# Public Health Assessment for

**JACOBSVILLE NEIGHBORHOOD SOIL CONTAMINATION SITE: OU1 AND OU2**

**EVANSVILLLE, VANDERBURGH COUNTY, INDIANA**

**EPA FACILITY ID: INN000508142**

**June 25, 2019**

**U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES**
**PUBLIC HEALTH SERVICE**
Agency for Toxic Substances and Disease Registry

THE ATSDR PUBLIC HEALTH ASSESSMENT: A NOTE OF EXPLANATION

This Public Health Assessment was prepared by ATSDR pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA or Superfund) section 104 (i)(6) (42 U.S.C. 9604 (i)(6)), and in accordance with our implementing regulations (42 C.F.R. Part 90). In preparing this document, ATSDR has collected relevant health data, environmental data, and community health concerns from the Environmental Protection Agency (EPA), state and local health and environmental agencies, the community, and potentially responsible parties, where appropriate.
In addition, this document has previously been provided to EPA and the affected states in an initial release, as required by CERCLA section 104 (i)(6)(H) for their information and review. The revised document was released for a 60 day public comment period. Subsequent to the public comment period, ATSDR addressed all public comments and revised or appended the document as appropriate. The public health assessment has now been reissued. This concludes the public health assessment 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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# PUBLIC HEALTH ASSESSMENT

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Prepared by the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry
Division of Community Heath
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# Public Health Assessment Summary

## Exposure to lead and arsenic in the Jacobsville Neighborhood Soil Contamination (JNSC) site Evansville, Vanderburgh County, Indiana

The Agency for Toxic Substances and Disease Registry (ATSDR) assessed whether exposure to lead and arsenic in soil, sediment, surface water, and groundwater near the Jacobsville Neighborhood Soil Contamination (JNSC) site in Evansville, Indiana could harm people's health. ATSDR reviewed other potential sources of lead in older housing near the site which is likely to be contributing to lead exposures. The JNSC site is nearly 4½ square miles of mostly residential properties. In 2004, the U.S. Environmental Protection Agency (EPA) added the site to the National Priorities List (NPL) for long-term cleanup.

The EPA found that JNSC residential soils contained lead and arsenic due, in part, to air emissions from former foundries and factories that operated in the area from the late 1800's to 1990. As of December 2018, EPA has sampled over 5,000 properties and cleaned up over 2,300 residential properties. Approximately 4,000 properties will need/receive cleanup at the Site.

In 2016, the City of Evansville achieved a Federal Promise Zone designation, which allows access to 16 federal agencies, including workgroups for: Crime, Job Development, Education, Health, Housing, Economic Development, and Community Engagement. In 2017, Evansville adopted new procedures for reporting, monitoring, and preventing lead poisoning.

### The Bottom Line:

- Children who swallow soil and dust containing lead in JNSC yards could experience health problems which include slower growth and development, hearing damage, and attention and learning problems. Pica behavior is the eating of non-food items. Children with pica behavior are at a very high risk.
- Pregnant women could accidentally swallow lead in soil that could affect their unborn child. The unborn child could experience similar health effects as the young exposed children from in utero exposures. Pregnant women with pica behavior present a high risk to their unborn children.
- People who are exposed to arsenic in soil for long periods of time could have an increased risk of cancer of the skin, liver, bladder, and lungs.
- Children in Vanderburgh County have higher blood lead levels (BLLs) compared to children statewide. ATSDR identified several factors associated with the increased risk of higher BLLs including age of housing, contaminated soil, poverty, and race.

In the public health assessment, ATSDR reached the following conclusions.

## Conclusion 1 – People contacting lead and arsenic in soil could be harmed: This presents a Health Hazard.

**Basis for Conclusion**

- **Lead and arsenic in JNSC yards:** EPA found lead and arsenic in soils of 13 Evansville neighborhoods. EPA clean-up of residential soils is ongoing; Approximately 4,000 properties were verified as contaminated. More than half have been cleaned up. Between 50 and 65 percent of properties that have been sampled require cleanup.
- **The average surface soil lead levels** were over 600 parts per million (ppm) based on sampling conducted in 2006, with levels as high as 8,210 ppm in some areas. Lead is not often detected in the background of Evansville. The extent of contamination has not been fully defined. Therefore, remediated soil may be re-contaminated by airborne dust and runoff.
- **Swallowing soil while playing** in contaminated JNSC yards could harm young children's health. They could have long-term health problems including slower growth and development, hearing damage, and trouble with attention and learning. Pregnant women and children may be exposed to lead in soil while outside or from dust that is tracked inside of the home from the soil. Too much lead in a pregnant woman's body can cause risks to mother and child, including risk of miscarriage and effects on child development.
- **Lead in locally grown garden vegetables and animals raised for food**: Lead and other metals can be taken up in plants and animals grazing on contaminated soils. Consuming poultry, eggs, and vegetables could be a concern for some areas of Evansville where lead and arsenic in soil are present at very high concentrations, however, no data was available to fully evaluate these exposures for people in Evansville. Raising livestock has been prohibited by Evansville City Code ordinances since 2010. Chickens and other poultry may still be kept in coops and allowed to roam and feed in fenced yards.
- **Extra cancer risk from exposure to arsenic in soil**: Arsenic is a known human carcinogen. Cancer risks were calculated for ingestion of arsenic using the EPA oral cancer slope factor of 1.5 $(mg/kg/day)^{-1}$ which is based on skin cancer. Adults, assumed to be exposed for 33 years, had an estimated risk of 1 to 5 extra cancer cases among 100,000 people exposed for exposures to 23 ppm (the residential average for operable unit 1 [OU1]) and 92 ppm (the residential maximum), respectively. This cancer risk is considered to be low. Childhood cancer estimates considered exposures throughout childhood (ages 1 to 21 years old). Children exposed to 23 ppm of arsenic had a calculated cancer risk of 3 extra cancer cases in 100,000 people exposed, also considered low. A slightly elevated cancer risk of 2 extra cases among 10,000 exposed was estimated for children who ingested soil with 92 ppm of arsenic (See appendix C).

## Next Steps

**Community members need to:**

- **Reduce exposure:** Because there is no known safe level of lead in children's blood, ATSDR and CDC recommend reducing lead exposure wherever possible. ATSDR recommends reducing your exposure (particularly if you are pregnant) and your children's contact with lead in soil and from other sources such as flaking or peeling lead paint and dust.
  - After working or playing in the yard
    - take shoes off before entering the home
    - use a damp cloth or damp/wet mop to remove dust and dirt from the home
    - wash hands, wash toys and wash pets
  - Create a raised bed and fill with clean soil for gardening to reduce exposures from gardening and digging. Rinse produce well to remove garden soil.
  - Ensure that any grazing and free-ranging animals be kept in areas with amended soils to prevent lead uptake.
- **Reduce lead absorption:** Eating a nutritious diet might help to reduce lead absorption. Eat several small meals per day (appropriate for age and growth) rich in iron, calcium, vitamins C & D and zinc from such foods as dairy products, green vegetables, and lean meats. Proper nutrition is particularly important for children and pregnant women.
- **Get yard tested:** To find out if you or your children are at greater risk for higher BLLs, allow EPA access to your property to test the soil.
- **Follow safe renovation guidelines:** If you live in older housing, ATSDR recommends following EPA's Lead Renovation, Repair, and Painting Rule (RRP Rule) to lower the risk of lead contamination from home renovation activities.
- A**TSDR recommends residents in older homes have their water tested for lead.** If you live in older housing, flush water lines for 30 seconds up to two minutes before using the water for drinking or cooking to reduce exposure to lead in drinking water. (See http://evansvillegov.org/index/asp?=2405 or http://www.epa.gov/safewater/lead or call EPA's Safe Drinking Water Hotline at 1-800-426-4791).
- Find additional general information about lead at the following EPA web site: www.epa.gov/lead/learn-about-lead.html, answers general questions about lead testing procedures.
- Reduce exposures to arsenic in soil by following similar practices to reduce lead exposures.

**EPA will:**

- Continue soil remediation to reduce lead and arsenic levels and protect public health.

**Vanderburgh County Health Department (VCHD) will:**

- Continue working with the community to help identify and reduce lead exposure.
- Continue to educate the community to improve community participation in the lead surveillance program.
- Continue to report, monitor, and prevent lead poisoning in accordance with the recently promulgated Evansville Lead poisoning standards [G-2017-23].
- Utilize their recently awarded state grant to remediate homes with lead paint.
- Strive to continue their recent improved success rates in monitoring, preventing, and stopping lead poisonings.

## Conclusion 2 –High blood lead levels in children indicate elevated lead exposures: This presents a Health Hazard

ATSDR reviewed blood lead level (BLL) data from the Vanderburgh County Health Department (VCHD) and the Indiana State Department of Health (ISDH) and found that children in Vanderburgh County had higher BLLs compared to children statewide. ATSDR identified several factors associated with the increased risk of higher BLLs including age of housing, contaminated soil, poverty, and race.

**Basis for Conclusion**

**BLLs**

- **Children of Vanderburgh have elevated blood lead exposure risks:**
  - From 1998-2006, several children living in Evansville and in the region of OU1 and OU2 had BLLs exceeding CDC's blood lead reference value of 5 µg/dL (shown in Figure 6).
  - From 2014-2015, nearly 7% of the county children had BLLs exceeding the CDC's reference level of 5 µg/dL compared with about 4% of the state.
  - From 2014-2017, about 4% of high risk children in the county had BLLs exceeding 10 µg/dL; while not directly comparable, 1ess than 1 % of the state's children were above 10 µg/dL in 2014 and 2015.
- **Low testing rate:** In 2014, 9%of children younger than 6 were tested for blood lead in the county. The percentage of children participating in VCHD's blood lead screening program is declining, indicating the need for additional outreach for blood lead testing.

**Additional factors associated with the increased risk of higher BLLs in JNSC neighborhoods**: The following are additional factors associated with the likelihood of increased risk for higher BLLs along with exposure to lead-contaminated soil:

- more than 64% of the population lives in older housing where lead can be found in the paint and plumbing
- nearly 21% of the population lives in poverty
- about 27% of people living in OU2 are black (compared with 11% black within all of Evansville).

**Next Steps**

**Community members need to:**

- **Test blood for lead:** ATSDR recommends blood lead testing as soon as is practical for people who live in or routinely visit the Evansville community, who haven't had a blood lead test in the past 6 to 12 months, and who are in the following groups:

  - women who are pregnant
  - women who want to become pregnant
  - children who are under 6 years of age

  VCHD offers free yearly blood lead screening and educational programs.

- **Get a child health check-up:** ATSDR recommends that children with BLLs of 5 µg/dL or higher be evaluated by a health care provider. As part of the evaluation, ATSDR recommends that the provider determine the child's exposure history.

**Vanderburgh County Health Department (VCHD) will continue to:**

- Investigate elevated BLL in homes and residences.
- Educate people on the need for blood lead testing**.**
  While VCHD offers free blood lead testing to area children, community participation in this program has been low. ATSDR recommends VCHD (and, as appropriate, EPA) take additional steps to increase the participation rate of eligible children in the blood lead testing program.

## For More Information

- VCHD: For public health information, call VCHD at (812) 435-2400.

- ATSDR: If you have questions or comments about this document, call ATSDR's regional office director, Mark Johnson, at (312) 353-3436 or our toll-free number at 1-800-CDC-INFO and ask for information on the Jacobsville Neighborhood Soil Contamination Site, Evansville, Indiana.

- EPA: If you have concerns about the JNSC site contamination or wish to have your soil sampled, you can contact EPA Region 5 at 800-621-8431, ext. 67472 and leave a message. This line is operational 24-hours a day.

## List of Abbreviations

| | |
|---|---|
| ATSDR | Agency for Toxic Substances and Disease Registry |
| BLL | blood lead level |
| CDC | Centers for Disease Control and Prevention |
| DHHS | Department of Health and Human Services |
| DNR | Department of Natural Resources |
| EPA | U.S. Environmental Protection Agency |
| EWD | Evansville Water Department |
| JNSC | Jacobsville Neighborhood Soil Contamination |
| IARC | International Agency for Research on Cancer |
| IDEM | Indiana Department of Environmental Management |
| ISHD | Indiana State Health Department |
| kg | kilogram |
| LBP | Lead based paint |
| mg/day | milligrams per day |
| mg/kg | milligrams per kilogram |
| mg/kg/day | milligrams per kilogram per day |
| NPL | National Priorities List |
| OU1&2 | Operable Unit (a distinct area defined by site condition parameters) |
| PHA | public health assessment |
| ppm | parts per million |
| µg/dL | micrograms per deciliter |
| VCHD | Vanderburgh County Health Department |
| XRF | X-ray fluorescence spectrometer |

## Background

### Purpose and Health Issues

The Jacobsville Neighborhood Soil Contamination (JNSC) site, located in Evansville, Vanderburgh County, Indiana, includes nearly 4½ square miles of mostly residential properties. The Environmental Protection Agency (EPA) found JNSC residential soils contained lead and arsenic due, in part, to air emissions from former foundries and other factories that operated in the area from the late 1800's until the late 1900's. Many of the major lead emissions to the air ended by 1990. EPA added JNSC to their National Priorities List (NPL) in July 2004 making it eligible for long-term cleanup. As of December 2018, EPA has cleaned up over 2,300 residential properties; up to 4,000 residential properties are proposed for future remediation.

ATSDR is working with other agencies and state and local governments to help people reduce or stop lead and arsenic exposures at the JNSC site. Additionally, there are other sources of lead in Evansville such as older housing which may have peeling paint and lead-containing plumbing.

