Health Consultation

SOIL DATA REVIEW FOR THE FORMER NEODESHA REFINERY SITE
AND NEARBY PROPERTIES

NEODESHA, WILSON COUNTY, KANSAS

JUNE 25, 2007

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
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Health Consultation: A Note of Explanation

An ATSDR 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.

HEALTH CONSULTATION

SOIL DATA REVIEW FOR THE FORMER NEODESHA REFINERY SITE AND NEARBY PROPERTIES

NEODESHA, WILSON COUNTY, KANSAS

Prepared By:

The U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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Summary and Statement of Issues

In response to a petition by the community members of Neodesha, the Agency for Toxic Substances and Disease Registry (ATSDR) released a Health Consultation titled "Neodesha Refinery (former Amoco Refinery)" for public comment October 2003. During the public comment period, numerous comments were received from community members, Kansas Department of Health and Environment (KDHE), city officials and personnel of BP Products North American Inc. (BP).

Since the release of the document for "Public Comment", additional investigations have been conducted at the site and additional environmental data were available for review. As a result ATSDR has chosen to produce a series of documents that focus on: 1) lead levels at the New Beginnings facility, 2) metals in soil in other areas of the former refinery site 3) metals in soil at the smelter site, and 4) volatile organic compounds in ground water, soil vapor, and ambient and indoor air at the former refinery site.

ATSDR released a health consultation that addressed the New Beginnings facility lead contamination in April 2006. Lead levels in the surface soil samples collected on and near the New Beginnings facility ranged from 15.6 to 181 milligrams per kilogram (mg/kg) of soil which are below the health-based comparison values and are not likely to result in adverse health effects. ATSDR concluded that the surface soil at New Beginnings facility poses No Apparent Public Health Hazard to people working or visiting the facility.

This document is the second health consultation for the site. The purposes of this health consultation are to review available soil data in other areas of the former refinery site, and to assess the possible implication of exposures to soil contaminants.

After reviewing the available environmental data, ATSDR determined that the primary route of potential human exposure is ingestion of soil and dust for residents who live near the site and use the Ballpark area. Environmental data evaluation and analysis indicated that:

- Adults and children who use the Ballpark area are unlikely to experience non-cancerous adverse health effects from exposure to arsenic, lead and mercury in soil in the past, present, or during anticipated use in the future.
- Exposures to lead-contaminated soil in the general areas (commercial and industrial businesses) are not likely to result in adverse health effects for adult workers.
- Individuals at the site are not at increased risk of developing cancer because of short exposure duration, occasional exposure frequency, and small doses of daily intake of contaminants.
- ATSDR categorizes this site as constituting "No Apparent Public Health Hazard". See Appendix D for definition.

ATSDR recommends: 1) KDHE verify actions are taken on the recommendations for the responsible parties to remove the contaminated soil at the former chromium plating facility and in the general area; 2) KDHE and all property owners in the area to implement control measures to effectively restrict child and adult community access to the site in areas other than those designated for community use (New Beginnings and the Ballpark); and 3) Commercial and

industrial property owner of the area to implement administrative controls to prevent and minimize potential exposures to soil during construction and removal activities at the site.

Background

The former refinery property encompasses approximately 185 acres in the west part of Neodesha, Kansas. The refinery operated for 73 years, from 1897 until 1970. The former refinery property is currently owned by the city of Neodesha, Williams Pipe Line Company, and various other businesses. The area is now occupied by light industries and small businesses. There are few site access controls. There are a few residences adjacent to the north and northwest site boundaries; the city of Neodesha is directly east. The U.S. Census Bureau statistics for Neodesha estimated a population of 2,848 within the city, and 3,049 within a 1 mile radius of the site (see Intro Map) [1].

The closest residences are 500 feet from the site boundary, just east of 12th Street. A baseball field is located on-site on the west side of the former tank farm property. This field was used by community members but is currently closed for use.

Since the early 1980s, environmental investigation and remediation activities were conducted by KDHE, BP and other businesses located at the site. Contaminants of concern for the site include benzene, toluene, ethylbenzene and xylenes (BTEX) in groundwater, and metals and petroleum hydrocarbons in the soil.

In response to a petition by the community members of Neodesha, ATSDR released a Health Consultation titled “Neodesha Refinery (former Amoco Refinery)” for public comment in October 2003 [2]. During the public comment period, numerous comments were received from community members, KDHE, city officials, and personnel of BP Products North American Inc. (BP).

Since the release of the document for “Public Comment”, additional investigations have been conducted at the site and additional environmental data were available for review. As a result ATSDR has chosen to produce a series of documents that focus on: 1) lead contamination at the New Beginnings facility, 2) metals in soil in other areas of the former refinery site 3) metals in soil at the smelter site, and 4) volatile organic compounds in ground water, soil vapor, and ambient and indoor air at the former refinery site.

ATSDR released a health consultation that addressed the New Beginnings facility lead contamination in April 2006. Lead levels in the surface soil samples collected on and near the New Beginnings facility ranged from 15.6 to 181 mg/kg which are below the health-based comparison values and are not likely to result in adverse health effects. ATSDR concluded that the surface soil at New Beginnings facility poses No Apparent Public Health Hazard to people working or visiting the facility [3].

This health consultation is the second document of a series of documents evaluating site contamination. Soil data in other areas of the former refinery site are evaluated in this health consultation.

Community Health Concerns

As part of the response to the petition for the investigation of the soil contamination, ATSDR staff participated in many public meetings, reviewed site documents, received numerous calls from residents, and conducted a public availability session to understand community member's concerns regarding the contamination, investigation, and remediation of the site. Major environmental health issues related to soil contamination include the following:

- Accuracy and adequacy of environmental sample results collected to date,
- Lead exposures at recreational areas,
- Possible exposures to site-related contaminants from ongoing BP work in the community, and
- Mercury contamination at the site.

Other health concerns related to groundwater and vapor intrusion will be addressed in the health consultation that focuses on volatile organic compounds in ground water, soil vapor, and indoor air at the former refinery site.

ATSDR's Exposure Pathway Analysis and Evaluation Process

ATSDR provides site-specific public health recommendations on the basis of toxicologic literatures, levels of environmental contaminants detected at a site compared to accepted comparison values, an evaluation of potential exposure pathways, frequency and duration of exposure, and the characteristics of the exposed population. Whether a person will be harmed by exposure to hazardous substances depends upon several factors, including the type and amount of the contaminant, the manner in which the person was exposed, the duration of the exposure, the amount of the contaminant absorbed by the body, genetic factors, and individual lifestyle factors. Ingestion of soil and dust is the primary exposure of concern for community members who live near the site and work on the site.

ATSDR's approach to evaluating a potential health concern has two components. The first component involves a screening process that could indicate the need for further analysis of selected contaminants. The second component involves a weight-of-evidence approach that integrates estimates of likely exposure with information about the toxicology and epidemiology of the substances of interest.
Screening is a process of comparing appropriate environmental concentrations and doses to ATSDR or EPA comparison values. These comparison values (CVs) include but not limited to

- Environmental Media Evaluation Guides (EMEGs)
- Reference Dose Media Evaluation Guides (RMEGs)
- Minimum Risk Levels (MRLs)
- Cancer Risk Evaluation Guidelines (CREGs)
- Reference Doses (RfDs)
- Risk-Based Concentrations (RBCs) or Preliminary Remediation Goals (PRGs)

When determining what environmental guideline value to use, this health consultation followed ATSDR's general hierarchy and used professional judgment to select CVs that best apply to the site conditions [4]. For example, some of the CVs and health guidelines used by ATSDR scientists include CREGs, EMEGs, and MRLs. If an ATSDR CV is not available for a particular chemical, ATSDR sometimes screens environmental data with CVs developed by other sources, including the EPA's reference doses (RfDs) and EPA's Region III risk-based concentrations (RBCs). These CVs and health guidelines, as well as all other health-based screening criteria, represent conservative levels of safety; they are not thresholds of toxicity. Although concentrations at or below a CV may reasonably be considered safe, concentrations above a CV will not necessarily be harmful. To ensure that they will protect even the most sensitive populations (such as children or the elderly), CVs are intentionally designed to be much lower, usually by two or three orders of magnitude, than the corresponding no-observed-adverse-effect-levels (NOAELs) or lowest-observed-adverse-effect-levels (LOAELs) on which the CVs were based. When a level is above a comparison value, it does not mean that health effects could be expected—it does, however, represent a point at which further evaluation is warranted.

After identifying potential chemicals of concern through the screening process, ATSDR evaluates a number of parameters depending on the contaminant and site-specific exposure conditions. Such parameters can include biological plausibility, mechanisms of action, cumulative interactions, health outcome data, strength of epidemiological and animal studies, and toxicological and pharmacological characteristics.

Discussion

Available environmental data for the site and data quality evaluation

ATSDR evaluated the available environmental sampling information for potential exposure to contaminants at the site. The information includes soil samples taken by The RETEC Group, Inc. (RETEC) under contract with BP and soil samples taken by KDHE on the former refinery site and nearby properties.

Soil samples were analyzed for metals, semi-volatile organic compounds (SVOCs), volatile organic compounds (VOCs) and total petroleum hydrocarbons (TPHs). The laboratory analysis methods selected were US EPA SW-846 method 8260B for VOCs, SW-846 method 8270C for SVOCs, SW-846 method 8015B for TPH, and SW-846 method 6010B for all metals except mercury. SW-846 method 7471A was selected for mercury [5-6].

To address community concerns, ATSDR also reviewed information on Quality Assurance (QA)/Quality Control (QC) specifications for field data quality and laboratory data quality to verify the acceptability and adequacy of data. For example, ATSDR reviewed available Chain of Custody sheets, project narratives, and laboratory certifications. The laboratory analysis methods and the QA/AC procedures were appropriate [5-6].

Environmental data evaluation and public health implications

Environmental data are grouped into two categories (data collected by RETEC and KDHE) and discussed in the following sections.

Soil Investigation performed by RETEC

In June and November 2001, RETEC conducted Phase 1 and Phase 2 soil investigations to characterize soil contamination that may be impacted by the former refinery operations and to gather data for a risk-based assessment. Approximately 170 soil samples (including background samples) were collected from 88 locations from surface soil (0-6”), subsurface soil (6-12”) and borings (>20”). [7]. Six sediment samples were collected from the south portion of the former refinery (the former separator pond area). In addition, RETEC collected additional soil samples at selected areas for mercury and lead analysis in 2002 and 2003, respectively [6-7]

Soil samples collected from the New Beginnings facility were evaluated in a health consultation released in 2006 [3]. Soil samples collected from the smelter area will be addressed separately in another health consultation. This health consultation focuses on the soil data in other areas of the former refinery site. Figure 1 shows soil sample locations selected for review for this health consultation. Based on soil sample locations and human exposure potentials, soil and sediment samples were grouped into three groups (background area, ballpark area, general areas) and discussed below.

