could occur in the future but insufficient information exists to reasonably conclude that people were exposed. During the health assessment process, TDH does not rule out a potential exposure pathway, even though not all of the five elements are identifiable.

If the site characteristics make past, current, and future human exposures extremely unlikely, the exposure pathways can be ruled out. When the pathway is ruled out, it is called an **eliminated exposure pathway.** Eliminated exposure pathways exist when one or more of the elements are missing and is likely never to exist. An exposure pathway may also be eliminated if people do not have access to a contaminated area or if site monitoring reveals that media (e.g., soil, water) in accessible areas are not contaminated.

Exposure Pathways at the Southside Chattanooga Lead Site

Throughout the SSCL site, swallowed soil and skin exposures are past, current, and future completed exposure pathways. Exposure occurs when people have direct contact with contaminated soils. For instance, when children play outside or when adults work in yards and gardens, contaminated soil particles can cling to their hands. Then, the contaminated soil may be unintentionally swallowed when they eat, drink, or touch their mouths (Table 2).

The factors that affect whether people have contact with contaminated soils include

- Vegetative cover – Vegetation reduces contact with contaminated soil when it is dense. Contact with soil increases when vegetative cover is sparse or bare ground is present. In the SSCL site, the amount and type of vegetative cover varies widely in the neighborhoods. Many areas of south Chattanooga are currently going through a revitalization that adds to the diversity of conditions. In many neighborhoods ground cover can range from bare earth to sodded yards. In some areas, residents have flower and vegetable gardens. In the areas that have undergone revitalization, the ground is extensively covered, often with grass. In older sections of the neighborhoods, ground cover ranges from bare earth to spotty grass cover.
- Weather conditions – Certain weather conditions reduce contact with outside soil. For instance, during cold months, people stay indoors more often. However, people may still be exposed to contaminated soils which have been tracked indoors. Similarly, wet weather conditions may result in the increased tracking of muddy soils into homes. Dry, dusty conditions outside may also increase exposures because loose soils can be blown indoors by wind.
- Personal habits when outside – Children who play in the dirt are likely to have greater exposure to contaminated soil than children who do not. Children who show pica behavior, which is the eating of nonfood items, may eat large amounts of soil. Eating soil increases their exposure to lead in the soil. Soil pica behavior is most likely to occur in preschool children as part of their normal exploratory behavior. Approximately 4% to 20% of preschool children exhibit soil pica behavior. Soil pica behavior diminishes as children age [ATSDR 2016].

- Hygiene – Regularly sweeping, vacuuming, or wet mopping floors can keep the levels of soil tracked indoors low. Ensuring children and adults wash their hands will help to reduce the amount of soil particles they ingest.

Some residents may be exposed to contaminated soil if they live on properties where contaminated soils have not been completely remediated. Other sources of lead exposure are also possible. Given the age of many of the homes in the Southside Chattanooga neighborhoods, it is possible that older homes contain lead-based paint. Homes built before 1978 are more likely to have lead-based paint. Thus, lead paint is still present in these older homes, sometimes under layers of newer paint. If the paint is in good shape, the lead paint is usually not a problem. Deteriorating lead-based paint (peeling, chipping, chalking, cracking, damaged, or damp) can lead to lead exposure in people who live in the house, particularly children. Lead pipes and lead-containing solder may also exist in some homes built before 1986. A graphic showing the age of homes at the SSCL site is in Appendix G. Based on 2017 American Cancer Society (ACS) estimates, 73.5% of homes built in the census tracts depicted on the map were built in 1979 or earlier.

Table 2. Exposure pathways for residents living in the boundaries of the Southside Chattanooga Lead site.

Contaminant	Environmental Medium	Exposure Point	Exposure Route	Exposed Population	Time Frame	Exposure Pathway Type
Lead, arsenic, cadmium, copper and PAHs	Soil	Residential Yards	Ingestion	Residents	Past	Completed
					Present	Completed
					Future	Potential or Eliminated
			Dermal	Residents	Past	Completed
					Present	Completed
					Future	Potential or Eliminated
		Indoor Dust/Soil (tracked or wind-blown inside from yard)	Ingestion	Residents	Past	Completed
					Present	Completed
					Future	Potential or Eliminated
			Dermal	Residents	Past	Completed
					Present	Completed
					Future	Potential or Eliminated

Completed indicates all 5 elements of the exposure pathway are either expected to occur or are occurring.
Potential indicates one or more of the elements of the exposure pathway may not be present, but information is insufficient to eliminate or exclude the element.
Eliminated indicates one or more of the elements is absent.
PAHs = polycyclic aromatic hydrocarbons
Dermal refers to skin contact.

Environmental Contaminants of Concern

TDH evaluated soil data from the neighborhoods included in the SSCL site. The soil investigations mainly focused on occupied residential properties and public parks [EPA 2017]. Composite ISM soil samples, collected from 0 to 6 inches below ground surface (bgs), were screened for lead using a handheld x-ray fluorescence (XRF) analyzer. Laboratory analysis was used on a portion of the samples collected to determine how well the XRF results correlated with the laboratory results. The correlation between the XRF data and lab data had an r-squared of 0.98, which shows excellent agreement between the XRF and laboratory levels. While EPA is using XRF screening results to identify properties that need remediation, TDH is only using laboratory data in this review and analysis. Lead became the primary focus of the EPA's NPL clean-up activities because early sampling activities revealed concentrations of lead that exceeded the EPA Regional Screening Level of 400 mg/kg. In addition, lead has the most data available for review.

TDH used ATSDR's Public Health Assessment Site Tool (PHAST) to evaluate exposure to site contaminants. PHAST is a web-based application with a flexible design built to assist ATSDR/partner health assessors in evaluating environmental data and performing complex dose calculations. The application integrates the core science and assessment processes outlined in ATSDR's Exposure Dose Guidance (EDG) documents and other public health assessment guidance. An exposure dose is an estimate of the amount of a substance a person may come into contact within the environment during a specific time period, expressed relative to body weight. Health guideline values represent daily human exposure levels to a substance that is likely to be without much risk of adverse (harmful) health effects during a specified exposure time. PHAST is useful for screening environmental contaminants, calculating exposure doses, and estimating cancer risks and non-cancer hazard quotients. A hazard quotient (HQ) is calculated to evaluate the potential for non-cancer health hazards to occur from exposure to a contaminant. A HQ is compared to 1. HQs less than one indicate a non-cancer health effect should not occur. PHAST also has the ability to generate output tables of results. Because comparison values for arsenic, cadmium, copper, and PAHs were exceeded, TDH selected these contaminants for further evaluation. Comparison values (CVs) are media-specific concentrations that are used to select contaminants for further evaluation in this document. Chemical-specific information and CVs can be found in Table 6 (PAHs) and Appendix A (metals).

If the substance being evaluated is not suspected to cause cancer, TDH uses ATSDR's Environmental Media Evaluation Guides (EMEGs) or Reference Dose Media Evaluation Guides (RMEGs). ATSDR EMEGs and RMEGs are chemical concentrations in water, soil, or air to which humans may be exposed to without experiencing adverse non-cancer health effects. EMEGs consider whether exposure occurs during a specific time (acute, intermediate, or chronic exposure). If the substance being evaluated is a known or a probable carcinogen with a cancer toxicity value, TDH uses ATSDR's Cancer Risk Evaluation Guides (CREGs). CREGs are estimated chemical concentrations in soil, water, or air which would be expected to cause no more than one excess cancer in a million persons exposed during their lifetime (78 years). In the U.S., it is estimated that 40 out of every 100 men and women will develop cancer during their lifetime [ACS 2020]. All cancer risk values used express the additional chance of developing cancer above this baseline. EMEGs, RMEGs, and CREGs are used to select contaminants of concern for further evaluation in the public health assessment process.

Additional analysis was necessary to determine whether health effects are likely to occur. Therefore, TDH used PHAST to derive exposure doses for community members exposed to arsenic, cadmium, and copper in soil. Based on EPA guidance, TDH used 60% as the default bioavailability factor for arsenic [EPA 2012]. Other assumptions that TDH made are listed in a table in Appendix B. Estimated doses for various ranges of arsenic, cadmium, and copper concentrations can be found in Appendix C, Appendix D, and Appendix E, respectively.

Arsenic: Interpretation and Health Significance

Soil Sample Concentrations

Based on the residential soil samples reviewed, arsenic concentration ranges varied slightly in each neighborhood:

- Cowart Place - 6.3 mg/kg to 17 mg/kg
- Jefferson Heights - 2.8 mg/kg to 30 mg/kg
- Southside Gardens - 2.8 mg/kg to 32 mg/kg
- Alton Park - 5.5 mg/kg to 50 mg/kg
- Richmond - 5.3 mg/kg to 11 mg/kg

In four of the five neighborhoods sampled, concentrations of arsenic in some properties exceeded the ATSDR chronic EMEG comparison value of 16 mg/kg but only by a small amount. During a background soil investigation conducted in 2016 and 2017, the background concentration for arsenic was determined to be 4 mg/kg by averaging the results of sixty-eight samples collected from nearby neighborhoods that are not part of the SSCL site. Figure 2 provides a map of the background investigation area. No soil lab results were available for arsenic in the Oak Grove, East Lake, or Highland Park neighborhoods. Soil sample data tables are available in Appendix A.

Exposure Doses and Non-Cancer Health Effects

TDH used exposure doses calculated over a range of concentrations to conduct the evaluation for exposures. The estimated doses for the various concentration ranges were calculated using the ATSDR PHAST tool. The total number of samples and properties for each range in each neighborhood can be found in Appendix C.

For chronic arsenic exposure, ATSDR has established a minimal risk level (MRL) of 0.0003 mg/kg/day for chronic oral exposure to inorganic arsenic [ATSDR 2007b]. The MRL is the level of exposure at or below which a substance is unlikely to pose a measurable risk of harmful, noncancerous effects. A chronic exposure describes regular contact with a substance that lasts 365 days or more.

At the highest arsenic concentration detected in soil at the SSCL site (50 mg/kg), the estimated dose exceeded ATSDR's chronic MRL only in children under 2 years (0.00065 mg/kg/day). Because children are exposed for only a few years at doses that just barely exceed the MRL, harmful non-cancer effects are unlikely.

Human studies suggests that, following long-term oral arsenic exposure, skin is the most sensitive noncancer target organ. With constant, low levels of exposure, human studies show that it takes about 10 to 20 years before skin effects appear depending upon the dose. Typical skin effects include the hyperkeratinization of the skin (a disorder of the cells lining the inside of a hair follicle), especially on the palms and soles, the formation of multiple hyperkeratinized corns or warts, and the hyperpigmentation of the skin (a condition where patches of skin become darker in color than the normal surrounding skin) with interspersed spots of hypopigmentation (a condition where patches of skin that are lighter than your overall skin tone). The threshold for these skin conditions is approximately 0.002 mg/kg/day but keep in mind that doses around this level require 10 to 20 years of exposure to result in skin lesions [ATSDR 2007b].

For intermediate arsenic exposure, ATSDR has not established a MRL for intermediate oral exposure (14 to 365 days) to arsenic, because there are insufficient studies based on human data.

For acute arsenic exposure, ATSDR has established an acute MRL of 0.005 mg/kg/day for acute oral exposure (14 days or less) to inorganic arsenic [ATSDR 2007b]. The acute MRL for arsenic was exceeded for a one-year-old child with pica behavior who intentionally eats soil containing concentrations of 50 mg/kg arsenic. At the highest arsenic concentration detected in soil at the SSCL site (50 mg/kg), the estimated dose in children with pica behavior exceeded ATSDR's chronic MRL only in one-year-old children (0.0057 mg/kg/day). Because this dose is well below harmful levels identified in human studies, harmful non-cancer effects are unlikely, even at the property with the highest arsenic soil levels.

Cancer Risk

To determine cancer risk from exposure to arsenic, TDH evaluated two exposure populations using ATSDR's PHAST: children exposed from birth to 21 years of age and adults exposed for 33 years. If children are exposed to arsenic in soil for 21 years with levels of arsenic at 50 mg/kg, this exposure may result in nine extra cancer cases for every 100,000 children exposed. For adults, arsenic soil levels at 50 mg/kg may result in three extra cancer cases for every 100,000 adults exposed for 33 years. The risk of cancer for adults and children in the SSCL site neighborhoods who were exposed to the concentrations of arsenic measured in the soil is low and is not a health concern. It's important to remember that these are the highest cancer risks that might exist at properties with 50 mg/kg arsenic in soil. The cancer risk at other properties with lower arsenic levels will be lower. The cancer risk from soil arsenic at background soil levels (7 mg/kg) is 1 in 100,000 for children and 4 in a million for adults.

Note: Of the 31 properties sampled with an arsenic concentration of 15 mg/kg or higher, 30 of the properties also have a lead concentration above the lead clean-up goal and will likely be remediated as part of the NPL removal activities.

Cadmium: Interpretation and Health Significance

Soil Sample Concentrations

Based on the residential soil samples reviewed, cadmium concentration ranges varied in each neighborhood but only by small amounts:

- Cowart Place - 0.68 to 2.4 mg/kg
- Jefferson Heights - 0.41 to 5.7 mg/kg
- Southside Gardens - 0.49 to 8.2 mg/kg
- Alton Park – 0.46 to 6.6 mg/kg
- Richmond - 0.15 to 2.3 mg/kg

In three of the five neighborhoods sampled, some concentrations of cadmium exceeded ATSDR's chronic EMEG of 5.2 mg/kg but only by a small amount. A background soil investigation was conducted in 2016 and 2017. The background concentration for cadmium was determined to be 0.78 mg/kg by averaging the results of twenty-nine samples collected. Figure 2 provides a map of the background investigation area. No soil lab results were available for cadmium in the Oak Grove, East Lake, or Highland Park neighborhoods. Soil sample data tables can be found in Appendix A.

Exposure Doses and Non-Cancer Health Effects

TDH used exposure doses calculated over a range of concentrations to conduct an evaluation for intermediate and long-term exposures. The estimated doses for the various concentration ranges can be found in Appendix D. Exposure to cadmium in soil at concentrations greater than 5 mg/kg could exceed the MRL for both intermediate and chronic exposure. However, because the doses only barely exceed the MRL and is far below effect levels, the SSCL site levels of cadmium are not expected to harm an exposed adult.

For chronic cadmium exposure, ATSDR has established an MRL of 0.0001 mg/kg/day for chronic oral exposure (365 days or more) to cadmium. Hazard quotients below 1 indicate that no non-cancer health effects are anticipated. Hazard quotients above 1 indicate further toxicological evaluation is needed to decide whether resident can experience non-cancerous harmful effects. For children under 2 years old, the calculated hazard quotients for chronic exposure to cadmium in soil were greater than 1 which indicates further assessment is needed. For children older than 2 and for adults, the hazard quotients for chronic exposure to cadmium were equal to or below 1 indicating that non-cancer health effects are unlikely.

Long-term exposure to low levels of cadmium leads to a buildup of cadmium in the kidneys and possible kidney disease [ATSDR 2012]. However, it takes about 20 years of exposure for enough cadmium to build up in the kidney to cause damage. When children are 2 years or older, their estimated cadmium doses are below ATSDR's chronic MRL. Because children's doses only briefly exceed the chronic MRL, they are not at risk of harmful effects to the kidneys. They are well below the 20-year exposure time for buildup of cadmium in kidneys to cause damage.