There is evidence of lead exposure in the Evansville and Vanderburgh County communities, showing children younger than 6 have a higher rate of elevated blood lead levels (BLLs) than the statewide and national levels and participation in blood lead testing is low. ATSDR strongly recommends children in this community participate in the blood lead screening as Vanderburgh County Health Department (VCHD) continues community health educational programs including free blood lead testing.

### Site Description

The JNSC site is in a mixed residential, industrial, and commercial area in Evansville, Vanderburgh County, Indiana. The Indiana Department of Environmental Management (IDEM) and EPA named the site the JNSC site because the contamination (lead and arsenic) was initially found in the Jacobsville Neighborhood.[1] After further sampling, IDEM and EPA found that soil contamination extended beyond the initial boundaries to other Evansville properties that are now included within the JNSC NPL site [EPA 2006; EPA 2009]. EPA found that residential soils in the JNSC site neighborhoods became contaminated by lead and arsenic in air emissions from former foundries and other factories in the area [EPA 2006; 2009].

**Cleanup areas**

**Operable Unit 1 (OU1):** 141 acres
Lloyd expressway (South)
Mary Street (West)
Iowa Street (North), and
Elliot Street (East)

**OU2:** 2,924 acres

The JNSC site (3,065$^+$ acres) is divided into *two cleanup areas*, or *operable units (OU)*, and includes a larger area than the Evansville's Jacobsville Neighborhood (Figures 1, 3, & 4).

[1] In Vanderburgh County, lead and arsenic were used by industries, businesses, and residents dating back to the 1880s.

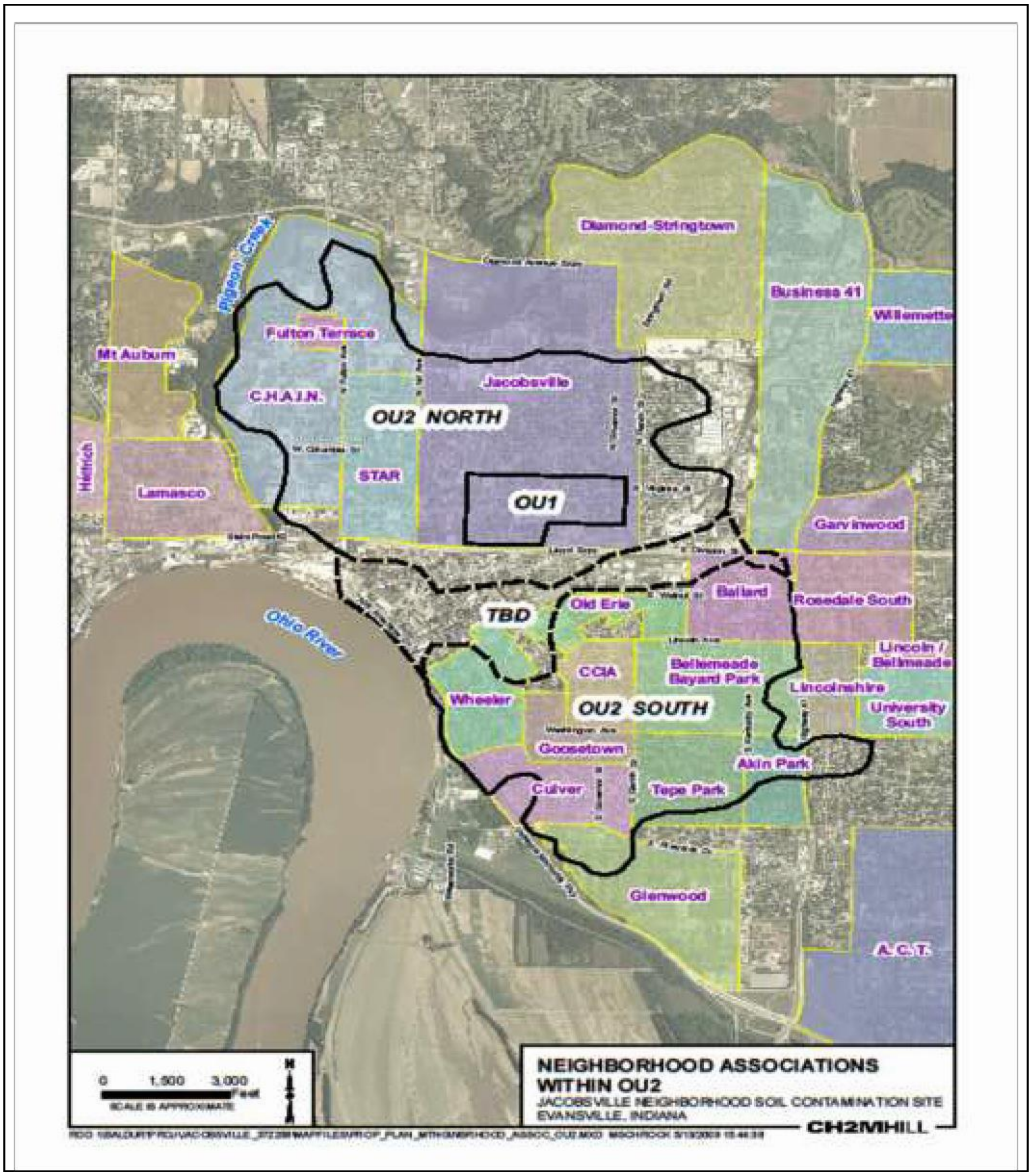



**Figure 1.** Jacobsville Neighborhood Soil Contamination Site Operable Unit Locations. The former to be determined (TBD aka Gap Area) area is now part of OU2 South.

EPA completed a *Superfund Emergency Removal Action* between September 2007 and April 2008. During this action, EPA, in consultation with IDEM and with the support of the City of Evansville and the VCHD, cleaned and replaced soil at 83 residential properties with topsoil lead levels above 1,200 ppm.

In 2009, EPA began soil sampling and design work for the cleanup of other properties. In 2010, EPA completed cleanup of 263 residential yards in OU1, the area shown by the L-shaped box in Figure 1 [EPA 2011]. An additional 20 properties in OU1 were cleaned up in 2011. By May 2014, more than 1,300 properties had been remediated. Another 600 properties were sampled and remediated in 2014 and 2015. As of December 2018, EPA has completed cleanup at over 2,300 residential properties and continues removals at OU2. Approximately 1700-2000 residential properties are planned for future cleanup. Residential soils are being cleaned up to 400 ppm for lead and 30 ppm for arsenic. Figure 3 in Appendix A identifies broader boundaries of OU2 as a result of lead sampling. While the 2009 ROD remains unchanged, the bounds of OU2 are expected to expand.

In 2016 the City of Evansville was successful in achieving a Federal Promise Zone designation, which focusses assistance from many agencies to fight poverty in the urban core. The Promise Zone area includes OU1 and OU2. The Promise Zone designation allows access to 16 federal agencies through competitive grants. The Promise Zone consists of 7 Working Groups: Crime, Job Development, Education, Health, Housing, Economic Development, and Community Engagement.

## Demographics

Throughout this document we will cite several censuses to correspond with other data collected throughout the period of EPA's involvement. In 2010, the number of people living within one mile of the operable units was 52,861 and had dropped by 8% between 2000 and 2010 (Appendix A: Figures 4 & 5) [U.S. Census 2010].

**Factors associated with higher blood lead levels**
We reviewed demographics and other factors associated with higher BLLs in Evansville. The factors for Evansville include [U.S. Census 2000, 2010, 2014-2015]:

*Older housing:* Prior to 1955, there were no limits on the amount of lead in paint, but in 1978, the levels were greatly reduced.

*People living in poverty:* Children who live in a household with a poverty income ratio (PIR) ≤ 1.3 have higher mean BLLs than children living in households with a PIR > 1.3 [CDC 2013]. At least 22 of the census tracts within OU1 and OU2 have PIR < 1.3. The average for Evansville is 1.5.

**Factors associated with higher blood lead levels**

Older Housing: Pre-1950 housing Units - 16,735, **64%**
Poverty: PIR < 1.3 in at least 22 census tracks

Minorities: 18% black and 27% in OU2

Children <6 years: 5,146, 9.7%

*Note:* These data are for people living within 1 mile of the site in 2010, except where noted for OU2

*Minority groups:* Studies of the U.S. population have shown that non-Hispanic black children have the highest BLLs followed by Mexican American and then non-Hispanic white children [CDC 2013].

*Children younger than age 6:* In general, children absorb approximately 30-50% of the lead they ingest, while adults only absorb 10% [Rowden et al. 2011].

### Environmental justice

The community is concerned about environmental justice issues and health disparities [EPA 2011; EPA 2012a; EPA 2012b; EPA 2012c]. Health disparities can result from multiple factors, such as poverty, race, environmental threats, inadequate access to health care, individual and behavioral factors, and educational inequalities (Appendix A: Figures 3 & 4 identify contaminated areas and demographics).

## Sampling Investigations

### Soil Sampling

EPA found that residential soils at the JNSC site were contaminated with lead and arsenic due in part to emissions from former foundries and other factories in the area [EPA 2011, 2009, 2006; CH2M HILL 2007].Table 1 in Appendix B shows the lead and arsenic levels by soil depth and location.

**2006 Soil Sampling**

| *Location* | Lead average | Lead range | Arsenic average | Arsenic range |
|---|---|---|---|---|
| *OU 1* | 374 | 20-8,210 | 15 | ND-92 |
| *OU 2* | 403 | ND-7,900 | 23 | ND-68.2 |

***All levels are in parts per million (ppm) [EPA 2006,2009]***

EPA sampled soil throughout the JNSC site to estimate the zones with lead contamination above 400 ppm—EPA's cleanup level. EPA used XRF (x-ray fluorescence spectrometry) for about 730 of the soil samples reported (before clean-up) in the 2009 Record of Decision [EPA 2011, 2009, 2006; CH2M HILL 2007]. EPA used laboratory confirmations to adjust XRF results reported in the Records of Decision [EPA 2009, 2006].

ATSDR used the results from EPA's Integrated Exposure Uptake Biokinetic Model (IEUBK) to make recommendations about soil clean-up [EPA 2003]. The IEUBK model is designed to integrate exposure from lead in air, water, soil, dust, food, paint, and other sources with pharmacokinetic modeling to predict blood lead concentrations in children 6 months to 7 years of age. The IEUBK model is a predictive tool that provides results that can be used for making public health decisions.

The IUEBK Model results predict that ongoing, routine exposure to soil lead levels at some homes in this community (that have not undergone remediation) could result in young children with blood lead levels above the current CDC reference value of 5 µg/dL. Therefore, actions are needed to reduce the levels of lead at some homes to protect the health of children and pregnant women. It is important to note that many factors influence lead exposure and uptake, and therefore limits the accuracy of the IEUBK model to predict individual BLLs.. These include the lead bioavailability and individual nutritional status, model limitations, lead exposure risk factors, seasonality, exposure age, and multiple sources of lead exposure. More information can be found in Appendix B.

### Surface Water and Sediment Sampling

ATSDR reviewed and summarized EPA's evaluation of surface water and sediment data to consider the potential for recreational exposure. EPA collected sediment and surface water samples from 10 co-located sample locations along tributaries and streams of Pigeon Creek. All water samples were within EPA's water standard criteria [EPA 2009]. This data better reflects impact upstream of the JNSC site. The sampling was not designed to characterize the impact of the JNSC site on Pigeon Creek, which passes the western side of the site.

Pigeon Creek has a state fish consumption advisory in place for polychlorinated biphenyls (PCBs) and mercury. The state advisory limits consumption of many species to one fish per week, available at: https://secure.in.gov/isdh/23650.htm.

### Groundwater Sampling

ATSDR reviewed and summarized EPA's evaluation of groundwater data. EPA collected groundwater samples to determine whether arsenic, iron, and lead in groundwater were of concern. The Indiana Department of Natural Resources (Indiana DNR) conducted a well survey to identify registered drinking wells located within the site. Groundwater samples were collected from two existing wells: one that supplied water to a private residence and one that supplied water to a business during emergencies, such as a water main break. Four samples were analyzed for arsenic, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, nickel, potassium, silver, sodium, vanadium, and zinc. The levels of lead, arsenic and other metals detected in the groundwater samples were not above EPA screening criteria, specifically, Maximum Contaminant Levels or Preliminary Remedial Goals [EPA 2006]. The Indiana DNR Water Well Record Database is available online at: http://www.in.gov/dnr/water/3595.htm.

### Drinking Water Sampling

The Evansville Water Department (EWD) is a public utility owned and operated by the City of Evansville. To comply with state and federal regulations, the EWD issues an annual report to customers describing the quality of their drinking water. Currently, the EWD monitors for nearly 100 contaminants, including bacteria, metals, and pesticides. Lead is included in the metals tested. The 2016 Annual Drinking Water Quality Report is the latest report available and it indicated that lead levels (2.0 parts per billion (ppb)) were below EPA's action level of 15 ppb. In 2015, 56 samples were collected throughout the city available at: http://www.evansvillegov.org/egov/documents/1499096779_12575.pdf

### Air Sampling

ATSDR obtained and summarized the air quality information for Vanderburgh County from EPA web sites and from the VCHD. The Clean Air Act requires EPA to set National Ambient Air Quality Standards for six common air pollutants commonly found across the United States.

These air pollutants are ozone, particulate pollution (often referred to as particle matter), carbon monoxide, sulfur dioxide, nitrogen oxides, and lead.

VCHD samples air for criteria pollutants in the Evansville area. The air samples are collected from building rooftops in downtown Evansville. Evansville regional air lead levels have been below EPA's National Ambient Air Quality Standards [http://www.epa.gov/air/criteria.html]. Although routine air sampling by VCHD does not include samples from the neighborhoods, during cleanup work, EPA also tests air quality for particulates and lead during remedial activities.