Background area soil samples

Background samples were collected outside of the former refinery property at various locations within the city of Neodesha from surface and subsurface soil. There were fourteen samples available for this evaluation. Of the more than 100 substances analyzed, 21 substances were detected. Table 1 is a summary of all detected substances in the background soil samples. All substances except arsenic were found at levels below their respective comparison values. Arsenic concentrations in surface and subsurface soil samples ranged from 1.9 to 10.3 mg/kg and 1.7 to 8.8 mg/kg, respectively (Table 1). The mean value for arsenic concentrations in surface and subsurface soil samples was 6.24 mg/kg, and 5.54 mg/kg, respectively.

Arsenic is a naturally occurring element present at low levels in soil, water, food, and air. The U.S. Geological Survey reports the background range of arsenic in soil and other surficial materials as <0.1–97 mg/kg, with a mean value of 7.2 mg/kg [8]. A recent KDHE assessment for the former Twin Rivers Plating facility located inside the former refinery property reported the background soil arsenic concentration of 7.0 mg/kg [9]. The levels of arsenic found in the background samples at various locations within the city of Neodesha were below levels of health concern based on a conservative dose calculation presented in Appendix A.

Ballpark area soil samples

The ballpark is located at the historical product storage area. In 2000 and 2003, BP contractors removed an approximate total of 410 cubic yards asphalt-like material (325 cubic yards in 2000 and 85 cubic yards in 2003, respectively) [7]. It should be noted that the removal actions were based on visual observation for asphalt-like materials other than based on analytical results of soil samples. There were five surface soil samples and five subsurface soil samples available for this evaluation for the ballpark area. Samples were taken during the RETEC soil investigation in 2001 after the first removal action in 2000. Of the more than 100 substances analyzed, 28 substances were detected in soil. Table 2 is a summary of all detected substances in the Ballpark area soil samples. All substances were found at levels below their respective comparison values except arsenic. Therefore, arsenic will be discussed below. In addition, lead and mercury will be included in the discussion to address community concerns about exposure in the ballpark area to these contaminants.

Arsenic

Arsenic concentrations in surface and subsurface soil samples ranged from 5.3 to 7.5 mg/kg and 2.6 to 12.7 mg/kg, respectively (Table 2). The mean value for arsenic concentrations in surface and subsurface soil samples was 6.7 mg/kg, and 7.24 mg/kg, respectively. These levels are similar to the levels detected in background samples.

To determine whether harmful effects might be possible, ATSDR reviewed the findings from numerous studies that have documented the effects of acute and chronic exposures to arsenic on humans. The several factors that should be considered when evaluating the health hazard associated with arsenic in soil include bioavailability of arsenic in soil, the prevalence of pica-like behavior in children in the community, and length of exposures. Children and children with soil-pica behavior are a special concern for acute exposures because ingesting high amounts of soil could lead to significant arsenic exposure. Pica-like behavior is most likely to occur in young children (1 to 2 years old) who are not likely to use the Ballpark. The most likely arsenic exposure scenario at the site is occasional ingestion or infrequent dermal contact with contaminated surface soil by residents who are conducting recreational activities in the Ballpark. Ingestion is the primary pathway of concern in those general activities.

ATSDR has developed a provisional acute (exposure duration of 14 days or less) and chronic (exposure durations of 365 days or more) oral MRL for arsenic of 0.005 mg/kg/day and 0.0003 mg/kg/day, respectively. MRL is an exposure level below which non-cancerous harmful effects are unlikely. The acute MRL is based on several transient (i.e., temporary) effects including nausea, vomiting, and diarrhea. When an estimated acute dose of arsenic is below 0.005 mg/kg/day, non-cancerous harmful effects are unlikely. It should be noted that 1) the acute MRL is 10 times below the levels that are known to cause harmful effects in humans, 2) the acute MRL is based on people being exposed to arsenic dissolved in water instead of arsenic in soil — a fact that might influence how much arsenic can be absorbed, and 3) the MRL applies to non-cancerous effects only and is not used to determine whether people could develop cancer [10].

ATSDR used the maximum surface soil arsenic concentration of 7.5 mg/kg for exposure dose calculations for the site specific exposure scenarios (Appendix A). A conservative dose calculation indicated that it is unlikely that adults and children (include children with pica-like behavior) at any of the properties at the site would experience non-cancerous harmful effects from exposure to arsenic in soil. In addition, currently the ballpark is closed for public use, therefore minimizing any potential exposures to arsenic at the site.

For cancer effects, the U.S. Department of Health and Human Services (DHHS), the International Agency for Research on Cancer, and EPA have all determined that arsenic is carcinogenic to humans. This is based on evidence from many studies of people who were exposed to either arsenic-contaminated drinking water, arsenical medications, or arsenic-contaminated air in the workplace for exposure durations ranging from a few years to an entire lifetime [10]. Because the most likely exposure to arsenic at the Ballpark is occasional ingestion or infrequent dermal contact with contaminated surface soil by residents who are conducting recreational activities, it is unlikely that exposed individuals will have an increased risk of developing cancer.

Lead

Lead concentrations in surface and subsurface soil samples ranged from 56.4 to 155 mg/kg and 9.4 to 30.6 mg/kg, respectively (Table 2). The mean value for lead concentrations in surface and subsurface soil samples was 116 mg/kg, and 18.6 mg/kg, respectively (Table 2). Ideally, ATSDR prefers surface soil samples taken from the top 3 inches for its evaluation. The surface samples for this site were collected from 0 to 6 inches as the selected EPA sample methods. ATSDR considers residential soil levels above 400 mg/kg as needing further evaluation on the basis of children's unique susceptibility, and the KDHE Tier 2 risk-based standards and EPA's Preliminary Remediation Goals (PRGs) (Region 9) for lead in residential soils are also 400 mg/kg [11-12]. The lead levels found at the ballpark are well below 400 mg/kg, therefore exposures to lead-contaminated soil at the ballpark are not likely to result in adverse health effects.

U.S. DHHS classifies lead and lead compounds as reasonably anticipated to be a carcinogen. This classification is primarily based on occupational epidemiology studies which are limited by poor exposure assessment methods and did not control for confounding exposures. Intermittent exposures to lead in the soils at the site would not cause additional cancers among residents.

Mercury

Mercury occurs naturally in the environment and exists in several forms (e.g., metallic, inorganic, and organic mercury). The U.S. Geological Survey reports the background range of mercury in soil and other surficial materials as less than 0.01 mg/kg to 4.6 mg/kg [8]. Because most of the mercury found in soil is in the form of metallic mercury and inorganic mercury, health-related comparison values used in this document are for inorganic mercury.

At the Ballpark area, mercury concentrations in surface and subsurface soil samples ranged from 0.033 to 0.09 mg/kg and 0.011 to 0.04 mg/kg, respectively (Table 2). The mean value for mercury concentrations in surface and subsurface soil samples was 0.059 mg/kg, and 0.02 mg/kg, respectively (Table 2). EPA has established a soil screening value of 23 mg/kg for mercury. The KDHE Tier 2 risk-based standard for mercury is 2 mg/kg. The mercury levels found at the ballpark are well below those values. ATSDR has MRLs for mercury exposures [13]. The ATSDR acute and intermediate oral MRLs for inorganic mercury are 0.007 and 0.002 mg/kg/day respectively. These MRLs are based on no-observed-adverse-effect levels (NOAELs) for renal effects in rat, with an uncertainty (safety) factor of 100 for extrapolation from animals to humans and human variability. For the site-specific exposure scenario, based on conservative dose calculations, the estimated mercury dose for adults and children ingesting mercury contaminated soil were far below the MRLs (Appendix A). Therefore, no adverse health effects would result from ingesting the surface and subsurface soil for mercury exposures. No evidence from epidemiological studies indicated that ingestion of inorganic mercury produces cancer in humans [13].

General areas soil and sediment samples

There were over 140 surface and subsurface soil samples available for this evaluation for the other general areas of the former refinery property. These areas consist of commercial and industrial businesses and open fields. All samples were taken before the RETEC removal of approximately 215 cubic yards of visibly impacted materials in the spring of 2003. Of the more than 100 substances analyzed, 29 substances were detected. Table 2 is a summary of all detected substances in the general area soil samples. All substances were found at levels below their respective comparison values except substances discussed below.

Lead concentrations in surface and subsurface soil samples ranged from 15.8 to 4,750 mg/kg and 8.5 to 11,900 mg/kg, respectively (Table 3). The mean value for lead concentrations in surface and subsurface soil samples was 606 mg/kg, and 295 mg/kg, respectively (Table 3). Among the 51 surface soil samples, 10 samples had lead concentrations that exceeded the KDHE Tier 2 risk-based standard of 1000 mg/kg for non-residential areas. Only one subsurface soil sample had a lead concentration above 1000 mg/kg. To further evaluate the risk of lead exposure at the other general areas of the former refinery property, RETEC used the EPA Adult Lead Model to determine removal action concentrations that would be protective for all indoor and outdoor workers [5]. Appendix C contains the assumptions used in the RETEC Risk Assessment Report [5]. The lead removal action concentration for the indoor workers was 4,800 mg/kg, and for the outdoor workers (assume an exposure frequency of 219 days per year) it was 1,754 mg/kg. There were 6 sample areas (RA-45, RA-49, RA-72, RA-73, RA-75, and RA-79) with lead concentrations above 1,754 mg/kg. Two areas (RA-72 and RA-73) were excavated in 2003. Other areas were identified as soil remediation areas for corrective action in the future [7]. However, the mean value for lead concentration in surface soil samples prior to the removal was 606 mg/kg, about three times lower than the removal action concentration. The most likely human exposures to lead in those areas were occasional ingestion or infrequent dermal contact with contaminated surface soil by workers. Children would be excluded from exposure because of the current deed restriction for non-residential use. Based on many studies on the toxicity of lead in adults and the site specific exposure scenario, ATSDR considers that exposures to lead-contaminated soil at those areas are not likely to result in adverse health effects for past, present and during anticipated use in the future.

The maximum concentrations of arsenic, benzo(A) pyrene, chrysene, indeno(1,2,3-CD)pyrene, and di(2-ethylhexyl)phthalate exceeded their respective CREGs However, the mean concentrations of chrysene, indeno(1,2,3-CD)pyrene, and di(2-ethylhexyl)phthalate were below their CREGs, and the mean concentrations of arsenic and benzo(A) pyrene were slightly above their respective CREGs. ATSDR considers that it is unlikely that exposed individuals (indoor and outdoor workers) will have increased risk of developing cancer at the site because of short exposure duration, occasional exposure frequency, and small doses of daily intake of contaminants.

There were six sediment samples collected at the south part of former refinery property. Of the more than 100 substances analyzed, 36 substances were detected. Table 4 is a summary of all detected substances in the general area soil samples. All substances were found at levels below their respective comparison values except arsenic and benzo(A)pyrene. Arsenic concentrations in sediment samples ranged from 7.5 to 32.9 mg/kg. The mean value for arsenic concentrations in sediment samples was 15.3 mg/kg. Benzo(A)pyrene concentrations in sediment samples ranged from 0.24 to 1.8 mg/kg. The mean value for benzo(A)pyrene concentrations in sediment samples was 0.77 mg/kg. As previous discussed, because of short exposure duration, infrequent exposure frequency, and small doses of daily intake of contaminants, it is unlikely that exposed individuals (indoor and outdoor workers) will have increased risk of developing cancer.

