HEALTH CONSULTATION

EVALUATION OF OHIO EPA SOIL SAMPLING

IN SUPPORT OF THE CLYDE AND EASTERN SANDUSKY COUNTY

CHILDHOOD CANCER INVESTIGATION

CLYDE, SANDUSKY COUNTY, OHIO

Prepared by

Health Assessment Section

Ohio Department of Health

JULY 28, 2011

This report was supported by funds from a cooperative agreement with the Agency for Toxic Substances and Disease Registry, U.S. Department of Health and Human Services. This document has not been reviewed and cleared by ATSDR.

SUMMARY

The Health Assessment Section at the Ohio Department of Health reviewed and evaluated the analytical results of surface soil sampling conducted by the Ohio Environmental Protection Agency (Ohio EPA) in the Clyde area in eastern Sandusky County in April, 2011. The Health Assessment Section investigates and evaluates the public health threats posed by the release of toxic chemicals to the environment in Ohio as part of a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR).

The soil sampling was part of a larger investigation by the Ohio Department of Health, the Sandusky County Health Department, and the Ohio EPA into a higher than expected incidence of childhood cancers in the Clyde community. Composite samples were collected from the upper six inches of soil at 10 locations in the general vicinity of Raccoon Creek on the west side of Clyde and from the public right-of-way in the downtown area near City Hall. Additional samples were collected from the City Park east of Race Street, the right-of-way along Mulberry Street and Coe Road in northwest Clyde, and the public right-of-way along Lynber Lane and from a private residence on the same street on the south side of Clyde. These samples were compared to background soil samples collected from public right-of-ways along Spayd and Limerick Roads west and south of Clyde in Green Creek Township (Figure 1). All soil samples were analyzed for a full suite of potential cancer-causing chemicals, including six metals, 21 pesticides, seven (7) varieties of polychlorinated biphenyls (PCBs), 65 semi-volatile organic compounds, and 66 volatile organic compounds (VOCs).

None of the samples collected provided any evidence of gross industrial contamination of these soils. None of the metals, pesticides, PCBs, or VOCs were detected in these soil samples at levels of public health concern. The soil sampling results indicate that the chemical constituents and their concentrations in soils in those areas of Clyde sampled by Ohio EPA were typical of background levels of these chemicals in urban and rural soils that have been sampled elsewhere in Ohio. Levels of some of the individual polycyclic aromatic hydrocarbons (PAHs) slightly exceeded their health-based screening levels at six (6) of the sites, including the background sample. Levels detected, however, were typical of urban soils elsewhere in Ohio, and when the soil sample with the highest detected concentrations of PAHs was further evaluated with regard to its toxicity, it did not exceed health-based cancer risk levels.

On the basis of laboratory analysis of the soil samples collected by the Ohio EPA in April, 2011, soils in the Clyde area sampled by Ohio EPA are not contaminated with toxic chemicals at levels of public health concern and exposure to these soils currently does not pose a cancer threat to residents, including area children.

STATEMENT OF ISSUES

The Health Assessment Section (HAS) at the Ohio Department of Health (ODH) reviewed and evaluated the analytical results of surface soil sampling conducted by the Ohio Environmental Protection Agency (Ohio EPA) in the Clyde area in eastern Sandusky County in April, 2010. Soil samples were collected by the Ohio EPA at several localities in the Clyde, Ohio area in response to community concerns regarding potential environmental exposures and the elevated incidence of childhood cancer cases documented in the Clyde area by the Ohio Department of Health and the Sandusky County Health Department (ODH and SCHD, 2007). Soil samples were collected from the upper six inches of soil at 11 locations in and around the city of Clyde, in eastern Sandusky County (Figure 1). The collected Ohio EPA soil samples were analyzed for a complete suite of chemicals, including potential cancer-causing metals, pesticides and polychlorinated biphenyls (PCBs), plus semi-volatile and volatile organic compounds (VOCs).

BACKGROUND

Clyde and eastern Sandusky County Childhood Cancer Investigation

In 2007 the Ohio Department of Health (ODH) and the Sandusky County Health Department (SCHD) completed an analysis of cancer incidence among residents aged 0-19 years in the city of Clyde and Green Creek Township for the years 1996-2006. This analysis (ODH and SCHD, 2007) revealed a higher than expected number of childhood cancers for the 11-year time period (10 cases observed; 5.32 expected). Cancers of the brain and the central nervous system were found to be significantly higher than the number of expected cases (4 cases observed; 0.92 expected). A 2007 profile of 14 of the children with cancer and their families using a standardized health questionnaire developed by the ODH did not reveal any common or individual factors that may have played a role in the development of cancer in these children (ODH and SCHD, 2008). A similar review of 21 childhood cancer cases and their families using an expanded health questionnaire and conducted in 2010 also failed to identify any factors or variables that were in common to the 21 children with cancer who participated in the cancer profile (ODH and SCHD, 2011). As noted in this review, the causes and risk factors for most childhood cancers remain unknown.

At several meetings with parents in 2008, concerns were expressed regarding chemical contaminants in the local environment as possible causes of these cancer cases. In response to these concerns, the Ohio EPA undertook a review of chemical releases in the Clyde area. With assistance from ODH and the SCHD, Ohio EPA also developed a plan to sample the environment in the Clyde and Green Creek Township area for chemical contaminants. This resulted in the following activities:

- Ohio EPA sampled groundwater in January and February, 2009 from four (4) private wells and collected seven (7) water samples from two public water supplies (City of Clyde and Ohio Rural Northern Water) that provided drinking water to families of the impacted children. The water was analyzed for metals, volatile organic compounds (VOCs), semi-volatiles, pesticides, and radioactive compounds. Analysis of the results of this drinking water sampling by Ohio EPA and the HAS indicated no cancer-causing contaminants in any of these water supplies at levels of public health concern (Ohio EPA, 2009a).

- A joint Ohio EPA/Ohio Department of Agriculture project collected nine (9) drinking water samples from three (3) wells and six (6) samples from two public water supplies in June, 2009 and tested them for 48 pesticides including 12 organophosphates. Five (5) of the 48 chemicals were detected and then only in the City of Clyde water supply. None of these pesticides were detected at levels that exceeded federal drinking water standards for these chemicals (Ohio EPA, 2009b).