## Other Sources of Lead

### Lead in Paint

Although ATSDR supports the soil removal, we are concerned that lead-based paint (LBP) in and on the homes (built before 1978) still represents a significant lead exposure source. LBP and contaminated dust are the most widespread and dangerous high-dose sources of lead exposure for young children [CDC 2015]. Un-renovated buildings built before 1950 have the highest levels of lead in paint; the lead in paint can be as high as 40% [ATSDR 2007b]. Of the more than 80 % of Evansville homes built before 1978, a high percentage (64%) of those homes are within a mile of the site and were built before 1950.

Children or pets might eat lead paint chips. Both children and adults may be exposed to lead in dust inside their homes. Thus, even in areas where soils have been cleaned up, lead based paint could still be a significant source of lead exposure to children.

**Lead Paint in Homes**

- Paint can contain up to **40% lead**
- Un-renovated homes built before **1950** have the highest lead in paint
- Soil in the roof's drip line was **5** times higher than the rest of the yard.

LBP can also re-contaminate outside soils as it continues to chalk and flake. The highest concentrations of lead in Jacobsville were detected along home drip lines (where water runs off the roof of houses). Lead in the drip line zone around homes ranged from 20 – 8,210 ppm (Appendix B, Table 1 - Lead and arsenic levels by depth and location). The average level detected along a drip line was 2,789 ppm, while the average lead levels detected in yards of the same depth was 604 ppm—a difference of nearly five times. Airborne lead deposited on the roofs and lead-based paint and other lead in houses would increase soil lead levels near drip lines.

### Lead in Plumbing

Drinking water is another possible source of lead exposure in this community. Historically, city ordinances required the use of lead service lines from city water mains to homes and businesses. Those lines could still be used and be a source of lead throughout Evansville. Additionally, homes built before 1986 are more likely to have lead pipes, fixtures and lead-based solder. Newer homes have less lead in plumbing, but are not "lead – free".

> **Lead in Drinking Water from Plumbing**
>
> When a faucet has not been used for several hours, minerals could build up in the pipes. The potential for lead exposure can be minimized by letting the water **run from the faucet for 30 seconds** to two minutes before using water for drinking or cooking.

Although the Evansville Water Department (EWD) is responsible for providing safe drinking water in Evansville, it cannot control the variety of materials used in plumbing components in individual buildings. When a faucet has not been used for several hours, minerals could build up in the pipes. In most cases, the potential for lead exposure can be minimized by letting the water run from the faucet for 30 seconds up to two minutes before using water for drinking or cooking. If people are concerned about lead in their water, they can have their water tested. Information on lead in drinking water, testing methods, and steps that can be taken to minimize exposure is available from the *EPA Safe Drinking Water Hotline at 1-800-426-4791 or at http://www.epa.gov/safewater/lead*.

The EWD is responsible for monitoring, maintaining and repairing water mains throughout its service area. This includes monitoring at the mains and a small percentage of the taps. While the tap samples do provide a general idea of the private tap system of a community, it does not provide the private property conditions of most residences. Property owners are responsible for the upkeep and repair of service lines and meter pits on their property, as defined in the Water Rules and Regulations Policy, approved by the utility's board on April 15, 2008. This includes the point where a customer's service line connects to the utility's water main, service lines entering buildings on the property, and the meter pit and cover (Water Handbook: http://evansvillegov.org/index.aspx?=2405).

> **Drinking Water Testing**
>
> If people are concerned about lead in their water, they may want to have their water tested. Information on lead in drinking water, testing methods, and steps that can be taken to minimize exposure is available from the *EPA Safe Drinking Water Hotline at 1-800-426-4791 or at http://www.epa.gov/safewater/lead*.

### Lead in urban raised livestock and poultry

ATSDR and the VCHD observed residents raising livestock and poultry near/on contaminated soil areas in 2008. Vanderburgh County then created ordinances restricting free-ranging because consuming meat, eggs, and milk from those areas could have exposed people to contamination [Ismail & Abolghait 2013; Spliethoff et al. 2013]. ATSDR was not able to evaluate this potential exposure pathway because no data was available. However, in 2010 raising livestock was prohibited by Evansville City Code. Chickens and other poultry may still be kept in coops and allowed to roam and feed in fenced yards.

Soil lead levels at 1000 ppm increased bone lead in grazing animals. The uptake of lead in soils by animals was reduced by amending the garden soils with other nutrients or by ensuring the animals received sufficient iron and calcium [Ryan et al. 2004 and Chaney et al. 1989].

**Lead in garden vegetables**

If people are growing root and leafy vegetables in areas with contaminated soil, eating those vegetables could expose people to contamination. While a child's uptake of lead from soil and dust is generally higher than from local vegetables, vegetables grown in soil exceeding 500 mg/kg lead has been shown to contribute significantly to overall risk [Sterette et al. 1996]. The main concern for gardens in lead or arsenic contaminated soil is that soil particles can adhere to the edible plant surface if not properly washed. Washing and peeling fruits and vegetables, especially root crops, can reduce exposure. This risk was also significantly reduced by amending the garden soils with other nutrients [Ryan et al. 2004 and Chaney et al. 1989].

## Blood Lead Data for Children

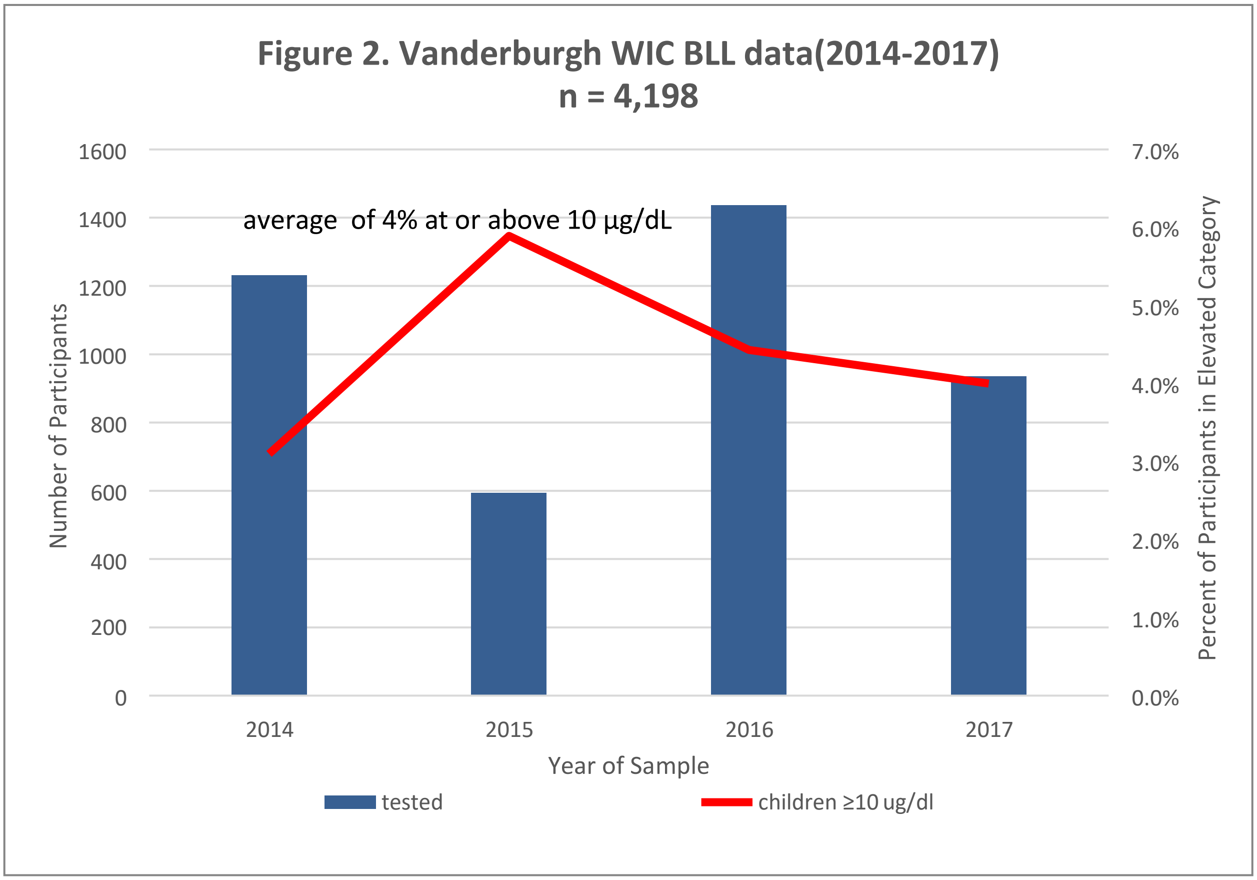
Because of the many sources of lead in Evansville, children are at higher risk for lead exposure. ATSDR reviewed current blood lead data for children who were tested and looked at trends over time by location. Children tested in Evansville have higher BLLs than all of the comparison groups. We review here the blood lead data.

**Blood lead data 2014-2017.**

- From 2014-2017, about 4% (168) of children age 1 to 6 in Vanderburgh County enrolled in the Women, Infants, and Children (WIC) nutritional program (N= 4,198) had BLLs at or above 10 µg/dL [ATSDR 2017]. (Explained in Figure 2 and adjacent text). While not directly comparable, of the (82,078) total state reported children in 2014 and 2015, less than 1% (644) were above 10 µg/dL. This data is currently available to ATSDR in quartile groups for the whole county and cannot be compared directly to the CDC reference value of 5 µg/dL nor can it be assessed for just the Evansville children.
- The state reported levels for 2014 and 2015 show that 7.1% and 6.8% (respectively) of the county children had BLLs exceeding CDC's reference value of 5 µg/dL[2] compared with 4.3% of the state [ISDH 2015].
- The county participation rate for children tested for blood lead continues to be low (4.2 %) [CDC 2015]. Fewer than 600 children participated in one of the county's blood lead surveillance programs [ATSDR 2017].
- In 2015, only 25% of Indiana counties had a higher percentage of children under 6 with BLL ≥ 5 µg/dL than Vanderburgh County [ISDH 2015].

[2] CDC uses a reference level of 5 micrograms per deciliter (5µg/dL) to identify children with blood lead levels that are higher than most children's levels. This level is based on the U.S. population of children ages 1-5 years who are in the highest 2.5% of children when tested for lead in their blood. This reference value is based on the 97.5th percentile of the National Health and Nutrition Examination Survey (NHANES)'s blood lead distribution in children. The current reference value is based on NHANES data from 2007-2008 and 2009-2010. CDC will update the reference value every four years using the two most recent NHANES surveys.

- Vanderburgh County is the 8th largest county in Indiana (by population). Only one other county in the top 10 (St. Joseph County) had a higher rate of elevated BLLs (85 per 1,000) in 2015 [ISDH 2015].
- In 2014, the percentage of children younger than 6 tested for blood lead in the county was 9%. The percentage of children participating in VCHD's blood lead screening program is declining, indicating the need for additional targeted blood lead testing. The number of children tested statewide has also declined from a high of 65,261 in 2007 to 40,811 in 2014 [ISDH 2014].




**The tested values (blue bars) refer to the number of participants (left axis labels) and percent children above 10 µg/dL (red line) refers to the Percent of Participants (right axis label). As a point of comparison: There are in 595 WIC children in 2015 and the state reports a total of 770 children tested in the county in 2015 [ISHD 2015].**

**Blood lead levels – evaluation within OU1 and OU2 and within Evansville.**

ATSDR worked with CDC, ISDH and the VCHD to obtain blood lead data for children ages 6 and younger for the period 1998 to 2006.

ATSDR did three evaluations (differentiated below) of blood lead levels using mapping. We mapped the location of higher blood lead levels, housing age, census block income, and soil concentrations. We used blood lead data from Vanderburgh County's 20,051 blood tests collected from 1998 to 2006 (Appendix A: Figures 6-8).

To map the geographic distribution of the children tested, children's home addresses were geo-coded. We cross-referenced with tax parcel information from the Vanderburgh County Assessor's office with the address to obtain the year the housing was built (Appendix A: Figure 7). Using ArcGIS software, we overlaid the blood lead testing locations with mapping and census data. In addition, we added data from historical maps of Evansville showing manufacturers that likely used lead in their processes. This data was presented to ISHD and VCHD on July 20, 2012, to help them investigate high risk households. There were three different analyses with the data based on different case definitions:

1) CDC's case per child methodology (some children multiple times per year and some for multiple years),
2) Case per child per address all years, (CDC cases that have addresses)
3) Case per child per address per year methodology [Jackson et al. 2012].

Since some children were retested the same year and some children moved during the period, the numbers of BLL samples were different for each case analysis. Limitations that result are discussed below.

We used Sat Scan software to find the strongest cluster of higher-than-usual blood lead levels. On average, the housing in the area delineated by Sat Scan was much older than that in other parts of Evansville. This is important because older housing is likely to contain lead-based paint.

Fewer than 7 percent of the children tested in the cluster area lived in homes built after 1978, compared with about 15 percent for the children tested outside the cluster area. We also found that block groups within the cluster area had a lower median income (~$26,060) compared with the other parts of Evansville (~$43,605) [U.S. Census 2000]. Figure 6 depicts an apparent association between higher BLLs and lower income blocks. While it also shows a shockingly high percentage (68%) of BLLs above CDC's reference value (of 5µg/dL), the case definitions differ in the datasets. The CDC reference range is a total US population representation from three national surveys and Figure 6 represents a convenience sample of 10,094 of the 20,051 individual blood tests reported over 9 (earlier) years for which we had addresses. Other limitations are discussed below.