KDHE Soil Samples

KDHE has collected soil and sediment samples since 2001 in response to community concerns throughout the former refinery area and nearby properties (Figure 1). The following is a summary of available KDHE soil and sediment samples.

In June 2001, KDHE collected one soil sample on the west side of the Airosol building which was located in the former refinery site. The sample was taken one foot below ground surface in an area of distressed vegetation. The soil sample was submitted for VOC analysis and VOCs were not detected [14].

June 2002, in response to a series of citizen's concerns, KDHE collected one sediment sample in the ditch near Rotary Park in the area of the intersection of 5^{th} and Osage Street. The sediment sample was analyzed for metals, semi-VOCs (SVOCs), and VOCs [15]. None of the analyzed SVOCs and VOCs was detected. Six metals (barium, cadmium, chromium, lead, silver, and mercury) were detected at levels below their respective comparison values (Table 5).

June 2002, KDHE collected two soil samples at the Neodesha High School due to spillage or leakage of transformer oil to the ground. The area of spillage was less than 10 feet in diameter and extended to six inches or less in depth below ground surface. Soil samples were analyzed for metals, semi-VOCs, VOCs, and polychlorinated biphenyls (PCBs) [16]. Four metals (barium, cadmium, chromium, and lead) were detected at levels below their respective comparison values (Table 5). Total petroleum hydrocarbons (TPH) were detected in one sample with a concentration of 130,000 mg/kg. No other analyzed chemical was detected. KDHE's Spill Response Program addressed the limited area of TPH-contaminated soil.

June 2002, KDHE collected three soil samples at a private residence with regard to lead and mercury contaminations in the yard. Soil samples were analyzed for metals, semi-VOCs, and VOCs [17]. Twenty metals were detected at levels below their respective comparison values (Table 5). Lead was detected in all three samples with a maximum concentration of 54.7 mg/kg. Mercury was not detected in any samples.

June 2002, KDHE collected two sediment samples at the north drainage ditch and the southern ditch areas. Soil samples were analyzed for metals, semi-VOCs, and VOCs [18]. Eight substances were detected (Table 5). Lead was detected in samples with a maximum concentration of 1,270 mg/kg. Mercury was detected in one sample at a concentration of 5.41 mg/kg. Diesel range TPH was detected in samples with a maximum concentration of 1,700 mg/kg and gasoline range TPH was detected in one sample with a concentration of 11 mg/kg. Although the maximum concentrations of lead and TPH exceeded their respective comparison values, ATSDR considers that the potential for human exposure to the contaminants is minimal because of the remote locations of the north drainage ditch and the southern ditch areas.

January 2006, KDHE collected three soil samples at the west Indiana Street in response to a reported cutting oil spill [19]. The sampled area consisted of an area of visually contaminated soil approximately 3.5 feet by 22 feet. Ten substances were detected (Table 5). Lead was detected in samples with a maximum concentration of 1,410 mg/kg that is below the removal action concentration of 1,754 mg/kg for outdoor workers. Mercury was detected in samples at a maximum concentration of 0.75 mg/kg. Diesel range TPH was detected in samples with a maximum concentration of 344,000 mg/kg and gasoline range TPH was detected in one sample with a concentration of 4,580 mg/kg. KDHE recommended and supervised the removal of the contaminated soil by the responsible party.

From October 2005 through February 2006, KDHE conducted a unified focused assessment for a former chromium plating facility located in the former refinery area. Eleven soil samples were taken for metals, semi-VOCs and VOCs laboratory analysis [9]. Thirteen substances were detected at levels below their respective comparison values. Lead was detected in samples with a maximum concentration of 840 mg/kg that is below the removal action concentration of 1,754 mg/kg for outdoor workers. Mercury was detected in samples at a maximum concentration of 45.1 mg/kg. Chromium was detected in samples at a maximum concentration of 3,000 mg/kg. KDHE recommended extensive characterization of mercury and chromium contamination, and remediation of lead contamination in the area by the responsible parties.

Child Health Considerations

ATSDR considers children in its evaluations of all exposures, and we use health guidelines that are protective of children. In general, ATSDR assumes that children are more susceptible to chemical exposures than are adults. ATSDR has taken into account that children are at a greater risk for exposure than are adolescents or adults because

- The normal behavior of children might result in higher rates of ingestion of contaminated soil and dust,
- Children might also receive a higher dose of contaminants because they have lower body weights than do adults, and
- Some children might eat soil excessively (called soil-pica behavior) and therefore have a higher exposure dose to contaminants in soil.

ATSDR has considered these factors in the development of its conclusions for this site. CVs used for this health consultation are intended to represent exposures that could be continued for a lifetime for the general population—including potentially susceptible subgroups such as children—without appreciable health risks.

Conclusions

Environmental data evaluation and analysis indicated that

- For the Ballpark area—the primary route of potential human exposure is ingestion of soil and dust for residents who live near the site and use the Ballpark area. Adults and children who use the Ballpark are unlikely to experience adverse health effects from exposure to arsenic, lead and mercury in soil.
- For the general areas—the most likely human exposures to arsenic and lead in the general areas (commercial and industrial businesses) were occasional ingestion or infrequent dermal contact with contaminated surface soil by workers. ATSDR considers that

exposures to lead-contaminated soil at those areas are not likely to result in adverse health effects. However, ATSDR concurs with the RETEC risk assessment to remove lead contaminated soil (over 1,754 mg/kg) to mitigate exposures for outdoor workers.

- Individuals do not face an increased risk of developing cancer because of short exposure duration, infrequent exposure frequency, and small doses of daily intake of contaminants at the site.
- ATSDR has categorized this site as constituting "No Apparent Public Health Hazard", that designates human exposure to contaminated soil at the site may have occurred but the exposure is not expected to cause any adverse health effects.

Recommendations

Based on best public health practices, ATSDR recommends:

KDHE should verify the recommendations for the responsible parties to remove the contaminated soil at the former chromium plating facility and at locations identified as soil remediation areas for corrective action.

KDHE, City of Neodesha, and other property owners should implement control measures to effectively restrict child and adult community access to the site in areas other than those designated for community use (New Beginnings and ball field).

Commercial and industrial property owners of the area as well as City of Neodesha should implement administrative controls to prevent and minimize potential exposures to soil during construction and removal activities at the site. For example, notify residents of activities, restrict access to worksite, and implement work health and safety plan for affected workers.

Public Health Action Plan

The Public Health Action Plan for the site contains a description of actions that have been or will be taken by ATSDR and/or other government agencies at the site. The purpose of the Public Health Action Plan is to ensure that this public health consultation not only identifies public health hazards, but also provides a plan of action designed to mitigate and prevent adverse human health effects resulting from exposure to hazardous substances in the environment. Included is a commitment on the part of ATSDR to follow up on this plan to ensure its implementation.

Actions Taken:

ATSDR conducted site visits in June, July and September, 2002, March 2003, and April 2006.
ATSDR released a health consultation for the former refinery site for public comment and held a public meeting in October and November 2003.
KDHE completed site reconnaissance and evaluation for the Johnson property site in 2003.
KDHE completed site reconnaissance and evaluation for the Neodesha pond site in 2003.
BP completed corrective action study revision 1 in February in 2005.
City of Neodesha closed the Ballpark area for public assess in 2005.
KDHE completed site reconnaissance and evaluation a preCERCLIS survey for West Indiana Street site in 2006.
KDHE completed Unified Focused Assessment for Former Twin Rivers Plating in May 2006.

Actions Planned:

ATSDR will continue to work with the community, KDHE and BP to respond to public health questions and concerns about the site.

BP will continue to complete corrective actions approved by KDHE for the site.

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Figure 1. Neodesha Former Refinery Vicinity Map (Intro Map)