For intermediate cadmium exposure, ATSDR has established an intermediate MRL of 0.0005 mg/kg/day for oral exposure (15–364 days) to cadmium. The calculated adult and child doses are well below the intermediate MRL. The calculated dose for a pica child, where concentrations of cadmium were 6 mg/kg or greater, exceeded the MRL. However, as stated regarding chronic exposure, the exposure time is well below the 20-year time for buildup of cadmium in the kidneys to cause damage. The benchmark dose and the 95% lower confidence limit estimate of the doses associated with a change of 1 standard deviation ($BMDL_{1SD}$) from the control was 0.05 mg/kg/day. A benchmark dose is calculated using available information from either animal or human studies to determine a dose with a low level of risk. A confidence limit conveys the accuracy of a calculation and is the limit defining the confidence interval. The doses estimated from the SSCL site soil data are 100 times lower than the $BMDL_{1SD}$.

For acute cadmium exposure, insufficient studies are available to derive acute MRLs for acute oral exposure (14 days or less) to cadmium. However, the highest estimated cadmium doses are more than 10,000 times lower than the lowest effect levels identified in an animal study. Harmful effects are unlikely from acute exposure to cadmium in soil.

Cancer Health Effects

There are no studies of orally ingested cadmium suitable for calculating risk. No cancer slope factor exists for cadmium; therefore, a cancer risk cannot be calculated. A cancer slope factor measures the risk of a lifetime exposure to a substance. While smelter workers were twice as likely to develop lung cancer from inhalation of cadmium, seven studies in rats and mice where cadmium salts (acetate, sulfate, chloride) were administered orally have shown no evidence of a carcinogenic response [EPA 1987]. Only one study in rats has shown cadmium is carcinogenic by the oral route [ATSDR 2012].

Note: Of the 5 properties sampled with cadmium concentrations of 5 mg/kg or higher, 4 properties also have lead concentration levels above the clean-up level of 360 mg/kg and will likely be remediated as part of the NPL removal activities.

Copper: Interpretation and Health Significance

Soil Sample Concentrations

Based on the residential soil samples reviewed, copper concentration ranges varied in each neighborhood but only by small amounts:

- Cowart Place **-** 63 to 110 mg/kg
- Jefferson Heights - 22 to 330 mg/kg
- Southside Gardens - 28 to 220 mg/kg
- Alton Park – 20 to 280 mg/kg
- Richmond **-** 16 to 140 mg/kg

During a background soil investigation conducted in 2016 and 2017, the urban background concentration for copper was determined to be 22 mg/kg by averaging the results of sixty-eight samples collected. Figure 2 provides a map of the background investigation area. No soil sample lab results were available for copper in the Oak Grove, East Lake, or Highland Park neighborhoods. Soil sample data tables can be found in Appendix A.

Exposure Doses and Non-Cancer Health Effects

For chronic copper exposure, there are no studies based on strong evidence about the health effects of long-term oral exposure (365 days or more) to copper in humans. Therefore, health guidelines like MRLs are not available.

For intermediate copper exposure, ATSDR has established an MRL of 0.01 mg/kg/day for intermediate oral exposure (15–364 days) to copper. The largest dose for intermediate copper exposure at the SSCL site was for a child with a dose of 0.0066 mg/kg/day. The highest dose (0.0066 mg/kg/day) is below ATSDR's intermediate oral MRL (0.01 mg/kg/day), therefore, health effects from intermediate exposures are not likely.

For acute copper exposure, some properties had concentrations of copper that exceeded the comparison value of 53 mg/kg (ATSDR EMEG for acute pica). TDH used PHAST to calculate the hazard quotients. Hazard quotients below 1 indicate that no harmful health effects are anticipated. Hazard quotients above 1 require a more thorough toxicological evaluation to determine whether non-cancer health effects might be possible. For copper in children who exhibit pica behavior from age 1 to less than 6 years of age, the calculated acute hazard quotients were greater than 1 in all the neighborhoods sampled. TDH used exposure doses calculated over a range of concentrations to further evaluate pica child exposures. The estimated doses for various concentration ranges of copper can be found in Appendix E. Several human studies show that the LOAEL for acute exposure ranges from 0.01 to 0.07 mg/kg/day. At the SSCL site, the doses calculated for acute exposure to copper for a pica child range from 0.01 (using a concentration of 53 mg/kg) to 0.062 mg/kg/day (using a concentration of 330 mg/kg). These doses fall within the LOAEL range for acute exposure. There is potential for non-cancer health effects to a pica child from acute exposure to copper at this site. Potential effects include gastric distress, or stomach-related pain, with nausea, abdominal pain, and vomiting.

In toxicology studies of copper in drinking water, the copper may be more highly absorbed by the body, compared to copper that is swallowed from soil. It is important to note that it is not recommended to use composite ISM sampling results to evaluate acute or pica scenarios. In addition, the concentrations used to estimate exposure in children may be underestimated because the composite sampling method cannot identify hot spots or areas of high contamination in a yard. TDH is unable to evaluate the possible health effects from potential hot spots with full confidence. Nevertheless, the composite sampling does show that children with soil-pica behavior could be at risk of gastrointestinal effects should they eat soil.

The table below shows the number of properties in selected neighborhoods that had a concentration of copper that equaled or exceeded 53 mg/kg but will not be cleaned up because the lead level in the soil was less than the established clean up level of 360 mg/kg to be remediated as part of the NPL project.

The number of properties in selected neighborhoods that had a concentration of copper that equaled or exceeded 53 mg/kg, the ATSDR EMEG for copper for an acute pica exposure.

Neighborhood	Number of Properties not being cleaned up*
Alton Park	27
Cowart Place	2
Jefferson Heights	6
Richmond	5
Southside Gardens	12

* Number of properties in the neighborhood that had a concentration of copper that equaled or exceeded 53 mg/kg but will not be cleaned up because the lead level in the soil was less than the established clean up level of 360 mg/kg.

Cancer Health Effects

No studies were found regarding cancer-related health effects people may experience following oral or dermal (skin) exposure to copper [ATSDR 2004b].

Lead: Interpretation and Health Significance

Soil Sample Concentrations

Based on the residential soil samples reviewed, lead concentration ranges varied in each neighborhood:

- Cowart Place - 38 to 1,000 mg/kg
- Jefferson Heights - 84 to 1,700 mg/kg
- Southside Gardens - 130 to 2,000 mg/kg
- Alton Park – 71 to 3,100 mg/kg
- Richmond - 110 to 460 mg/kg

During a background soil investigation conducted in 2016 and 2017, the background concentration for lead was determined to be 99 mg/kg by averaging the results of sixty-eight samples collected in other parts of Chattanooga. Figure 2 provides a map of the background investigation area. No soil sample lab results were available for lead in the Oak Grove, East Lake, or Highland Park neighborhoods. Soil sample data tables can be found in Appendix A.

Exposure Doses and Non-Cancer and Cancer Health Effects

Neither ATSDR nor U.S. EPA have developed a minimal risk level (MRL) or reference dose (RfD) for human exposure to lead. Therefore, TDH cannot use the usual approach to evaluate human exposure to lead. The usual approach involves estimating the human exposure dose to an environmental contaminant and then comparing this dose to health guidelines such as an MRL or RfD [ATSDR 2005]. Instead, human exposure to lead was evaluated using a biological model that predicts the blood lead concentration that was caused by exposure to environmental lead contamination. More information about this model, the EPA's Integrated Exposure Uptake and Biokinetic (IEUBK) model, and how it is used to determine bioavailability is discussed below.

Although lead can affect almost every organ and system in the body, in both adults and children, the nervous system is most harmed by lead poisoning. In general, the level of lead in a person's blood gives a good indication of both past and current ongoing exposure to lead. The level of lead also correlates well with harmful health effects [ATSDR 2007]. For children, repeated contact with lead can:

- slow growth and development
- damage hearing
- affect ability to pay attention and learn.

Information on lead poisoning prevention is available in Appendix H.

Bioavailability of Lead in Soils of SSCL Site Neighborhoods

Some of the soil samples collected in October 2016 were used to determine bioavailability or how easily lead found in the SSCL site soil could cross the gut into the blood stream. A bioavailability analysis was done to determine a site-specific bioavailability factor (36%) for the site. The results of the bioavailability analysis indicated that the lead in the soils at the SSCL site were slightly more likely to be absorbed into the body than the soil used to determine the U.S. EPA's default clean up value (30%). Using the U.S. EPA's Integrated Exposure Uptake and Biokinetic (IEUBK) model, version 1 with exposure unit values proposed for use in the IEUBK model version 2, EPA determined that 160 mg/kg lead in soil could result in a 5% risk that preschool children could exceed 5 µg/dL of lead in blood [EPA2017b].

The concentration of lead in soil that correlates to a 5% risk of exceeding 5 µg/dL is 160 mg/kg, which is near the urban background level of 99 mg/kg identified by EPA [EPA 2017]. Using a target BLL of 5 µg/dL and 36% bioavailability, our analysis showed that ingesting soil at 360 mg/kg lead could result in a 25% higher risk of a child's BLL exceeding 5 µg/dL. This risk is a health concern for children.

EPA chose 360 mg/kg as a remedial action level based on using 36% bioavailability and a target BLL of 8 µg/dL instead of 5 µg/dL, which is the default value in the recently released IEUBK v2. Using 8 µg/dL as the target BLL is less protective of public health. Properties that have 360 mg/kg or higher of lead in the soil will be identified by EPA as needing to be cleaned up at the SSCL site.

Table 3 provides a summary of soil sampling events from October 2016 through December 2018. It should be noted that there is no safe level of lead in the blood. Therefore, it is important to note that residents living on properties where lead levels are greater than 160 mg/kg and less than 360 mg/kg need to be aware of the potential risk of lead poisoning.

Table 3. Summary of Lead Soil Sample Results for Sampling Events October 2016, January 2017, and May through December 2018

Neighborhood	Number of Properties Investigated	Number of Properties with Lead Between 160 and 360 mg/kg**	Number of Properties with Lead Greater than 360 mg/kg*
Alton Park	116	83 (72%)	27 (23%)
College Hill Courts	23	8 (35%)	0 (---)
Cowart Place	14	5 (35%)	5 (35%)
Jefferson Heights	97	25 (26%)	45 (46%)
Mountain View Court	10	3 (33%)	0 (---)
Richmond	16	11 (69%)	5 (31%)
Southside Gardens	44	12 (27%)	15 (34%)

* EPA's risk-based clean-up goal was established following bioavailability analysis of lead found in soil.
** Range is between the EPA clean-up goal and the EPA Integrated Exposure Uptake Biokinetic Model result using a target blood lead level of 5 µg/dL. More information is provided in the Lead: Interpretation and Health Significance section.
(72%) = Percentage of total properties in neighborhood.
Source: EPA Interim Remedial Investigation Report, Southside, Chattanooga Lead Superfund Site (EPA 2018)

Table 4 below shows the number of properties where the probability of children ages 0-5 years having a blood lead level exceeding 5 µg/dL may occur based on average surface soil lead concentrations. This table includes soil sample result from the 320 properties investigated in October 2016, January 2017, and May through December 2018.

Table 4. Surface Soil Lead Concentrations and Modeled Blood Lead Levels in Children

Average Lead Concentration Range in Soil (mg/kg)	Estimated Probability (%) of exceeding a Blood Lead Level of 5 µg/dL	Estimated Geometric Mean Blood Lead Level (µg/dL) **	Number of Properties
ND-160	NA-6.5	NA-2.5	174
161-360	6.6-32.7	2.5-4.1	147

NA = Not applicable; µg/dL = micrograms of lead per deciliter of blood

** Blood lead levels were calculated using the USEPA Integrated Exposure Uptake Biokinetic (IEUBK) model (Windows Version 2.0) with default assumptions with the exception of bioavailability fraction absorption for soil and dust was set to 36%. The model was run with results displayed as a density curve for ages 0-60 months (5 years), geometric standard deviation (GSD) of 1.6, and target BLL of 5 µg/dL.

More information about bioavailability and the process used to evaluate soil can be found in Appendix F. EPA plans to prioritize addressing soil with lead levels greater than 1,200 mg/kg where children are present. That is, in the prioritized locations, the contaminated soil will be removed, properly disposed of, and replaced with clean soil. Because no safe BLL has been identified in children, ATSDR and the TDH support remediating soil lead levels as low as possible to reduce BLLs in children.

Review of Blood Lead Data

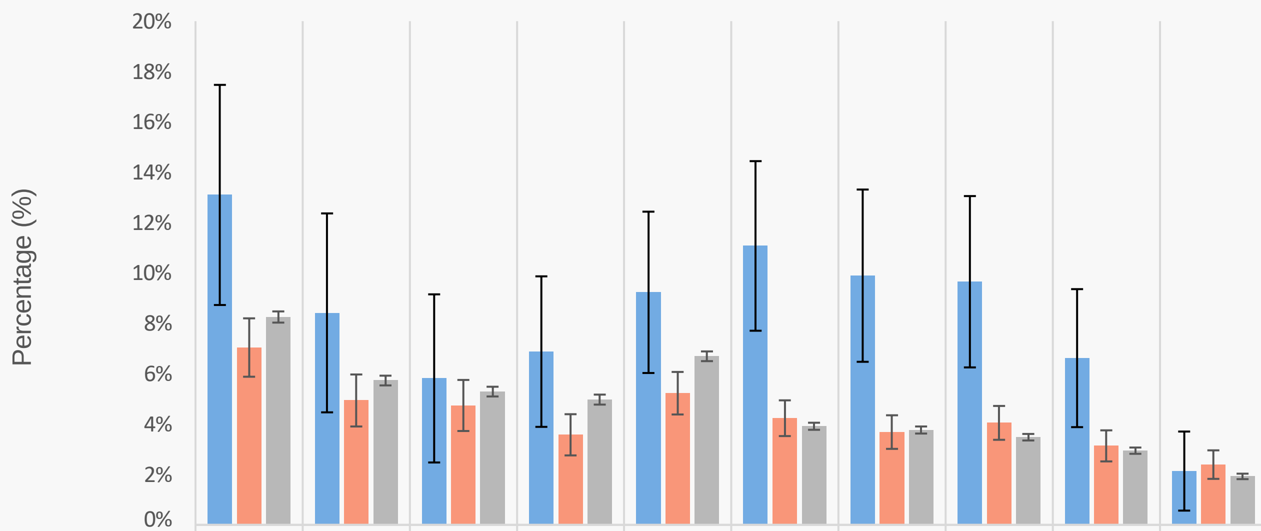
Based upon TDH's review of the soil sampling data, soil lead concentrations in many of the sampled residential areas are high enough to harm the health of preschool children if they are exposed for a long period of time. In 2021, Centers for Disease Control and Prevention (CDC) updated its recommendations on children's BLLs. CDC shifted the focus to the primary prevention of lead exposure in order to reduce or eliminate dangerous lead sources in children's environments. CDC's current blood lead reference value of 3.5 µg/dL is used to identify excessive exposure to lead.

TDH reviewed blood lead surveillance data from the Tennessee Department of Health to see how the blood lead levels in the SSCL site area compared to those of Hamilton County and the state. Blood lead screening results for Chattanooga are based on convenience sampling, a type of non-probability sampling which is vulnerable to selection bias and sampling error. Surveillance data are rarely representative of the general population. Surveillance data results may vary based on factors such as perceived risk by a health care provider, level of parental concern, or both, which may result in children at higher or lower risk being screened. Other socio-economic factors that could influence blood lead testing frequency and results include the age of the child's home and their poverty status. Information found in Appendix G provides an overview of these factors.

The percentage of children with BLL exceeding CDC's reference value of 3.5 µg/dL was compared for children living in the boundaries of the SSCL site with children living in Hamilton County and the state. For each year from 2012 to 2021, BLL results for children living in the boundaries of the SSCL site were consistently higher compared to statewide level of BLLs for Tennessee. Each year, the percent of children ages 6 to 72 months from the SSCL site, whose tests showed elevated BLLs (greater than or equal to 3.5 µg/dL) was 1.1 to 6.9 percentage is points higher than the percent of children tested with elevated BLLs in the rest of Hamilton County (excluding the SSCL site area). In addition, the percent of SSCL site children with elevated BLLs was 0.2 to 7.2 points higher than the total of other children in the state whose tests also indicated elevated BLLs. The difference was statistically significant in 9 of the 10 years.