- Ohio EPA conducted ambient (outdoor) air monitoring in the Clyde area in Clyde from January, 2009 to January, 2010. The air was monitored for particulates, heavy metals, and volatile organic compounds (VOCs). None of these chemicals were detected at concentrations that exceeded health-based standards (Ohio EPA, 2010a). Air quality in the Clyde and Green Springs Township area was in full compliance with National Ambient Air Quality Standards established by U.S. EPA for all criteria pollutants (particulates, nitrogen dioxide, ozone, carbon monoxide, lead, and sulfur dioxide).

- Ohio EPA conducted an extensive sampling of area surface water bodies in 2009, including Beaver Creek and Clyde Reservoirs plus the various Sandusky Bay tributaries, including Green Creek, Pickerel Creek, Raccoon Creek, Mills Creek, Pipe Creek, and the Sandusky River. No chemicals were detected in these waters, their sediments, or in fish at levels of public health concern (Ohio EPA, 2010b).

- Ohio EPA sampled an additional two private wells that provided drinking water to families with impacted children in September, 2010. No chemicals were detected at levels that would pose a cancer risk to these families.

In addition, the Bureau of Radiation Protection (BRP) at the ODH, in partnership with the Sandusky County Health Department, conducted radiological sampling in schools and residences in Clyde and eastern Sandusky County in 2009 and 2010. This resulted in:

- Completion of six radiological studies conducted by the BRP at the Ohio Department of Health. These included 1) a survey of radiation levels in 20 area schools; 2) a survey of

radiation levels in 11 of the homes with cancer cases; 3) radiological results from the Ohio EPA air monitoring in Clyde; 4) radiological results from the Ohio EPA sampling of area surface water bodies in 2009; 5) a historical review of radioactive material license holders in the county; and 6) a review of the compliance history and historical releases from the Davis-Besse nuclear power plant in Ottawa County. In each of these studies, no radioactive materials or radiation fields were identified that would pose a public health concern (BRP, 2010).

Based on the environmental sampling conducted by Ohio EPA and ODH's Bureau of Radiation Protection in Clyde and adjacent portions of eastern Sandusky County from 2008 to 2010, there is no evidence of significant environmental contamination in the Clyde area nor evidence of a "completed exposure pathway" currently linking any cancer-causing chemicals in the environment with any of the individual or collective childhood cancer cases in the Clyde area.

Land forms, Soil Types, and Land Use in the Clyde area, Sandusky County

Clyde and adjacent portions of Green Creek Township and eastern Sandusky County are situated on a broad, mostly level, gently northward-tilted glaciated lake plain created by the advance and retreat of the most recent glacier and subsequent formation and retreat of a series of glacial melt-water lakes that eventually retreated north to the current configuration of Lake Erie. Unconsolidated glacial soils include clay-rich ground moraine and lake-bottom deposits that average 50 to 60 feet thick underlying the nearly flat topography in the area (Ohio Department of Natural Resources well logs). Weathering of these lake-plain glacial tills has resulted in the development of silty to clay-rich limey loamy Nappanee Series soils north of U.S. Rt. 20 and west of Raccoon Creek (Ernst and Hunter, 1987, General Soil Map and Sheet 52). These areas are largely rural with Green Creek Township having a total population of 3,646 (U.S. Census Bureau, 2010). Seventy-six percent of the total land area in Sandusky County, including most of the area north and west of Clyde, is farmed with major crops being soybeans, corn, and wheat and a wide array of specialty crops including tomatoes, cucumbers, cabbage, and other vegetable crops (The Ohio State University Extension Service – Sandusky County, 2011).

Exceptions to the nearly flat topography in the area consist of a series of northeast-southwest trending linear sandy beach ridges that occur in southeastern Sandusky County, including ridges that occur in Clyde paralleling Maple Street and to the south of town, paralleling County Rt. 175 (South Ridge Road). These sandy ridges represent the remnants of ancient beaches formed along the shores of the various stages of the Lake Erie Basin since the retreat of the last glacier. These ridges weather to form the fine sand and sandy loams of the Spinks-Rimer-Kibbee soils group that underlie most of Clyde within the city limits (Ernst and Hunter, 1987, General Soil Map and Sheet 52). These soils are also well-suited to crop agriculture, orchards, and pasture land, but are

better suited for supporting urban infrastructure (buildings) than the more clay-rich Nappanee soils described above. Clyde is the second largest city in Sandusky County (population = 6,325; U.S. Census Bureau, 2010) and has manufacturing as its economic base (City-Data.com; Clyde, Ohio).

Ohio EPA 2011 Soil Sampling in Clyde

Ohio EPA collected composited soil samples from the upper six inches of soil at 11 locations in and around Clyde (Figure 1). A "composite" soil sample consists of 10 discrete (separate) samples collected from a particular area that then are mixed together and analyzed as a single sample. Soil samples for VOC analyses were not composited but consisted of separate, discrete samples. The soil sampling conducted April 14, 2011, included three composited samples (10 individual samples from each site) from the City Park east of Race Street (samples SO-1 from along the creek, SO-2 from the playground, and SO-3 from the baseball diamonds); a composite of 10 samples was collected from the public right-of-way in the City Hall area in downtown Clyde (sample SO-4); a composite of 10 samples was collected from the public right-of-way along Mulberry Street adjacent to the former Clyde Paint plant (sample SO-5); a composite of 10 samples was collected from the public right-of-way in the vicinity of Ridgeview Street (sample SO-6); a composite of 10 samples was collected from the public right-of-way surrounding a pond south of Mulberry Street (sample SO-7); and a composite of 10 samples was collected from the public right-of-way in the vicinity of Coe Road (sample 8), also in the northwest corner of Clyde. An additional 10 samples were collected and composited from the public right-of-way along Lynber Lane on the east side of Raccoon Creek in the south end of the city (SO-9) and 10 samples were collected and composited from a private residence also on Lynber Lane (SO-11). Additional composited regional background soil samples (sample SO-10) were collected from the public right-of-way at three locations along Spayd Road west of Clyde, plus single samples from Clapp and Riehl Roads, and samples from five locations along Limerick Road, south of Clyde (Figure 1).