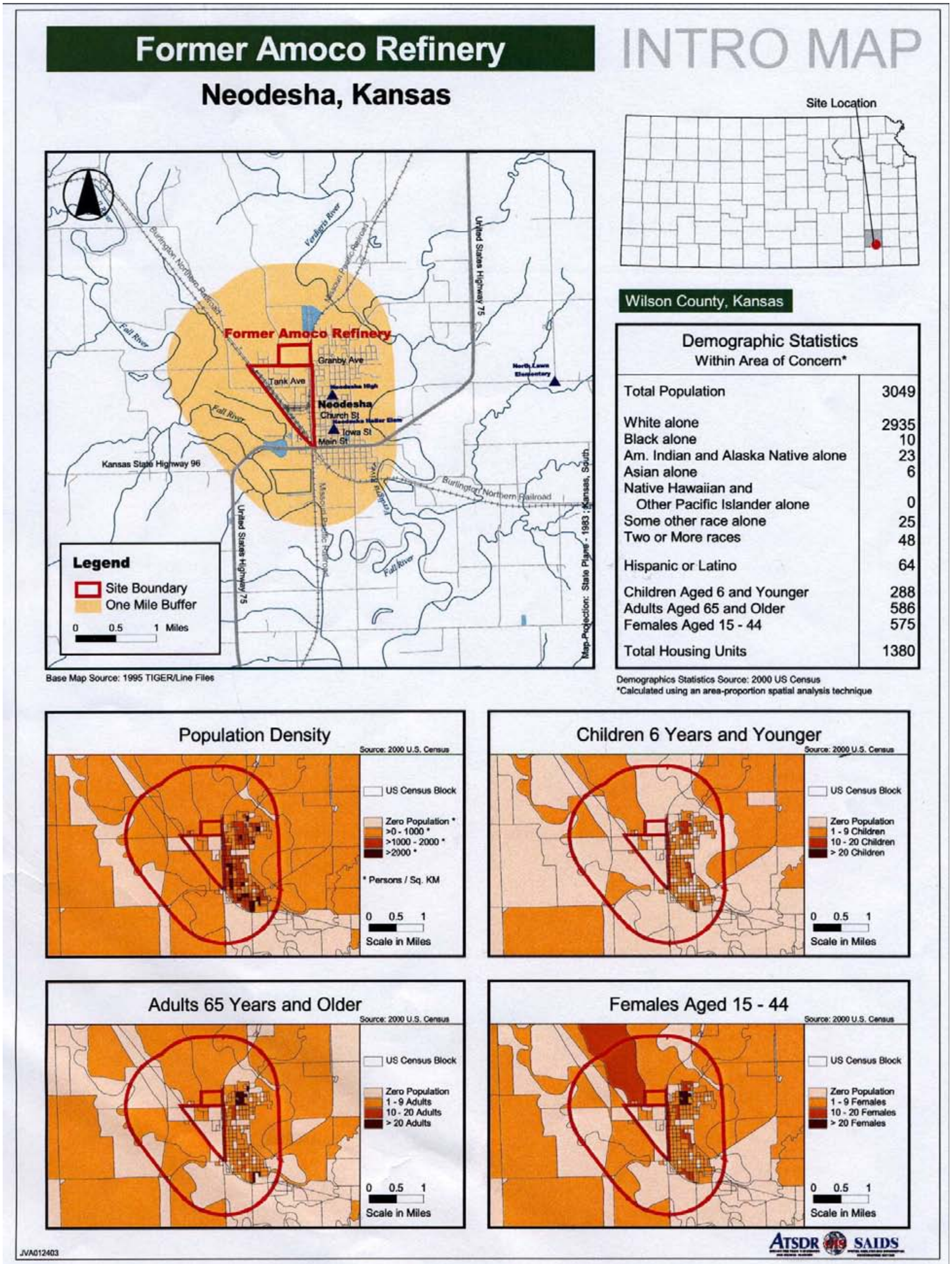

Figure 2. Soil and Sediment Sample Locations

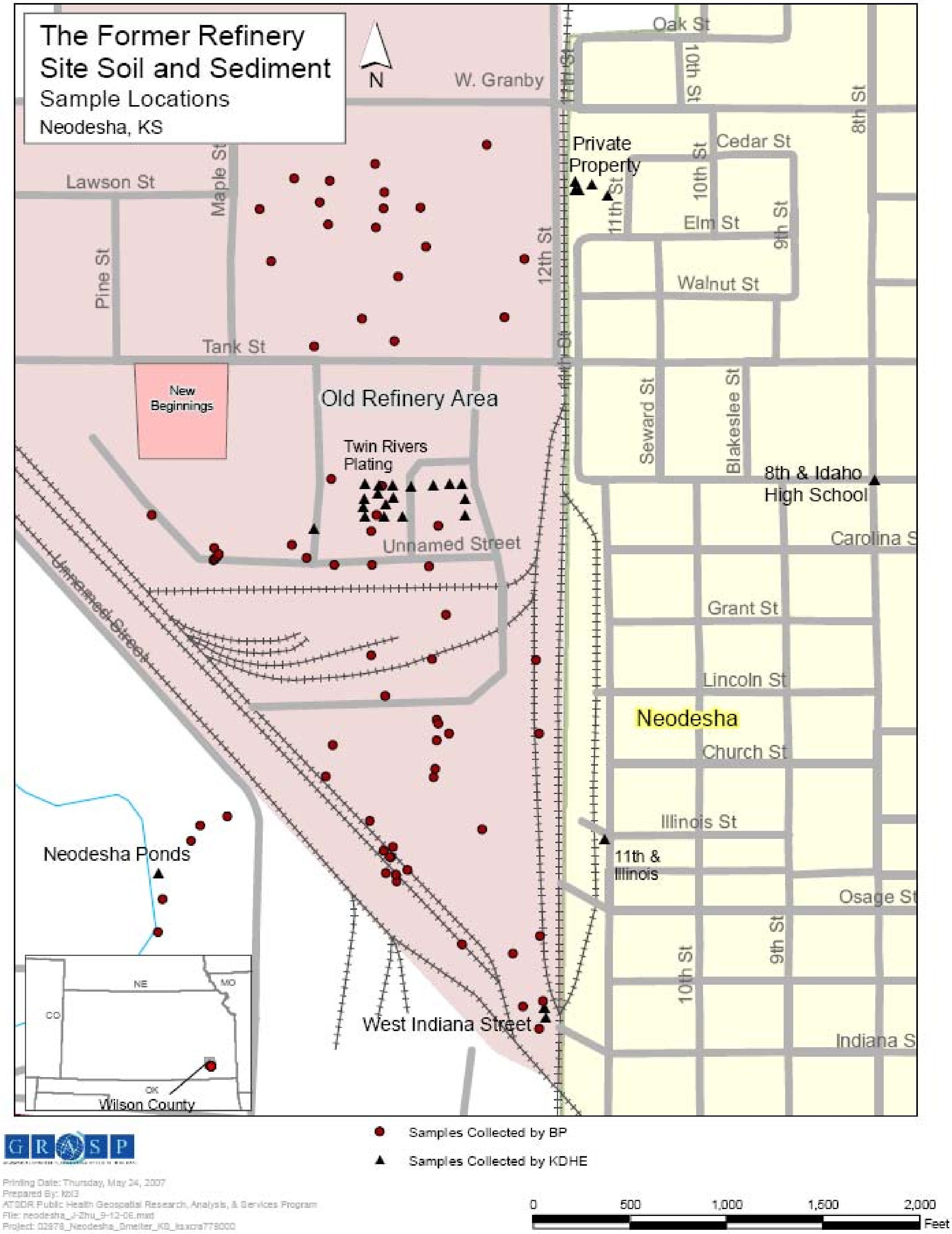

Table 1— Summary of Background Surface and Subsurface Soil Samples (mg/kg)

	Substance	Min	Max	Mean	Median	D/S	CV	CV Type
Subsurface Soil samples (> 0.5 feet)	2-BUTANONE	0.0041	0.011	0.00614	0.0049	5/7	30000	RMEG child
	ACETONE	0.006	0.024	0.0124	0.0115	6/7	4000	IEMEG pica
	ARSENIC	1.7	8.8	5.54	5.3	7/7	0.5	CREG
	BARIUM	88	225	157	138	7/7	1000	IEMEG pica
	BENZO(A)ANTHRACENE	0.061	0.061	0.061	0.061	1/7	12	KDHE
	CHROMIUM	25.6	35	30.9	31.9	7/7	390	KDHE
	CHRYSENE	0.089	0.089	0.089	0.089	1/7	6.4	KDHE
	DIESEL FUEL	3.2	3.2	3.2	3.2	1/7	2000	KDHE
	FLUORANTHENE	0.1	0.1	0.1	0.1	1/7	800	IEMEG pica
	LEAD	6.8	23.5	14.9	15.4	7/7	400	EPA SSL
	MERCURY	0.01	0.063	0.0234	0.014	7/7	23	EPA SSL
	PHENANTHRENE	0.13	0.13	0.13	0.13	1/7	NA	NA
	PYRENE	0.13	0.13	0.13	0.13	1/7	2000	RMEG child
	TPH (C10-C36)	3.3	3.3	3.3	3.3	1/7	200	KDHE
Surface Soil Samples (0-0.5 feet)	1,2,4-TRIMETHYLBENZENE	0.0025	0.0067	0.00435	0.00425	6/7	9.7	KDHE
	ARSENIC	1.9	10.3	6.24	6.7	7/7	0.5	CREG
	BARIUM	106	539	206	120	7/7	1000	IEMEG pica
	CADMIUM	0.18	2.1	1.14	1.14	2/7	10	CEMEG child
	CHROMIUM	20.3	44.7	29.5	29.8	7/7	4000	KDHE
	DIESEL FUEL	4.2	4.2	4.2	4.2	1/7	2000	KDHE
	GASOLINE RANGE ORGANICS (GRO)	1.7	1.7	1.7	1.7	1/7	200	KDHE
	LEAD	9.8	153	39.8	21.4	7/7	400	EPA SSL
	M,P- XYLENE OR TOTAL XYLENES	0.0045	0.0062	0.0052	0.0049	3/7	2000	IEMEG pica
	MERCURY	0.005	0.1	0.0284	0.02	7/7	23	EPA SSL
	PHENANTHRENE	0.1	0.1	0.1	0.1	1/7	NA	NA
	PYRENE	0.078	0.078	0.078	0.078	1/7	2000	RMEG child
	SELENIUM	0.53	0.67	0.6	0.6	3/7	300	CEMEG child
	SILVER	0.22	0.22	0.22	0.22	1/7	300	RMEG child
	TOLUENE	0.0025	0.0025	0.0025	0.0025	1/7	40	IEMEG pica
	TPH (C10-C36)	4.3	4.3	4.3	4.3	1/7	200	KDHE

Note:
NA = not available
Mg/kg = milligram per kilogram
Min: minimum concentration
Max: maximum concentration
Mean: mean concentration
Median: median concentration
NA: not applicable
D/S: number of detection/number of samples
CV: comparison value
CEMEG: chronic environmental media evaluation guide
CEMEGchild: chronic environmental media evaluation guide for children
RMEG: reference dose media evaluation guide
RMEGchild: reference dose media evaluation guide for children
CREG: cancer risk evaluation guide for 1×10^{-6} excess cancer risk
IEMEG: intermediate environmental media evaluation guide
IEMEGpica: intermediate environmental media evaluation guide for children with pica-behavior
EPA SSL: EPA soil screening level
KDHE: The Risk-Based Standards for Kansas (RSK) for residential scenarios

Table 2— Summary of Ballpark Soil Samples (mg/kg)

	SUBSTANCE	MIN	MAX	MEAN	MEDIAN	D/S	CV	CV TYPE
Subsurface soil samples (>0.5 feet)	1,2,4-TRIMETHYLBENZENE	0.02	0.12	0.07	0.07	2/5	9.7	KDHE
	1,3,5-TRIMETHYLBENZENE	0.0065	0.075	0.0408	0.0408	2/5	2.5	KDHE
	2-BUTANONE	0.0079	0.0079	0.0079	0.0079	1/5	30000	RMEG child
	ARSENIC	2.6	12.7	7.24	7	5/5	0.5	CREG
	BARIUM	173	313	230	234	5/5	1000	IEMEG pica
	BENZENE	0.02	0.12	0.067	0.061	3/5	10	CREG
	CADMIUM	0.5	1.5	0.96	0.91	5/5	10	CEMEG child
	CHROMIUM	31.6	50	39.6	40.8	5/5	390	KDHE
	CUMENE	0.029	0.029	0.029	0.029	1/5	5000	RMEG child
	DIESEL FUEL	6.1	46	26.1	26.1	2/5	2000	KDHE
	ETHYL BENZENE	0.0022	0.32	0.113	0.017	3/5	5000	RMEG child
	GASOLINE RANGE ORGANICS (GRO)	1.7	29	11.6	4.2	3/5	220	KDHE
	LEAD	9.4	30.6	18.6	18.8	5/5	400	EPA SSL
	M,P- XYLENE OR TOTAL XYLENES	0.041	0.16	0.101	0.101	2/5	2000	IEMEG pica
	MERCURY	0.011	0.04	0.02	0.017	5/5	2	KDHE
	METHYL-4-(1-METHYLETHYL)BENZENE	0.015	0.015	0.015	0.015	1/5	NA	NA
	N-PROPYL BENZENE	0.0042	0.071	0.0376	0.0376	2/5	140	KDHE
	SELENIUM	0.6	1.6	0.918	0.73	5/5	300	CEMEG child
	TOLUENE	0.0053	0.013	0.00915	0.00915	2/5	40	IEMEG pica
	TPH (C10-C36)	6.1	46	26.1	26.1	2/5	NA	NA
Surface soil samples (0-0.5 feet)	2-METHYLNAPHTHALENE	0.089	0.089	0.089	0.089	1/5	2000	CEMEG child
	ARSENIC	5.3	7.5	6.7	6.9	5/5	0.5	CREG
	BARIUM	172	189	177	174	5/5	1000	IEMEG pica
	BENZO(GHI)PERYLENE	0.057	0.31	0.184	0.184	2/5	NA	NA
	CADMIUM	1.3	5.8	4.64	5.3	5/5	10	CEMEG child
	CHROMIUM	21.1	34.8	26.7	25.4	5/5	390	KDHE
	DI(2-ETHYLHEXYL)PHTHALATE	0.088	0.14	0.114	0.114	2/5	50	CREG
	DIESEL FUEL	23	58	42.3	46	3/5	2000	KDHE
	LEAD	56.4	155	116	128	5/5	400	EPA SSL
	MERCURY	0.033	0.09	0.059	0.052	5/5	2	KDHE
	PHENANTHRENE	0.1	0.24	0.17	0.17	2/5	NA	NA
	PYRENE	0.067	0.086	0.0765	0.0765	2/5	2000	RMEG child
	SELENIUM	0.89	1.4	1.07	0.94	5/5	300	CEMEG child
	SILVER	0.28	0.3	0.29	0.29	3/5	300	RMEG child
	TOLUENE	0.0011	0.0013	0.00117	0.0011	3/5	40	IEMEG pica
	TPH (C10-C36)	26	60	43	43	2/4	NA	NA