The percentage of children in Hamilton County living outside of the SSCL site who were tested and had a BLL equal to or greater than 3.5 µg/dL exceeded the statewide level of BLLs for Tennessee in 5 of the 10 years evaluated. However, the percent difference between Hamilton County and the state is small and likely not statistically significant. Figure 3 and Table 5 summarize the data.

Figure 3. Percent of Tested Children* (Ages 6 Months to 72 Months) with BLL ≥ 3.5 µg/dL



	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Southside	13.1%	8.4%	5.8%	6.9%	9.2%	11.1%	9.9%	9.7%	6.6%	2.1%
Hamilton†	7.0%	4.9%	4.7%	3.6%	5.2%	4.2%	3.7%	4.1%	3.1%	2.4%
Statewide	8.3%	5.7%	5.3%	5.0%	6.7%	3.9%	3.8%	3.5%	2.9%	1.9%

Southside Hamilton† Statewide

Data Source: Lead TRK, TN Dept. of Health, Updated March 25, 2022
*Error bars represent 95% confidence intervals
†Hamilton County totals exclude Southside Children
BLL = Blood Lead Level
µg/dL = micrograms per deciliter

Table 5. Number of Children Tested for Blood Lead Levels 2012 – 2021 in the Southside Chattanooga Lead Site, Hamilton County, and Tennessee Statewide

Year	Area	Number Screened and Geocoded*
2012	Hamilton County†	1874
	TN Statewide	59092
2013	Southside	190
	Hamilton County†	1699
	TN Statewide	56780
2014	Southside	189
	Hamilton County†	1686
	TN Statewide	51983
2015	Southside	276
	Hamilton County†	1984
	TN Statewide	46306
2016	Southside	314
	Hamilton County†	2675
	TN Statewide	64175
2017	Southside	334
	Hamilton County†	3114
	TN Statewide	73243
2018	Southside	293
	Hamilton County†	3064
	TN Statewide	72628
2019	Southside	290
	Hamilton†	3305
	Statewide	77173
2020	Southside	317
	Hamilton County†	3056
	TN Statewide	69954
2021	Southside	327
	Hamilton County†	2796
	TN Statewide	63481

*Totals listed include only children between the ages of 6 and 72 months who received a blood lead test and whose home address could be successfully geocoded. See "Tables" Sheet for a breakdown of geocoding percentages by year.
†Hamilton County totals exclude children whose addresses were geocoded to within the Southside Chattanooga Lead Site Neighborhood.

Nutritional Status and Other Considerations

How much lead gets into the body, especially from the gastrointestinal (GI) tract, is influenced by the nutritional status of adults and children (e.g., calcium, iron, phosphate, vitamin D, fats). Lead uptake describes the process of lead entering the body. More lead enters the body as dietary levels of nutrients decrease [ATSDR 2007]. In addition, lead uptake is a function of developmental stage or age, the amount of lead swallowed or breathed in, the chemical species, and the particle size of the lead-containing media.

TDH did not have garden produce data to evaluate; however, exposure to lead can occur through garden produce grown in lead-contaminated soil. A scientific study showed that some garden vegetable plants grown in contaminated soil accumulate lead to some level, and that most of the contamination is in the plant root. Smaller levels of lead were found in the plant shoot, with low to non-detectable levels of lead in the edible fruit (e.g., tomatoes, peppers, beans, zucchini) [Finster et al. 2003]. Most lead compounds are relatively insoluble; therefore, natural plant uptake is minimal [Barocsi et al. 2003].

Eating vegetables grown in soil that contains lead can be harmful. Cleaning vegetables well before cooking and eating can reduce the lead content. Growing vegetables in raised beds or containers with clean soil is recommended [EPA 2011].

ATSDR promotes health education and outreach events called "soilSHOPs" to help people learn if their soil is contaminated with lead, and how to reduce exposures to contaminated soil and produce. The name soilSHOP stands for Soil Screening, Health, Outreach and Partnership. A soilSHOP was held in October 2016 offering free soil screening and health education materials about lead poisoning prevention to residents in Chattanooga.

Polycyclic Aromatic Hydrocarbons (PAHs): Interpretation and Health Significance

Polycyclic aromatic hydrocarbons (PAHs) are a group of over 100 different chemicals that are formed during the incomplete burning of coal, oil and gas, garbage, or other organic substances like tobacco or charbroiled meat. PAHs are usually found as a mixture containing two or more of these compounds [ATSDR 1996]. Soil sample laboratory results for PAHs, including benzo(a)pyrene (BaP), are only available for Jefferson Heights and Southside Gardens.

Soil Sample Concentrations

PAHs measured in Jefferson Heights and Southside Gardens include anthracene, benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(g,h,i)perylene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, fluoranthene, indeno(1,2,3-cd)pyrene, phenanthrene, and pyrene. See Table 6.

Exposure Doses and Non-Cancer Health Effects

Although the health effects of individual PAHs are not exactly alike, the following 17 PAHs are considered as a group in the ATSDR toxicological profile: acenaphthene, acenaphthylene, anthracene, benz[a]anthracene, benzo[a]pyrene, benzo[e]pyrene, benzo[b]fluoranthene, benzo[g,h,i]perylene, benzo[j]fluoranthene, benzo[k]fluoranthene, chrysene, dibenz[a,h]anthracene, fluoranthene, fluorine, indeno[1,2,3-c,d]pyrene, phenanthrene, and pyrene.

An MRL is an estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects [ATSDR 1995]. No acute-, intermediate-, or chronic-duration dermal MRLs have been derived for these 17 PAHs. No acute or chronic oral MRLs have been derived for PAHs.

If no MRL is available to derive an EMEG, ATSDR develops an RMEG using EPA's reference doses (RfDs). RMEGs represent concentrations of substances in soil to which humans may be exposed without experiencing adverse health effects. RfDs consider lifetime exposures; therefore, RMEGs apply to chronic exposures [ATSDR 2005]. Of the 17 PAHs listed above, RMEGs have been established for the six PAHs listed in the table below [ATSDR 2020].

Chronic RMEGs for Polycyclic Aromatic Hydrocarbons (PAHs)

Contaminant Name	ATSDR Chronic RMEGs (mg/kg)	
	Child	Adult
Acenaphthene	3,100	48,000
Anthracene	16,000	240,000
Benzo(A)pyrene	16	240
Fluoranthene	2,100	32,000
Fluorene	2,100	32,000
Pyrene	1,600	24,000

None of the soil samples contained concentrations of these contaminants at levels that exceeded the established RMEGs. Therefore, non-cancerous effects are not likely from exposure to these PAHs in soil. The soil data and information about the health evaluation can be found in Appendix A.

EPA has established a reference dose (RfD) of 0.0003 mg/kg/day for benzo(a)pyrene. The RfD is an estimate of the daily lifetime dose of a substance that is unlikely to cause harm in humans [ATSDR 1995]. The RfD has uncertainty and safety factors built in to assure that the exposure assessment is protective of health. The point of departure for the RfD study is a $BMDL_{1SD}$ (HED) of 0.092 mg/kg/day. A neurodevelopmental study determined that after birth, exposure to BaP can result in behavioral impairments that may not be apparent in juveniles but are present in young adulthood [Chen et al. 2012]. A dose was calculated using ATSDR's PHAST tool and the maximum concentration of BaP. The dose measured at the SSLC site was equal to the RfD for children under one year old. However, adverse non-cancer health effects are not expected for this age group because the dose in young children is far below effect levels. In addition, the chronic hazard quotient calculated for the maximum concentration of BaP using ATSDR's PHAST tool was equal to or below 1. The results indicate a lack of non-cancer health effects expected for both children and adults.

Table 6. Analytical Results for Polycyclic Aromatic Hydrocarbons (PAH) Soil Samples in milligrams per kilogram (mg/kg) and Calculated Toxicity Equivalency Factors (TEF) Compared to ATSDR Comparison Values (mg/kg)

Analyte	ATSDR CV (mg/kg)	JH018-SF-EY DUP AVG	Calculated TEF	JH019-SF-BY	Calculated TEF	JH021-SF-EY	Calculated TEF	JH033-SF-EY	Calculated TEF	JH041-SF-EY	Calculated TEF	JH049-SF-BY	Calculated TEF	JH052-SF-EY	Calculated TEF
2-Methylnaphthalene	Chronic RMEG 210	0.064	NA	0.160	NA	0.100	NA	NA	NA	0.110	NA	0.072	NA	0.063	NA
Acenaphthene	Chronic RMEG 3,100	0.063	NA	0.110	NA	0.350	NA	NA	NA	0.130	NA	NA	NA	NA	NA
Acenaphthylene	Ngv	0.045	NA	0.150	NA	0.180	NA	0.110	NA	0.180	NA	0.074	NA	0.043	NA
Anthracene	16,000	0.113	NA	0.370	NA	1.100	NA	0.130	NA	0.430	NA	0.077	NA	0.100	NA
Benzo(a)anthracene	Ngv	0.460	0.046	1.400	0.140	3.400	0.340	0.830	0.083	1.600	0.160	0.430	0.043	0.490	0.049
Benzo(a)pyrene	0.11	0.445	0.445	1.300	1.300	2.800	2.800	0.930	0.930	1.800	1.800	0.460	0.460	0.490	0.490
Benzo(b)fluoranthene	Ngv	0.745	0.075	2.700	0.270	4.800	0.480	1.700	0.170	3.500	0.350	0.890	0.089	0.860	0.086
Benzo(g,h,i)perylene	Ngv	0.205	NA	0.490	NA	1.000	NA	0.390	NA	0.680	NA	0.180	NA	0.190	NA
Benzo(k)fluoranthene	Ngv	0.250	0.025	0.720	0.072	1.200	0.120	0.400	0.040	0.850	0.085	0.260	0.026	0.290	0.029
Chrysene	Ngv	0.450	0.005	1.400	0.014	3.400	0.034	0.870	0.009	1.600	0.016	0.480	0.005	0.500	0.005
Dibenzo(a,h)anthracene	Ngv	0.057	0.234	0.160	0.656	0.380	1.558	0.120	0.492	0.220	0.902	0.052	0.213	0.053	0.217
Fluoranthene	Chronic RMEG 2,300	1.110	NA	2.900	NA	6.900	NA	1.600	NA	3.500	NA	0.820	NA	1.100	NA
Indeno(1,2,3-cd)pyrene	Ngv	0.225	0.023	0.590	0.059	1.300	0.130	0.460	0.046	0.850	0.085	0.210	0.021	0.210	0.021
Phenanthrene	Ngv	0.650	NA	1.700	NA	4.100	NA	0.560	NA	1.600	NA	0.290	NA	0.550	NA
Pyrene	Chronic RMEG 1,700	0.855	NA	2.500	NA	4.800	NA	1.300	NA	2.700	NA	0.900	NA	0.980	NA
BaP TE	ATSDR CREG for benzo(a)pyrene 0.11	NA	**0.851**	NA	**2.511**	NA	**5.462**	NA	**1.770**	NA	**3.398**	NA	**0.857**	NA	**0.897**

Analyte	ATSDR CV (mg/kg)	JH053-SF-EY	Calculated TEF	JH055-SF-EY	Calculated TEF	JH056-SF-EY	Calculated TEF	JH057-SF-EY	Calculated TEF	JH060-SF-EY DUP AVG	Calculated TEF	JH060-SF-GD	Calculated TEF	JH061-SF-EY	Calculated TEF
2-Methylnaphthalene	Chronic RMEG 210	NA	NA	0.094	NA	0.045	NA	NA	NA	1.500	NA	0.230	NA	0.130	NA
Acenaphthene	Chronic RMEG 3,100	0.056	NA	0.069	NA	0.071	NA	NA	NA	0.053	NA	NA	NA	NA	NA
Acenaphthylene	Ngv	0.055	NA	0.390	NA	0.100	NA	0.068	NA	0.180	NA	0.090	NA	0.110	NA
Anthracene	16,000	0.120	NA	0.320	NA	0.220	NA	0.140	NA	0.220	NA	0.120	NA	0.150	NA
Benzo(a)anthracene	Ngv	0.530	0.053	2.500	0.250	1.200	0.120	0.820	0.082	1.800	0.180	0.850	0.085	1.000	0.100
Benzo(a)pyrene	0.11	0.570	0.570	1.800	1.800	1.200	1.200	0.850	0.850	1.900	1.900	0.890	0.890	0.990	0.990
Benzo(b)fluoranthene	Ngv	0.950	0.095	2.800	0.280	2.000	0.200	1.500	0.150	3.200	0.320	1.700	0.170	2.000	0.200
Benzo(g,h,i)perylene	Ngv	0.230	NA	0.840	NA	0.450	NA	0.310	NA	0.820	NA	0.300	NA	0.320	NA
Benzo(k)fluoranthene	Ngv	0.330	0.033	0.950	0.095	0.640	0.064	0.400	0.040	0.840	0.084	0.420	0.042	0.530	0.053
Chrysene	Ngv	0.520	0.005	2.700	0.027	1.100	0.011	0.900	0.009	1.900	0.019	0.850	.009	1.000	0.010
Dibenzo(a,h)anthracene	Ngv	0.057	0.234	0.240	0.984	0.140	0.574	0.091	0.373	0.255	1.046	0.100	0.410	0.100	0.410
Fluoranthene	Chronic RMEG 2,300	1.100	NA	3.200	NA	2.800	NA	2.200	NA	3.400	NA	NA	NA	2.000	NA
Indeno(1,2,3-cd)pyrene	Ngv	0.250	0.025	0.950	0.095	0.540	0.054	0.360	0.036	1.005	0.101	0.360	0.036	0.390	0.039
Phenanthrene	Ngv	0.610	NA	1.500	NA	1.400	NA	0.890	NA	1.100	NA	0.640	NA	0.690	NA
Pyrene	Chronic RMEG 1,700	1.000	NA	2.400	NA	2.700	NA	1.900	NA	2.750	NA	1.700	NA	2.000	NA
BaP TE	ATSDR CREG for benzo(a)pyrene 0.11	NA	**1.015**	NA	**3.531**	NA	**2.223**	NA	**1.540**	NA	**3.649**	NA	**1.642**	NA	**1.802**

Table 6. Analytical Results for Polycyclic Aromatic Hydrocarbons (PAH) Soil Samples in milligrams per kilogram (mg/kg) and Calculated Toxicity Equivalency Factors (TEF) Compared to ATSDR Comparison Values (mg/kg) (continued)