### *Limitations of the BLL Evaluation*

Our evaluation had the following limitations:

- Lack of blood lead sampling for children living at many different residential properties;
- No information available for the large transient population of residents living at one or more properties for short periods of time (2-15 weeks);
- BLL data was reported as integers and the instrument was less accurate than CDC methods;
- There are 80 addresses for which we have BLLs and corresponding soil lead levels to correlate; and

- We do see a relationship between elevated BLL's and census block income (Figure 6). However, the apparent association might be the result of age of house due to the high relative risk of house age for elevated BLLs. (Census blocks with lower income also had older homes.)

The more recent blood lead data (2014-2017) from the county do not have addresses and cannot be compared directly the children BLLs in Jackson et al. 2012.

## Public Health Implications

### *Soil exposure*

The primary lead and arsenic exposure routes are direct or indirect soil ingestion of soil particles or dust. Through ingestion, soil containing lead and arsenic could get on hands and transfer to the mouth. By touching soil and then touching the mouth, food, drinks, and other items—including cigarettes—will allow contaminated soil and dust to enter the body. A portion will enter the body and blood stream. Children naturally put things in their mouths, and some children do this more than others.

Tracking contaminated surface soils into living spaces is another exposure route. People and animals could also track or carry contaminated soils and dust on clothes and dust into the house, into vehicles, or into other places they live, work, or play.

Some portions of the soil, especially bare spots, allow easier access to contamination and allow greater potential for exposure. Soil areas might become re-contaminated when

- deteriorating lead-based paint continues to chalk and flake on the outside of houses,
- older homes with lead-based paint are demolished or remodeled and can redeposit lead on the soil, garden, or other areas of the yard or home, or
- buried or covered lead or arsenic is disturbed and redeposits in surface soils, gardens, or other areas of a yard or home.

ATSDR observed several car batteries and wheel/tire weights in the community. Lead car-tire weights, lead pellets, and lead shot—if present in some yards and if swallowed—could result in acute lead-poisoning events.

### *Health effects of Lead*

There are several sources of lead that people in the Jacobsville neighborhood may be exposed to. Lead is highly toxic to people, pets and other animals. Today, lead is present in all parts of our environment [ATSDR 2007b]. It has no known beneficial effects in the body. Any level of lead exposure is currently considered harmful to people. Very low levels of lead that enter the body are believed to have significant health effects, especially to children and unborn babies [ATSDR 2007b]. The higher the amount of lead that enters the blood stream, the more severe the effects.

Lead can affect almost every organ and system in the body, although the main target for lead toxicity is the nervous system. In general, the level of lead in a person's blood gives a good indication of exposure to lead and correlates well with adverse health effects.

- *Health Effects in Children with Measurable Blood Lead Levels less than (<) 5 µg/dL and 10 µg/dL* - In studies with sufficient evidence of health effects, children with BLLs both < 5 µg/dL and < 10 µg/d, showed the following conditions: [CDC 2012].
    - Decreased academic achievement (< 5 µg/dL),
    - Decreased intelligence quotient (IQ) (< 5 µg/dL and < 10 µg/dL),
    - Decreased specific cognitive measures (< 5 µg/dL),
    - Increased incidence of attention-related and problem behavior (< 5 µg/dL),
    - Decreased hearing (< 10 µg/dL),
    - Reduced postnatal growth (< 10 µg/dL), and
    - Delays in puberty (< 10 µg/dL).

It is difficult to predict what health effects children with elevated BLLs could have in the future. Those children could experience an impact on academic achievement due to cognitive impairment and consequent problems with learning and attention. They could also have difficulty hearing.

Children with elevated BLLs need to have their behavior, cognition and attention evaluated by their primary care provider when deemed necessary. Some examples include when the child presents certain difficulties such as:

- a short attention span,
- has trouble concentrating, and
- gets overly excited in the classroom, as noted by the teacher and in the home as noted by parents.

These children should be fully evaluated by a Behavioral/Developmental Pediatrician when they test positive by the pertinent tests administered at school or by their primary care provider.

**Health Effects from Lead Exposure**

Children who come in repeated contact with lead might have:

- Slower growth and development
- Hearing damage
- Attention and learning problems

Review of the BL data for Evansville children shows that a large number of those tested are at risk for developing some of the health conditions described above.

- *Health Effects of Lead on Unborn Babies*: Lead crosses the placenta; consequently it can pass from a mother to her unborn baby. Follow-up testing, increased patient education, and environmental, nutritional and behavioral interventions are indicated for all pregnant women with blood lead levels (BLL) greater than or equal to 5 µg/dL to prevent undue exposure to the fetus and newborn [CDC 2012]. Too much lead in a pregnant women's body can lead to the following outcomes:
    - put her at risk for miscarriage,
    - cause the baby to be born too early or too small,
    - hurt the baby's brain, kidneys, and nervous system, and
    - cause the child to have learning or behavior problems.

## Arsenic

Most arsenic compounds have no smell or distinctive taste. Although elemental arsenic sometimes occurs naturally, arsenic usually appears in the environment in two forms—inorganic (i.e., arsenic combined with oxygen, chlorine, and sulfur) and organic (i.e., arsenic combined with carbon and hydrogen).

Arsenic is released to the environment through natural sources such as wind-blown soil and volcanic eruptions. But anthropogenic (i.e., human-made) arsenic sources release much higher amounts of arsenic than do natural sources. These anthropogenic sources include nonferrous metal mining and smelting, pesticide application, coal combustion, wood combustion, and waste incineration. The use of arsenic in treated lumber has been phased out through manufacturers voluntarily no longer using arsenic. In the past, arsenic was widely used as a pesticide; in fact, some pesticides still use organic arsenic compounds.

People might be exposed through incidentally ingesting arsenic in the soil. Generally, arsenic in uncontaminated soils ranges from 1–40 ppm, with a mean of 5 ppm [ATSDR 2007a]. Higher arsenic levels might occur near arsenic-rich geological deposits, some mining and smelting sites, or agricultural areas where arsenic pesticides were applied in the past.

### *Health effects of Arsenic*

Touching arsenic is usually not of concern because only a small amount will pass through skin and into the body (4.5% of inorganic arsenic in soil) [ATSDR 2007a]. The metabolism of inorganic arsenic has been extensively studied in humans and animals. Several studies in humans indicate that arsenic is well absorbed across the gastrointestinal tract (approximately 95% absorption for inorganic arsenic compounds and 75–85% for organic arsenic compounds) [ATSDR 2007a].

Non-cancer health effects that have associated with arsenic exposure in the scientific literature include a skin condition known as hyperkeratosis (or a darkening of the skin and the appearance of corns, or warts). Exposure to arsenic over prolonged periods of time may also be associated with red and white blood cell impacts, damage to blood vessels as well as cardiovascular effects (eg. abnormal heart rhythm) [ATSDR 2007a].

*JNSC Average arsenic soil levels:* The estimated arsenic exposure doses calculated for children (less than 21 years of age) exposed to arsenic in soil at 23 ppm at the JNSC site ranged from 0.00005 to 0.0003 mg/kg/day. The exposure dose is 0.00002 mg/kg/day (see appendix C).

Exposure doses for children and adults exposed to the mean arsenic concentration (23 ppm) did not exceed the ATSDR health guideline, or Minimal Risk Level (MRL) for arsenic of 0.0003 mg/kg/day). MRLs are health-protective doses at which it is unlikely for health effects to occur.

*JNSC Maximum arsenic soil levels:* The estimated arsenic exposure doses calculated for children exposed to arsenic in soil at 92 ppm at the JNSC site ranged from 0.0002 to 0.001 mg/kg/day and 0.00008 mg/kg/day for adults.

Exposure doses for adults exposed to the maximum arsenic concentration (92 ppm) did not exceed the ATSDR MRL. However, exposure doses for children (ages 1 to 11 years old) did exceed warranting further evaluation of their exposure scenario. Closer study of the childhood exposure doses indicated that doses associated with health effects in the available studies were considerably lower than those associated with the JNSC site. Non-cancer health effects associated with arsenic exposure are not expected.

The Department of Health and Human Services (DHHS), the International Agency for Research on Cancer (IARC), and EPA have all determined that inorganic arsenic is carcinogenic to humans (Appendix C: Arsenic non-cancer and cancer evaluation). Ingestion of inorganic arsenic can cause skin damage and increases the risk of skin, liver, bladder and lung cancer [ATSDR 2007a]. A report by the National Research Council suggests that the calculated risks based on increases in incidence of lung and bladder cancers could be greater than those calculated risks based on incidences of skin cancer [ATSDR 2007a].

Cancer risks for JNSC were calculated for arsenic using the EPA oral cancer slope factor of 1.5 $(mg/kg/day)^{-1}$. It should be noted that cancer risk estimates guide public health professions as to when health protective recommendations are needed. They are not an actual estimate of the cancer risk expected in this community.

At the JSNC site, adults exposed to arsenic in soil for 33 years had an estimated risk of 1 to 5 extra cancer cases among 100,000 people exposed for exposures to 23 ppm and 92 ppm, respectively. These values refer to the average and maximum residential measurements reported in the EPA’s 2009 Record of Decision (Appendix B, Table 1). This cancer risk is considered to be low. Childhood cancer estimates considered exposures throughout childhood (ages 1 to 21 years old). Children exposed to 23 ppm of arsenic had a calculated cancer risk of 4 extra cancer cases in 100,000 people exposed, also considered low. A slightly elevated cancer risk of two extra case among 10,000 exposed was estimated for children who ingested soil with 92 ppm of arsenic (Appendix C).

# Conclusions

## Conclusion 1- People contacting lead and arsenic in soil could be harmed: This presents a Health Hazard.

Young children who play in JNSC yards could swallow enough soil and dust containing lead to harm their health. Soil and dust that sticks to their hands is often swallowed because young children frequently bring their hands, fingers, and objects to their mouths. This activity and the high lead levels in JNSC yards increase their risk for health problems. Children, including the developing babies of pregnant women, are at greatest risk for harmful health effects from lead exposure. Pregnant women may be exposed to lead in soil while outside or from dust that is tracked inside of the home from the soil.

Children who come in repeated contact with lead might have

- slower growth and development,
- hearing damage, and
- attention and learning problems.

Too much lead in a pregnant women's body can

- put her at risk for miscarriage,
- cause the baby to be born too early or too small,
- hurt the baby's brain, kidneys, and nervous system, and
- cause the child to have learning or behavior problems.

The added cancer risk from exposure to average levels of arsenic in JNSC residential soils over a lifetime was low. Exposure to maximum levels of arsenic in soil is associated with a slightly elevated risk for cancer.

**Basis for Conclusion**

- **Lead and arsenic in JNSC yards:** EPA found lead and arsenic in soils of 13 Evansville neighborhoods. EPA clean-up of residential soils is ongoing; Approximately 4,000 properties were verified as contaminated. More than half have been cleaned up. Between 50 and 65 percent of properties that have been sampled require cleanup.
- **The average surface soil lead levels** were over 600 parts per million (ppm) based on sampling conducted in 2006, with levels as high as 8,210 ppm in some areas. Lead is not often detected in the background of Evansville. The extent of contamination has not been fully defined. Therefore, remediated soil may be re-contaminated by airborne dust and runoff.
- **Swallowing soil while playing** in contaminated JNSC yards could harm young children's health. They could have long-term health problems including slower growth and development, hearing damage, and trouble with attention and learning. Pregnant women and children may be exposed to lead in soil while outside or from dust that is tracked inside of the home from the soil. Too much lead in a pregnant woman's body can cause risks to mother and child, including risk of miscarriage and effects on child development.

- **Lead in locally grown garden vegetables and animals raised for food**: Lead and other metals can be taken up in plants and in animals grazing on contaminated soils. Consuming poultry, eggs, and vegetables could be a concern for some areas of Evansville where lead and arsenic in soil are present at very high concentrations, however, no data was available to fully evaluate these exposures for people in Evansville. Raising livestock has been prohibited by Evansville City Code ordinances since 2010. Chickens and other poultry may still be keep in coops and allowed to roam and feed in fenced yards.

- **Extra cancer risk from exposure to arsenic in soil**: Arsenic is a known human carcinogen. Cancer risks were calculated for ingestion of arsenic using the EPA oral cancer slope factor of 1.5 $(mg/kg/day)^{-1}$ which is based on skin cancer. Adults, assumed to be exposed for 33 years, had an estimated risk of 1 to 5 extra cancer cases among 100,000 people exposed for exposures to 23 ppm (the residential average for operable unit 1 [OU1]) and 92 ppm (the residential maximum), respectively. This cancer risk is considered to be low. Childhood cancer estimates considered exposures throughout childhood (ages 1 to 21 years old). Children exposed to 23 ppm of arsenic had a calculated cancer risk of 3 extra cancer cases in 100,000 people exposed, also considered low. A slightly elevated cancer risk of 2 extra cases among 10,000 exposed was estimated for children who ingested soil with 92 ppm of arsenic (See appendix C).

**Next Steps**

**Community members need to:**

- **Reduce exposure:** Because no level of lead in children's blood has been proven safe, ATSDR and CDC recommend reducing lead exposure wherever possible. ATSDR recommends reducing your exposure (particularly if you are pregnant) and your children's contact with lead in soil and from other sources such as flaking or peeling lead paint and dust.
  - After working or playing in the yard
    - take shoes off before entering the home
    - use a damp cloth or damp/wet mop to remove dust and dirt from the home
    - wash hands, wash toys and wash pets
  - Create a raised bed and fill with clean soil for gardening to reduce exposures from gardening and digging. Rinse produce well to remove garden soil.
  - Ensure that any grazing and free-ranging animals be kept in areas with amended soils to prevent lead uptake.
- **Reduce lead absorption:** Eating a nutritious diet might help to reduce lead absorption. Eat several small meals per day (appropriate for age and growth) rich in iron, calcium, vitamins C & D and zinc from such foods as dairy products, green vegetables, and lean meats. Proper nutrition is particularly important for children and pregnant women.
- **Get yard tested:** To find out if you or your children are at greater risk for higher BLLs, allow EPA access to your property to test the soil.

