Health Consultation

DAVIS MILL SURFACE WATER SUB OU 1-D GYPSUM POND AREA

COPPER BASIN MINING DISTRICT
COPPERHILL, POLK COUNTY, TENNESSEE

EPA FACILITY ID: TN0001890839

Prepared by the
Tennessee Department of Health

SEPTEMBER 30, 2009

REVISED: APRIL 22, 2010

Prepared under a Cooperative Agreement with the
U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

A health consultation is a verbal or written response from ATSDR or ATSDR's Cooperative Agreement Partners 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 or ATSDR's Cooperative Agreement Partner which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

You May Contact ATSDR Toll Free at
1-800-CDC-INFO
or
Visit our Home Page at: http://www.atsdr.cdc.gov

HEALTH CONSULTATION

DAVIS MILL SURFACE WATER SUB OU 1-D GYPSUM POND AREA

COPPER BASIN MINING DISTRICT
COPPERHILL, POLK COUNTY, TENNESSEE

EPA FACILITY ID: TN0001890839

Prepared By:

Tennessee Department of Health
Under a Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry

Foreword

This document summarizes an environmental public health investigation performed by the State of Tennessee Department of Health's Environmental Epidemiology Program. Our work is conducted under a Cooperative Agreement with the federal Agency for Toxic Substances and Disease Registry. In order for the Health Department to answer an environmental public health question, several actions are performed:

Evaluate Exposure: Tennessee health assessors begin by reviewing available information about environmental conditions at a site. We interpret environmental data, review site reports, and talk with environmental officials. Usually, we do not collect our own environmental sampling data. We rely on information provided by the Tennessee Department of Environment and Conservation, U.S. Environmental Protection Agency, and other government agencies, businesses, or the general public. We work to understand how much contamination may be present, where it is located on a site, and how people might be exposed to it. We look for evidence that people may have been exposed to, are being exposed to, or in the future could be exposed to harmful substances.

Evaluate Health Effects: If people have the potential to be exposed to contamination, then health assessors take steps to determine if it could be harmful to human health. We base our health conclusions on exposure pathways, risk assessment, toxicology, cleanup actions, and the scientific literature.

Make Recommendations: Based on our conclusions, we will recommend that any potential health hazard posed by a site be reduced or eliminated. These actions will prevent possible harmful health effects. The role of Environmental Epidemiology in dealing with hazardous waste sites is to be an advisor. Often, our recommendations will be action items for other agencies. However, if there is an urgent public health hazard, the Tennessee Department of Health can issue a public health advisory, warning people of the danger and can work with other agencies to resolve the problem.

If you have questions or comments about this report, we encourage you to contact us.

Please write to: Environmental Epidemiology
Tennessee Department of Health
1st Floor, Cordell Hull Building
425 5th Avenue North
Nashville TN 37243

Or call us at: 615-741-7247 or toll-free 1-800-404-3006 during normal business hours

Table of Contents

Table of Contents continued

SUMMARY

INTRODUCTION

Ensuring the wellbeing of those living in, working in, or visiting the Copper Basin is a priority of the Tennessee Department of Health's (TDH) Environmental Epidemiology Program (EEP).

EEP wrote this health consultation at the request of the Tennessee Department of Environment and Conservation (TDEC) Division of Remediation (DoR). The purpose of this health consultation is to document our review of supplied environmental soil sampling data collected within the Davis Mill Surface Water area of the Copper Basin Mining District. The Copper Basin Mining District is located in southeast Tennessee and northern Georgia. The data was collected to support a Human Health Risk Assessment (HHRA). The Davis Mill Creek Surface Water area consists of the Gypsum Pond Area and adjacent disposal areas to the west in the Davis Mill Watershed. The Gypsum Pond area is divided into two areas, the Waterfront Area and the Perimeter Area. The Waterfront Area consists of 5 former disposal ponds (4 large and 1 small) and immediately surrounding land. The Perimeter Area consists of land outside of the former disposal ponds. The property owner, Intertrade Holdings, Inc., would like to redevelop both the Waterfront and Perimeter Areas into single family residential properties. Soils and sediments contain high amounts of iron, especially in the Waterfront Area. TDEC DoR asked EEP to review the soil data and to evaluate if future residents would be affected by coming into contact with or eating iron-rich soils.