Soil samples were analyzed in the laboratory for six metals identified by the National Toxicological Program as being "known" or "likely" human cancer-causing chemicals (arsenic, beryllium, cadmium, lead, nickel, and hexavalent chromium) (NTP, 2011). Soil samples were also analyzed using standardized U.S. EPA methods for total chromium; a suite of 21 pesticides and seven (7) types of polychlorinated biphenyls (PCBs); a total of 65 semi-volatile organic compounds (SVOCs); and 66 volatile organic compounds (VOCs).

EXPOSURE PATHWAYS

People have to come into physical contact or be *exposed* to chemical contaminants in the environment in order for these chemicals to cause the development of adverse health effects. In order for a person to come into direct contact with the chemicals of concern at a site, there must be a **completed exposure pathway**. A completed exposure pathway consists of *five main parts* that must be present for exposure to occur. These include:

- A **Source** of the hazardous chemicals;
- A method of **Environmental Transport** which allows the chemicals to move from the source area and bring them into contact with the residents (surface water, groundwater, air releases, soil, soil gas, dust, food chain);
- A **Point of Exposure** which is the place where the people come into physical contact with the chemical(s) of concern;
- A **Route of Exposure** is how the chemical enters the resident's body (drinking it, eating it, breathing it, touching it); and
- A **Population at Risk** consisting of the people who live near the source of the chemical contamination and come into contact with the chemicals from the site.

Exposure pathways can also be characterized by when the exposure occurred and might have occurred in the *Past, Present,* or the *Future*.

Physical contact with a chemical contaminant alone does **not** necessarily result in adverse health effects. A chemical's ability to affect the resident's health is also controlled by a number of other factors, including:

- How much of the chemical a person comes into contact with (the *Dose*);
- How long a person is exposed to the chemical (*duration* of the exposure);
- How often a person is exposed to the chemical (*frequency* of the exposure);
- How the chemical affects the body and the person's health (chemical's *toxicity*)

Other factors affecting a chemical's likelihood of causing adverse health effects upon contact include the resident's :

- History of past exposure to chemicals;

- Smoking, drinking of alcohol, or taking certain medicines or drugs;
- Current health status;
- Age and Sex; and
- Family medical history

Characteristics of the Soil Pathway

As is indicated above, environmental sampling by Ohio EPA of the drinking water, surface water, and outside air in the Clyde area in 2009 and 2010 have not indicated any exposures to cancer-causing chemicals at levels of health concern via the ingestion (drinking water) or inhalation (breathing air) routes. No carcinogenic chemicals or radioactive materials have been detected at levels of health concern in either the water or sediments in area water bodies or in area groundwater. Drinking water and ambient air are the two most likely pathways for residential populations to be exposed to toxic chemicals (ATSDR, 2005). Both of these pathways typically have the potential to transport chemicals significant distances from the source and both pathways can, under the right circumstances, result in significant exposures with chemicals being absorbed directly into the blood via absorption through the gastro-intestinal tract or through capillaries in the lungs.

By way of comparison, with regard to the soil pathway, chemicals often firmly attach to soil particles and pretty much stay where they are at. Soils, in contrast to water and air, are a much more local phenomena and typically aren't easily transported any distance, especially in humid climates like those in north-central Ohio. Soils in the Clyde area form a diverse mosaic of distinctive soil types and different land uses resulting from differing geological conditions going from the southeast to the northwest across Clyde (Ernst and Hunter, 1987, General Soil Map and Map Inset 52). As a result, there are significant differences in the textures and specific chemical composition of the soils exposed at the surface as you go from one neighborhood to another within the Clyde area. Differences in texture and composition can lead to differences in amount and type of chemicals held by the soil and how firmly the chemicals are attached to the soil particles (Turkall et al., 2008).

Our skin is a major barrier to the absorption of chemicals into the body, especially chemicals attached to soil particles. The main routes in which chemicals in the soils are absorbed by the body is not through dermal contact but through incidental ingestion of particles via hand-to-mouth actions and the inhalation of dust particles. Once taken into the body, the chemicals must become separated from the soil particles and then find their way to the blood stream. As a result, in contrast to direct ingestion of water and inhalation of air, when humans are exposed to chemical contaminants in soils, they are exposed only to a fraction of the total concentration of

these chemicals found in these soils, the "bioavailable" fraction (Alexander, 1995, 2000; NEPI, 2000; Turkall et al., 2008, 2010; and US EPA, 2009). Due to these characteristics, in comparison to air and water, it would take frequent exposure to heavily-contaminated soil, ingested or inhaled in very large quantities, to result in similar adverse health effects. This scenario is unlikely due to the aversion of most people to eating large quantities of dirt and the normal reaction of sneezing back out inhaled dust. In addition, where drinking water and breathing air are required everyday activities, exposure to contaminated dirt for most of the public would be an infrequent, incidental event.

Typically, the most mobile and toxic group of chemical compounds are the volatile organic compounds (VOCs). In contrast to metals, pesticides, PCBs, and most semi-volatile organic compounds, all of which firmly attach to soil particles, when VOCs are spilled onto soils, the majority of these chemicals vaporize (turn from a liquid to a gas) and are released to the outside air. Or, if the liquid is denser than water, the chemicals sink down through the soil until they hit the underground water table. As a result, compared to air or groundwater , VOC levels in surface soils are usually very low (single-digit parts per billion level) – concentrations generally too low to pose a health threat.

Exposure to chemicals in soil also requires direct contact with the soil particles to which the chemical compounds are typically firmly attached to. As a result, chemical exposure via the soil pathway requires the presence of bare, exposed dirt. If there is a thick layer of grass or sod covering the soil, this insulates the resident from direct exposure to the soil and the risk of chemical exposure decreases significantly regardless of the levels of chemicals detected in the soil.

RESULTS OF OHIO EPA SOIL SAMPLING IN CLYDE

Ohio EPA field crews from the Northwest District Office and the Site Investigation Field Unit collected the soil samples from the Clyde area April 14, 2011. As indicated in Figure 1, composite samples were collected from the upper six inches of soil at 10 locations within Clyde plus background samples were collected from a number of localities west and southwest of Clyde in Green Creek Township. Ohio EPA's field crews reported that a healthy grass cover was present at all of the soil sample sites collected with the exception of the baseball diamonds at the City Park (SO-3, bare dirt) and the samples collected from the boulevard area in Clyde (SO-4) where the grass cover was described as rather "sparse" (Ohio EPA, pers. comm., 2011).