Analyte	ATSDR CV (mg/kg)	JH062-SF-EY	Calculated TEF	JH063-SF-EY	Calculated TEF	JH064-SF-EY	Calculated TEF	PPSG080-SF-02	Calculated TEF	PPSG080-SF-03	Calculated TEF
2-Methylnaphthalene	Chronic RMEG 210	0.060	NA	0.190	NA	0.280	NA	NA	NA	NA	NA
Acenaphthene	Chronic RMEG 3,100	NA	NA	0.610	NA	0.860	NA	NA	NA	NA	NA
Acenaphthylene	Ngv	0.066	NA	0.490	NA	0.710	NA	NA	NA	NA	NA
Anthracene	16,000	0.100	NA	1.700	NA	2.400	NA	0.034	NA	NA	NA
Benzo(a)anthracene	Ngv	0.630	0.063	12.000	1.200	9.900	0.990	0.170	0.017	0.120	0.012
Benzo(a)pyrene	0.11	0.680	0.680	12.000	12.000	9.700	9.700	0.200	0.200	0.120	0.120
Benzo(b)fluoranthene	Ngv	1.200	0.120	18.000	1.800	16.000	1.600	0.380	0.038	0.210	0.021
Benzo(g,h,i)perylene	Ngv	0.240	NA	5.200	NA	4.000	NA	0.093	NA	0.100	NA
Benzo(k)fluoranthene	Ngv	0.370	0.037	5.300	0.530	4.000	0.400	0.110	0.011	0.065	0.007
Chrysene	Ngv	0.640	0.006	12.000	0.120	9.100	0.091	0.200	0.002	0.130	0.001
Dibenzo(a,h)anthracene	Ngv	0.077	0.316	1.300	5.330	1.100	4.510	NA	0.000	0.025	0.103
Fluoranthene	Chronic RMEG 2,300	1.400	NA	34.000	NA	26.000	NA	0.360	NA	0.230	NA
Indeno(1,2,3-cd)pyrene	Ngv	0.280	0.028	5.700	0.570	4.600	0.460	0.100	0.010	0.110	0.011
Phenanthrene	Ngv	0.600	NA	24.000	NA	16.000	NA	0.160	NA	0.120	NA
Pyrene	Chronic RMEG 1,700	1.400	NA	27.000	NA	19.000	NA	0.380	NA	0.190	NA
BaP TE	ATSDR CREG for benzo(a)pyrene 0.11	NA	**1.250**	NA	**21.550**	NA	**17.751**	NA	**0.278**	NA	**0.274**

Notes:

All soil samples were composite and collected from 0 to 6 inches below ground surface.
All soil sample results are reported in milligrams per kilogram (mg/kg) and equivalent to parts per million in soil.
CV = ATSDR Comparison Value used.
PAH = Polycyclic aromatic hydrocarbons
ATSDR RMEG = Reference Dose Media Evaluation Guide
ATSDR intermediate exposure duration (15 to 364 days) EMEG for mercuric chloride used; Chronic EMEG unavailable.
ATSDR CREG = Cancer Risk Evaluation Guide
AVG = Average
JH018-SF-EY DUP AVG = For sample JH08-SF-EY the reported value is the average of the original soil sample and the duplicate soil sample collected at the same location.
Ngv = no guidance value available.
TEF = PAH average concentrations multiplied by the compound toxicity equivalency factor [CalEPA 2011].
NA = not applicable – No TEF.
BaP TE = benzo(a)pyrene (BaP) toxic equivalents which equals the sum of the individual compound concentrations adjusted for their toxicity relative to BaP.
BY = Back yard
EY = Entire yard
DUP = Duplicate
GC = Garden
JH = Jefferson Heights
SG = Southside Gardens;
PPSG080 (Pringle Park sample)

Cancer Health Effects

To evaluate PAHs for potential cancer effects, TDH adjusted the toxicity of each of the individual compounds by multiplying the measured concentrations by the corresponding California EPA toxicity equivalent factor (TEF). The adjusted compounds were compared to selected cancer comparison values. The BaP toxic equivalent (BaP TE) equals the sum of the individual compound concentrations adjusted for their cancer toxicity relative to BaP. In the Jefferson Heights and Southside Gardens neighborhoods, BaP TE was calculated using benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, chrysene, dibenzo(a,h)anthracene, and indeno(1,2,3-cd)pyrene. The adjusted BaP TE and estimated cancer risks can be found in Table 6.

Benzo(a)pyrene toxicity equivalent factors (TEF) used in calculating overall B(a)P equivalent concentrations [CalEPA 2011]

PAH compound	TEF
Benzo(a)pyrene	1
Benzo(a)anthracene	0.1
Benzo(b)fluoranthene	0.1
Benzo(k)fluoranthene	0.1
Chrysene	0.01
Dibenz(a,h)anthracene	4.1
Indeno(123-cd)pyrene	0.1

Of the PAHs measured in soil in the Jefferson Heights and Southside Gardens neighborhoods, only benzo(a)pyrene exceeded levels for available comparison values. In the Jefferson Heights neighborhood, concentrations of BaP in the sampled residential soil ranged from 0.33 mg/kg to 12 mg/kg. All 19 samples collected in the Jefferson Heights neighborhood contained amounts of BaP that exceeded the ATSDR CREG comparison value of 0.11 mg/kg. One sample location in the Southside Gardens neighborhood contained soil samples with BaP levels of 0.12 mg/kg and 0.2 mg/kg. Both exceeded the ATSDR CREG.

The calculated soil sample concentration of BaP TE in residential soil in the Jefferson Heights and Southside Gardens neighborhoods exceeded the ATSDR CREG BaP of 0.11 mg/kg. The calculated BaP TE concentrations can be found in Table 6.

To determine cancer risk from exposure to PAHs, TDH used ATSDR's PHAST tool to evaluate the BaP TE for two exposure populations: children exposed from birth to 21 years of age and adults exposed for 33 years. See Table 7 for the results.

The calculated BaP TE from samples collected at Southside Gardens were 0.274 mg/kg and 0.278. In each case, there is a risk of 3 excess cancers in 1 million children and 2 excess cancers in 10 million adults from exposure. The excess cancer risk is the number of additional cases of cancer that would be expected over a lifetime for children exposed for 21 years and for adults exposed for 33 years. The risk to adults and children from exposure to PAHs in the Southside Gardens neighborhood is considered low and is not a health concern.

The calculated BaP TE from samples collected in the Jefferson Heights neighborhood ranged from 0.8 mg/kg to 21.5 mg/kg (Table 7). The risk to adults from exposure to PAHs in the Jefferson Heights neighborhood is considered low and is not a health concern. The risk to children from exposure to PAHs in the Jefferson Heights neighborhood is considered low to moderate. The cancer risks at two locations that exceeded 1 extra cancer in 10,000 exposed people is a health concern (Table 7).

Table 7. Calculated Excess Cancer Risk in the Jefferson Heights and Southside Garden Neighborhoods Based on BaP Toxic Equivalents

Sample ID	BaP TE[1] (mg/kg)	Child Cancer Risk* (exposure 21 years)	Adult Cancer Risk* (exposure 33 years)
JH018	0.851	9.7E-6	7.0E-7
JH019	2.511	2.9E-5	2.1E-6
JH021	5.462	6.2E-5	4.5E-6
JH033	1.770	2.0E-5	1.4E-6
JH041	3.398	3.9E-5	2.8E-6
JH049	0.857	9.7E-6	7.0E-7
JH052	0.897	1.0E-5	7.3E-7
JH053	1.015	1.2E-5	8.3E-7
JH055	3.531	4.0E-5	2.9E-6
JH056	2.223	2.5E-5	1.8E-6
JH057	1.540	1.8E-5	1.3E-6
JH060	3.649	4.1E-5	3.0E-6
JH061	1.802	2.0E-5	1.5E-6
JH062	1.250	1.4E-5	1.0E-6
JH063	21.550	**~2.5E-4**	1.8E-5
JH064	17.751	**~2.0E-4**	1.5E-5
SG080-02	0.278	3.2E-6	2.3E-7
SG080-03	0.274	3.1E-6	2.2E-7

Notes:
[1] BAP TE (mg/kg) = Benzo(a)pyrene toxic equivalent in milligrams per kilogram.
* The calculations in this table were generated using ATSDR's PHAST v1.7.1.0. The cancer risks were calculated using the cancer slope factor of 1 $(mg/kg/day)^{-1}$ and age-dependent adjustment factors.
~ indicates cancer risk at or greater than $1x10^{-4}$.

Combined Health Effects

A review of blood lead data indicates that some children living within the boundaries of the SSCL site have been exposed to lead at levels that could harm their health. While no safe BLL has been identified, blood lead testing has identified a higher-than-expected percentage of children at the SSCL site with BLLs above CDC's blood lead reference value of 3.5 µg/dL. Adverse neurological, hematological, and other health effects may occur. Experimental studies suggest that exposure to mixtures of lead and arsenic and mixtures of lead and cadmium can cause additive or greater than additive toxicity for health effects. If the combined exposure to arsenic and lead are high enough, evidence suggests that there is a greater potential for developing neurological effects than when exposure is to lead or arsenic alone [ATSDR 2004]. For example, children exposed to arsenic displayed decreases in reading and spelling performance, which was further decreased in children with arsenic and lead exposure [Marlow 1985, Moon 1985]. However, the levels of arsenic and cadmium in soil are not high enough to contribute to a mixtures effect. The estimated doses of arsenic and cadmium from ingesting small amounts of soil is very low and well below harmful levels.

More information on the interactive effects from exposure to several metals can be found in the ATSDR report titled *Interaction Profile for Arsenic, Cadmium, Chromium, and Lead* [ATSDR 2004].

Uncertainties

This health consultation has some known limitations.

- Reliance on model predictions: The IEUBK model depends on reliable estimates of site-specific information for several key parameters that include the following uncertainties:
    - Lead concentration in outdoor soil (fine fraction) and indoor dusts,
    - Soil and dust ingestion rates,
    - Lead concentration in deteriorating paint and indoor paint dust,
    - Individual variability in child blood lead concentrations affecting the Geometric Standard Deviation (GSD).
    - Lead exposure sources outside of the home (e.g. child care, friends or relative's homes, food sources).
- Model assumptions: The IEUBK model was designed to evaluate relatively stable exposure situations, rather than rapidly varying exposures or exposure occurring for less than a year. In addition, the IEUBK model was not developed to assess lead risks for age groups older than 7 years. The model does not account for the soil cover (e.g., vegetation) and whether there is limited contact with the bare soil. The model assumes that children do not have any nutritional challenges or intentionally eat soil. Overall, there are recognized uncertainties in TDH's evaluation.
- EPA uses XRF soil screening to determine which yards need remediation: During early investigation at the SSCL site, the sieved XRF sample data and the lab data for those samples had an r-squared correlation of 0.98. This correlation is a measure of accuracy.

An r-squared value of 0.98 indicates a very good level of accuracy between XRF data and lab data. Note: TDH only used the laboratory data for review and analysis in this document.

- Missing data: Sample location, sample collection, and quality assurance procedures were established and resulted in a consistent, well-documented data set. However, not all property owners allowed access for sampling activities. In addition, lead was the primary contaminant of concern and many properties were not tested for other chemicals.

- Exposure assumptions: Estimating an exposure dose requires estimating how much, how often, and how long a person may come in contact with the contaminant in a specific medium. TDH made several assumptions for the site-specific exposure scenarios. Although TDH's assumptions were conservative, each person's exposure might be higher or lower depending on their lifestyle and individual characteristics that influence contact with contaminated media.

- Reliance on data from animal studies: ATSDR's evaluation required the examination and interpretation of reliable, substance-specific, health effects data. The evaluation included a review of epidemiologic (human) and experimental (animal) studies. A study based on human data would hold the greatest weight in describing relationships between a particular exposure and a human health effect. However, in some cases, only animal studies were available.

- Dose assumptions: Substance-specific health effects data are generally expressed in terms of "ingested dose" rather than "absorbed dose." The distinction between ingested dose and absorbed dose is important regarding heavy metal exposure in soil. In general, a lower percentage of the metals are absorbed from contaminated soil than those ingested through contaminated drinking water or food.

- Composite ISM soil sampling: TDH used the results of composite ISM soil sampling to evaluate potential adverse health effects from exposure to different substances. Soil particles can vary in size, shape, and composition. Minerals present in soils can affect how well contaminants bind to the soil. A smaller particle of soil has more surface area per volume which allows more contaminant to attach per volume. In addition, organic carbon is unevenly distributed throughout soil and can affect the distribution and amount of contamination in soil. There are also other variables that contribute to distribution of contaminants in an area of soil. Because it is not reasonable to test all soil in an area of concern, samples are selected. The variability of soil samples can add to an over-estimation or under-estimation of the contamination. Where hot spots are present and not sampled, using incremental sampling results to evaluate acute and pica scenarios may lead to under-estimation of potential adverse health effects. TDH is unable to evaluate possible health effects from such potential hot spots with full confidence.

Child Health Considerations

To ensure that the health of the nation's children is protected, ATSDR requires that public health assessments determine whether children are being exposed to site-related hazardous wastes and whether contaminants may affect children's health.

In communities faced with air, water, or food contamination, the physical differences between children and adults demand special attention. Children could be at greater risk than adults from certain kinds of exposure to hazardous substances. Children play outdoors and sometimes engage in hand-to-mouth behaviors that increase their exposure potential. Children are shorter than are adults; this means they breathe dusts, soil, and vapors close to the ground. A child's lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. If toxic exposure levels are high enough during critical growth stages, children's developing body systems can be more sensitive than adults. Finally, children are dependent on adults for access to housing, access to medical care, and risk identification. Thus, adults need as much information as possible to make informed decisions regarding children's health.

Health Education Activities

TDH and ATSDR have a long history of meeting with the community to address their questions and concerns about hazardous waste in their community. A description of those efforts and meetings can be found below.

On March 26, 2012, EPA held a public meeting to inform the citizens affected by the sampling activities of the Read and Mitchell Avenue area about the newly discovered lead contamination. EPA provided an update about the sampling activities that had taken place and the planned sampling events. TDH provided information on lead exposure and ways to be protect oneself from lead poisoning. TDH also answered health-related questions from the community.

In October 2012, TDH participated in another public meeting with EPA. EPA provided information to the community about what had been discovered and explained what could be expected during the upcoming remediation work. EPA also set up a community outreach center in the vicinity to continue to answer community questions. TDH provided information on lead exposure and ways to be protect oneself from lead poisoning and answered health-related questions from the community.

In October 2016, TDH coordinated a Screening, Health, Outreach and Partnership (SoilSHOP) event in one of the SSCL site neighborhoods. The event offered free soil screening for lead contamination and was an opportunity to educate the community on ways to reduce exposure to contaminated soil and produce. Partners provided information about the study EPA was conducting, the effects of lead poisoning, safe gardening practices, and other topics. The soil screenings conducted at the event provided new information to EPA about areas of the community that needed further investigation.

On December 13, 2016, EPA hosted a public meeting and provided updated information about the project. EPA also introduced plans to further study residential soils in the Southside Chattanooga area. TDH participated in the December 2016 meeting and provided information on lead exposure and ways to be protected from lead poisoning. TDH also answered health-related questions from the community.

In January 2017, TDH partnered with ATSDR to prepare health education messaging and canvas selected neighborhoods. During canvassing, packages with information were provided about the EPA project and how to protect families from lead poisoning.

In April 2017, TDH partnered with the TDH Division of Family, Health and Wellness (FHW), the Chattanooga-Hamilton County Health Department, and ATSDR. The group sent letters to pediatricians in Chattanooga, informing them about the lead contamination that had been discovered in the Southside Chattanooga area, and encouraging the pediatricians to conduct blood-lead testing for their patients. In February 2017, TDH also partnered with the FHW and a local community center to promote blood-lead testing for children ages 6 and under.

In February, May, and November 2018, EPA scheduled public meetings to discuss adding the SSCL site to the NPL. As a long-term partner with EPA at this site, TDH attended the meeting to provide health education materials and to address health concerns about exposure to the lead in soil.

In February 2019, TDH partnered with EPA and TDEC to hold a public availability session. The session was used to address additional questions from the community about the addition of the SSCL site to the NPL.

In April 2019, TDH coordinated with Erlanger Children's Hospital in Chattanooga to present a Ground Rounds Session about lead poisoning and the importance of blood lead testing for doctors in the Chattanooga area.

During 2020 and 2021, and into August 2022, there were no scheduled in-person public meetings or public availability sessions due to the Coronavirus pandemic. There also were no virtual public meetings during this time frame.