- **Follow safe renovation guidelines:** If you live in older housing, ATSDR recommends following EPA's [Lead Renovation, Repair, and Painting Rule (RRP Rule)] to lower the risk of lead contamination from home renovation activities.
- A**TSDR recommends residents in older homes have their water tested for lead.** If you live in older housing, flush water lines for 30 seconds up to two minutes before using the water for drinking or cooking to reduce exposure to lead in drinking water. (See http://evansvillegov.org/index/asp?=2405 or http://www.epa.gov/safewater/lead or call EPA's Safe Drinking Water Hotline at 1-800-426-4791).
- **Find additional general information** about lead at the following EPA web site: www.epa.gov/lead/learn-about-lead.html, answers general questions about lead testing procedures.
- **Reduce exposures** to arsenic in soil by following similar practices to reduce lead exposures.

**EPA will:**

- Continue soil remediation to reduce lead and arsenic levels and protect public health.

**Vanderburgh County Health Department (VCHD) will:**

- Continue working with the community to help identify and reduce lead exposure.
- Continue to educate the community to improve community participation in the lead surveillance program.

## Conclusion 2 –High blood lead levels in children indicate elevated lead exposures: This presents a Health Hazard.

ATSDR reviewed BLL data from the Vanderburgh County Health Department (VCHD) and the Indiana State Department of Health and found that children in Vanderburgh County had higher BLLs compared to children statewide. ATSDR identified several factors associated with the increased risk of higher BLLs including age of housing, contaminated soil, poverty, and race.

**Basis for Conclusion**

**Elevated BLLs**

- **Children of Vanderburgh have elevated blood lead exposure risks:**
    - From 1998-2006, several children with living in Evansville and in the region of OU1 and OU2 had BLL's exceeding CDC's blood lead reference level of 5 µg/dL (shown in Figure 6).
    - From 2014-2015, nearly 7% of the county children had BLLs exceeding the CDC's reference level of 5 µg/dL compared with about 4% of the state.
    - From 2014-2017, about 4% of county high risk children had BLLs exceeding 10 µg/dL; while not directly comparable, less than 1ess than 1 % of the state's children were above 10 µg/dL in 2014 and 2015.

- **Low testing rate:** In 2014, the percentage of children younger than 6 tested for blood lead in the county was 9%. The percentage of children participating in VCHD's blood lead screening program is declining, indicating the need for additional outreach for blood lead testing.

**Additional factors associated with the increased risk of higher BLLs in JNSC neighborhoods**:

- more than 64% live in older housing where lead can be found in the paint and plumbing
- nearly 21% live in poverty
- about 27% of people living in OU2are black (compared with 11% black within all of Evansville).

These are additional factors associated with the likelihood of increased risk for higher BLLs along with exposure to lead-contaminated soil.

**Next Steps**

**Community members need to:**

- **Test blood for lead:** ATSDR recommends blood lead testing as soon as is practical for people who live in or routinely visit the Evansville community, who haven't had a blood lead test in the past 6 to 12 months, and who are in the following groups:

    - women who are pregnant
    - women who want to become pregnant
    - children who are under 6 years of age

  VCHD offers free yearly blood lead screening and educational programs.

- **Take action:** ATSDR recommends that children with BLLs of 5 µg/dL or higher be evaluated by a health care provider. As part of the evaluation, ATSDR recommends that the provider determine the child's exposure history.

**Vanderburgh County Health Department (VCHD) will continue to:**

- Investigate elevated BLL in homes and residences.
- **Educate people on the need for blood lead testing.**
  While VCHD offers free blood lead testing to area children, community participation in this program has been low. ATSDR recommends VCHD (and, as appropriate, EPA) take additional steps to increase the participation rate of eligible children in the blood lead testing program.

## Public Health Action Plan (PHAP) for the JNSC Site, Evansville, Indiana

The public health action plan (PHAP) for the Jacobsville Neighborhood Soil Contamination (JNSC) site describes key actions taken (and ongoing) by ATSDR, EPA, ISDH, IDEM and VCHD near the site subsequent to the completion of this public health assessment. The purpose of the PHAP is to ensure that this public health assessment identifies potential and on-going public health hazards, and provide a plan of action designed to prevent adverse human health effects resulting from exposure to hazardous substances in the environment. If JNSC site conditions change and any significant data or information becomes available, ATSDR offers our assistance to evaluate and review new findings.

The following public health actions for the Jacobsville Neighborhood Soil Contamination Site were undertaken (many of these actions are still continuing in this community):

- ATSDR conducted a Webinar for the VCHD and the ISHD on July 20, 2012, on how to use GIS to evaluate surveillance data to target health education and recruitment for VCHD's Blood Lead Screening Program.
- ATSDR conducted a soil-shop in June 2014 for the JNSC site with assistance from the VCHD, EPA Region 5, EPA Cincinnati, ISDH, IDEM and ATSDR Region 5.
- VCHD and ATSDR conducted community health education outreach events (e.g., National Neighborhood Night Out, July 2015).
- EPA sampling and soil remedial/removal activities were conducted and continue at the site.
- EPA held and continues to hold public meetings in the JNSC community that are attended by VCHD, ISDH, IDEM, and/or ATSDR.
- VCDH continues to offer public health education programs.
- VCHD continues to offer free blood lead screening.
- City of Evansville continues regulatory tap water sampling and analyses (approximately 10%) and with guidance from VCHD and ATSDR. Individuals in the community were and are encouraged to test their tap water.
- In 2017, The city of Evansville passed an ordinance to accept the powers and procedures for reporting, monitoring, and preventing lead poisoning set forth by the State of Indiana, including giving the health officer the authority to issue citations with fines [Evansville 2017].
- In 2018, VCHD received a $675,000 grant award from the state to remediate homes with lead-based paint.

**For More Information:**

- VCHD: For public health information, call VCHD at (812) 435-2400.
- ATSDR: If you have questions or comments, call ATSDR's regional office director, Mark Johnson, at (312) 353-3436 or our toll-free number at 1-800-CDC-INFO and ask for information on the Jacobsville Neighborhood Soil Contamination Site, Evansville, Indiana.
- EPA: If you have concerns about the JNSC site, you can contact EPA Region 5 at 800-621-8431, ext. 67472 and leave a message. This line is operational 24-hours a day.

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## References

[ATSDR 2007a] Agency for Toxic Substances and Disease Registry. 2007a. Toxicological profile for arsenic (update). Atlanta: US Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp2.html.

[ATSDR 2007b] Agency for Toxic Substances and Disease Registry. 2007b. Toxicological profile for lead (update). Atlanta: US Department of Health and Human Services. Available at: http://www.atsdr.cdc.gov/toxprofiles/tp13.html.

[ATSDR 2016] Agency for Toxic Substances and Disease Registry. 2016. Exposure Dose Guidance for Soil Ingestion. Atlanta, GA: U.S. Department of Health and Human Services, Public Health Service, October 26.

[ATSDR 2017] Agency for Toxic Substances and Disease Registry, Activity of Record for the Jacobsville Neighborhood Soil Contamination Site, August 30, 2017.

[Casteel et al. 1997] Casteel SW, Brown LD, Dunsmore ME, Weis CP, Henningsen GM, Hoffman E, Brattin WJ, Hammon TL. 1997. Relative bioavailability of arsenic in mining wastes. Document control number: 4500-88-AORH. Prepared for US Environmental Protection Agency, Region VIII, Denver, Colorodo. Cited in Battelle and Exponent. 2000. Final guide for incorporating bioavailability adjustments into human health and ecological risk assessments at US Navy and Marine Corps Facilities. Part 1: overview of metals bioavailability. Prepared for Naval Facilities Engineering Service Center and Engineering Field Activity West.

[CDC 2015] U.S. Centers for Disease Control and Prevention. CDC Lead web page. Last Updated May 29, 2015 Available online@ http://www.cdc.gov/nceh/lead/tips/sources.htm

[CDC 2013] Centers for Disease Control and Prevention. 2013. Blood lead levels in children aged 1–5 years — United States, 1999–2010 (April 5, 2013). MMWR: Morbidity and Mortality Weekly Report 62(13):245-248. Available at: http://www.cdc.gov/mmwr/preview/mmwrhtml/mm6213a3.htm?s_cid=mm6213a3_e

[CDC 2012] Centers for Disease Control and Prevention. 2012. CDC Response to the Advisory Committee on Childhood Lead Poisoning Prevention (ACCLPP) Recommendations on Low Level Lead Exposure and Primary Prevention of Lead Poisoning http://www.nchh.org/Portals/0/Contents/CDC_Response_Lead_Exposure_Recs.pdf. And http://www.nchh.org/Portals/0/Contents/NCHH%20CDC%20ACCLPP%20Response%20Summ ary%20Chart.pdf.

[CDC 2005] Centers for Disease Control and Prevention. 2005. http://www.cdc.gov/nceh/lead/ACCLPP/Final_Document_011212.pdf. Atlanta: US. Department of Health and Human Services;

[CH2M HILL 2007] Ecology and Environmental International, Inc. and Teska Associates Inc. Final Feasibility Study Report, Jacobsville Neighborhood Soil Contamination Site, Evansville, Indiana; January 2007.

[Chaney et al. 1989] Chaney RL, Mielke HW, Sterrett SB. 1989. Speciation, mobility, and bioavailability of soil lead. Environmental Geochemistry and Health, 11 (Suppl.), 105–129.

[EPA 2003] Environmental Protection Agency. 2003d. Integrated exposure uptake biokinetic model for lead in children (IEUBKwin v1.0). U.S. EPA OERR Office of Emergency and Remedial Response: Washington, D.C.

[EPA 2012a] US Environmental Protection Agency. 2012a. Lead: Enforcing Lead Laws and Regulations online at http://www.epa.gov/lead/pubs/enforcement.html. Last accessed October 2, 2012.

[EPA 2012b] US Environmental Protection Agency Region 5. 2012b. September 6, 2012. Jacobsville Neighborhood Contamination Gateway Home Page. Available online at http://www.epa.gov/region5/cleanup/jacobsville/.

[EPA 2012c] US Environmental Protection Agency Region 5. 2012c. July 2012 Jacobsville Neighborhood Contamination -- Cleanup Site Profile Available online at http://www.epa.gov/R5Super/npl/indiana/INN000508142.html.

[EPA 2012d] US Environmental Protection Agency. 2012d. December 2012. Recommendations for Default Value for Relative Bioavailability of Arsenic in Soil. OSWER 9200.1-113.

[EPA 2011] US Environmental Protection Agency Region 5. 2011. Fact Sheet: Superfund Program Implements the Recovery Act, Jacobsville Neighborhood Contamination, Evansville, Indiana. Available online at http://www.epa.gov/superfund/eparecovery/jacobsville.html.

[EPA 2009] U.S. Environmental Protection Agency Region 5. 2009. Jacobsville Neighborhood Soil Contamination Site, Evansville, Indiana, Vanderburgh County Record of Decision.

[EPA 2006] United States Environmental Protection Agency Region 5. 2006. Final Remedial Investigation Report, Jacobsville Neighborhood Soil Contamination Site, Evansville Indiana.

[Evansville 2017] Lead poisoning standards. City of Evansville Municipal Code 8.05.260. Lead poisoning enforcement and violations. Municipal Code 8.05.270 [Ord. G-2017-23 § 1, passed 9-15-17.]

[Freeman et al. 1995] Freeman GB, Schoof RA, Ruby MV, et al. 1995. Bioavailability of arsenic in soil and house dust impacted by smelter activities following oral administration in cynomolgus monkeys. Fundam Appl Toxicol. 28(2):215-222. Cited in Battelle and Exponent. 2000. Final guide for incorporating bioavailability adjustments into human health and ecological risk assessments at US Navy and Marine Corps Facilities. Part 1: overview of metals bioavailability. Prepared for Naval Facilities Engineering Service Center and Engineering Field Activity West.

[Freeman et al. 1993] Freeman GB, Johnson JD, Killinger JM, et al. 1993. Bioavailability of arsenic in soil impacted by smelter activities following oral administration in rabbits. Fundam

Appl Toxicol. 21(1):83-88. Cited in Battelle and Exponent. 2000. Final guide for incorporating bioavailability adjustments into human health and ecological risk assessments at US Navy and Marine Corps Facilities. Part 1: overview of metals bioavailability. Prepared for Naval Facilities Engineering Service Center and Engineering Field Activity West.

[Groen et al. 1994] Groen K, Vaessen H, Kliest JJG, et al. 1994. Bioavailability of Inorganic Arsenic from Bog Ore-Containing Soil in the Dog. Environ. Health Perspect., 102(2): 182–84. Cited in Battelle and Exponent. 2000. Final guide for incorporating bioavailability adjustments into human health and ecological risk assessments at US Navy and Marine Corps Facilities. Part 1: overview of metals bioavailability. Prepared for Naval Facilities Engineering Service Center and Engineering Field Activity West.

[Health Canada 1993] Canadian Environmental Protection Act. 1993. Priority substances list assessment report: arsenic and its compounds. Government of Canada, Environment Canada. Available at: http://www.hc-sc.gc.ca/ewh-semt/pubs/contaminants/psl1-lsp1/arsenic_comp/index_e.html.

[ISDH 2012] Sunny Start, Healthy Bodies and Healthy Minds 2012. Indiana State Department of Health; http://www.in.gov/isdh/files/Sunny_Start_2012_Environmental_Report.pdf .