Note:
NA = not available
Mg/kg = milligram per kilogram
Min: minimum concentration
Max: maximum concentration
Mean: mean concentration
Median: median concentration
D/S: number of detected samples/number of total samples

CV: comparison value
NA: not applicable
CEMEG: chronic environmental media evaluation guide
CEMEGchild: chronic environmental media evaluation guide for children
RMEG: reference dose media evaluation guide
RMEGchild: reference dose media evaluation guide for children
CREG: cancer risk evaluation guide for 1×10^{-6} excess cancer risk
IEMEG: intermediate environmental media evaluation guide
IEMEGpica: intermediate environmental media evaluation guide for children with pica-behavior
EPA SSL: EPA soil screening level
KDHE: The Risk-Based Standards for Kansas (RSK) for residential scenarios

Table 3 — Summary of Soil Sample Results for Other Areas (mg/kg)

Depth	SUBSTANCE	MIN	MAX	MEAN	MEDIAN	D/S	CV	CV TYPE
Subsurface soil samples (>0.5 feet)	1,2,4-TRIMETHYLBENZENE	0.0022	15	2.52	0.235	22/48	9.7	KDHE
	1,3,5-TRIMETHYLBENZENE	0.0022	6.6	1.13	0.285	18/48	69.4	KDHE
	1,3-DICHLOROBENZENE	2.2	2.2	2.2	2.2	1/49	60	IEMEG pica
	1,4-DICHLOROBENZENE	0.8	0.8	0.8	0.8	1/49	100	IEMEG pica
	1-METHYLNAPHTHALENE	0.074	38	4.32	0.96	23/49	4000	CEMEG child
	2,4-DIMETHYLPHENOL	0.35	3.1	1.15	0.57	4/49	1000	RMEG child
	2-BUTANONE	0.0044	0.13	0.0348	0.022	11/41	30000	RMEG child
	2-HEXANONE	0.0045	0.0065	0.0055	0.0055	2/48		NA
	2-METHYLNAPHTHALENE	0.087	66	6.89	1.55	24/49	2000	CEMEG child
	3-METHYLPHENOL AND 4-METHYLPHENOL	2.4	2.4	2.4	2.4	1/12		NA
	ACENAPHTHENE	0.058	5.6	1	0.245	8/49	1000	IEMEG pica
	ACENAPHTHYLENE	0.14	0.14	0.14	0.14	1/49		
	ACETONE	0.0069	1.6	0.261	0.11	21/39	4000	IEMEG pica
	ANTHRACENE	0.096	10	2.31	0.265	10/49	20000	IEMEG pica
	ARSENIC	1.4	19.2	5.33	4.9	49/49	0.5	CREG
	BARIUM	19.3	845	220	183	49/49	1000	IEMEG pica
	BENZENE	0.001	2.5	0.399	0.0965	26/48	10	CREG
	BENZO(A)ANTHRACENE	0.081	17	2.45	0.12	9/49	26	KDHE
	BENZO(A)PYRENE	0.091	9.7	2.19	0.46	7/49	0.1	CREG
	BENZO(B)FLUORANTHENE	0.066	3	1.17	1.1	5/49	19	KDHE
	BENZO(GHI)PERYLENE	0.16	6.5	1.63	0.795	8/49		NA
	BENZO(K)FLUORANTHENE	0.85	1.4	1.12	1.1	3/49	10	KDHE
	CADMIUM	0.21	5.8	1.2	0.455	40/49	10	CEMEG child
	CARBON DISULFIDE	0.0009	0.016	0.00492	0.0022	5/48	20	AEMEG pica
	CHLOROBENZENE	0.17	0.17	0.17	0.17	1/48	800	IEMEG pica
	CHROMIUM	8.7	37.2	27.5	28.8	49/49	4,000	KDHE
	CHRYSENE	0.13	23	3.35	0.265	10/49	6.4	KDHE
	CRESOL, ORTHO-	0.098	6.1	2.4	1.7	4/49	100	AEMEG pica
	CRESOL, PARA-	0.12	9.9	3.4	0.19	3/37	100	AEMEG pica
	CUMENE	0.0019	1.4	0.336	0.135	24/48	5000	RMEG child
	DI(2-ETHYLHEXYL)PHTHALATE	0.17	10	2.67	0.265	4/49	50	CREG
	DIBENZO(A,H)ANTHRACENE	0.18	2.3	1.05	0.855	4/49	2.6	KDHE
	DIESEL FUEL	2.2	23000	2230	370	31/49	20,000	KDH
	ETHANOL	0.22	0.22	0.22	0.22	1/48	NA	NA
	ETHYL BENZENE	0.0036	4.1	0.844	0.48	20/48	5000	RMEG child
	FLUORANTHENE	0.18	9.9	4.29	3.55	4/49	800	IEMEG pica
	FLUORENE	0.12	10	1.95	0.335	10/49	800	IEMEG pica
	GASOLINE RANGE ORGANICS (GRO)	0.79	3500	304	76	31/48	450	KDHE
	INDENO(1,2,3-CD)PYRENE	0.081	1.9	0.685	0.605	6/49	0.76	KDHE
	LEAD	8.5	11900	295	17.2	49/49	400	EPA SSL
	M,P- XYLENE OR TOTAL XYLENES	0.0045	15	1.97	0.545	20/48	2000	IEMEG pica
	MERCURY	0.0046	1.6	0.0792	0.015	48/49	20	KDHE
	METHYL ISOBUTYL KETONE	0.0023	0.0035	0.00303	0.0033	3/48	3,600	KDHE
	METHYL-4-(1-METHYLETHYL)BENZENE	0.0085	1.5	0.498	0.265	14/48	NA	NA
	METHYLENE CHLORIDE	0.02	0.31	0.187	0.23	3/18	90	CREG
	NAPHTHALENE	0.089	30	3.25	1.25	20/49	1000	IEMEG pica
	N-BUTYLBENZENE	0.0048	5.5	1.17	0.59	17/48	395	KDHE
	N-PROPYL BENZENE	0.0061	9.2	1.02	0.45	21/48	400	KDHE
	PHENANTHRENE	0.061	27	3.51	0.635	22/49	NA	NA
	PHENOL	0.11	4.7	1.35	0.13	5/49	20000	RMEG child
	PYRENE	0.05	25	2.29	0.245	20/49	2000	RMEG child
	QUINOLINE	0.1	0.1	0.1	0.1	1/49	NA	NA
	SEC-BUTYLBENZENE	0.0047	2.5	0.615	0.165	14/48	380	KDHE
	SELENIUM	0.5	3.5	1.09	0.76	10/49	300	CEMEG child
	SILVER	0.32	1.3	0.71	0.37	5/49	300	RMEG child
	TOLUENE	0.0015	1.8	0.281	0.0165	24/48	40	IEMEG pica
	TPH (C10-C36)	1.7	28000	2500	320	33/49	220	KDHE
	TRANS-1,4-DICHLORO-2-BUTENE*	0.12	0.12	0.12	0.12	1/48	NA	NA

Depth	SUBSTANCE	MIN	MAX	MEAN	MEDIAN	D/S	CV	CV TYPE
Surface soil samples (0-0.5 feet)	1,2,4-TRIMETHYLBENZENE	0.0029	0.082	0.0176	0.00535	12/51	9.7	KDHE
	1,3,5-TRIMETHYLBENZENE	0.002	0.026	0.00828	0.00365	6/51	69.4	KDHE
	1-METHYLNAPHTHALENE	0.07	69	7.41	0.96	23/50	4000	CEMEG child
	2,4-DIMETHYLPHENOL	0.14	9.7	2.6	0.64	5/50	1000	RMEG child
	2-BUTANONE	0.0036	0.046	0.0191	0.0076	3/39	30000	RMEG child
	2-METHYLNAPHTHALENE	0.074	95	9.86	1.9	27/50	2000	CEMEG child
	3-METHYLPHENOL AND 4-METHYLPHENOL	1.1	4.1	2.17	1.3	3/13	NA	NA
	ACENAPHTHENE	0.06	13	2.73	0.715	6/50	1000	IEMEG pica
	ACENAPHTHYLENE	0.049	0.32	0.143	0.059	3/50		NA
	ACETONE	0.0046	0.55	0.111	0.0061	7/46	4000	IEMEG pica
	ANTHRACENE	0.07	19	2.04	0.305	16/50	20000	IEMEG pica
	ARSENIC	1.6	30.4	10.1	7.1	51/51	0.5	CREG
	BARIUM	43.2	2610	224	145	51/51	30000	CEMEG child
	BENZENE	0.0006	1.4	0.119	0.0025	13/52	10	CREG
	BENZO(A)ANTHRACENE	0.047	13	1.29	0.22	25/50	26	KDHE
	BENZO(A)PYRENE	0.062	11	1.35	0.28	25/50	0.1	CREG
	BENZO(B)FLUORANTHENE	0.061	11	1.04	0.205	14/50	19	KDHE
	BENZO(GHI)PERYLENE	0.075	5.9	1.16	0.44	28/50	NA	NA
	BENZO(K)FLUORANTHENE	0.1	9.1	1.93	0.11	5/50	10	KDHE
	CADMIUM	0.33	122	8.16	2.6	49/51	100	CEMEG
	CARBON DISULFIDE	0.0015	0.0034	0.00245	0.00245	2/51	20	AEMEG pica
	CHROMIUM	7.9	1350	50	23.5	51/51	4,000	KDHE
	CHRYSENE	0.071	21	1.67	0.465	28/50	6.4	KDHE
	CRESOL, ORTHO-	0.1	10	2.89	0.93	5/50	100	AEMEG pica
	CRESOL, PARA-	0.42	12	6.21	6.21	2/37	100	AEMEG pica
	CUMENE	0.0024	4.1	1.11	0.17	4/51	5000	RMEG child
	DI(2-ETHYLHEXYL)PHTHALATE	0.083	53	8.32	1.3	13/49	50	CREG
	DIBENZO(A,H)ANTHRACENE	0.085	2.6	0.542	0.21	11/50	2.6	KDHE
	DIESEL FUEL	1.7	28000	2030	245	46/52	20,000	KDHE
	DIMETHYL PHTHALATE	0.26	14	7.13	7.13	2/50		NA
	ETHANOL	0.15	2	0.657	0.24	4/51		NA
	ETHYL BENZENE	0.0017	1.3	0.221	0.0019	6/52	5000	RMEG child
	FLUORANTHENE	0.083	27	2.65	0.32	14/50	800	IEMEG pica
	FLUORENE	0.11	23	2.89	0.46	10/50	800	IEMEG pica
	GASOLINE RANGE ORGANICS (GRO)	0.49	7700	399	6.3	33/52	450	KDHE
	INDENO(1,2,3-CD)PYRENE	0.063	5.1	0.622	0.19	19/50	0.76	KDHE
	LEAD	15.8	4750	606	206	51/51	400	EPA SSL
	M,P- XYLENE OR TOTAL XYLENES	0.0041	0.81	0.0836	0.007	11/52	2000	IEMEG pica
	MERCURY	0.01	17.2	0.638	0.0815	52/53	20	KDHE
	METHYL-4-(1-METHYLETHYL)BENZENE	0.16	0.16	0.16	0.16	1/51	NA	NA
	METHYLENE CHLORIDE	0.22	0.22	0.22	0.22	1/7	90	CREG
	NAPHTHALENE	0.067	49	4.99	0.95	17/50	1000	IEMEG pica
	N-BUTYLBENZENE	0.34	9.8	5.07	5.07	2/51	395	KDHE
	N-PROPYL BENZENE	0.011	15	5.11	0.33	3/51	400	KDHE
	PHENANTHRENE	0.061	96	5.45	0.465	34/50		NA
	PHENOL	0.14	4.1	1.38	0.6	5/50	20000	RMEG child
	PYRENE	0.052	85	4.23	0.315	32/50	2000	RMEG child
	QUINOLINE	0.22	0.22	0.22	0.22	1/50	NA	NA
	SEC-BUTYLBENZENE	0.41	6.1	3.25	3.25	2/51	380	KDHE
	SELENIUM	0.6	5.3	1.17	0.75	27/51	300	CEMEG child
	SILVER	0.11	3.4	0.796	0.475	26/51	300	RMEG child
	TOLUENE	0.001	0.41	0.034	0.00285	36/52	40	IEMEG pica
	TPH (C10-C36)	2.3	36000	2460	255	48/52	450	KDHE