Each soil sample was analyzed in the laboratory for the metals arsenic, beryllium, cadmium, total chromium, hexavalent chromium, lead, and nickel. Samples were also analyzed using standard U.S. EPA methodology for a suite of 21 pesticides, seven (7) varieties of polychlorinated biphenyls (PCBs), 65 semi-volatile organic compounds (SVOCs), and 66 volatile organic compounds (VOCs). The following tables (see Appendix A) list only those chemical compounds

that were detected and compare the results with health-based screening or "comparison values" developed by the federal Agency for Toxic Substances and Disease Registry (ATSDR) or the U.S. EPA. These "comparison values" (see Appendix A) are health-based, media-specific (air, water, soil) concentrations that identify environmental contaminants that require further evaluation. Soil samples with concentrations of specific chemicals less than the comparison values for these chemicals are highly unlikely to pose a health threat. Soil concentrations above a comparison value do not necessarily represent a health threat but denote chemicals that need to be evaluated further to ensure they do not pose a public health threat to exposed populations. ATSDR CREGs are cancer risk evaluation guides that calculate concentrations of chemicals that would be expected to cause more than one excess cancer in a million people exposed to the chemical in their lifetime.

DISCUSSION

Soil Sample Results

PCBs and hexavalent chromium were not detected in any of the samples collected. The concentrations of metals detected in the soil samples collected are typical of background levels for these metals in soils in northwest Ohio and for Ohio as a whole (Logan and Miller, 1983). None of these metals (arsenic, beryllium, cadmium, total chromium, lead, or nickel) were detected at concentrations that came close to exceeding a health-based soil screening value and none indicated contamination of these soils by industrial sources. The only VOCs detected were acetone and methylene chloride in samples SO-1, SO-4, SO-5, and SO-11, all at very low levels. Both of these chemicals are common laboratory contaminants -- solvents used to clean glassware. The detected levels of these chemicals were far below ATSDR health-based screening numbers and would not pose a risk to residents even if they are actually present in the soil samples.

Trace levels, significantly below one part of chemical per million parts of soil, of the environmentally-persistent pesticides DDT, DDE, and dieldrin were detected in a number of samples, including the background samples. Use of DDT was prohibited in the US after 1972 (ATSDR, 2002a). DDT is slowly biodegraded in soils to the compounds DDE and DDE. All three compounds are very persistent in soils. Dieldrin is a similar very persistent pesticide whose use was discontinued in the US in 1987. Like DDT and its breakdown products, dieldrin binds tightly to the soil particles and breaks down only very slowly in the environment (ATSDR, 2002b). These persistent pesticides exist everywhere in the environment but at very low levels. The detected levels for all three pesticides were several orders of magnitude below ATSDR health-based screening levels (ATSDR, 2002a and b) and do not pose a risk to residents. There is no conclusive evidence that exposure to these persistent pesticides in soils causes cancer in humans (ATSDR, 2002a and b).

The only problematic chemicals detected in area soils were the Polycyclic Aromatic Hydrocarbons (PAHs) – a group of environmentally ubiquitous semi-volatile organic compounds.

PAHs

Polycyclic aromatic hydrocarbons (PAHs) are a group of over 100 different chemicals that are formed as the result of the incomplete burning of coal, oil and gas, garbage, or other organic substances such as tobacco or charbroiled meat. PAHs are usually found as a mixture containing two or more of these compounds. PAHs are found in coal tar, crude oil, creosote, roofing tar, and driveway sealers, but a few are used in medicines or to make dyes, plastics, and pesticides. Others make up the asphalt used in road surfacing. PAHs are commonly found throughout environment at low levels in the air, water, and soil. Diesel exhaust contains significant amounts of PAHs. They can occur in the air attached to dust particles or as solids in soil or sediment (ATSDR, 1995). The primary routes of potential human exposure are through the inhalation of PAH-polluted air, wood smoke, and/or tobacco smoke, and the ingestion of food containing PAHs, especially smoked, barbecued, or char-broiled foods (NTP, 2011).

Urban soils often contain PAHs at the parts per million level, primarily from airborne fall-out from car and truck exhaust, the residential burning of wood, releases from industrial sources, and from the weathering and breakdown of asphalt surfaces along paved roads and highways (ATSDR, 2009). Due to their low solubility in water and strong tendency to bind to soil particles, PAHs released to the environment tend to be concentrated in soils near the site of their deposition. Low-molecular weight PAHs (anthracene, fluorene, phenanthrene, etc.) tend to be more readily removed from the environment via evaporation and biodegradation (ATSDR, 1995). Higher-molecular weight PAHs (benzo(a)anthracene, benzo(a)pyrene, chrysene, etc.) remain tightly adsorbed to soils and biological breakdown occurs much more slowly (ATSDR, 1995). Documented background levels of individual PAHs in soils in cities and areas with heavy traffic can range up into the 14 to 166 parts per million levels (ATSDR, 1995).

PAHs have a low degree of acute toxicity to people (ATSDR, 2009). The public health risk is usually a chronic one – long-term exposure to high levels of certain PAH compounds in the environment possibly leading to the possible development of cancers. The cancer-causing nature of certain PAH compounds has been observed in exposure studies using laboratory animals. Researchers have reported increased incidence of skin, lung, bladder, liver, and stomach cancers in exposed lab animals (NTP, 2011). Increased incidence of lung, skin, and bladder cancer in humans has been associated with occupational exposures to certain PAH compounds (ATSDR, 2009). Because of the typical occurrence of PAH compounds as mixtures, the most toxic compound, benzo(a)pyrene [B(a)P], is often used as the indicator compound. While not all PAH compounds are considered to be cancer-causing (i.e., fluoranthene, phenanthene, pyrene, etc.), the US EPA and the National Toxicology Program (NTP, 2011) have determined that 15 compounds, including benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene,

benzo(k)fluoranthene, chrysene, and indeno(123-cd)pyrene, are probable human carcinogens and "reasonably anticipated" to cause cancer in humans. The International Agency for Research on Cancer (IARC) recently upgraded benzo(a)pyrene from a 2B (Probable) to Group 1 carcinogen (carcinogenic to humans) (IARC, 2010). However, none of these PAH compounds have been linked with the development of childhood cancers (ATSDR, 2009). Several of these carcinogenic PAHs were detected in individual soil samples at levels that slightly exceeded screening values (see Appendix A). These exceedances required further evaluation of the levels of PAHs detected in area soils.