[ISDH 2014] Indiana State Department of Health, Lead & Healthy Homes Program. 2014 Surveillance Report. Available at: http://www.in.gov/isdh/files/Lead_Report_2014.pdf Accessed September 5, 2017

[ISDH 2015] 2015 Childhood Lead Surveillance Report, Environmental Public Health Division Lead & Healthy Homes Program. 10 Years of Childhood Blood Lead Level Data in Indiana. Available at: https://www.in.gov/isdh/files/Lead_Report_2015_w_reportable_disease.pdf Accessed September 5, 2017

[Ismail SA and Abolghait SK, December 2013] Estimation of Lead and Cadmium residual levels in chicken giblets at retail markets in Ismailia city, Egypt. Int.Jour Vet Sci and Med. V1 Issu 2. *(pp109-112)*, Dec 2013.

[Jackson et al. 2012] Jackson D, Grosse C, Zarus GM, Rosales-Guevara L, 2012. Higher blood lead levels among children living in older homes in Evansville Indiana: associations between year house built, soil lead levels and blood lead levels among children aged 1-5 years 1998 to 2006. Spanish Association of Environmental Health. Rev. salud ambient: 12(1)34-45.

[Rodriguez et al. 2000] Rodriguez RR, Basta NT, Casteel SW, et al. 2000. An In Vitro Gastrointestinal Method to Estimate Bioavailable Arsenic in Contaminated Soils and Solid Media. Environ. Sci. Technol., 33(4): 642-649. Cited in Battelle and Exponent. 2000. Final guide for incorporating bioavailability adjustments into human health and ecological risk assessments at US Navy and Marine Corps Facilities. Part 1: overview of metals bioavailability. Prepared for Naval Facilities Engineering Service Center and Engineering Field Activity West.

[Rowden et al. 2011] Rowden AK. 2011. Pathophysiology and etiology of lead toxicity. Medscape Reference, Drugs, Diseases, and Procedures. Available at: http://emedicine.medscape.com/article/2060369-overview

[Ryan et al. 2004] Ryan JA, Scheckel KG, Berti WR, Brown SA, Casteel SW, Chaney RL, Hallfrish J, Doolan M, Grevatt P, Maddaloni M, Mosby M. 2004. Reducing children's risk from lead in soil. Environmental Science & Technology. American Chemical Society. 19-24A. January 2004.

[Spliethoff et al. 2013] Spliethoff HM; Mitchell RG, Ribaudo LN, Talyor LN, Shayler HA, Green V, Oglesby D. Lead In New York City Community Garden Chicken Eggs: Influential Factors and Health Implications. Environmental Geochemistry, Nov 2013 (Online Early Access).

[Sterrett et al. 1996] Sterrett SB, Chaney RL, Gifford CH, Mielke HW. 1996. Influence of fertilizer and sewage sludge compost on yield and heavy metal accumulation by lettuce grown in urban soils Environmental Geochemistry and Health, 18, 135-142.

[U.S. Census 2000] Demographic Trends and selected housing characteristics. census.gov

[U.S. Census 2010] Demographic Trends and selected housing characteristics. census.gov

[U.S. Census 2012] Selected housing characteristics, American Community Survey, 5-year estimates. August 2012.

[U.S. Census 2014-2015] Selected housing characteristics, American Community Survey, 1-year supplemental estimates.

## Appendix A: Figures 3–8

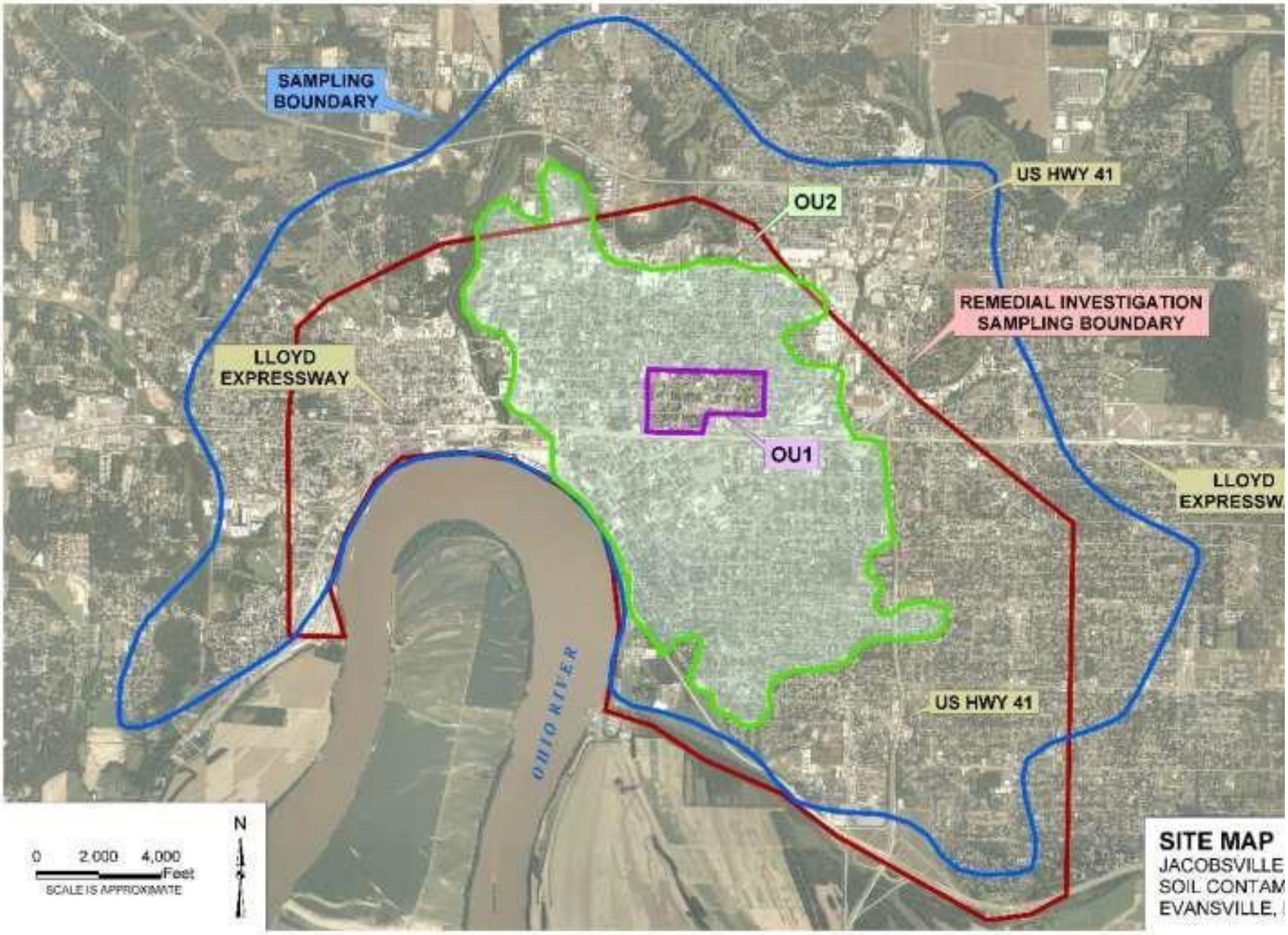
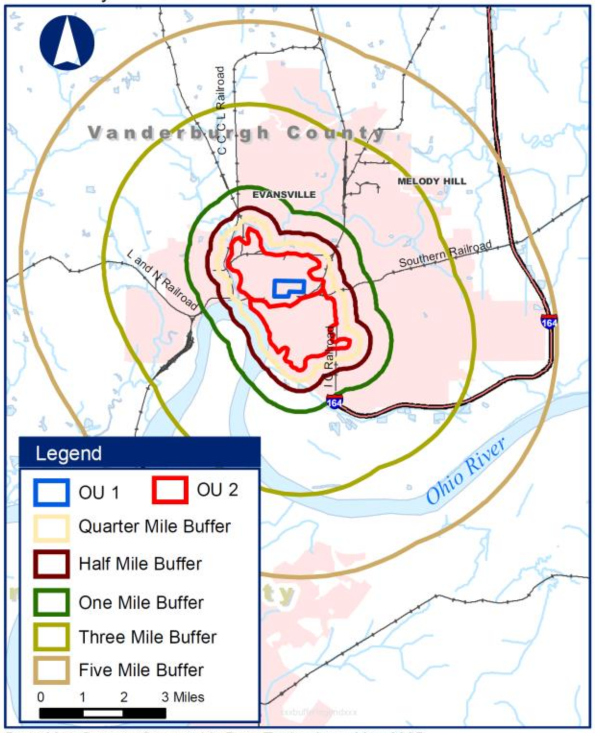



**Figure 3. Operable Units 1 (OU1) and OU2 Areas of the Jacobsville Neighborhood Soil Contamination Site, Evansville, Indiana.**

Note: The current sampling boundary could result in another expansion of the OU2 boundary.

## Jacobsville Neighborhood Soil Contamination
Evansville, IN

EPA Facility ID: IND000508142



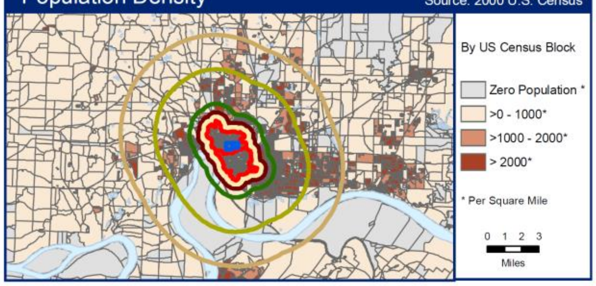

Site Location: Vanderburgh County, IN


| Demographic Statistics Within Area of Concern* | Within OU1 | Within OU2 | .25mi | .5mi | 1mi |
|---|---|---|---|---|---|
| Total Population | 1,270 | 24,701 | 31,784 | 40,023 | 57,072 |
| White Alone | 1,101 | 17,340 | 22,660 | 30,164 | 45,964 |
| Black Alone | 138 | 6,659 | 8,204 | 8,714 | 9,499 |
| Am. Ind. & AK Nat. Alone | 8 | 87 | 98 | 119 | 155 |
| Asian Alone | 2 | 72 | 87 | 123 | 258 |
| Native Hawaiian & Other Pacific Is. Alone | 0 | 14 | 18 | 19 | 25 |
| Other Race Alone | 6 | 100 | 132 | 174 | 257 |
| Two or More Race | 16 | 430 | 585 | 710 | 914 |
| Hispanic or Latino** | 13 | 293 | 381 | 489 | 678 |
| Child. (6 & Younger) | 153 | 2,355 | 3,094 | 3,876 | 5,365 |
| Adults (65 & Older) | 111 | 13,695 | 4,593 | 5,809 | 8,547 |
| Femal. (15 to 44) | 296 | 5,168 | 6,765 | 8,697 | 13,141 |
| Total Housing Unit | 676 | 12,190 | 15,496 | 19,498 | 26,904 |

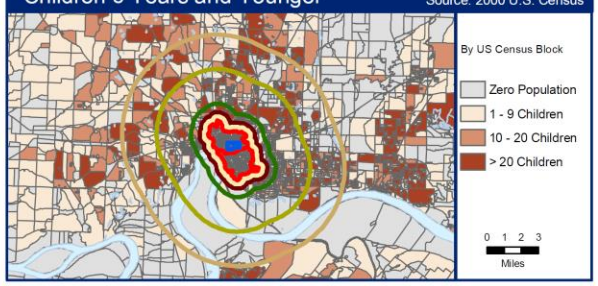
Base Map Source: Geographic Data Technology, May 2005.
Site Boundary Data Source: ATSDR Geospatial Research, Analysis, and Services Program, Current as of Generate Date (bottom left-hand corner).
Coordinate System (All Panels): NAD 1983 StatePlane Indiana West FIPS 1302 Feet

Demographics Statistics Source: 2000 U.S. Census
* Calculated using an area-proportion spatial analysis technique
** People who identify their origin as Hispanic or Latino may be of any race.

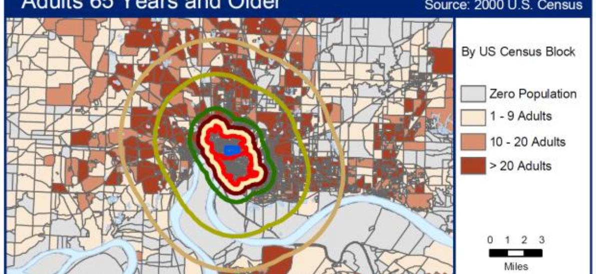
Population Density — Source: 2000 U.S. Census




Children 6 Years and Younger — Source: 2000 U.S. Census




Adults 65 Years and Older — Source: 2000 U.S. Census




Females Aged 15 to 44 — Source: 2000 U.S. Census

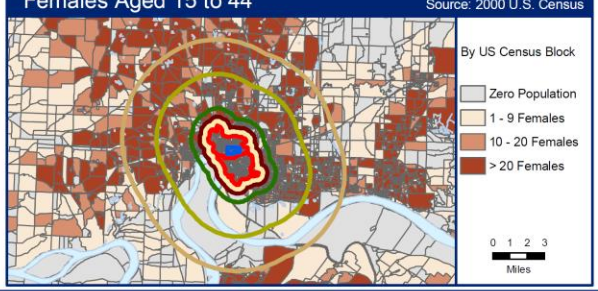



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**Figure 4. 2000 Demographics, Jacobsville Neighborhood Soil Contamination Site, Evansville, Indiana.**

# Jacobsville Neighborhood Soil Contamination

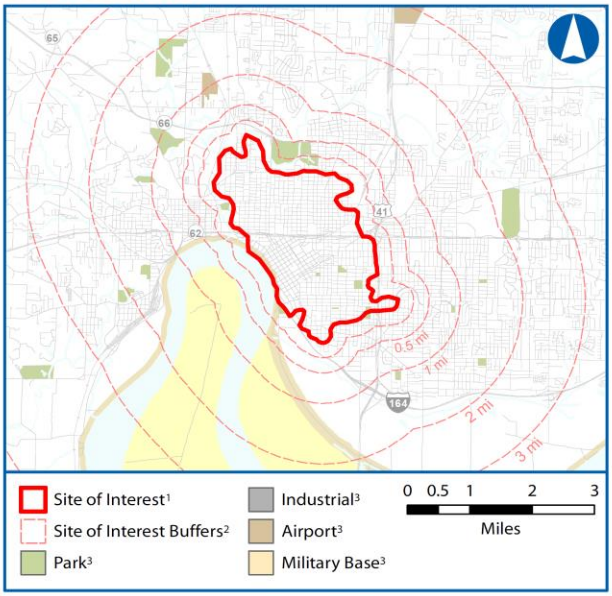
EPA FACILITY ID INN000508142

INTRODUCTORY MAP SERIES

## Evansville, Vanderburgh County, IN

## GENERAL SITE PROFILE

### Site Vicinity Map



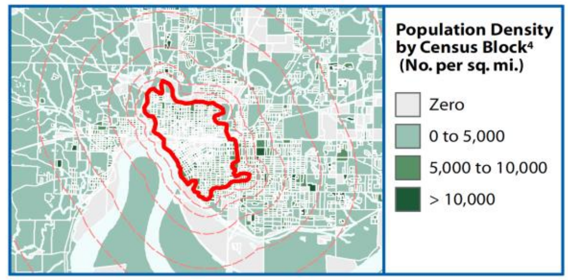

The **General Site Profile Map** depicts the hazardous waste site of interest, along with any airport, industrial, military, or park land uses. It also provides community demographic and housing statistics.