In October 2022, TDH partnered with EPA and TDEC to hold a Public Availability Session, the first in two and one-half years due to the Coronavirus pandemic. The session was used to allow residents of the Alton Park and Richmond communities to ask questions about ongoing soil sampling and EPA cleanups. Cleanups occurred in these two neighborhoods during the remainder of 2022.

A draft of this health consultation was prepared and posted for public comment on December 16, 2022. The public comment period ended on February 16, 2023. No comments were received from the public on the health consultation during the comment period.

Conclusions

TDH reached the following three conclusions in this health consultation concerning the **Southside Chattanooga Lead (SSCL)** site:

1. **Residents, and in particular young children, at some residential properties inside the boundaries of the SSCL site are exposed to lead, copper, and polycyclic aromatic hydrocarbons (PAHs) in the soil at levels that could harm their health.**

   In particular, young children, pregnant women, and developing babies are at greatest risk for harmful health effects from lead exposure.

   <u>Basis for Decision:</u> Concentrations of lead and copper measured in the soil of some properties inside the boundaries of the SSCL site exceeded health-based comparison values and required further evaluation to understand the health implications of contacting contaminated soil. As soil sampling continues at this site, the extent of contamination and potential for exposure will become more well defined.

   EPA assessed the ability of the body to take up the type of lead found in soil within the boundaries of the SSCL site and used the Integrated Exposure Uptake and Biokinetic (IEUBK) model to evaluate lead in the soil. EPA used version 1 of the IEUBK model incorporating the exposure unit values proposed for use in the IEUBK model version 2 to calculate the site-specific values for SSCL. More information about blood lead models and the IEUBK model can be found in Appendix F.

   The Centers for Disease Control and Prevention (CDC) has not identified a safe blood lead level (BLL) in humans. CDC's blood lead reference value of 3.5 micrograms per deciliter (µg/dL) is used to identify children with BLLs that are higher than most children's levels. This value is based on the U.S. population of children ages 1-5 years who are in the highest 2.5 percent of children when tested for lead in their blood. Based on the evaluation of SSCL site soil data, it is possible that BLLs would exceed 3.5 µg/dL in young children who live at certain properties because of lead contamination in soil.

   When people, particularly children, purposely eat dirt they have pica behavior. Based on the gastrointestinal effects (abdominal pain, nausea, vomiting) small children would experience from eating about a teaspoon of soil, it was determined that copper could pose a hazard when soil levels exceed 53 mg/kg. These effects are not usually persistent [ATSDR 2004b]. A total of 52 properties had soil copper levels that exceeded 53 mg/kg with a lead concentration that did not exceed the established clean up level of 360 mg/kg to be remediated as part of the NPL project. Note: the evaluation of copper hazards for acute and pica exposure may be underestimated based on the use of incremental sampling methodology (ISM) [EPA 2018f].

   In addition, the estimated cancer risk from PAHs found at two locations in soil samples from the Jefferson Heights neighborhood were considered moderate for children. PAHs at these two locations could pose a health concern.

2. **Based on blood lead testing, the percentage of children with elevated blood lead levels in the SSCL area was greater than in the surrounding area of Hamilton County and the state of Tennessee for 9 out of the previous 10 years.**

   Basis for Decision: TDH reviewed blood lead level (BLL) data from the Tennessee Department of Health from 2012-2021. For 9 out of the past 10 years, the percent of SSCL site children ages 6 to 72 months, whose tests showed elevated BLLs (greater than or equal to 3.5 µg/dL) was higher than the percent of children tested with elevated BLLs in the rest of Hamilton County (excluding the SSCL site area). In addition, the percent of SSCL site children with elevated BLLs was higher than the percent of children in the state whose tests also indicated elevated BLLs. TDH identified multiple factors that could be associated with the increased risk of higher BLLs in the SSCL site community. The factors include age of housing, contaminated soil, poverty, and race.

3. **Data gaps limit TDH's ability to determine whether some residents may have been exposed to harmful levels of lead and other contaminants in soil from their yards. TDH cannot determine whether health effects may occur from soil at properties that were not sampled, or that had samples that were not analyzed for the full list of metals or PAHs. We were unable to evaluate the risk for children with soil-pica behavior on some properties where only composite incremental sampling methodology (ISM) was conducted.**

   Basis for Decision: EPA has not sampled and analyzed soil from all properties within the boundaries of the SSCL site. Access agreements giving EPA permission to conduct soil sampling activities were not signed by some property owners. Without soil samples from these yards, it is not possible to determine the potential for exposure to harmful levels of lead or other chemicals of concern for those residents.

   In addition, soil sampling activities were limited to testing for lead in many areas within the boundaries of the SSCL site after 2018. Without lab results for other contaminants, TDH cannot determine whether other contaminants are present or pose a potential hazard through exposure.

   There are limitations to using ISM to evaluate acute and pica exposures. Soil contamination may be underestimated based on the use of composite ISM, and TDH is unable to evaluate the possible health effects from potential hot spots with full confidence.

Recommendations

During the health assessment process, TDH makes recommendations about actions that the agency believes are needed to protect public health. TDH's recommendations may be directed to other agencies or community members. TDH works with other agencies to ensure that, when appropriate, someone is available to follow up on the recommendations. The following are TDH's recommendations for the Southside Chattanooga Lead (SSCL) site.

TDH recommendations for EPA:

- Consider re-evaluating the cleanup level using a lower blood lead level in the IEUBK model and updating/revising the plan to remove lead-contaminated soil.

- Remove lead-contaminated soil based on an updated and revised plan.
- Take measures to reduce exposures to copper and PAHs where concentrations were elevated, and lead levels did not warrant removal action under current plans. Consider conducting additional sampling in yards with no remediation to evaluate hot spots where children may be likely to play.
- Continue efforts to obtain signed access agreements to sample soil on neighborhood properties.

TDH recommendations for residents around the Southside Chattanooga Lead (SSCL) site:

- TDH recommends that residents around the SSCL site engage in testing:
  - Have children's venous blood tested for lead.
  - Allow EPA access to conduct soil sampling and removal activities, as needed.
  - If eating produce from a home garden, consider having the soil tested, if it has not already been tested and using raised-bed gardening with uncontaminated soil.

- TDH recommends that residents around the SSCL site become informed about pica behavior and how to reduce potential exposures in children with this behavior.

- TDH recommends that residents around the SSCL site, with children or pets, take the following steps to reduce exposure to contaminants in soil:
  - Regularly wash children's hands, especially before eating.
  - Watch children to identify any hand-to-mouth behavior or excessive intentional dirt eating – these behaviors should be modified or eliminated.
  - Make sure your child does not have access to peeling paint or chewable surfaces painted with lead-based paint.
  - Pregnant women and preschool children should not be present in housing built before 1978 that is undergoing renovation.
  - Create safe play areas for children with appropriate and clean ground covers. Consider covered sand boxes for children that like to dig.
  - Frequently bathe your pets since they can also track contaminated soil into your home.

- TDH recommends that all residents around the SSCL site take the following steps to reduce exposure to contaminants in soil:
  - Regularly use a damp mop or damp duster to clean surfaces.
  - Vacuum with a properly maintained high-efficiency particulate air (HEPA) filter. Non HEPA-filter vacuums may suspend the particles during the vacuuming process making the contaminated particles breathable. In addition, frequent filter changes may be necessary.
  - Remove shoes before going in the house and ask others to do the same.
  - Use walk-off mats at exterior doorways.
  - Cover bare, unremediated soil with mulch or vegetation (grass, etc.).

- Create a raised garden bed and fill with clean soil to reduce exposures from gardening and digging.
- Rinse produce well to remove garden soil.

More information about lead poisoning to protect your family can be found in Appendix F.

Public Health Action Plan

The public health action plan contains a list of actions that have been taken or will be taken by TDH. The public health action plan is designed to mitigate and prevent harmful health effects that may result from exposure to hazardous substances at the Southside Chattanooga Lead (SSCL) site. TDH is committed to following up on this plan to ensure that it is implemented.

TDH Actions Completed

- Reviewed numerous reports summarizing environmental data collected from and activities performed at the SSCL site.

- Prepared this health consultation based on data collected during SSCL site environmental investigations.

- Attended various public meetings and availability sessions held in March 2012, October 2012, December 2016, January 2017 February 2018, May 2018, November 2018, February 2019, and October 2022. Public meetings and sessions were also attended by EPA, TDEC, ATSDR, and Chattanooga-Hamilton County Health Department partners. TDH provided a tabletop information booth along with various handouts. Topics included information about the SSCL site, the health assessment procedure, lead poisoning prevention, healthy homes, and common environmental issues homeowners could experience in the course of owning a home. We also answered many health-related questions citizens had about the site during each meeting.

- Conducted a SoilSHOP in October 2016 to screen neighborhood soil for lead and offer health education materials about lead poisoning prevention.

- Partnered with ATSDR in January 2017 to prepare health education messages and to canvas selected neighborhoods. During canvassing, we provided packages with information about the EPA project and how to protect families from lead poisoning.

- In 2017, partnered with the TDH Division of Family, Health and Wellness (FHW), the Chattanooga-Hamilton County Health Department, Pediatric Health Specialty Units (PEHSU) and ATSDR to send letters to pediatricians in Chattanooga. The letters informed pediatricians about the lead contamination that had been discovered in the Southside Chattanooga area and encouraged the doctors to test their patients for lead poisoning. TDH also partnered with the FHW and a local community center to promote blood-lead testing for children aged 6 and younger.

- In April 2019, worked with Erlanger Children's Hospital in Chattanooga to present a Ground Rounds Session about lead poisoning and the importance of blood-lead testing for doctors in the Chattanooga area.

- Partnered with the Tennessee Childhood Lead Poisoning Prevention Program, the University of Tennessee Agricultural Extension Program, and the Hamilton County Health Department for a Lead Education Station. The station became operational in October 2019 and is housed in a library near the SSCL site neighborhoods. One priority of this station will be to encourage physicians and parents to increase blood-lead testing in the vicinity of the NPL boundaries and other areas of the county. More information about the station, including the schedule for the on-site staff person, can be found at leadedu.tennessee.edu.

TDH Actions Planned

- Provide a copy of this health consultation to the Lead Education Station for the Southside Chattanooga Lead (SSCL) Site. The station is located at

  Chattanooga Public Library
  South Chattanooga Branch
  925 39th Street
  Chattanooga, TN 37410

- Continue to partner with the Tennessee Childhood Lead Poisoning Prevention Program, the University of Tennessee Agricultural Extension Program, and the Hamilton County Health Department for the Lead Education Station.

- Answer any questions community members have about their current and past exposures.

- Communicate regularly with EPA, ATSDR, TDEC, the Chattanooga-Hamilton County Department of Health, and other interested stakeholders to follow site progress and safeguard public health.

- Continue outreach and education activities about the existing lead contamination and lead poisoning prevention for the SSCL site communities and surrounding area.

- Work with EPA to continue door-to-door canvasing and public availability sessions that educate the community about the importance of providing access to their property for soil sampling.

- Organize additional soilSHOP events to educate surrounding communities on the importance of testing their soil for lead. Use soilSHOP screening results to update EPA about lead patterns in the community.

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Glossary of Terms and Acronyms

ATSDR: Agency for Toxic Substances and Disease Registry.

Cancer: Any one of a group of diseases that occur when cells in the body become abnormal and grow or multiply out of control.

Cancer risk: The theoretical excess risk for getting cancer if exposed to a substance every day for 78 years (a lifetime exposure). The true risk might be lower. The excess cancer risk is often expressed as $1x10^{-6}$ for one excess cancer in 1 million people.

Carcinogen: A substance that may cause cancer.

Chronic exposure: Contact with a substance that occurs over a long time (more than 1 year).

Cleanup actions: Activities designed to removed contamination.

Comparison Value (CV): Calculated concentration of a substance in air, water, food, or soil unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs are selected for further evaluation in the public health assessment process.

Cancer Risk Evaluation Guide (CREG): Estimated chemical concentrations in soil, water, or air developed by ATSDR which would be expected to cause no more than one excess cancer in a million persons exposed during their lifetime (78 years).

Contaminant: A substance that is present in an environment where it does not belong.

Detection limit: The lowest concentration of a chemical that can reliably be distinguished from a zero concentration.

Environmental Media Evaluation Guide (EMEG): Estimated levels of chemicals in water, soil, or air developed by ATSDR to which humans may be exposed to during a specific time (acute, intermediate, or chronic exposure).

EPA: United States Environmental Protection Agency.

Exposure: Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term (acute exposure), of intermediate duration, or long-term (chronic exposure).

Exposure pathway: The route a substance takes from its source (where it began) to its end point (where it ends), and how people can come into contact with (or get exposed to) it. An exposure pathway has five parts: (1) a source of contamination (such as an abandoned business), (2) an environmental media and transport mechanism (such as movement through groundwater), (3) a point of exposure (such as a private well), (4) a route of exposure (eating, drinking, breathing, or touching), and (5) a receptor population (people potentially or actually exposed). When all five parts are present, the exposure pathway is called a completed exposure pathway.

Hazard: A source of potential harm from past, current, or future exposures.

Hazard Quotient: The hazard quotient for a chemical is the ratio of the estimated exposure dose to the Minimal Risk Level (MRL) or the Reference Dose (RfD). If the hazard index is greater than one, then there is a potential for adverse health effects from the combined exposure to the chemicals. If the hazard quotient is less than one, then no adverse health effects would be expected based on additivity of toxicity.

Health Consultation: A review of available information or collection of new data to respond to a specific health question or request for information about a potential environmental hazard. Health Consultations are focused on a specific exposure issue. Health Consultations are therefore more limited than a public health assessment, which reviews the exposure potential of each pathway and chemical.

Inhalation: The act of breathing.

Intermediate duration exposure: Contact with a substance that occurs for more than 14 days and less than a year.

Minimal Risk Level (MRL): An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects.

Lowest Observed Adverse Effect Level (LOAEL): The lowest tested dose of a substance that has been reported to cause harmful (adverse) health effects in people or animals.

No Observed Adverse Effect Level (NOAEL): The highest tested dose of a substance that has been reported to have no harmful (adverse) health effects in people or animals.

Pica behavior: Behavior primarily seen in children that involves eating of nonfood items.

Reference dose: A U.S. Environmental Protection Agency estimate, with uncertainty or safety factors built in, of the daily lifetime dose of a substance that is unlikely to cause non-cancer health effects in humans.

Remediation: Cleanup or other methods used to remove or contain a toxic spill or hazardous materials from a site.

RMEG: Reference Dose Media Evaluation Guide which represents the level of a chemical in water or soil at which a chronic human exposure is not likely to result in adverse non-carcinogenic effects.

Risk: The probability that something will cause injury or harm. For non-carcinogen health effects, it is evaluated by comparing an exposure level over a period to a reference dose derived from experiments on animals. For carcinogenic health effects, risk is estimated as the incremental probability of an individual developing cancer over a lifetime (70 years) as a result of exposure to a potential carcinogen.

Risk assessment: Activities taken to evaluate the risk associated with the presence of contamination to determine the extent to which site cleanup is needed.

Route of exposure: How people come into contact with a hazardous substance. Three routes of exposure are breathing (inhalation), eating or drinking (ingestion), or contact with the skin (dermal contact).

Sample: An environmental sample, such as a small amount of soil, water, or air collected to measure contamination in the environment.

Toxicology: The study of the harmful effects of substances on humans or animals.

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APPENDIX A. Soil Sample Data Summary Tables

Cowart Place Neighborhood

Metals in soils from the 2017 Southside Chattanooga Lead site assessment with additional samples gathered in 2018. All sample values are presented in milligrams per kilogram (mg/kg). Data source: [EPA 2018b].