Health Effects Discussion

Benzo(a)pyrene is the most extensively-studied of the cancer-associated PAHs. B(a)P is often used as a surrogate to assess the relative toxicity of the six other PAHs classified by US EPA as "probable human carcinogens." To determine the toxicity of mixtures of PAHs, the concentration of each cancer-associated PAH is multiplied by a "Toxic Equivalency Factor" (TEF) which relates its toxicity to that of B(a)P. The sum of the weighted concentrations can be used to evaluate the public health hazard posed by the PAH mixture (U.S. EPA, 1993).

For this site, the total B(a)P equivalent concentration was calculated using the maximum concentrations of "carcinogenic PAHs" detected in the soils sampled. The total B(a)P Equivalent Concentration was 1.89 ppm (Table in Appendix C). The location with the highest levels of B(a)P equivalents in the soil, SO-10, was the composite sample collected from rural roads west and south of Clyde that served as the "background" soil samples for the area. The likely sources of the PAH compounds in these soils are fall-out from car and truck exhaust and weathering and erosion of the asphalt-paved surfaces of these roads.

The Health Assessment Section at ODH calculated a cancer risk level for a child and an adult based on the maximum concentration of benzo(a)pyrene detected in soils in the Clyde area (=1.89 ppm) and a US EPA Cancer Slope Factor of 7.3 per mg/kg/day. This assumed a 16 kg child (1-6 years) with an incidental ingestion of 200 mg of soil per day over a six-year exposure period or a 70 kg adult with incidental ingestion of 100 mg soil per day over a 30-year exposure period. The overall calculated cancer risk from exposure to the maximum amounts of PAHs detected in surface soils in the Clyde area for both children and adults was NOT above public health guidelines (for more information see Appendix C).

CHILD HEALTH ISSUES

The HAS recognizes that children are inherently at a greater risk of developing illness due to exposure to hazardous chemicals given their smaller stature and developing body systems.

Children are likely to breathe more and consume more food and water per body weight than are adults. Children are also likely to have more opportunity to come into contact with environmental pollutants in soils due to their being closer to the ground surface and taking part in activities on the ground such as crawling, sitting, and lying down on the ground. The health concern in the Clyde area is the higher than expected rate of childhood cancer in the community. When available, the federal environmental screening guidelines used in evaluating the results of this soil sampling utilized values developed specifically for children (see Appendix A).

CONCLUSIONS

The Health Assessment Section at the Ohio Department of Health reviewed the analytical results of surface soil sampling conducted by Ohio EPA in the Clyde area in eastern Sandusky County in April, 2011.

- The Clyde soil sampling results indicate chemical constituents and concentrations typical of background levels for these chemicals in urban and rural soils that have been sampled elsewhere in Ohio. None of the samples collected provided any evidence of significant contamination of these soils by industrial sources.
- None of the metals, pesticides, PCBs, or VOCs were detected in these soil samples at levels of public health concern.
- Levels of some individual polycyclic aromatic hydrocarbons (PAHs) slightly exceeded their health-based screening levels at six of the sites sampled, including the background soil samples. Levels detected, however, were typical of urban soils elsewhere in Ohio, and when the soil sample with the highest concentrations of PAHs detected was evaluated with regard to its total toxicity, it did not exceed health-based cancer risk levels for either children or adults.

In conclusion, based on the soil samples collected by Ohio EPA in April, 2011, soils in the Clyde area sampled by Ohio EPA are not contaminated with toxic chemicals at levels of public health concern and exposure to these soils currently does not pose a cancer threat to residents, including area children.

PREPARERS OF REPORT

Robert C. Frey, Ph.D.
Chief, Health Assessment Section

John R. Kollman, M.S.
Toxicologist, Health Assessment Section

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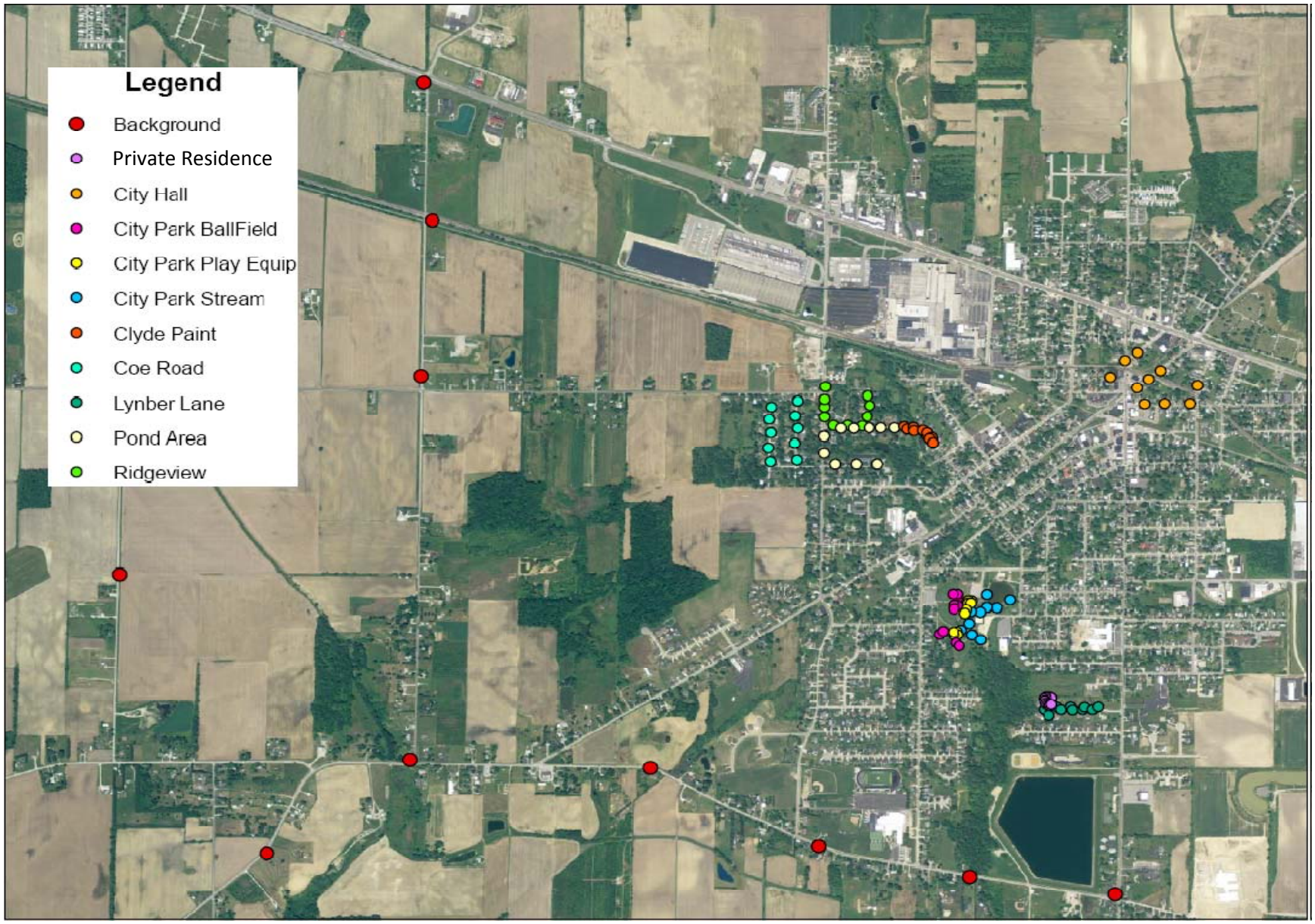
FIGURE