Note:
NA = not available
Mg/kg = milligram per kilogram
Min: minimum concentration
Max: maximum concentration
Mean: mean concentration
Median: median concentration

D/S: number of detected samples/number of total samples
NA: not applicable
CEMEG: chronic environmental media evaluation guide
CEMEGchild: chronic environmental media evaluation guide for children
AEMEGpica: acute environmental media evaluation guide for children with pica-behavior
RMEG: reference dose media evaluation guide
RMEGchild: reference dose media evaluation guide for children
CREG: cancer risk evaluation guide for 1×10^{-6} excess cancer risk
IEMEG: intermediate environmental media evaluation guide
IEMEGpica: intermediate environmental media evaluation guide for children with pica-behavior
EPA SSL: EPA soil screening level
KDHE: The Risk-Based Standards for Kansas (RSK) for residential scenarios

Table 4 Summary of Sediment samples (mg/kg)

SUBSTANCE	MIN	MAX	MEAN	MEDIAN	D/S	CV	CV TYPE
1,1,1-TRICHLOROETHANE					0/6	40000	IEMEG pica
1,1,2,2 -TETRACHLOROETHANE					0/5	4	CREG
1,1-DICHLOROETHANE					0/5	2100	KDHE
1,1-DICHLOROETHENE					0/5	500	CEMEG child
1,2,4-TRIMETHYLBENZENE	0.0042	0.071	0.0376	0.0376	2/5	9.7	KDHE
1,2-DIBROMOETHANE					0/5	0.4	CREG
1,2-DICHLOROBENZENE					0/4	800	IEMEG pica
1,2-DICHLOROETHANE					0/5	8	CREG
1,2-DICHLOROETHYLENE					0/5	NA	NA
1,2-DICHLOROPROPANE					0/5	100	IEMEG pica
1,3,5-TRIMETHYLBENZENE					0/5	69.4	KDHE
1,3-DICHLOROBENZENE					0/4	60	IEMEG pica
1,4-DICHLOROBENZENE					0/4	100	IEMEG pica
1,4-DIOXANE					0/5	60	CREG
1-METHYLNAPHTHALENE	0.16	0.93	0.44	0.23	3/4	4000	CEMEG child
2,4-DIMETHYLPHENOL					0/4	1000	RMEG child
2,4-DINITROPHENOL					0/4	20	AEMEG pica
2-BUTANONE	0.0049	0.022	0.011	0.006	3/5	30000	RMEG child
2-HEXANONE					0/5	NA	NA
2-METHYLNAPHTHALENE	0.22	1.8	0.77	0.53	4/4	2000	CEMEG child
4-NITROPHENOL					0/4	NA	NA
ACENAPHTHENE					0/4	1000	IEMEG pica
ACENAPHTHYLENE					0/4	NA	NA
ACETONE	0.011	0.75	0.204	0.0275	4/5	4000	IEMEG pica
ACRYLONITRILE					0/5	1	CREG
ANTHRACENE	0.2	0.8	0.427	0.28	3/4	20000	IEMEG pica
ARSENIC	7.5	32.9	15.3	10.4	4/4	0.5	CREG
BARIUM	158	197	178	179	4/4	1000	IEMEG pica
BENZENE					0/5	10	CREG
BENZO(A)ANTHRACENE	0.18	1.1	0.54	0.44	4/4	26	KDHE
BENZO(A)PYRENE	0.24	1.8	0.77	0.52	4/4	0.1	CREG
BENZO(B)FLUORANTHENE	0.17	0.91	0.483	0.425	4/4	19	KDHE
BENZO(GHI)PERYLENE	0.48	2.8	1.49	1.2	3/4	NA	NA
BENZO(K)FLUORANTHENE	0.19	0.65	0.423	0.43	3/4	10	KDHE
BROMODICHLOROMETHANE					0/5	10	CREG
CADMIUM	6.5	24.3	12.9	10.4	4/4	100	CEMEG
CARBON DISULFIDE					0/5	20	AEMEG pica
CHLOROBENZENE					0/5	800	IEMEG pica
CHLORODIBROMOMETHANE					0/5	8	CREG
CHLOROETHANE					0/5	NA	NA
CHLOROFORM					0/5	200	IEMEG pica
CHLOROMETHANE					0/5	140	KDHE
CHROMIUM	36.8	112	61.2	48	4/4	4000	KDHE
CHRYSENE	0.36	3.5	1.47	1.01	4/4	6.4	KDHE
CRESOL, META-					0/4	100	AEMEG pica
CRESOL, ORTHO-					0/4	100	AEMEG pica

SUBSTANCE	MIN	MAX	MEAN	MEDIAN	D/S	CV	CV TYPE
CRESOL, PARA-					0/4	100	AEMEG pica
CUMENE	0.38	0.38	0.38	0.38	1/5	5000	RMEG child
DI(2-ETHYLHEXYL)PHTHALATE	0.82	5.5	2.94	2.5	3/4	50	CREG
DIBENZO(A,H)ANTHRACENE	0.18	0.94	0.49	0.35	3/4	2.6	KDHE
DIBROMOMETHANE					0/5	NA	NA
DIESEL FUEL	420	630	525	525	2/2	20000	KDHE
DIETHYL PHTHALATE					0/4	10000	IEMEG pica
DIMETHYL PHTHALATE	0.11	0.11	0.11	0.11	1/4	NA	NA
DI-N-BUTYL PHTHALATE					0/4	1000	AEMEG pica
ETHANOL					0/5	NA	NA
ETHYL BENZENE					0/5	5000	RMEG child
FLUORANTHENE	0.23	0.54	0.37	0.34	3/4	800	IEMEG pica
FLUORENE					0/4	800	IEMEG pica
GASOLINE RANGE ORGANICS (GRO)	2	75	38.5	38.5	2/5	450	KDHE
INDENO(1,2,3-CD)PYRENE	0.16	1.3	0.535	0.34	4/4	0.76	KDHE
ISOPROPANOL					0/4	NA	NA
LEAD	167	616	335	279	4/4	400	EPA SSL
MERCURY	0.18	0.4	0.26	0.23	4/4	20	KDHE
METHYL ISOBUTYL KETONE					0/5	3600	KDHE
METHYLENE CHLORIDE	0.0044	0.53	0.11	0.0052	5/5	90	CREG
METHYL-T-BUTYL ETHER					0/5	600	IEMEG pica
NAPHTHALENE	0.12	0.58	0.31	0.23	3/4	1000	IEMEG pica
N-BUTYLBENZENE	3.1	3.1	3.1	3.1	1/5	395	KDHE
N-PROPYL BENZENE	2.3	2.3	2.3	2.3	1/5	400	KDHE
PHENANTHRENE	0.38	0.75	0.578	0.59	4/4	NA	NA
PHENOL					0/4	20000	RMEG child
PYRENE	0.33	3.6	1.3	0.63	4/4	2000	RMEG child
PYRIDINE					0/4	50	RMEG child
QUINOLINE					0/4	NA	NA
SEC-BUTYLBENZENE	2.5	2.5	2.5	2.5	1/5	380	KDHE
SELENIUM	1	1.2	1.1	1.1	2/4	300	CEMEG child
SILVER					0/2	300	RMEG child
STYRENE					0/5	400	IEMEG pica
TETRACHLOROETHYLENE					0/5	100	AEMEG pica
TOLUENE	0.0017	0.0024	0.002	0.0019	3/5	40	IEMEG pica
TPH (C10-C36)	1000	1400	1200	1200	2/2	450	KDHE
TRICHLOROETHYLENE					0/5	400	AEMEG pica
TRICHLOROFLUOROMETHANE					0/5	20000	RMEG child
VINYL ACETATE					0/5	NA	NA
VINYL CHLORIDE					0/5	0.5	CREG

Blank cells: not detected
NA = not available
Mg/kg = milligram per kilogram
Min: minimum concentration
Max: maximum concentration
Mean: mean concentration
Median: median concentration
D/S: number of detected samples/number of total samples
NA: not applicable

CEMEG: chronic environmental media evaluation guide
CEMEGchild: chronic environmental media evaluation guide for children
AEMEGpica: acute environmental media evaluation guide for children with pica-behavior
RMEG: reference dose media evaluation guide
RMEGchild: reference dose media evaluation guide for children
CREG: cancer risk evaluation guide for 1×10^{-6} excess cancer risk
IEMEG: intermediate environmental media evaluation guide
IEMEGpica: intermediate environmental media evaluation guide for children with pica-behavior
EPA SSL: EPA soil screening level
KDHE: The Risk-Based Standards for Kansas (RSK) for residential scenarios

Table 5 – Summary of Soil and Sediment Sampling Results for Samples collected by KDHE (mg/kg)

Date	Location	Media	# of sample	Analyte	Detection	Concentration*
June 2001	Airosol	Sediment	1	Metals	None	NA
June 2002	5th & Osage	Sediment	1	Metals SVOCs VOCs	Barium Cadmium Chromium Lead Silver Mercury	64.6 1.13 6.98 73.1 1.69 0.298
June 2002	Neodesha High School	Soil	2	Metals SVOCs VOCs	Barium Cadmium Chromium Lead TPH	161 8.08 18.1 231 130,000
June 2002	Private property	Soil sediment	3	Metals SVOCs VOCs	Aluminum Arsenic Barium Beryllium Boron Cadmium Calcium Chromium Cobalt Copper Iron Lead Magnesium Manganese Nickel Potassium Silica Sodium Vanadium Zinc	32102 7.35 279 0.76 13.75 2.65 20622 31.31 24.49 16.93 19150 54.70 2666 719.43 16.95 3455 2354 126.99 48.71 369.73
June 2002	Neodesha ponds	soil Sediment	2	Metals SVOCs VOCs	Barium Cadmium Chromium Lead Mercury TPH/DRO TPH/GRO Xylene	157 90.4 30.2 1270 5.41 1700 11 0.25
January 2006	West Indiana Street	soil	3	Metals SVOCs VOCs	Arsenic Barium Cadmium Chromium Lead Mercury Silver TPH/DRO TPH/GRO	18.9 145 14.9 30.7 1,410 0.75 0.99 344,000 4,580

Date	Location	Media	# of sample	Analyte	Detection	Concentration*
October 2005 – February 2006	Former Twin Rivers Plating	soil	18	Metals SVOCs VOCs	Arsenic Barium Beryllium Cadmium Chromium Chromium (VI) Copper Lead Manganese Mercury Silver Vanadium Zinc	15 430 1.2 7.4 3,000 22.7 440 840 640 45.1 1.7 64 4,800

Note:

* Detected maximum concentrations

TPH: total petroleum hydrocarbons

mg/kg: milligram per kilogram

Appendix A. Dose Calculation for Estimating Arsenic and Mercury Exposure Doses

The major exposure pathway by which residents can be exposed to arsenic and mercury at the site is incidental ingestion of contaminated soil. Children and children with soil-pica behavior are a special concern for acute exposures because ingesting high amounts of soil could lead to significant arsenic exposure.