Metal/ Chemical	Concentration Average Value (mg/kg)/number of samples)	Background Average Value (mg/kg)/ number of samples)	Selected Comparison Value (CV) (mg/kg)	Source of Selected CV	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Number of Locations at or above CV	Selected for Further Evaluation
arsenic	13/5	4/68	16	ATSDR Chronic EMEG	6.3	17	2/5	YES
cadmium	2/5	0.78/29	5.2	ATSDR Chronic EMEG	0.68	2.4	0/5	NO
chromium	29/5	20/68	78,000	ATSDR Chronic RMEG	19	36	0/5	NO
copper	85/5	22/68	53	ATSDR EMEG Acute Pica	63	110	5/5	YES
lead	361/10	99/68	ngv	ngv	38	1000	NA	YES
nickel	19/5	14/68	1,000	ATSDR Chronic RMEG	13	28	0/5	NO
zinc	640/5	124/68	16,000	ATSDR Chronic EMEG	270	880	0/5	NO

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2017). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR Reference Dose Media Evaluation Guide (RMEG) for trivalent chromium used in absence of CV for total chromium.

ATSDR RMEG = Reference Dose Media Evaluation Guide; ATSDR RMEG used as there was no Chronic EMEG available for the chemical.
ATSDR intermediate exposure duration (15 to 364 days) EMEG for mercuric chloride used; Chronic EMEG unavailable.

mg/kg = milligrams per kilogram, equivalent to parts per million in soil.

ngv = no guidance value available.

NA = not applicable due to lack of guidance value available for comparison.

All soil samples were composite and collected from 0 to 6 inches below ground surface.

Jefferson Heights Neighborhood

Metals in soils from the 2017 Southside Chattanooga Lead site assessment with additional samples gathered in 2018. All sample values are presented in milligrams per kilogram (mg/kg). Data source: [EPA 2018b].

Metal/'Chemical	Concentration Average Value (mg/kg)/number of samples)	Background Average Value (mg/kg) /number of samples)	Selected Comparison Value (CV) (mg/kg)	Source of Selected CV	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Number of Locations at or above CV	Selected for Further Evaluation
arsenic	11/61	4/68	16	ATSDR Chronic EMEG	2.8	30	8/61	YES
cadmium	2/61	0.78/29	5.2	ATSDR Chronic EMEG	0.41	5.7	1/61	YES
chromium	25/61	20/68	78,000	ATSDR Chronic RMEG	14	52	0/61	NO
copper	74/61	22/68	53	ATSDR EMEG Acute Pica	22	330	35/61	YES
lead	486/66	99/68	ngv	ngv	84	1,700	NA	YES
nickel	15/61	14/68	1,000	ATSDR Chronic RMEG	6	110	0/61	NO
zinc	510/61	124/68	16,000	ATSDR Chronic EMEG	150	1,300	0/61	NO

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2017). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR Reference Dose Media Evaluation Guide (RMEG)for trivalent chromium used in absence of CV for total chromium.

ATSDR RMEG = Reference Dose Media Evaluation Guide; ATSDR RMEG used as there was no Chronic EMEG available for the chemical.
ATSDR intermediate exposure duration (15 to 364 days) EMEG for mercuric chloride used; Chronic EMEG unavailable.

mg/kg – milligrams per kilogram, equivalent to parts per million in soil.

ngv = no guidance value available.

NA = not applicable due to lack of guidance value available for comparison.

All soil samples were composite and collected from 0 to 6 inches below ground surface.

Southside Gardens Neighborhood

Metals in soils from the 2017 Southside Chattanooga Lead site assessment with additional samples gathered in 2018. All sample values are presented in milligrams per kilogram (mg/kg). Data source: [EPA 2018b].

Metal/Chemical	Concentration Average Value (mg/kg)/number of samples)	Background Average Value (mg/kg) /number of samples)	Selected Comparison Value (CV) (mg/kg)	Source of Selected CV	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Number of Locations at or above CV	Selected for Further Evaluation
arsenic	11/22	4/68	16	ATSDR Chronic EMEG	2.8	32	3/21	YES
cadmium	2/24	0.78/29	5.2	ATSDR Chronic EMEG	0.49	8.2	1/21	YES
chromium	27/24	20/68	78,000	ATSDR Chronic RMEG	16	47	0/24	NO
copper	87/24	22/68	53	ATSDR EMEG Acute Pica	28	220	1524	YES
lead	466/25	99/68	ngv	ngv	130	2,000	NA	YES
nickel	18/24	14/68	1,000	ATSDR Chronic RMEG	7	34	0/24	NO
zinc	587/24	124/68	16,000	ATSDR Chronic EMEG	160	1,800	0/24	NO

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2017). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR Reference Dose Media Evaluation Guide (RMEG)for trivalent chromium used in absence of CV for total chromium.

ATSDR RMEG = Reference Dose Media Evaluation Guide; ATSDR RMEG used as there was no Chronic EMEG available for the chemical.
ATSDR intermediate exposure duration (15 to 364 days) EMEG for mercuric chloride used; Chronic EMEG unavailable.

mg/kg – milligrams per kilogram, equivalent to parts per million in soil.

ngv = no guidance value available.

NA = not applicable due to lack of guidance value available for comparison.

All soil samples were composite and collected from 0 to 6 inches below ground surface.

Alton Park Neighborhood

Metals in soils from the 2017 Southside Chattanooga Lead site assessment with additional samples gathered in 2018. All sample values are presented in milligrams per kilogram (mg/kg). Data source: [EPA 2018b].

Metal/Chemical	Concentration Average Value (mg/kg)/number of samples)	Selected Comparison Value (CV) (mg/kg)	Source of Selected CV	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	Number of Locations at or above CV	Selected for Further Evaluation
arsenic	11/117	16	ATSDR Chronic EMEG	5.5	50	0/117	NO
cadmium	1/117	5.2	ATSDR Chronic EMEG	0.46	6.6	2/117	YES
chromium	29/117	78,000	ATSDR Chronic RMEG	13	74	0/117	NO
copper	65/117	53	ATSDR EMEG Acute Pica	20	280	62/117	YES
lead	282/125	ngv	ngv	71	3,100	NA	YES
nickel	16/117	1,000	ATSDR Chronic RMEG	7	62	0/117	NO
zinc	346/117	16,000	ATSDR Chronic EMEG	100	1000	0/117	NO

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2017). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR Reference Dose Media Evaluation Guide (RMEG)for trivalent chromium used in absence of CV for total chromium.

ATSDR RMEG = Reference Dose Media Evaluation Guide; ATSDR RMEG used as there was no Chronic EMEG available for the chemical.
ATSDR intermediate exposure duration (15 to 364 days) EMEG for mercuric chloride used; Chronic EMEG unavailable.

mg/kg – milligrams per kilogram, equivalent to parts per million in soil.

ngv = no guidance value available.

NA = not applicable due to lack of guidance value available for comparison.

All soil samples were composite and collected from 0 to 6 inches below ground surface.

Richmond Neighborhood

Metals in soils from the 2017 Southside Chattanooga Lead site assessment with additional samples gathered in 2018. All sample values are presented in milligrams per kilogram (mg/kg). Data source: [EPA 2018b].

Metal/Chemical	Concentration Average Value (mg/kg)/number of samples)	Selected Comparison Value (CV) (mg/kg)	Source of Selected CV	Minimum Detection (mg/kg)	Maximum Detection (mg/kg)	No. Locations at or above CV	Selected for Further Evaluation
arsenic	9/17	16	ATSDR Chronic EMEG	5.3	11	0/17	NO
cadmium	1/17	5.2	ATSDR Chronic EMEG	0.15	2.3	0/17	NO
chromium	22/17	78,000	ATSDR Chronic RMEG	16	33	0/17	NO
copper	48/17	53	ATSDR EMEG Acute Pica	16	140	5/17	YES
lead	247/19	ngv	ngv	110	460	NA	YES
nickel	13/17	1,000	ATSDR Chronic RMEG	10	21	0/17	NO
zinc	302/17	16,000	ATSDR Chronic EMEG	70	690	0/17	NO

Notes:

ATSDR EMEG = Agency for Toxic Substances and Disease Registry Environmental Media Evaluation Guide (ATSDR 2017). Chronic non-cancer exposure comparison values for an exposure greater than 365 days used to determine if chemical concentrations warrant further health-based screening.

ATSDR Reference Dose Media Evaluation Guide (RMEG) for trivalent chromium used in absence of CV for total chromium.

ATSDR RMEG = Reference Dose Media Evaluation Guide; ATSDR RMEG used as there was no Chronic EMEG available for the chemical.
ATSDR intermediate exposure duration (15 to 364 days) EMEG for mercuric chloride used; Chronic EMEG unavailable.

mg/kg – milligrams per kilogram, equivalent to parts per million in soil.

ngv = no guidance value available.

NA = not applicable due to lack of guidance value available for comparison.

All soil samples were composite and collected from 0 to 6 inches below ground surface.

APPENDIX B. Exposure Dose Equation and Calculation Assumptions

For this document, TDH calculated exposure doses for community members exposed to arsenic, copper, and cadmium in soil using the following equation for ingestion of soil.

Exposure Dose Equation for Ingestion of Soil

$$D = \frac{C \times IR \times EF \times AF \times CF}{BW}$$

D	=	exposure dose in milligrams per kilogram per day (mg/kg/day)
C	=	chemical concentration in milligrams per kilogram (mg/kg)
IR	=	intake rate in milligrams per day (mg/day)
EF	=	exposure factor (unitless)
AF	=	bioavailability factor
CF	=	conversion factor, 1×10^{-6} kilograms/milligram (kg/mg)
BW	=	body weight in kilograms (kg)

The equation shows the Exposure Dose (D) equals the Concentration (C) multiplied by Intake Rate (IR) multiplied by Exposure Factor (EF) multiplied by Bioavailability Factor (AF) multiplied by a Conversion Factor (CF) all divided by Body Weight (BW).

The following table lists the exposure dose assumptions used in calculating doses.

Exposure Dose Calculation Assumptions

Group	**Reasonable Maximum Exposure Soil Intake** (mg/kg)	**Central Tendency Exposure Soil Intake** (mg/kg)	**Exposure Frequency** (daily exposure = 1 unless otherwise noted)	**Body Weight** (kilograms)	**Exposure Duration for Cancer Risk** (years)
Child, Age Birth to < 1 year	150	55	1	7.8	1
Child, Age 1 to < 2 years	200	90	1	11.4	1
Child, Age 2 to < 6 years	200	60	1	17.4	4
Child, Age 6 to < 11 years	200	60	1	31.8	5
Child, Age 11 to < 16 years	100	30	1	56.8	5
Child, Age 16 to < 21 years	100	30	1	71.6	5
Child (who intentionally eats soil), Age 1 < 2 years	Not applicable	5,000	0.43	11.4	Not applicable
Child (who intentionally eats soil), Age 2 < 6 years	Not applicable	5,000	0.43	17.4	Not applicable
Adults Age ≥ 21 years	100	30	1	80	33

Source: ATSDR 2019

APPENDIX C. Estimated Doses for Various Ranges of Arsenic Concentrations in Residential Soils for Neighborhoods Tested

Arsenic Concentration Range (milligrams/kilogram)	**Child Dose Range[1]** (milligrams/kilogram/day)	**Child who intentionally Eats Soil Dose Range[2]** (milligrams/kilogram/day)	**Adult Dose Range[3]** (milligrams/kilogram/day)
Not Detected - 14	Not Applicable – 0.00018	Not Applicable – 0.0016	Not Applicable – 0.00001
15-28	0.00019 – 0.00036	0.0017 – 0.0032	0.000014 – 0.000025
29-42	0.00037 – 0.00054	0.0033 – 0.0048	0.000026 – 0.000038
43-50	0.00055 – 0.00065	0.0049 – 0.0057	0.000039 – 0.000045

[1] The child doses provided are for the most highly exposed group, i.e., reasonable maximum exposure (RME) for children aged birth to <1 year of age who are considered to have the highest ingestion rate of soil per body weight.
[2] The child doses provided use intermediate exposure rates for child 1 to <2 years. 5,000 milligrams/event for the amount of soil ingested and a frequency of 3 days a week. Note that 5,000 milligrams/event probably represents the central tendency intake; no reliable upper percentile intake rate is available [ATSDR 2014].
[3] The adult doses provided are for ≥ 21 years of age.

Number of Samples Collected in Range and Number of Properties Affected for Each Neighborhood

Arsenic Concentration Range (milligrams/kilogram)	Cowart Place		Jefferson Heights		Southside Gardens		Alton Park		Richmond	
	Number of Samples	Number of Properties	Number of Samples	Number of Properties	Number of Samples	Number of Properties	Number of Samples	Number of Properties	Number of Samples	Number of Properties
Not Detected - 14	3	3	50	38	17	16	104	75	17	16
15-28	2	2	10	7	4	4	12	9	0	0
29-42	0	0	1	1	1	1	0	0	0	0
43-50	0	0	0	0	0	0	1	1	0	0

APPENDIX D. Estimated Doses for Various Ranges of Cadmium Concentrations in Residential Soils for Neighborhoods Tested

Cadmium Concentration Range (milligrams/kilogram)	**Child Dose Range[1]** (milligrams/kilogram/day)	**Child who intentionally Eats Soil Dose Range[2]** (milligrams/kilogram/day)	**Adult Dose Range[3]** (milligrams/kilogram/day)
Not Detected - 5	Not Applicable – 0.00011	Not Applicable – 0.00095	Not Applicable – 0.0000073
6-10	0.00013 – 0.00021	0.0011 – 0.0019	0.0000088 – 0.000015

[1] The child doses provided are for the most highly exposed group, i.e., reasonable maximum exposure (RME) for children aged birth to <1 year of age who are considered to have the highest ingestion rate of soil per body weight.
[2] The child doses provided use intermediate exposure rates for child 1 to <2 years. 5,000 milligrams/event for the amount of soil ingested and a frequency of 3 days a week. Note that 5,000 milligrams/event probably represents the central tendency intake; no reliable upper percentile intake rate is available [ATSDR 2014].
[3] The adult doses provided are for ≥ 21 years of age.

Number of Samples Collected in Range and Number of Properties Affected for Each Neighborhood

Cadmium Concentration Range (milligrams/kilogram)	Cowart Place		Jefferson Heights		Southside Gardens		Alton Park		Richmond	
	Number of Samples	Number of Properties	Number of Samples	Number of Properties	Number of Samples	Number of Properties	Number of Samples	Number of Properties	Number of Samples	Number of Properties
Not Detected - 5	5	5	59	40	23	21	115	84	17	16
6-10	0	0	2	2	1	1	2	2	0	0

APPENDIX E. Estimated Doses for Various Ranges of Copper Concentrations in Residential Soils for Neighborhoods Tested

Copper Concentration Range (milligrams/kilogram)	**Child Dose Range**[1] (milligrams/kilogram/day)	**Child who intentionally Eats Soil Dose Range**[2] (milligrams/kilogram/day)	**Adult Dose Range**[3] (milligrams/kilogram/day)
Not Detected - 52	Not Applicable – 0.0010	Not Applicable – 0.0098	Not Applicable – 0.000070
53-110	0.0011 – 0.0022	0.01 – 0.021	0.000071 – 0.00015
111-140	0.0019 - 0.0028	0.021 - 0.026	0.00014 - 0.00019
141-220	0.0028 – 0.0044	0.027 – 0.042	0.00019 – 0.00030
221-280	0.0044 – 0.0056	0.042 – 0.053	0.00030 – 0.00038
281-330	0.0056 – 0.0066	0.053 – 0.062	0.00038 – 0.00044

1 The child doses provided are for the most highly exposed group, i.e., reasonable maximum exposure (RME) for children aged birth to <1 year of age who are considered to have the highest ingestion rate of soil per body weight.
2 The child doses provided use intermediate exposure rates for child 1 to <2 years. 5,000 milligrams/event for the amount of soil ingested and a frequency of 3 days a week. Note that 5,000 milligrams/event probably represents the central tendency intake; no reliable upper percentile intake rate is available [ATSDR 2014].
3 The adult doses provided are for ≥ 21 years of age.