Figure 1. Soil Sample Locations



APPENDIX A

Tables with Soil Sampling Results for Sampling sites SO-1 through SO-11

Chemical Specific Screening Values and their Sources

Chemical	Soil Screening Value (ppm)	Source
Arsenic	20	ATSDR Chronic Child EMEG
Beryllium	100	ATSDR Chronic Child EMEG
Cadmium	5	ATSDR Chronic Child EMEG
Total Chromium	80,000	ATSDR RMEG/Child /Chromium^{+3}
Lead	400	US EPA Residential Soil Screening Guide
Nickel	1,000	ATSDR RMEG/Child
Chlordane	2	ATSDR CREG
DDT/DDD/DDE	2	ATSDR CREG
Dieldrin	3	ATSDR Chronic Child EMEG
Heptachlor epoxide	0.08	ATSDR CREG
Benzo(a)anthracene	0.150	US EPA Regional Screening Level
Benzo(a)pyrene	0.100	ATSDR CREG
Benzo(b)fluoranthene	1.5	US EPA Regional Screening Level
Benzo(ghi)perylene	NA	--
Benzo(k)fluoranthene	1.5	US EPA Regional Screening Level
Bis(2-ethylhexyl)phthalate	50	ATSDR CREG
Chrysene	15	US EPA Regional Screening Level
Fluoranthene	2,300	US EPA Regional Screening Level
Fluorene	2,300	US EPA Regional Screening Level
Indeno(ghi-123)pyrene	0.150	US EPA Regional Screening Level
Phenanthrene	NA	--
Pyrene	1,700	US EPA Regional Screening Level
Acetone	50,000	ATSDR RMEG/Child
Methylene chloride	90	ATSDR CREG

ppm = Parts of chemical per million parts of soil
EMEG = Environmental Media Evaluation Guide
RMEG = Reference Dose Media Evaluation Guide
CREG = Cancer Risk Evaluation Guide

Table 1

Soil Sample Results for Sample Site SO-1 (City Park near Raccoon Creek, Clyde)

Chemical	EPA Cancer Class[1]	Soil Sample Result (ppm)	Soil Screening Value (ppm)
Arsenic	A	8.13	20
Beryllium	B1	0.372 J	100
Cadmium	B1	0.228	5
Total Chromium	D	10.5	80,000
Lead	B2	15.6	400
Nickel	B2	16.1	1,000
Acetone	D	0.073	100,000
Methylene chloride	B2	0.003	90

[1]=US EPA Cancer classification (see Appendix B for explanation)
J=Chemical detected but concentration estimated
ppm=Chemical concentration in parts per million

Table 2

Soil Sample Results for Sample Site SO-2 (City Park playground area, Clyde)

Chemical	EPA Cancer Class	Soil Sample Result (ppm)	Soil Screening Value (ppm)
Arsenic	A	6.60	20
Beryllium	B1	0.291 J	100
Cadmium	B1	0.157	5
Total Chromium	D	6.28	80,000
Lead	B2	16.9	400
Nickel	B2	10.1	1,000
Dieldrin	B2	0.001	3

J=Chemical detected but concentration estimated

Table 3

Soil Sample Results for Sample Site SO-3 (City Park baseball diamonds, Clyde)

Chemical	EPA Cancer Class	Soil Sample Result (ppm)	Soil Screening Value (ppm)
Arsenic	A	7.34 (7.60)	20
Beryllium	B1	0.370 J (0.361 J)	100
Cadmium	B1	0.092 (0.084)	5
Total Chromium	D	10.5 (10.4)	80,000
Lead	B2	11.3 (10.9)	400
Nickel	B2	12.8 (12.9)	1,000
DDE	B2	0.0004	2

J=Chemical detected but concentration estimated

Table 4

Soil Sample Results for Sample Site SO-4 (City Hall area, Downtown Clyde)

Chemical	EPA Cancer Class	Soil Sample Result (ppm)	Soil Screening Value (ppm)
Arsenic	A	5.28	20
Beryllium	B1	0.261 J	100
Cadmium	B1	0.399	5
Total Chromium	D	10.2	80,000
Lead	B2	134	400
Nickel	B2	11.1	1,000
DDE	B2	0.002	2
DDT	B2	0.002	2
Dieldrin	B2	0.001	3
Benzo(a)anthracene	B2	0.313 J	0.150
Benzo(a)pyrene	B2	0.387 J	0.100
Benzo (b)fluoranthene	B2	0.428	0.150
Benzo(ghi)perylene	D	0.259 J	NA
Benzo(k)fluoranthene	B2	0.413 J	1.5
Bis(2-ethylhexyl)phthalate	B2	0.760	50
Fluoranthene	D	0.841	2,300
Indeno(123-cd)pyrene	B2	0.233 J	0.150
Phenanthrene	D	0.333 J	NA
Pyrene	D	0.642	1,700
Methylene chloride	B2	0.010	90