Estimate ingestion exposure dose for arsenic

The following assumptions were made to estimate ingestion exposure dose for arsenic:

(1) a adult resident's body weight is 70 kg,

(2) a adult resident soil ingestion rate is 100 mg/day

(3) a child's body weight is 16 kg,

(4) a child's soil ingestion rate is 200 mg/day,

(5) a soil-pica child's maximum soil ingestion rate is 5,000 mg/day, and a soil-pica frequency of 3 days per week.

The following mathematical formula was used to estimate the daily intake of arsenic:

ID = C x IR x BA x EF x10¯6/BW

Where,

ID=ingestion exposure dose (mg/kg/day)

C=contaminant concentration (mg/kg), the maximum arsenic concentrations in surface soil of 10.3 mg/kg (background) and 7.5 mg/kg (Ballpark) are used to represent the worst case scenario for acute exposures, chronic exposures and soil-pica child exposures.

IR=ingestion rate (mg/day)

BA=bioavailability factor (unitless, conservatively assumed to be 42 % based on an EPA study by Casteel SW, Evans T, Dunsmore ME, et al. 2001)

EF=exposure factor (unitless, conservatively assumed to be 1.0 for adults and children, and 0.429 for soil-pica children)

BW= body weight (kg)

For adults and children, the following table shows the estimated absorbed doses at acute and chronic exposure durations:

Population	*Estimated Arsenic exposure dose (mg/kg/day) Background area*	*Estimated Arsenic exposure dose (mg/kg/day) Ballpark area*	*Acute MRL (mg/kg/day)*	*Chronic MRL (mg/kg/day)*
Adult	0.0000062	0.0000045	0.005	0.0003
Child	0.00054	0.000039	0.005	0.0003
Pica-child	0.00058	0.00042	0.005	0.0003

It is unlikely that adults and children at the site experience non-cancerous harmful effects from exposure to arsenic in soil.

For mercury exposures, use the same assumptions and the maximum concentration in surface soil of 0.4 mg/kg and bioavailability factor of 1 to represent the worst case scenario for acute exposures, chronic exposures and soil-pica child exposures. The following table shows the estimated absorbed doses at acute and chronic exposure durations:

Population	*Estimated Mercury exposure dose (mg/kg/day)*	*Acute MRL (mg/kg/day)*	*Chronic MRL (mg/kg/day)*
Adult	0.00000057	0.007	0.002
Child	0.000005	0.007	0.002
Pica-child	0.000054	0.007	0.002

For industrial workers who have potential exposures to mercury-contaminated soil, using the maximum mercury concentration of 45.1 mg/kg, the estimated maximum dose is 0.000064 mg/kg/day.

It is unlikely that adults and children at the site experience non-cancerous harmful effects from exposure to mercury in soil.

Because the most likely exposure to soil at site is occasional ingestion or infrequent dermal contact with contaminated surface soil by residents and out door workers, ATSDR consider the possibility of causing cancer among exposed individuals is minimal.

Appendix B. ATSDR's comparison values and definitions

ATSDR comparison values (CVs) are media-specific concentrations considered safe under default exposure scenario. ATSDR uses them as screening values to identify contaminants (site-specific substances) that require further evaluation to determine the potential for adverse health effects.

Generally, a chemical at a site requires further evaluation when its maximum concentration in air, water, or soil exceeds one of ATSDR's comparison values. Comparison values are *not*, however, thresholds of toxicity. While concentrations at or below the relevant comparison value may reasonably be considered safe, it does not automatically follow that any environmental concentration that exceeds a comparison value would be expected to produce adverse health effects. Indeed, the purpose behind these highly conservative, health-based standards and guidelines is to enable health professionals to recognize and resolve potential public health problems *before* they become actual health hazards. The probability that adverse health outcomes will actually occur as a result of exposure to environmental contaminants depends on individual lifestyles and genetic factors and site-specific conditions that affect the route, magnitude, and duration of actual exposure, and not on environmental concentrations alone.

ATSDR derives screening values on the basis of noncancerous effects by dividing a NOAEL (no observed adverse effect level) by LOAELs (lowest observed adverse effect level). These levels stem from animal or human studies and include cumulative safety margins (variously called safety factors, uncertainty factors, or modifying factors) that typically range from 10 to 1,000 or more.

By contrast, cancer-based screening values come from linear extrapolations from animal data obtained at high doses because human cancer incidence data for very low levels of exposure simply do not exist, and probably never will.

Listed below are the comparison values that ATSDR uses to select chemicals for further evaluation, along with the abbreviations for the most common units of measure.

EMEG = environmental media evaluation guides

RMEG = reference dose media evaluation guide

MRLs = minimal risk levels

ppm = parts per million, e.g., mg/L or mg/kg

ppb = parts per billion, e.g., µg/L or µg/kg

kg = kilogram (1,000 gram)

mg = milligram (0.001 gram)

µg = microgram (0.000001 gram)

L = liter

m^3 = cubic meter (= 1,000 liters)

acute exposure: exposure to a chemical for a duration of 14 days or less.

cancer risk evaluation guide (CREG): estimated contaminant concentration in water, soil, or air that would be expected to cause no more than one excess case of cancer in a million persons exposed over a lifetime. CREGs are calculated from EPA's cancer slope factors.

chronic exposure: exposure to a chemical for 365 days or more.

environmental media evaluation guide (EMEG): concentration of a contaminant in water, soil, or air unlikely to produce any appreciable risk of adverse, non-cancer effects over a specified duration of exposure. EMEGs are derived from ATSDR minimal risk levels by factoring in default body weights and ingestion rates. ATSDR computes separate EMEGs for acute (≤14 days), intermediate (15–364 days), and chronic (>365 days) exposures.

intermediate exposure: exposure to a chemical for a duration of 15–364 days.

lowest observed adverse effect level (LOAEL): The lowest exposure level of a chemical in a study or group of studies that produces statistically or biologically significant increase(s) in frequency or severity of adverse health effects between the exposed and control populations.

minimal risk level (MRL): estimate of daily human exposure to a hazardous substance that is not likely to pose an appreciable risk of adverse noncancer health effects over a specified route and duration of exposure.

no observed adverse effect level (NOAEL): The dose of a chemical at which no statistically or biologically significant increases in frequency or severity of adverse health effects were seen between the exposed population and its appropriate control**.** Effects may be produced at this dose, but they are not considered to be adverse.

uncertainty factor (UF): a factor used in deriving the MRL or reference dose or reference concentration from exposure data.

The following comparison values were used for this health consultation:

Environmental media evaluation guide (EMEGs)

Reference dose media evaluation guide (RMEGs)

Cancer risk evaluation guides (CREGs)

Appendix C. Adult Lead Model

Methodology of U.S. EPA Adult Lead Model (adopted from the RETEC Risk Assessment Report, Appendix G)

The U.S. EPA Technical Review Workgroup for Lead developed a biokinetic model for nonresidential adult exposure to lead in soil (U.S. EPA, 1996). The model was developed to address adults exposed to high levels of lead in soil and dust in situations where there are no exposures to children. These situations include adults working on a daily basis in occupations that involve lead exposures, or adults involved in construction or remediation activities at lead-contaminated sites. The model was developed to be protective of the most sensitive non-residential scenario, namely women of childbearing age. This recommended approach for assessing nonresidential adult risk utilizes a methodology to relate soil and dust lead intake to blood lead concentrations in women of childbearing age and is conceptually similar to a slope factor approach for deriving remedial action concentrations (RACs) proposed by Bowers et al. (1994) (U.S. EPA, 1996). For this site, the Adult Lead Model will be utilized to evaluate RACs from lead exposure to industrial/commercial workers, construction workers, and lawncare workers.
The model assumes an adult baseline blood lead level, calculates an estimated blood lead level due to exposure to lead at a site, and then compares the difference of those blood levels to a blood lead benchmark. In the case of women of childbearing age, the benchmark is 10 μg/dL, which is the level deemed protective of fetuses and neonates.
The model is comprised of four equations (described below) that determine a receptor-specific RAC. All input values for the following equations are presented in Table C-1.
Equation 1 calculates the central estimate of blood lead concentrations in adults who have site exposure to lead at concentration PbS:

$$PbS_{adult-central} = PbB_{adult-0} + (PbB * BKSF * PbS * IRs * EFs / AT) \qquad (1)$$

where:

$PbB_{adult\text{-}central}$ = Central estimate of blood lead concentrations (μg/dL) in adults (i.e., women of childbearing age) who have site exposures to soil and dust lead at concentration PbS

$PbB_{adult\text{-}0}$ = Baseline or typical blood lead concentration (μg/dL) in adults in the absence of exposures to the site that is being assessed. The default values for this model are based on a range for women according to ethnic population: 2.0 μg/dL for mixed racial or Mexican American women, 2.2 μg/dL for non-Hispanic black women, and 1.7 for non-Hispanic white women. The value of 1.7 was chosen due to the assumed characteristics of receptors at the Neodesha Former Refinery site.

PbS = Appropriate average soil lead concentration (μg/g) that receptor is exposed.