All data supplied for this health consultation was compared to soil health comparison values provided by the Agency for Toxic Substance and Disease Registry (ATSDR). Screening levels are chemical concentrations based on toxicology below which no adverse health effects are predicted to occur. When a screening level is exceeded, it does not immediately indicate that people would be expected to develop adverse health effects. Instead, it simply means that the potential health risk requires further investigation. Soil and sediment data collected were also compared to upper intake levels for iron for infants 7 to 12 months, children and adults established by the National Institutes for Health.

CONCLUSIONS

EEP reached three important conclusions in this health consultation:

Conclusion 1

EEP concludes that walking on former ponds, and walking into, wading, or swimming in existing ponds in the Waterfront Area could harm people's health. The unknown stability of the caps on the former ponds

and the thickness and consistency of sediment within the existing ponds could cause a physical hazard.

Basis for Conclusion

Undulating and potentially unstable caps are present over former ponds which would be a hazard to recreational trespassers, potential homeowners, and children of those homeowners. Dams of unknown stability are also present. Potential hazards specific to children are present if they wander into the large ponds that are present in the Waterfront Area. The sediment thickness in the ponds is unknown and likely poses a danger of trapping or engulfing adults and children, or causing them to lose their footing and balance. If they are engulfed or lose their balance then drowning is possible.

Next Steps

If the property is redeveloped by the responsible party, access to these areas should be limited and controlled. Methods to limit access are the responsibility of the responsible party.

Conclusion 2

EEP concludes that a child, especially a child exhibiting pica behavior (dirt-eating) could be harmed if the child ate soils/waste and exposed sediment in the Waterfront Area of the Gypsum Pond Area.

Basis for Conclusion

If the Waterfront Area were developed to include residential home sites, an increased health risk to children could occur. EEP believes the concentrations of iron present may lead to increased risk of adverse health effects in children, especially pica (dirt-eating) children. The area is impacted with high iron concentrations and for this reason the health impact of this area should not be overlooked. For children and adults who do not exhibit pica behavior, dermal exposure and ingestion exposure intakes are lower than recommended daily iron upper limits.

Next Steps

If development occurs within the Perimeter Area, recreational trespassers should be made aware by the responsible party of the potential harm to their health entering the Waterfront Area could cause.

Restricting the entry of recreational trespassers into the Waterfront Area would lessen any potential harm to their health. Restricting entry by using some type of physical barrier would be the most efficient and is the responsibility of the responsible party.

EEP will provide education to TDEC and future community members by providing fact sheets or an outreach campaign.

Conclusion 3

EEP could not conclude whether iron in soils in the Perimeter Area of the Gypsum Pond Area in the Copper Basin Mining District would cause harm to future adult and children residents of this area.

Basis for Conclusion

The limited number of soil samples collected from the Perimeter Area represents a very large areal extent and may not reflect an accurate representation of the iron distribution over the Perimeter Area.

Next Steps

Additional soil samples from each residential property lot should be collected and analyzed prior to the lot being sold and redeveloped. These samples will help in understanding the distribution of iron in property-lot specific soils. The responsible party, with oversight by TDEC, should collect additional samples for analysis in order to understand any potential for increased iron concentrations.

EEP will work with TDEC to evaluate the data prior to starting development activities.

Conclusion 4

EEP concludes that individuals with iron-overload diseases such as homochromatosis or other iron-overload disease may also be affected by the iron concentrations in the Waterfront Area. Individuals with homochromatosis absorb up to 30 percent of iron. Over time, they absorb and retain between five and twenty times more iron than the body needs. The extra iron builds up in the body's organs and damages them. Without treatment, the disease can lead to an increased risk of failure of the liver, heart, and pancreas.