Table 5

Soil Sample Results for Soil Sample Site SO-5 (Clyde Paint on Mulberry Street)

Chemical	EPA Cancer Class	Soil Sample Result (ppm)	Soil Screening Value (ppm)
Arsenic	A	5.13	20
Beryllium	B1	0.234 J	100
Cadmium	B1	0.751	5
Total Chromium	D	11.5	80,000
Lead	B2	85	400
Nickel	B2	11.0	1,000
DDE	B2	0.004	2
DDT	B2	0.004	2
Benzo(a)anthracene	B2	0.337 J	0.150
Benzo(a)pyrene	B2	1.11	0.100
Benzo(b)fluoranthene	B2	1.09	0.150
Benzo(ghi)perylene	D	0.319 J	NA
Benzo(k)fluoranthene	B2	1.49	1.5
Chrysene	B2	1.30	15
Fluoranthene	D	2.95	2,300
Indeno(123-cd)pyrene	B2	0.334 J	0.150
Phenanthrene	D	1.51	NA
Pyrene	D	2.44	1,700
Methylene chloride	B2	0.002	90

J=Chemical detected but concentration estimated

Table 6

Soil Sampling Results for Sample Site SO-6 (Ridgeview Street area)

Chemical	EPA Cancer Class	Soil Sampling Result (ppm)	Soil Screening Value (ppm)
Arsenic	A	6.04	20
Beryllium	B1	0.266 J	100
Cadmium	B1	0.245	5
Total Chromium	D	10.2	80,000
Lead	B2	31.3	400
Nickel	B2	11.4	1,000
DDE	B2	0.001 J	2
DDT	B2	0.001 J	2
Chlordane	B1	0.007	2
Dieldrin	B2	0.003	3
Hepachlor epoxide	B2	0.001 J	0.08
Benzo (a) anthracene	B2	0.425 J	0.150
Benzo(a) pyrene	B2	0.513	0.100
Benzo(b)fluoranthene	B2	0.637	0.150
Benzo(k)fluoranthene	B2	0.637	1.5
Bis(2-ethylhexyl)phthalate	B2	0.561	50
Chrysene	B2	0.610	15
Fluoranthene	D	1.11	2,300

J=Chemical detected but concentration estimated

Table 7

Soil Sampling Results for Sample Site SO-7 (Mulberry Street Pond area)

Chemical	EPA Cancer Class	Soil Sampling Result (ppm)	Soil Screening Value (ppm)
Arsenic	A	4.91	20
Beryllium	B1	0.241 J	100
Cadmium	B1	0.326	5
Total Chromium	D	9.42	80,000
Lead	B2	28.5	400
Nickel	B2	10.5	1,000
DDE	B2	0.001 J	2
DDT	B2	0.001 J	2
Chlordane	B1	0.005	2
Dieldrin	B2	0.010 J	3
Benzo(a)anthracene	B2	0.430	0.150
Benzo(a) pyrene	B2	0.495	0.100
Benzo(b)fluoranthene	B2	0.584	0.150
Benzo(ghi)perylene	D	0.135 J	NA
Benzo(k)fluoranthene	B2	0.602	1.5
Bis(2-ethyhexyl)phthalate	B2	0.212	50
Chrysene	B2	0.609	15
Fluoranthene	D	1.14	2,300
Indeno(123-cd)pyrene	B2	0.145 J	0.150
Phenanthrene	D	0.531	NA
Pyrene	D	0.927	1,700

J=Chemical detected but concentration estimated

Table 8

Soil Sampling Results for Sample Site SO-8 (Coe Road area)

Chemical	EPA Cancer Class	Soil Sample Result (ppm)	Soil Screening Value (ppm)
Arsenic	A	5.39	20
Cadmium	B1	0.188	5
Total Chromium	D	7.12	80,000
Lead	B2	18.7	400
Nickel	B2	8.36	1,000
DDE	B2	0.007	2
DDT	B2	0.003	2
Benzo(a)anthracene	B2	0.210 J	0.150
Benzo(a)pyrene	B2	0.257	0.100
Benzo(b)fluoranthene	B2	0.311	0.150
Benzo(k)fluoranthene	B2	0.331	1.5
Chrysene	B2	0.316	15
Fluoranthene	D	0.641	2,300
Phenanthrene	D	0.293	NA
Pyrene	D	0.529	1,700

J=Chemical detected but concentration estimated

Table 9

Soil Sampling Results for Sample Site SO-9 (Lynber Lane, Clyde)

Chemical	EPA Cancer Class	Soil Sample Result (ppm)	Soil Screening Value (ppm)
Arsenic	A	6.06	20
Beryllium	B1	0.456 J	100
Cadmium	B1	0.117	5
Total Chromium	D	12.1	80,000
Lead	B2	17.2	400
Nickel	B2	16.6	1,000
Chlordane	B1	0.002	2
Bis(2 ethylhexyl)phthalate	B2	0.120	50

J=Chemical detected but concentration estimated

Table 10

Soil Sample Results for Sample Site SO-10 (Background samples west and south of Clyde)

Chemical	EPA Cancer Class	Soil Sampling Result (ppm)	Soil Screening Value (ppm)
Arsenic	A	8.72	20
Beryllium	B1	0.273 J	100
Cadmium	B1	0.202	5
Total Chromium	D	8.13	80,000
Lead	B2	38.9	400
Nickel	B2	9.39	1,000
DDE	B2	0.008	2
DDT	B2	0.004	2
Dieldrin	B2	0.010	3
Anthracene	D	0.815	20,000
Benzo(a)anthracene	B2	1.64	0.150
Benzo(a)pyrene	B2	1.49	0.100
Benzo(b)fluoranthene	B2	1.78	0.150
Benzo(ghi)perylene	D	0.334 J	NA
Benzo(k)fluoranthene	B2	2.37	1.5
Chrysene	B2	2.6	15
Fluoranthene	D	2.7	2,300
Fluorene	D	0.222 J	2,300
Indeno(123-cd)pyrene	B2	0.380	0.150
Phenanthrene	D	2.08	NA
Pyrene	D	2.44	1,700