BKSF = Biokinetic slope factor relating (quasi-steady state) increase in typical adult blood lead concentration to average daily lead uptake (μg/dL blood lead increase per μg/day lead uptake)

IRs = Intake rate of soil, including both outdoor soil and indoor soil derived dust (g/day)

AFs = Absolute gastrointestinal absorption fraction for ingested lead in soil and lead in dust derived from soil (dimensionless)

EFs = Exposure frequency for contact with assessed soils and/or dust derived in part from these soils (days of exposure during the averaging period); may be taken as days per year for continuing, long term exposure.
AT = Averaging time; the total period during which soil contact may occur; 365 days/year for continuing long-term exposures

Equation 1 does not contain an input parameter for exposure duration (ED), which is the number of years that a receptor may potentially be exposed to soil at the site. For this site, the ED for the indoor/outdoor industrial worker and the lawncare worker is identified as 11.9 years. The default exposure frequency is identified as 219 day/year (as presented in Table C-1). This value is used for the outdoor industrial worker. The maximally exposed receptor for lead exposure in soil is identified as the outdoor industrial worker. Therefore, this receptor is represented by the baseline exposure by which all other receptors are compared to when calculating lead RACs in soil.

The total exposure (EFs x ED) is calculated as 2,606.1 days for the outdoor industrial worker.
To modify the exposure frequency for the indoor industrial worker, construction worker, and lawncare worker, the total exposure (EFs x ED) [Total Exposure $_{(receptor\ X)}$] is calculated and that value is used to extrapolate the modified exposure frequency [$EFs_{(receptor\ X)}$] based on the following equation:

$$EFs_{(receptor\ X)} / Total\ Exposure_{(receptor\ X)} = EFs_{(outdoor\ indust\ worker)} / Total\ Exposure_{(outdoor\ indust\ worker)} \quad (2)$$

where:

$EFs_{(receptor\ X)}$ = calculated (days/year). This calculated value is the input value used for the lead model.

Total Exposure $_{(receptor\ 1\ =\ construction\ worker)}$ = 219 days (219 d/yr x 1 year)

Total Exposure $_{(receptor\ 2\ =\ lawncare\ worker)}$ = 171.6 days (26 d/yr x 6.6 years)

Total Exposure $_{(receptor\ 3\ =\ indoor\ indust.\ worker)}$ = 952 days (80 days/yr x 11.9 years)

EFs $_{(outdoor\ indust\ worker)}$ = 219 days/year
Total Exposure $_{(outdoor\ indust\ worker)}$ = 2606.1 days (219 d/yr x 11.9 years)

By rearranging Equation 2 to solve for EFs $_{(receptor)}$, the equation becomes:

$$EFs_{(receptor\ X)} = [\ EFs_{(outdoor\ indust\ worker)} / Total\ Exposure_{(outdoor\ indust\ worker)}\ ] \times Total\ Exposure_{(receptor\ X)} \quad (3)$$

Example for the Construction Worker:

$EFs_{(construction\ worker)}$ = [219 days/yr/ 2606.1 days] x 219 days= 18.4 days/yr

Therefore, the modified exposure frequencies for the indoor industrial worker, construction worker, and lawncare worker are 80 days/year, 18.4 days/year and 14.4 days/year, respectively.

These values are presented in Table C-1.

Equation 4 describes the estimated relationship between the blood lead concentration in adult women and the corresponding 95th percentile fetal blood lead concentration:

$$PbB_{fetal-0.95} = PbB_{adult-central} * GSD_{i-adult}^{1.645} * R_{fetal/maternal} \quad (4)$$

where:

$PbB_{fetal-0.95}$ = Goal for 95th percentile blood lead concentration (µg/dL) among fetuses born to women having exposures to the specified site soil concentration; this is interpreted to mean that there is a 95% likelihood that a fetus, in a women who experiences such exposures, would have a blood lead concentration no greater than $PbB_{fetal-0.95}$ (i.e., likelihood of a blood lead concentration greater than 10 µg/dL would be less than 5% for this model)

$GSD_{i-adult}$= Estimated value of the individual geometric standard deviation (dimensionless); the GSD among adults (i.e., women of childbearing age) that have exposures to similar on-site lead concentrations, but have non-uniform response (intake, biokinetics) to site lead and non-uniform off-site lead exposures; the exponent, 1.645, is the value of the standard normal deviate used to calculate the 95th percentile from a lognormal distribution of blood lead concentration. $GSD_{i-adult}$ values vary from 1.8 (homogeneous population) to 2.1 (heterogeneous urban population). The value of 1.8 was chosen due to the rural setting of the Neodesha Former Refinery site.

$R_{fetal/maternal}$ = Constant of proportionality between fetal blood lead concentration at birth and maternal blood lead concentration (dimensionless).

Equation 4 can be rearranged to reflect a risk-based goal for central estimate of blood lead concentrations in adult women:

$$PbB_{adult-central=goal} = PbB_{fetal-0.95-goal} / GSD_{i-adult}^{1.645} * R_{fetal/maternal} \quad (5)$$

where:

$PbB_{adult-central-goal}$ = Goal for central estimate of blood lead concentration (µg/dL) in adults (i.e., women of childbearing age) that have site exposures; the goal is intended to ensure that $PbB_{fetal-0.95}$ does not exceed 10 µg/dl

The soil lead concentration associated with a given exposure scenario and $PbB_{adult-central-goal}$ can be calculated by rearranging Equation 1 and substituting the $PbB_{adult-central-goal}$ for $PbB_{adult-central}$:

$$RAC = PbS = \left(PbB_{adult-central-goal} - PbB_{adult-0} \right) * AT / BKSF * Irs * Afs * Efs \quad (6)$$

where:

RAC = Remedial action concentration (mg/kg)

Results
The Adult Lead Model was utilized at the Neodesha Former Refinery to determine the RAC protective of indoor and outdoor adult industrial/commercial workers, construction workers, and lawncare workers. Input parameters for the model equations are presented in Table C-1.
Table C-1 also presents the calculated lead RAC for the outdoor industrial worker, which is 1,754 mg/kg and the indoor industrial/commercial worker, which is 4,800 mg/kg. The calculated lead RACs for the construction worker and the lawncare worker are 20,871 mg/kg and 26,668 mg/kg, respectively.

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Table C-1 EPA Adult Lead Model Results for Neodesha

Parameter	Units	Value	Comment
PbS (RAC)	**µg/g**	**1,754**	**Calculated soil lead concentration protective of an Outdoor industrial/commercial worker**
PbS (RAC)	**µg/g**	**4,800**	**Calculated soil lead concentration protective of an Indoor industrial/commercial worker**
PbS (RAC)	**µg/g**	**20,871**	**Calculated soil lead concentration protective of Construction worker**
PbS (RAC)	**µg/g**	**26,668**	**Calculated soil lead concentration protective of a lawncare worker**
$EF_{s\ (default)}$	day/yr	219	219 days/yr is model default based on EPA guidance for average time spent at work by both full-time and part-time workers (EPA, 1996). This value is also used for the outdoor industrial worker.
EF_s	day/yr	80	80 days/yr is based on current site conditions of how much time the indoor workers are possibly exposed to outside soil.
$EF_{s\ (construction\ worker)}$	day/yr	18.4	Based on a construction worker exposure scenario and adjusted for exposure duration (ED).
$EF_{s\ (lawncare\ worker)}$	day/yr	14.4	Based on a lawncare worker exposure scenario and adjusted for exposure duration (ED).
AF_s	--	0.12	Default based on absorption factor for soluble lead of 0.2 and a relative bioavailability of 0.6 (soil/soluble) (EPA, 1996-default value)
AT	days/year	365	Default assumption for steady state model- the total period during which soil contact may occur
$PbB_{adult-central-goal}$	µg/dL	4.225	Calculated goal for central estimate of blood lead concentration in adults that is protective of the $PbB_{fetal-0.95}$
$PbB_{fetal-0.95}$	µg/dL	10	For estimating RBRGs based on risk to developing fetus (EPA, 1996-default value)
$GSD_{i-adult}$	--	1.8 – 2.1	1.8 represents homogenous population and 2.1 represents heterogenous urban population **(1.8 was selected for use at the Neodesha Former Refinery)**
$R_{fetal/maternal}$	--	0.9	Based on Goyer (1990) and Graziano et al. (1990) (EPA, 1996-default value)
$PbB_{adult-0}$	µg/dL	1.7 – 2.2	Plausible range based on NHANES III phase 1 for Mexican American and non-Hispanic, black, and white women of child-bearing age (Brody et al., 1994); point estimate should be based on site-specific demographics **(1.7 was selected for this site as it is representative of non-Hispanic white women)** (EPA, 1996)

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Appendix D ATSDR's levels of public health hazard

Category A: Urgent Public Health Hazard

This category is used for sites where short-term exposures (<1 year) to hazardous substances or conditions could result in adverse health effects that require rapid intervention.

This determination represents a professional judgment based on critical data that ATSDR has judged sufficient to support a decision. Such a designation does not necessarily mean that the available data are complete; in some cases, additional data may be required to confirm or further support the decision made.

Criteria:

Evaluation of available relevant information* indicates that site-specific conditions or likely exposures have had, are having, or are likely to have an adverse impact on human health that requires immediate action or intervention. Such site-specific conditions or exposures may include the presence of serious physical or safety hazards, such as open mine shafts, poorly stored or maintained flammable or explosive substances, or medical devices, which, if ruptured, could release radioactive materials.

Category B: Public Health Hazard

This category is used for sites that pose a public health hazard because of the existence of long-term exposures (>1 yr) to hazardous substances or conditions that could result in adverse health effects.

This determination represents a professional judgment based on critical data that ATSDR has judged sufficient to support a decision. Such a designation does not necessarily mean that the available data are complete; in some cases, additional data may be required to confirm or further support the decision made.

Criteria:

Evaluation of available relevant information* suggests that, under site-specific conditions of exposure, long-term exposures to site-specific contaminants (including radionuclides) have had, are having, or are likely to have an adverse impact on human health that requires one or more public health interventions. Such site-specific exposures may include the presence of serious physical hazards, such as open mine shafts, poorly stored or maintained flammable or explosive substances, or medical devices, which, if ruptured, could release radioactive materials.

Category C: Indeterminate Public Health Hazard

This category indicates that a professional judgment on the level of health hazard cannot be made because information critical to such a decision is lacking.

Criteria:

This category is used for sites for which available *critical* data are insufficient with regard to the extent of exposure and/or toxicological properties at estimated exposure levels. Using professional judgment, the health assessor must determine the importance of such data and the likelihood that the data can and will be obtained in a timely manner.

Where some data—even limited data—are available, health assessors should, to the extent possible, select other hazard categories and support their decision with a clear narrative that explains the limits of the data and the rationale for the decision.

Category D: No Apparent Public Health Hazard

This category designates sites where human exposure to contaminated media may be occurring, may have occurred in the past, and/or may occur in the future, but the exposure is not expected to cause any adverse health effects.

This determination represents a professional judgment based on critical data that ATSDR has judged sufficient to support a decision. Such a designation does not necessarily mean that the available data are complete; in some cases, additional data may be required to confirm or further support the decision made.

Criteria:

Available relevant information* indicates that, under site-specific conditions of exposure, exposures to site-specific contaminants in the past, present, or future are not likely to result in adverse impact on human health.

Category E: No Public Health Hazard

This category is used for sites that, because of the absence of exposure, do *not* pose a public health hazard.

Criteria:

Sufficient evidence indicates that no human exposures to contaminated media have occurred, none are occurring, and none are likely to occur in the future.

* *Examples include environmental, demographic, health outcome, exposure, toxicological, medical, or epidemiologic data, as well as community health concerns information.*