Number of Samples Collected in Range and Number of Properties Affected for Each Neighborhood

Copper Concentration Range (milligrams/kilogram)	Cowart Place		Jefferson Heights		Southside Gardens		Alton Park		Richmond	
	Number of Samples	Number of Properties	Number of Samples	Number of Properties	Number of Samples	Number of Properties	Number of Samples	Number of Properties	Number of Samples	Number of Properties
Not Detected - 52	0	0	22	20	9	8	53	44	12	11
53-110	5	5	27	23	10	10	54	38	4	4
111-140	0	0	5	4	2	2	5	5	1	1
141-220	0	0	5	5	3	3	4	4	0	0
221-280	0	0	1	1	0	0	1	1	0	0
281-330	0	0	1	1	0	0	0	0	0	0

APPENDIX F. Overview of Blood Lead Models

Children 6 months to 7 years

The most widely used model to estimate blood lead levels in children is the U.S. EPA's Integrated Exposure Uptake and Biokinetic (IEUBK) model. The IEUBK model is designed to integrate lead exposure from soil and lead exposures from other sources (e.g., diet, air, water, paint) with pharmacokinetic modeling to predict blood lead concentrations in children 6 months to 7 years of age. The model estimates a distribution of blood lead concentrations centered on the geometric mean blood lead concentration and predicts the percent of children above a user-specified target blood level. The model is verified down to 5 µg/dL, and EPA is currently evaluating model verification at lower blood lead levels [EPA 2002; personal communication, Dr. David Mellard, ATSDR, 2021].

Pregnant Women

The Adult Lead Methodology (ALM) can be used to estimate BLLs in a developing fetus. The method is often used for women of child-bearing age. ALM is used to estimate BLLs because the developing fetus is likely to be more sensitive to lead than adult women. More information about U.S. EPA's adult lead methodology can be found at https://www.epa.gov/superfund/lead-superfund-sites-risk-assessment.

Estimating BLLs from Exposure to Soil

EPA conducted a bioavailability analysis on approximately 30 soil samples. EPA followed directives and guidance from the Office of Land and Emergency Management to conduct the analysis. The results of the bioavailability analysis indicated that the lead in the soils at the SSCL site were slightly more bioavailable than the EPA default value. The site-specific lead value of 36% was used in EPA's IEUBK Model. To calculate potential site-specific clean-up goal options, target BLLs of 5, 6, 7, and 8 micrograms per deciliter (µg/dL) were used in the model. A target BLL of 5 µg/dL resulted in a clean-up goal of 160 mg/kg. A target BLL of 6 µg/dL resulted in a clean-up goal of 230 mg/kg. A target BLL of 7 µg/dL resulted in a clean-up goal of 290 mg/kg. A target BLL of 8 µg/dL resulted in a clean-up goal of 360 mg/kg. The soil lead values were based on no greater than 5% probability of exceeding the blood lead target [EPA 2017].

Based on the site-specific sieving data collected for the SSCL site, lead concentrations in the fines (soils that passed thru the 150-micron sieve) have a higher concentration of lead than in the raw samples. Based on this site-specific data, concentrations in the raw samples can be used without sieving to make cleanup decisions except when they fall within a certain range of lead concentrations. EPA established a preliminary risk-based clean-up goal for lead in residential soil of the SSCL site. The preliminary clean-up goal was 360 mg/kg. It was recommended that when the clean-up goal is 360 mg/kg, then x-ray fluorescence results (95% Upper Confidence Level [UCL]) between 270 and 360 mg/kg should be sieved and screened. A time critical removal action level for the entire SSCL site was established at 1,200 mg/kg for lead [EPA 2018b].

APPENDIX G. Socio-Economic Factors Present at the SSCL Site

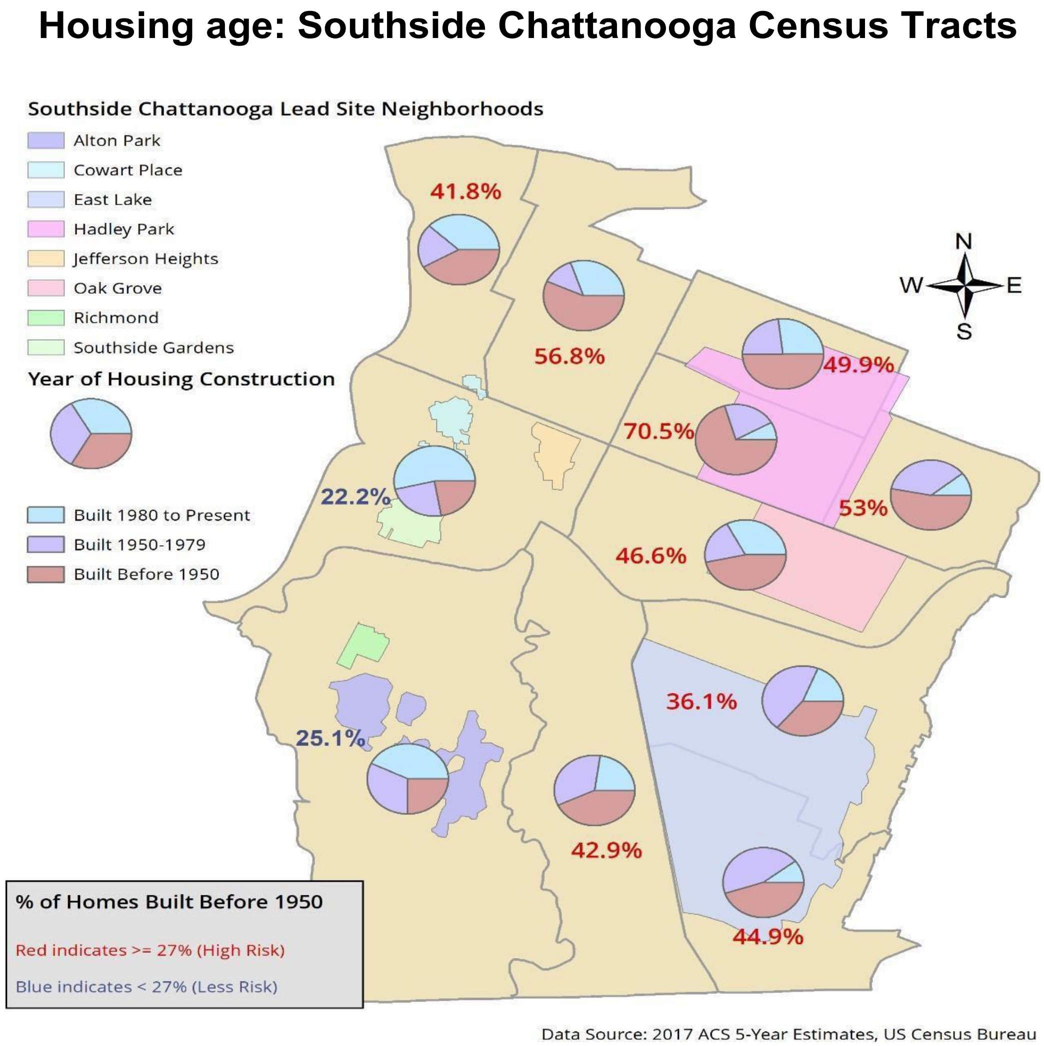


Figure shows the percentage of homes built during the years before 1950, 1950 to 1979, and 1979 to present for each of the eleven Southside Chattanooga Lead area census tracts. For homes built before 1950 the percentage in a pie chart is shown in brown. For homes built from 1950 to 1979, the percentage in the pie chart is shown in purple. For 1980 to present, the percentage in the pie chart is shown in blue. For homes bult before 1950, the percentage of homes in the eleven census tracts that are deemed high risk, greater than 27 percent, is shown. The percentage of homes in the high risk category ranges from 36.1 percent to 70.5 percent. Also shown are homes built before 1950 in the eleven census tracts that are deemed low risk, less than 27 percent. Also shown are the Southside Chattanooga neighborhoods where soil has been tested in the eleven census tracts.

Poverty status: Southside Chattanooga Census Tracts

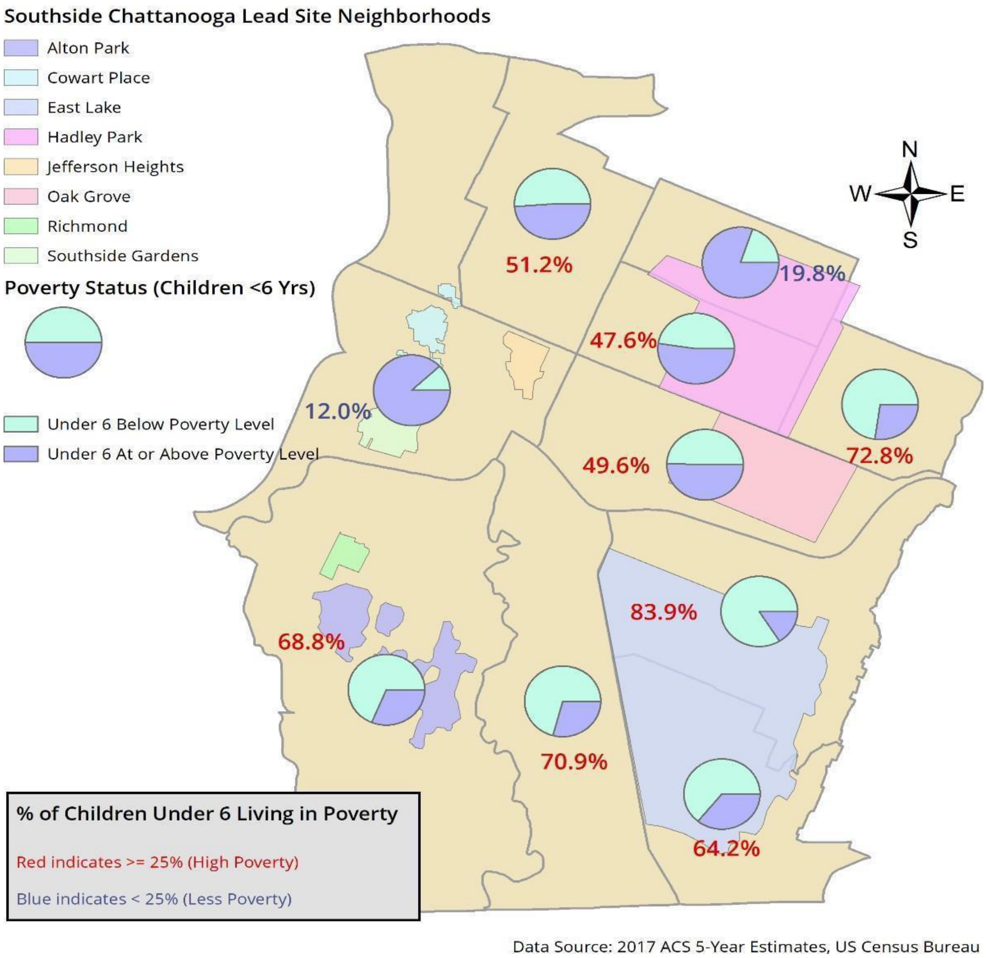


Figure shows the poverty status of children under the age of six years old in each of the eleven Southside Chattanooga Lead area census tracts. For homes bult before 1950, the percentage of children under the age of six living in poverty deemed high risk, greater than 25 percent, is shown in blue in a pie chart. The percentage of children under age six living in poverty in the eleven census tracts ranges from 47.6 percent to 83.9 percent. For homes built before 1950 in the eleven census tracts that are deemed low risk, less than 25 percent are shown in purple in the pie chart. The percentage of children living in poverty deemed low risk ranges from 12 to 19.8 percent. Also shown are the Southside Chattanooga neighborhoods where soil has been tested in the eleven census tracts.

APPENDIX H. Lead Poisoning Prevention Attachments

LEAD poisoning Know the Facts

Lead poisoning is caused by swallowing or breathing lead. Children under 6 years old are most at risk. If you are pregnant, lead can harm your baby.

FACT Lead can cause learning and behavior problems.

Lead poisoning hurts the brain and nervous system. Some of the effects of lead poisoning may never go away.

Lead in a child's body can:

- Slow down growth and development
- Damage hearing and speech
- Make it hard to pay attention and learn

FACT Most children get lead poisoning from paint in homes built before 1978.

When old paint cracks and peels, it makes dangerous dust. The dust is so small you cannot see it. Most children get lead poisoning when they breathe or swallow the dust on their hands and toys.

FACT A lead test is the only way to know if your child has lead poisoning.

Most children who have lead poisoning do not look or act sick. Ask your doctor to test your child for lead.

Protect Your Family

1. Test your home for lead.

- If you live in a home built before 1978, have your home inspected by a licensed lead inspector.
- Contact your local health department for more information.

Sometimes lead comes from things other than paint in your home, such as:

- Candy, toys, glazed pottery, and folk medicine made in other countries
- Work like auto refinishing, construction, and plumbing
- Soil and tap water

2. Keep children away from lead paint and dust.

- Use wet paper towels to clean up lead dust. Be sure to clean around windows, play areas, and floors.
- Wash hands and toys often, especially before eating and sleeping. Use soap and water.
- Use contact paper or duct tape to cover chipping or peeling paint.

3. Renovate safely.

Home repairs like sanding or scraping paint can make dangerous dust.

- Keep children and pregnant women away from the work area.
- Make sure you and/or any workers are trained in lead-safe work practices.
- Home repairs like sanding or scraping paint can make dangerous dust.

Contact us for more information:

Tennessee Lead Hazard Reduction Program

1-888-771-LEAD

CENTERS FOR DISEASE CONTROL AND PREVENTION

LEAD poisoning

Are You Pregnant?

Prevent Lead Poisoning. Start Now.

Lead poisoning is caused by breathing or swallowing lead. Lead can pass from a mother to her unborn baby.

Too much lead in your body can:

- Put you at risk of miscarriage
- Cause your baby to be born too early or too small
- Hurt your baby's brain, kidneys, and nervous system
- Cause your child to have learning or behavior problems

Lead can be found in:

- Paint and dust in older homes, especially dust from renovation or repairs
- Candy, make up, glazed pots, and folk medicine made in other countries
- Work like auto refinishing, construction, and plumbing
- Soil and tap water

Contact your local health department to learn more.

Now is the time to keep your baby safe from lead poisoning. Here's what you can do:

1 Watch out for lead in your home.

Most lead comes from paint in older homes. When old paint cracks and peels, it makes dangerous dust. The dust is so small you cannot see it. You can breathe in lead dust and not even know it.

Home repairs like sanding or scraping paint can make dangerous lead dust. Pregnant women should not be in the house during cleaning, painting, or remodeling a room with lead paint.

Tip: If you live in an older home, have your home inspected by a licensed lead inspector.

2 Eat foods with calcium, iron and vitamin C.

These foods may help protect you and your unborn baby.

- **Calcium** is in milk, yogurt, cheese, and green leafy vegetables like spinach.
- **Iron** is in lean red meat, beans, cereals, and spinach.
- **Vitamin C** is in oranges, green and red peppers, broccoli, tomatoes, and juices.

3 Talk to your doctor.

Talk to your doctor about any medicines or vitamins you are taking. Some home remedies and dietary supplements have lead in them. It is important that you tell your doctor about any cravings you are having such as eating dirt or clay.