J=Chemical detected but concentration estimated

Table 11

Soil Sample Results for Sample Site SO-11 (Private residence on Lynber Lane)

Chemical	EPA Cancer Class	Soil Sample Result (ppm)	Soil Screening Result (ppm)
Arsenic	A	11.6	20
Beryllium	B1	0.771	100
Cadmium	B1	0.465	5
Total Chromium	D	16.6	80,000
Lead	B2	20.9	400
Nickel	B2	17.2	1,000
DDE	B2	0.001 J	2
DDT	B2	0.001 J	2
Methylene chloride	B2	0.002 J	90

J = estimated value

APPENDIX B: U.S. EPA 1986 CANCER ASSESSMENT GUIDELINES

EPA CLASS	CLASSIFICATION	DESCRIPTION
A	Human Carcinogen	Sufficient evidence that substance causes cancer in humans
B1	Probable human carcinogen	Limited human evidence, sufficient animal studies
B2	Probable human carcinogen	Inadequate human evidence, sufficient animal studies
C	Possible human carcinogen	No human evidence, limited animal studies
D	Not classifiable	No or inadequate human or animal studies
E	Not a human carcinogen	Evidence that substance does not cause cancer in humans

APPENDIX C: Estimated Cancer Risk - Polycyclic Aromatic Hydrocarbons (PAHs)

The Health Assessment Section (HAS) of the Ohio Department of Health (ODH) evaluated exposures to soils in Clyde, Ohio that included an estimate of cancer risk from exposure to PAHs from incidental ingestion of soils.

Benzo(a)pyrene [B(a)P] was used as a surrogate to assess the relative toxicity of the seven carcinogenic PAHs (cPAHs) classified by EPA as probable human carcinogens. To determine the toxicity of the mixture of PAHs, the concentration of each cPAH was multiplied by a Toxic Equivalency Factor (TEF) which relates its toxicity to that of B(a)P. The sum of the weighted concentrations can be used to evaluate the PAH mixture (U.S. EPA 1993).

$$\boldsymbol{TEQ} = \sum [\boldsymbol{C_i}] \times \boldsymbol{TEF_i}$$

where,

TEQ = Toxic Equivalent of a mixture
C_i = Concentration of individual compound
TEF_i = Toxic Equivalency Factor of an individual PAH relative to B(a)P

For this site, the total B(a)P equivalent concentration was calculated using the maximum concentrations of carcinogenic PAHs detected in the soil samples. The total B(a)P Equivalent Concentration was 1.89 ppm. The location, SO-10, had the highest levels of PAHs in the soil (This location was previously selected as a background for the 10 area samples.)

Equivalent Concentration of Benzo(a)pyrene

Contaminant	***Toxicity Equivalency Factor***	***Maximum Detected Concentration (ppm)***	***Location of Maximum Detection***	***Equivalent Concentration of B(a)P (ppm)***
Benz(a)anthracene	0.1	1.64	SO-10	0.16
Benzo(b)fluoranthene	0.1	1.78	SO-10	0.18
Benzo(k)fluoranthene	0.01	2.37	SO-10	0.02
Benzo(a)pyrene	1	1.49	SO-10	1.49
Chrysene	0.001	2.6	SO-10	0.003
Dibenz(a,h)anthracene	1	ND	NA	0
Indeno(1,2,3-cd)pyrene	0.1	0.38	SO-10	0.04
Total B(a)P Equivalent Concentration				**1.89**

ppm = parts per million
ND = Not detected
NA = Not applicable

Exposure Dose

Soil ingestion can occur by the inadvertent (incidental) ingestion of soil on hands or food items, mouthing of objects, or through intentional ingestion of soil. ODH's HAS used the following exposure dose equation for soil ingestion, according to ATSDR's Public Health Assessment Guidance Manual:

D = (C x IR x EF x CF) / BW

where,

D = exposure dose (mg/kg/day)
C = contaminant concentration (mg/kg)
IR = intake rate of contaminated soil (mg/day)
EF = exposure factor (unitless)
CF = conversion factor (10^{-6} kg/mg)
BW = body weight (kg)

Using this formula, the estimated exposure dose for a 16 kg child (1-6 years) with incidental ingestion of 200 mg soil per day can be calculated as 2.36×10^{-5} mg/kg/day. For a 70 kg adult with incidental ingestion of 100 mg soil per day, the exposure dose is calculated as 2.7×10^{-6} mg/kg/day.

Cancer Risk

Theoretical cancer risk can be defined as the number of additional cases of cancer in a population due to exposure to a toxic substance during a lifetime of exposure, usually written as a negative power of 10. For example, one additional case of cancer per one hundred thousand individuals is written as 1×10^{-5}. The estimated theoretical cancer risk from exposure to contaminants is calculated by multiplying the estimated exposure dose for children and adults by the Cancer Slope Factor (CSF) for a suspected or known carcinogenic substance. Because of conservative safety factors used to calculate the CSFs, using these values provides only a theoretical estimate of risk; the true or actual risk is unknown and could be as low as zero.

ER = CSF x dose

where,

ER = estimated theoretical cancer risk
CSF = cancer slope factor $(mg/kg/day)^{-1}$
Dose = estimated exposure dose (mg/kg/day)

ODH HAS estimated the cancer risk for a child and an adult, based on the maximum detected B(a)P equivalent concentration of 1.89 ppm and EPA's Cancer Slope Factor of 7.3 per mg/kg-day. The resulting estimate of the theoretical increase in cancer risk was 1.48×10^{-5} for a child over a 6-year exposure period. The resulting estimate of the theoretical increase in cancer risk for an adult over a 30-year exposure period was 8.45×10^{-6}. The total estimated cancer risk, combining the child and adult exposure periods, was 2.3×10^{-5} . The overall cancer risk from exposure to surface soil is not above health guidelines of 1 in 10,000 or 1×10^{-4}.