### Demographic Statistics[4,5]

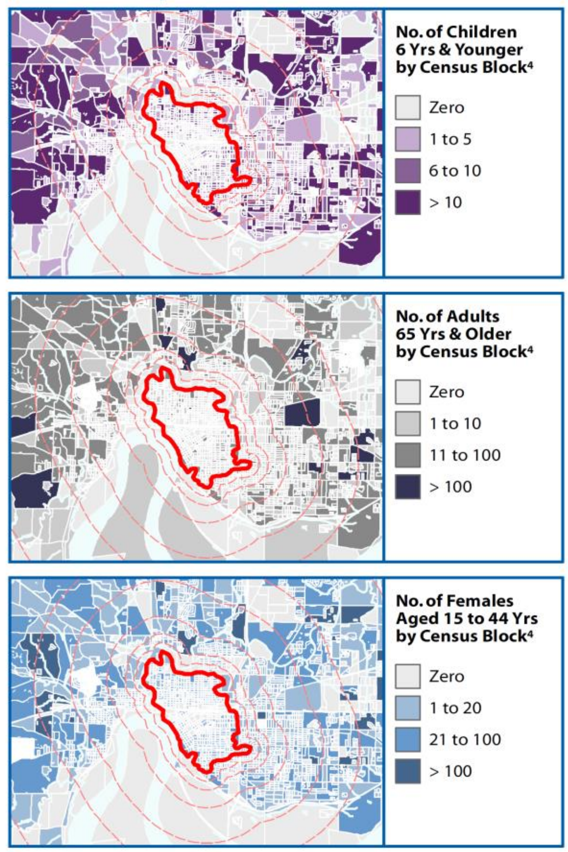
Within 1 Miles buffer of site boundary

| Measure | 2000 | 2010 | Change |
|---|---|---|---|
| Total Population | 57,542 | 52,861 | -8% |
| White Alone | 46,383 | 40,358 | -12% |
| Black Alone | 9,531 | 9,577 | +0% |
| Am. Indian & Alaska Native Alone | 156 | 168 | +7% |
| Asian Alone | 268 | 250 | -6% |
| Native Hawaiian & Other Pacific Islander Alone | 25 | 45 | +80% |
| Some Other Race Alone | 255 | 674 | +164% |
| Two or More Races | 921 | 1,789 | +94% |
| Hispanic or Latino[6] | 677 | 1,283 | +89% |
| Children Aged 6 and Younger | 5,398 | 5,146 | -4% |
| Adults Aged 65 and Older | 8,712 | 6,769 | -22% |
| Females Aged 15 to 44 | 13,238 | 11,238 | -15% |
| Housing Units | 27,201 | 26,100 | -4% |
| Housing Units Pre 1950 | 32,462 | 16,735 | -48% |

### General Population Density




### Sensitive Populations




**Data Sources:** [1]ATSDR GRASP Hazardous Waste Site Boundary Database. [2]ATSDR GRASP. [3]TomTom International BV (2012). [4]US Census 2010. **Notes:** [5]Calculated using area-proportion spatial analysis method. [6]Individuals identifying origin as Hispanic or Latino may be of any race.
**Projection:** Projection used for all map panels is NAD 1983 StatePlane Indiana West FIPS 1302 Feet.

PRJ 03727 JXA0 4/14/17

GRASP

Agency for Toxic Substances and Disease Registry

Division of Toxicology and Human Health Sciences

ATSDR

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**Figure 5. 2010 Demographics, Jacobsville Neighborhood Soil Contamination Site, Evansville, Indiana.**

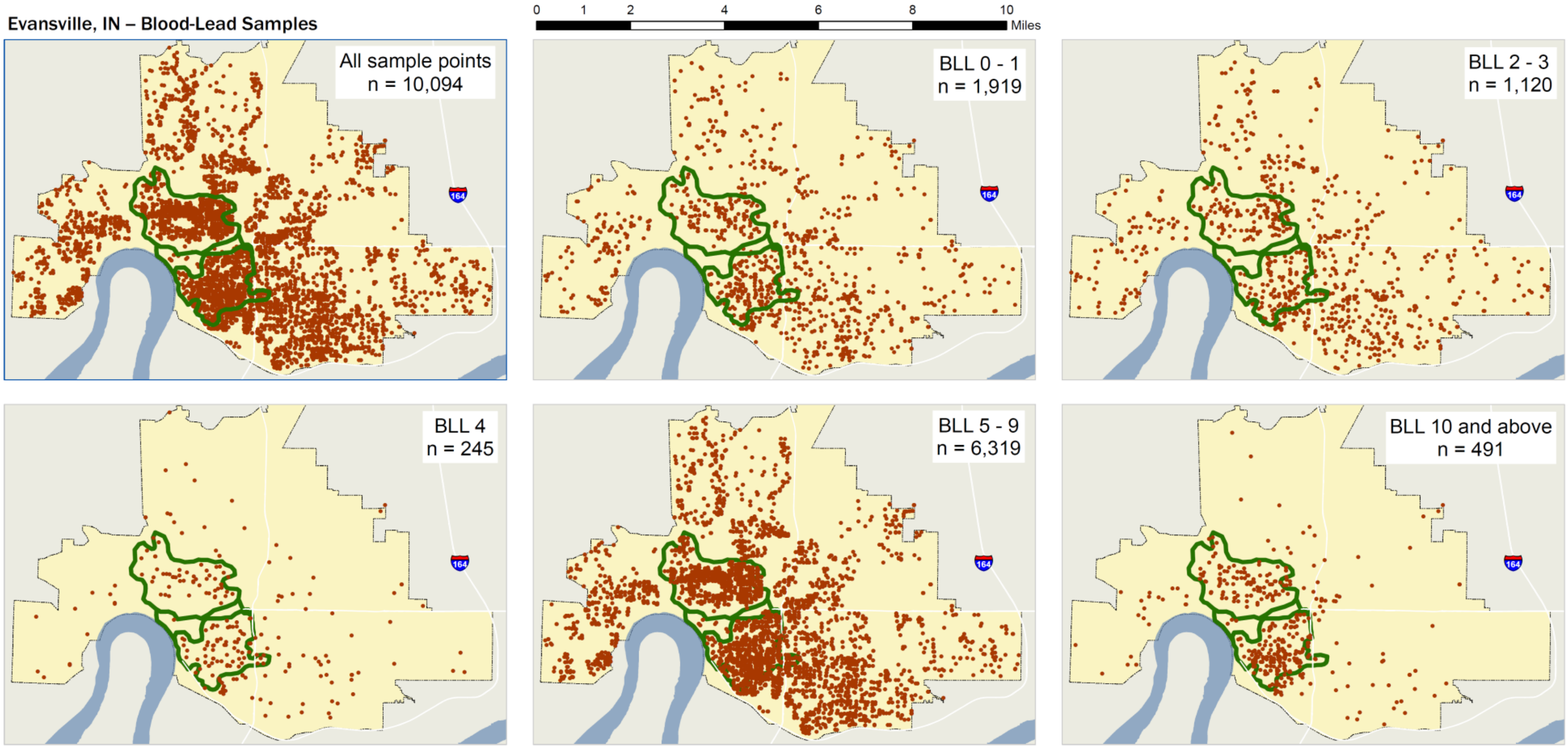


**Figure 6. 1998-2006 Blood-Lead Levels (BLL) Observed in Evansville, Indiana [Jackson et al. 2012]. BLL 0-1 (etc.) indicates BLL measurements of 0-1 µg/dL. Sample results were reported as whole numbers (0,1,2,3,…). The minimum BLL value in the dataset was zero. n = 10,094 refers to 10,094 sample results from children aged 1-5 years of age at a specific address within this Evansville area. The location of EPA operable units are within green boundary lines.**

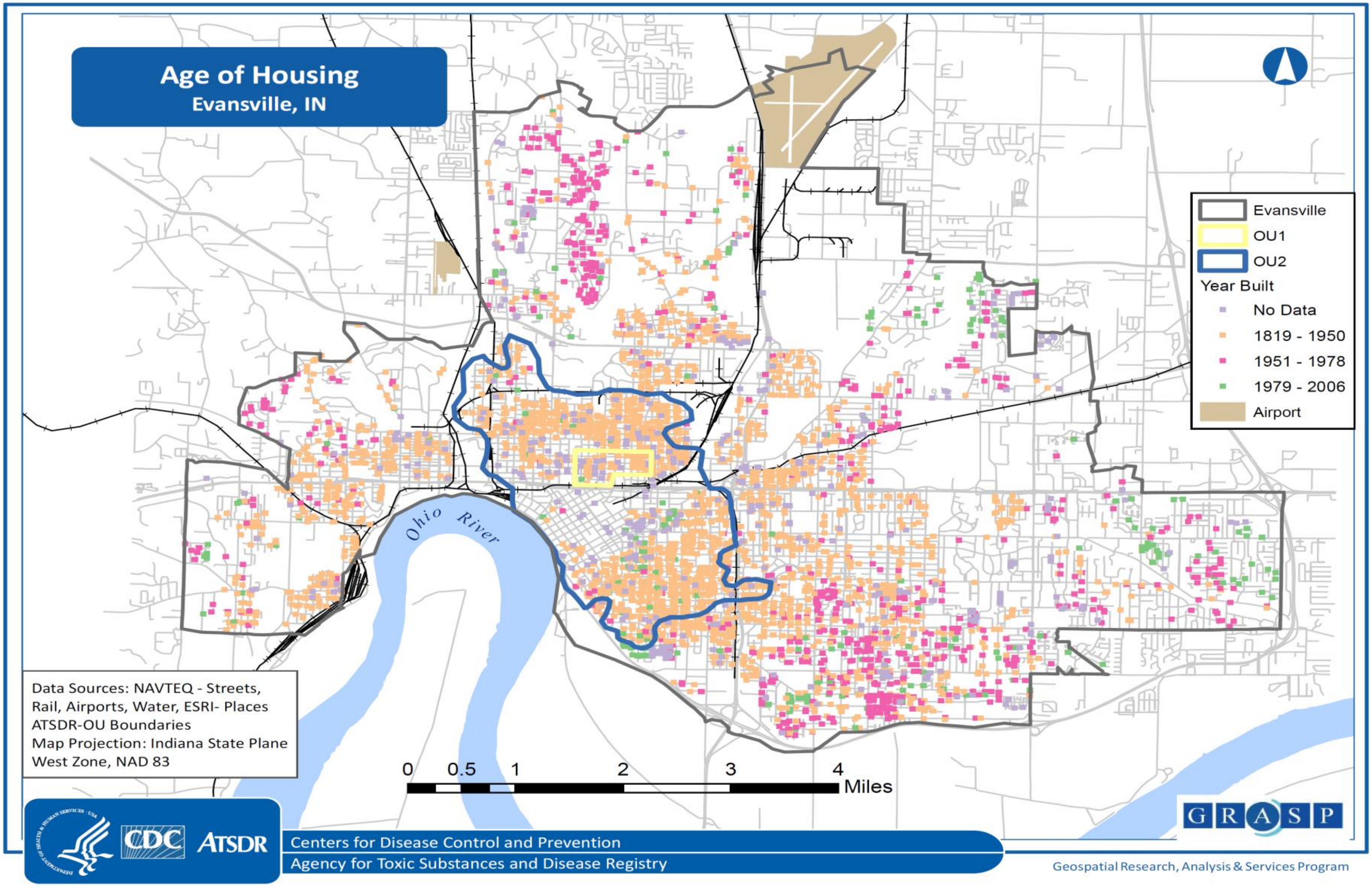


**Figure 7. Age of Housing, Jacobsville Neighborhood Soil Contamination Site, Evansville, Indiana [U.S. Census 2012; U.S. Census 2014-2015]. Color codes indicate the date ranges during which the homes were built.**