Contact us for more information:

Tennessee Lead Hazard Reduction Program
1-888-771-LEAD

CENTERS FOR DISEASE CONTROL AND PREVENTION

REUSING POTENTIALLY CONTAMINATED LANDSCAPES:

Growing Gardens in Urban Soils

This fact sheet provides communities and individuals with general urban gardening information about:

- **Common contaminants that can be found in urban soil.**
- **Ways to identify contaminants and reduce exposure.**
- **Improving soils and growing plants in mildly contaminated soil.**
- **Additional resources and technical assistance.**

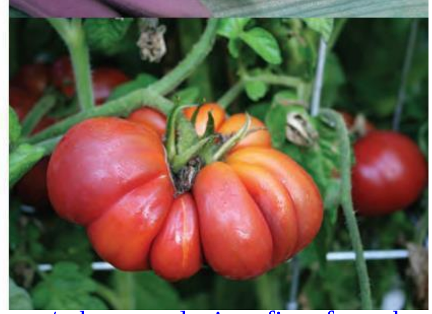
Introduction

Communities throughout the country are turning to urban agriculture and gardening as a reasonable option to increase their access to healthy, nutritious, and low-cost produce. Some of the sites that communities are using for urban gardens were previously home to industrial and commercial operations. A garden on abandoned land can become a new community asset by improving the visual look of a neighborhood and potentially increasing nearby property values. Community gardens provide many benefits, including healthier lifestyles by increasing activity levels, providing fresh produce, growing community pride, and nurturing social interactions and cooperation among people.

For communities interested in gardening on a site that might be contaminated, it is important to first determine the health and suitability of the soil at the site. It is a common gardening practice to test soil for characteristics such as pH and nutrient availability. When creating a garden on land with an industrial or commercial history, it is highly recommended that communities consider the site's land use history and test the soil accordingly for potential contamination. Knowledge of soil health and potential contamination are keys to helping communities identify and correct problems so that each urban garden is safe and productive.

The possibility of contamination at a garden site should not keep you from planning an urban garden there. This fact sheet presents steps that you can take to find out and address potential contamination at your site to help create a safe and healthy garden for your community.

More information for the urban gardener on soil science, soil amendments, plants, contaminants and their health effects, and additional links is available on EPA's CLU-IN website: www.clu-in.org/ecotools/urbangardens.cfm.



U.S. Environmental Protection Agency
Office of Superfund Remediation and Technology Innovation

View full fact sheets at: https://www.epa.gov/sites/production/files/2014-03/documents/urban_gardening_fina_fact_sheet.pdf

United States Environmental Protection Agency

Office of Pollution Prevention and Toxics (7404)

EPA-747-F-01-004
November 2001

EPA

Fight Lead Poisoning with a Healthy Diet

Lead Poisoning Prevention Tips for Families

View full fact sheets at: https://www.epa.gov/sites/production/files/2014-02/documents/fight_lead_poisoning_with_a_healthy_diet.pdf

Pica

Many young kids put nonfood items in their mouths at one time or another. They're naturally curious about their environment and might, for instance, eat some dirt out of the sandbox. Kids with pica, however, go beyond this innocent exploration of their surroundings.

About Pica

The word pica comes from the Latin word for magpie, a bird known for its large and indiscriminate appetite.

Pica is most common in people with developmental disabilities, like autism and intellectual disabilities, and in children between the ages of 2 and 3. Pica also may surface in children who've had a brain injury affecting their development. It can also be a problem for some pregnant women, as well as people with epilepsy.

People with pica frequently crave and eat nonfood items such as:

- dirt
- clay
- paint chips
- plaster
- chalk
- cornstarch
- laundry starch
- baking soda
- coffee grounds
- cigarette ashes
- burnt match heads
- cigarette butts
- feces
- ice
- glue
- hair
- buttons
- paper
- sand
- toothpaste
- soap

Pica is a normal behavior in very young children as part of their normal exploratory behavior but is an eating disorder in older children that can result in serious health problems, such as lead poisoning and iron-deficiency anemia.

Signs of Pica

Warning signs that a child may have pica include:

- eating of nonfood items, despite efforts to restrict it, for a period of at least 1 month or
- longer the behavior is considered inappropriate for your child's age or developmental stage
- the behavior is **not** part of a cultural, ethnic, or religious practice

Why Do Some People Eat Nonfood Items?

The specific causes of pica are unknown, but certain conditions and situations can increase a person's risk:

- **nutritional deficiencies**, such as iron or zinc, that may trigger specific cravings (however, the nonfood items craved usually don't supply the minerals lacking in the person's body)
- **dieting** — people who diet may attempt to ease hunger by eating nonfood substances to get a feeling of fullness
- **malnutrition**, especially in developing countries, where people with pica most commonly eat soil or clay
- **cultural factors** — in families, religions, or groups in which eating nonfood substances is a learned practice
- **parental neglect, lack of supervision, or food deprivation** — often seen in children living in poverty
- **developmental problems**, such as autism, other developmental disabilities, or brain abnormalities
- **mental health conditions**, such as obsessive-compulsive disorder (OCD) and schizophrenia
- **pregnancy**, but it's been suggested that pica during pregnancy occurs more frequently in women who exhibited similar practices during their childhood or before pregnancy or who have a history of pica in their family

Eating earth substances such as clay or dirt is a form of pica known as **geophagia**, which can cause iron deficiency. One theory to explain geophagia is that in some cultures, eating clay or dirt is believed to help relieve nausea (and therefore, morning sickness), control diarrhea, increase salivation, remove toxins, and alter odor or taste perception.

Some people claim to enjoy the taste and texture of dirt or clay or other non-food item and eat it as part of a daily habit (much like smoking is a daily routine for others). Pica may also be a behavioral response to stress.

Another explanation is that pica is a cultural feature of certain religious rituals, folk medicine, and magical beliefs. For example, some people in various cultures believe that eating dirt will help them incorporate magical spirits into their bodies.

None of these theories, though, explains every form of pica. A doctor must treat each case individually to try to understand what's causing the condition.

When to Call the Doctor

If your child is at risk for pica, talk to your doctor. If your child has consumed a harmful substance, seek medical care immediately. If you think your child has ingested something poisonous, call Poison Control at (800) 222-1222.

A child who continues to consume nonfood items may be at risk for serious health problems, including:

- lead poisoning (from eating lead-based paint chips or dirt contaminated with lead)
- constipation or diarrhea (from consuming indigestible substances like hair, cloth, etc.)
- **intestinal obstruction or perforation** (from eating objects that could block or injure the intestines)
- **tooth or mouth injuries** (from eating hard substances that could harm the teeth)
- **parasitic and other infections** (from eating dirt, feces, or other infected substances)

Medical emergencies and death can occur if the craved substance is toxic or contaminated with lead or mercury, or if the item forms an indigestible mass blocking the intestines. Pica involving lead-containing substances during pregnancy may be associated with an increase in both maternal and fetal lead levels.

What Will the Doctor Do?

Your doctor will play an important role in helping you manage and prevent pica-related behaviors, educating you on teaching your child about acceptable and unacceptable food substances. The doctor will also work with you on ways to restrict the nonfood items your child craves (i.e., using child-safety locks and high shelving, and keeping household chemicals and medications out of reach).

Some kids require behavioral intervention and families may need to work with a psychologist or other mental health professional.

Medication may also be prescribed if pica is associated with significant behavioral problems not responding to behavioral treatments.

Your doctor may check for anemia or other nutritional deficiencies. A child who has ingested a potentially harmful substance, such as lead, will be screened for lead and other toxic substances and might undergo stool testing for parasites. In some cases, X-rays or other imaging may be helpful to identify what was eaten or to look for bowel problems, such as an obstruction.

Fortunately, pica usually improves as kids get older. But for individuals with developmental or mental health concerns, pica may continue to be problem. Ongoing treatment and maintaining a safe environment and are key to managing this condition.

Categories: Cerebral Palsy Center, Diseases & Conditions, Emotions & Behavior, First Aid & Safety, Growth & Development, Nutrition & Fitness Center, Pregnancy & Baby, Pregnancy & Newborn Center, Preventing Premature Birth

Local Partners for Lead Poisoning Prevention

Chattanooga - Hamilton County Health Department
921 E. 3rd Street
Chattanooga, Tennessee 37403
(423) 209-8000
http://health.hamiltontn.org/

Tennessee Childhood Lead Poisoning Prevention Program
630 Hart Lane
1st Floor, R.S. Gass Laboratory
Nashville, Tennessee 37243
Phone: (615) 532-8462
https://www.tn.gov/health/health-program-areas/mch-lead.html

University of Tennessee Childhood Lead Poisoning Prevention
https://extension.tennessee.edu/publications/documents/SP599.pdf

Tennessee Department of Environment and Conservation Lead Hazard Program
https://www.tn.gov/environment/toxic-substances-program/lead-hazard-program.html

Text Description for Figures and Fact sheets

Figure 3. Percent of Tested Children (Ages 6 Months to 72 Months) with BLL ≥ 3.5 µg/dL

Figure 3 presents percentage of children ages 6 months to 72 months in the Southside Chattanooga Lead Superfund site neighborhoods, Hamilton County, and Statewide who were tested and have a blood lead level greater than or equal to 3.5 micrograms per deciliter. The table shows percentages of elevated blood lead levels in the Southside Chattanooga Lead site neighborhoods, for Hamilton County, and Statewide for the years 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, and 2021. Percentages of tested children with elevated blood lead levels are higher for the Southside Chattanooga Lead site Neighborhoods in 9 of the past 10 years compared to Hamilton County percentages. Percentages in the Southside Chattanooga Lead site neighborhoods are higher than percentages Statewide.

Fact sheet: Ways to protect your health by keeping dirt from getting into your house and into your body

Infographic shows ways to protect your health by keeping dirt from getting into your house and your body. Infographic shows seven ways. One picture shows vegetables being washed in a sink recommending you wash and peel all fruits, vegetables, and root crops. The second picture shows a front door and recommends you wipe your shoes on doormat or remove shoes. The third picture shows a person outside gardening and recommends you not eat food, chew gum, or smoke when working in the yard. The fourth picture shows a woman dusting a 2 drawer table and recommending damp mop floors and damp dust counters and furniture regularly. The fifth picture shows a dog in a washtub and recommends washing dogs regularly. The sixth picture shows a tub faucet with water coming out with a children's ball beneath it and recommends washing children's toys regularly. The seventh picture shows a sink with water running and recommends wash children's hands and feet after they have been playing outside. The fact sheet also shows the logo of ATSDR.

Fact sheet: Know the facts for lead poisoning for children

The infographic shows one half of a face of young boy on the right half of the page with three main lead poisoning facts to the left. In the upper center the fact sheet states Lead poisoning is caused by swallowing or breathing lead. Children under 6 years old are most at risk. If you are pregnant, lead can harm your baby.

The first fact states lead can cause learning and behavior problems. Lead poisoning hurts the brain and nervous system. Some of the effects of lead poisoning may never go away. Lead in a child's body can:

- Slow down growth and development
- Damage hearing and speech
- Make it hard to pay attention and learn

The second fact states most children get lead poisoning from paint in homes built before 1978. When old paint cracks and peels, it makes dangerous dust. The dust is so small you cannot see it. Most children get lead poisoning when they breathe or swallow the dust on their hands and toys.

The third fact states a lead test is the only way to know if your child has lead poisoning. Most children who have lead poisoning do not look or act sick. Ask your doctor to test your child for lead.

Fact sheet: Protect Your Family from lead

The infographic lists three ways to protect your family from lead exposure and shows a picture at the bottom right of the fact sheet shows a mom, dad, and child walking on grass. The three main ways are: 1. Test your home for lead, 2. Keep children away from lead paint and dust. 3. Renovate safely.

Beneath the first main way to protect your family from lead exposure is to Test your home for lead.

- If you live in a home built before 1978, have your home inspected by a licensed lead inspector.
- Contact your local health department for more information

Sometimes lead comes from things other than paint in your home, such as:

- Candy, toys, glazed pottery, and folk medicine made in other countries
- Work like auto refinishing, construction, and plumbing
- Soil and tap water

The second main way to protect your family from lead exposure is to keep children away from lead paint and dust.

- Use wet paper towels to clean up led dust. Be sure to clean around windows, play areas, and floors/
- Wash hands and toys often, especially before eating and sleeping. Use soap and water.
- Use contact paper or duct tape to cover chipping or peeling paint.

The third main way to protect your family from lead exposure is to renovate safely. Home repairs like sanding or scraping paint can make dangerous dust.

- Keep children and pregnant women away from the work area.
- Make sure you and/or any workers are trained in lead-safe work practices.
- Home repairs like sanding or scraping paint can make dangerous dust

The fact sheet also states Contact us for more information, and lists the Tennessee Lead Hazard Reduction Program telephone number at 1-888-771-LEAD.

Fact sheet: Are You Pregnant–Ways to prevent lead poisoning while you are pregnant

Infographic shows pregnant woman on left hand side of the page and lead facts on right half. It asks Are you Pregnant? and to prevent lead poisoning, start now.

Beneath the above text it states Lead poisoning is caused by breathing or swallowing lead. Lead can pass from mother to her unborn baby.

It states too much lead in your body can:

- Put you at risk of a miscarriage
- Cause your baby to be born too early or too small
- Hurt your baby’s brain, kidneys, and nervous system
- Cause your child to have learning or behavior problems.

The infographic also states lead can be found in:

- Paint and dust in older homes, especially dust from renovation or repairs
- Candy, make up, glazed pots, and folk medicine made in other countries
- Work like auto refinishing, construction, and plumbing
- Soil and tap water

The infographic tells you to contact your local health department to learn more.

The fact sheet also states: Now is the time to keep your baby safe from lead poisoning. Here's what you can do, and lists three things:

1. Watch out for lead in your home. Most lead comes from paint in older homes. When old paint cracks and peels, it makes dangerous dust. The dust is so small you cannot see it. You can breathe in lead dust and not even know it. Home repairs like sanding or scraping paint can make dangerous lead dust. Pregnant women should not be in the house during cleaning, painting, or remodeling a room with lead paint.

   The infographic includes a Tip: If you live in an older home, have your home inspected by a licensed lead inspector.

2. Eat foods with calcium, iron, and vitamin C. These foods may help protect you and your unborn baby.
   - Calcium is in milk, yogurt, cheese, and green leafy vegetables like spinach.
   - Iron is in lean red meat, beans, cereals, and spinach.
   - Vitamin C is in oranges, green and red peppers, broccoli, tomatoes, and juices.

3. Talk to your doctor. Talk to your doctor about any medicines or vitamins you are taking. Some home remedies and dietary supplements have lead in them. It is important that you tell your doctor about any cravings you are having such as eating dirt or clay.

The infographic also states Contact us for more information and lists the telephone number for the Tennessee Lead Hazard Reduction Program at 1-877-771-LEAD.

The infographic also has the logos for the Department of Health and Human Services and for the Centers for Disease Control and Prevention – CDC.

Fact sheet: Reusing potentially contaminated landscapes: Growing gardens in urban soils

Infographic begins with Reusing Potentially contaminated landscapes: Growing gardens in urban soils. The fact sheet shows raised garden beds, person planting or harvesting vegetables in raised bed, young plants and vegetables. It also provides and Introduction about urban agriculture. Accessible version of Growing Gardens in Urban Soils: infographic-https://www.epa.gov/sites/production/files/2014-03/documents/urban_gardening_fina_fact_sheet.pdf

Fact sheet: Fight lead poisoning with a healthy diet–Lead Poisoning Prevention Tips for Families

Picture shows a pear on front page of fact sheet. Accessible version of Fight Lead Poisoning with a Healthy Diet: Infographic-https://www.epa.gov/sites/production/files/2014-02/documents/fight_lead_poisoning_with_a_healthy_diet.pdf