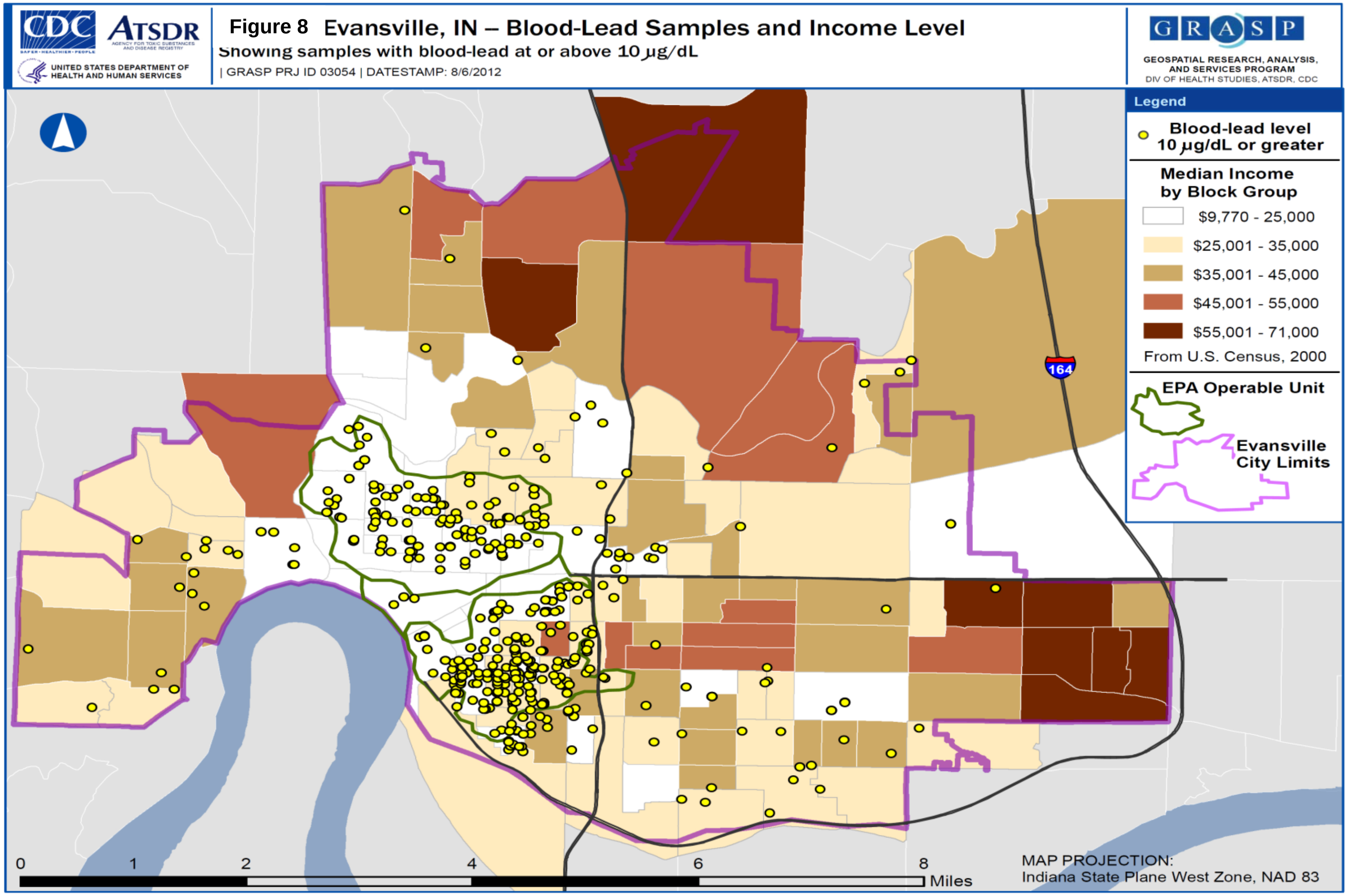


**Figure 8. 1998-2006 Blood Lead Levels Greater or Equal to 10 µg/dL and Median Income Levels, Evansville, IN, Census 2000.**

## Appendix B: Soil and Modeling Analysis

## Table 1 - Lead and arsenic levels by depth and location

Lead and Arsenic in Residential and High Access Areas in Surface Soil at the Jacobsville Neighborhood Soil Contamination Site, Evansville, Indiana.

| *Contaminant and Sample Location* | *Exceedances/ (# of Samples above the JNSC Cleanup Standard)*[1] | *Range of Results (ppm) (Average)*[2] |
|---|---|---|
| Residential Yards | | |
| Lead (0 to 2 inches) Drip Line Zone | 25/26 | 20 - 8210 (2789) |
| Lead (0 to 2 inches) | 20/28 | 136 - 1900 (604) |
| Lead (0 to 6 inches) | 19/28 | 88 - 1070 |
| Lead (6 to 12 inches) | 8/28 | 49.8 – 2040 |
| Lead (12 to 18 inches) | 0/28 | 29.9 – 371 |
| Arsenic (0 to 2 inches) | 1/28 | 3.9 - 31.2 (10.7) |
| Arsenic (0 to 6 inches) | 1/28 | 2.5 - 31.8 |
| Arsenic (6 to 12 inches) | 2/28 | 7 – 37 |
| High Access Areas (Day Cares and Other Areas (Parks, Playgrounds, Schools, Ball Fields)) Surface Soil (0 to 2 inches) Results | | |
| Day Care Lead | 7/7 | 23.4 - 145 |
| Day Care Arsenic | 7/7 | 9.6 - 13.4 |
| Lead | 70/70 | 9.3 – 1520 |
| Arsenic | 70/70 | 4.1- 18.2 |

Source: EPA 2006 Remedial Investigation, EPA 2009 Record of Decision

Notes: Only contaminants that exceed their respective EPA Cleanup values are presented in the table.

1 Exceedances/Detects represents the number of times a contaminant level exceeds its respective screening value the JNSC Site Cleanup Standard (400 ppm for lead and 30 ppm for arsenic) over the total number of samples.

2 Numbers in parentheses represent arithmetic mean (average) concentration for detectedvalues.

| **Table 1 Continued —— <u>Lead Concentrations in ppm</u>**; Lead Summary for Selected Data Reported in Jacobsville Soil Contamination Site, Combined XRF and Laboratory Results [EPA 2006; EPA 2009]. | | | | | |
|---|---|---|---|---|---|
| Area | Residential | Daycare | Park | Play Ground | Commercial /Industrial |
| OU1 per property basis | Range 20-8,210<br><br>Average 373 | Range NA<br><br>Average NA | Range 217<br><br>Average 217 | Range 63-411<br><br>Average 192 | Range 50-606<br><br>Average 297 |
| OU2 per property basis | Range ND-7,910<br><br>Average 403.4 | Range 23.4-145<br><br>Average 85.2 | Range 56.9-182.8<br><br>Average 99.4 | Range 30-532<br><br>Average 140 | Range NA<br><br>Average NA |
| Gap (TBD) area per property basis | Range NA<br><br>Average NA | Range NA<br><br>Average NA | One sample 42<br><br>Average NA | Range NA<br><br>Average NA | Range 106.12-118.13<br><br>Average 110 |

| **Table 1 continued —— Arsenic Concentrations in ppm**; Arsenic Summary for Selected Data Reported in Jacobsville Soil Contamination Site, Combined XRF and Laboratory Results for Composite Samples. Arsenic results will measure lower than present because lead levels are above 10 ppm for XRF samples. | | | | | |
|---|---|---|---|---|---|
| Area | Residential | Daycare | Park | Play Ground | Commercial /Industrial |
| OU1 per property basis | Range ND-92<br><br>Average 15.2 | Range NA<br><br>Average NA | Range NA<br><br>Average NA | Range ND-45<br><br>Average 15.7 | Range ND<br><br>Average ND |
| OU2 per property basis | Range ND-68.2<br><br>Average 23.3 | Range 10.6-13<br><br>Average 11.3 | Range ND-29.3<br><br>Average 13.6 | Range 4.1-18.2<br><br>Average 9.9 | Range NA<br><br>Average NA |
| Gap (TBD) area per property basis | Range NA<br><br>Average NA | Range NA<br><br>Average NA | Range ND<br><br>Average ND | Range NA<br><br>Average NA | Range ND-25.7<br><br>Average 5.5 |

### Integrated Exposure Uptake Biokinetic Model (IEUBK)

ATSDR used the results from EPA's Integrated Exposure Uptake Biokinetic Model (IEUBK) to make recommendations about exposure [EPA 2003]. The IEUBK model is designed to integrate exposure from lead in air, water, soil, dust, food, paint, and other sources with pharmacokinetic modeling to predict blood lead concentrations in children 6 months to 7 years of age. The IEUBK model is a predictive tool that provides results that can be used for making public health decisions.

## Table 2 – IEUBK results at various lead soil concentrations

| Lead concentration range (ppm) | Estimated probability (%) of exceeding a BLL of 5 µg/dL* | Estimated geometric mean BLL (µg/dL)** |
|---|---|---|
| ND – 99 | NA – 2.30 | NA – 1.96 |
| 100 – 199 | 2.4 – 13.8 | 1.97 – 3.00 |
| 200 – 399 | 14.0 – 48.8 | 3.01 – 4.93 |
| 400 – 799 | 48.9 – 86.0 | 4.94 – 8.31 |
| 800 – 1,199 | 86.1 – 95.7 | 8.32 – 11.2 |
| 1,200 | >96.3 | >11.6 |

*The reference level is based on the highest 2.5% of the U.S. population of children ages 1-5 years. That level is currently 5 µg/dL and based on the 2009-2010 National Health and Nutrition Examination Survey (NHANES). The current (2011-2012) geometric mean level for that age group is 0.97 (µg/dL). CDC will periodically update the reference level.

**Blood lead levels were calculated using the EPA Integrated Exposure Uptake Biokinetic (IEUBK) model with default assumptions with exception of blood lead level set to 5 µg/dL. Model run with results displayed as density curve for ages 0 to 60 months, bioavailability of 0.3 and geometric standard deviation (GSD) of 1.6.

The IUEBK Model results predicts that ongoing, routine exposure to soil lead levels at some homes in this community (that have not undergone remediation) could result in young children with blood lead levels above the current CDC reference level of 5 µg/dL. It is important to note that many factors can influence lead exposure and uptake, and therefore the estimates of blood lead levels from the IEUBK model. These include the lead bioavailability and individual nutritional status, model limitations, lead exposure risk factors, seasonality, exposure age, and multiple sources of lead exposure.

A detailed description of the model and supporting documentation is available on EPA's web site: https://www.epa.gov/superfund/lead-superfund-sites-frequent-questions-risk-assessors-integrated-exposure-uptake

# Appendix C: Arsenic non-cancer and cancer evaluation

ATSDR evaluated arsenic exposures in JNSC site soils for children (ages 1 to 21 years) and adults. The estimated exposure doses calculated for children and adults were then compared with established health guidelines [ATSDR 2016]. In addition, ATSDR used EPA's default arsenic bioavailability value of 60% [EPA 2012d]. This means that of the arsenic detected in soil, the human gastrointestinal tract would absorb only 60%.

Arsenic levels in the JNSC site ranged from non-detect to 92 ppm, with an average level of 23 ppm. ATSDR used the average and maximum level of arsenic detected in residential soils to determine a range of exposure doses for children and adults.[3] The values used in these cases are considered Reasonable Maximum Exposure (RMA) doses which are expected to be higher than expected to be protective of public health. Exposure doses are presented for combined ingestion and dermal contact with arsenic in soil.

### Non-cancer

*Average soil levels:* The estimated exposure doses calculated for children (ages 1 to 21 years old) exposed to arsenic in soil at 23 ppm at the JNSC site ranges from 0.00005 to 0.0003 mg/kg/day. The adult exposure dose is 0.00002 mg/kg/day (assuming RME).

Exposure doses for children and adults exposed to the mean arsenic concentration (23 ppm) did not exceed the ATSDR health guideline, or Minimal Risk Level (MRL) for arsenic of 0.0003 mg/kg/day (assuming the RME).

*Maximum soil levels:* The estimated arsenic exposure doses calculated for children exposed to arsenic in soil at 92 ppm at the JNSC site ranged from 0.0002 to 0.001 mg/kg/day and 0.00008 mg/kg/day for adults.

Exposure doses for adults exposed to the maximum arsenic concentration (92 ppm) did not exceed the ATSDR MRL (assuming RME). However, exposure doses for children (ages 1 to 11 years old) did exceed warranting further evaluation of their exposure scenario. Closer study of the childhood exposure doses indicated that the doses associated with health effects in the available studies were considerably lower than those associated with the JNSC site. Non-cancer health effects associated with arsenic exposure are not expected.

### Cancer

Cancer risks were calculated for arsenic using the EPA oral cancer slope factor of 1.5 $(mg/kg/day)^{-1}$. Adults, assumed to be exposed for 33 years, had an estimated risk of 1 to 5 extra cancer cases among 100,000 people exposed for exposures to 23 ppm and 92 ppm, respectively (assuming RME). This cancer risk is considered to be low. Childhood cancer estimates considered exposures throughout childhood (ages 1 to 21 years old). Children exposed to 23 ppm of arsenic had a calculated cancer risk of 4 extra cancer cases in 100,000 people exposed, also

[3] To calculate a childhood estimated exposure doses, body weights ranging from 11.4 kilograms (for 1 to 2 year olds) to 71.6 kilograms (16 to 21 years olds) were used with an ingestion rate of 200 milligram per day (mg/day). Adults were assumed to weigh 80 kilograms and have an ingestion rate of 100 mg/day. The default residential occupancy of 33 years was used for the evaluation of adulthood exposures. Children were assumed to be exposed throughout childhood (ages 1 to 21 years)

considered low. A slightly elevated cancer risk of two extra case among 10,000 exposed was estimated for children who ingested soil with 92 ppm of arsenic.