Basis for Conclusion

If the individual with this disease ingests soils/waste from the Waterfront Area of the Gypsum Pond Area, the potential for health effects increases based on health studies conducted.

Next Steps

Any future development of the Perimeter Area into residential building lots should not be undertaken without further investigation of the area. Any future development of the Perimeter Area into residential building lots should not be undertaken without consideration for human health hazards in the adjacent Davis Mill Watershed areas. If development occurs within the Perimeter Area, recreational trespassers should be made aware by the responsible party of the potential harm to their health entering the Waterfront Area could cause.

FOR MORE INFORMATION

If you have any questions or concerns about your health, you should contact your healthcare provider. For more information on this site call TDH EEP at 615-741-7247 or toll free 1-800-404-3006, or TDEC at toll free 888-891-8332 during normal business hours.

Introduction

The Davis Mill Surface Water - Sub Operational Unit (OU) 1-D Gypsum Pond Area is located near Isabella, Polk County, Tennessee, in the Copper Basin Mining District of Tennessee and Georgia. The Sub OU 1-D area is the land in and around Gypsum Ponds which were part of approximately 1,120 acres of primarily industrial lands located in the southeastern portion of the Copper Basin Mining District (Figure 1).

The Tennessee Department of Health's (TDH) Environmental Epidemiology Program (EEP) was asked on September 3, 2008, by the Tennessee Department of Environment and Conservation (TDEC), Division of Remediation (DoR), to provide guidance on the possibility of adverse health effects from iron in soil and sediment in the Davis Mill Surface Water - Sub OU 1-D Gypsum Pond Area (the Gypsum Pond Area). Most of the Gypsum Pond Area has been essentially abandoned with only infrequent need for workers to enter to conduct short-duration maintenance or operations tasks. The majority of the area is unused most of the time (BWSC 2008).

Because the property owner would like to redevelop the property into residential home sites, EEP was asked to review iron data collected from two areas within the Gypsum Pond Area: the Waterfront Area and the Perimeter Area. EEP was provided a Human Health Risk Assessment (HHRA) (BWSC 2008) which evaluated the health effects of future land use of the Gypsum Pond Area. The HHRA evaluated the health hazards of redevelopment of both the Waterfront and Perimeter Areas into residential properties. Soil sampling data and information supplied by TDEC DoR were used for evaluating the possible adverse health effects of iron in the two areas. DoR felt confident in their ability to work with the consultant and the property owner to ensure that the public would not be harmed by the chemicals of concern identified in the HHRA. However, DoR was not confident in their ability to adequately assess the public health implications of the high concentrations of iron in soil and sediment.

Background

The Copper Basin Mining District Site (CERCLIS ID TN0001890839) is located in southeast Tennessee in Polk County and northern Georgia in Fannin County near the state border with North Carolina. The Copper Basin is the site of extensive former copper and sulfur mining operations that date back to the early 1800s (Figure 1). For more than 150 years, numerous companies and individuals were involved in various mining, refining and manufacturing operations in the area. Mining operations ceased in 1987, and sulfuric acid production was discontinued in 2000. Approximately 95 million tons of ore have been processed in the mining district (EPA 2005). Mining and related activities have resulted in the environmental degradation of portions of the Copper Basin, including the North Potato Creek Watershed, the Davis Mill Creek Watershed, and parts of the Ocoee River (Figures 2 and 3). Waste materials from mining and processing activities remain as sources of contaminants in the form of acidic drainage and high levels of metals in the soils, sediments, and surface waters of the watersheds that drain into and impact the Ocoee River. Acidic conditions and leaching of metals have impaired water quality, and deforestation has resulted in severe erosion. Abandoned and collapsing mine works and other deteriorating facilities and waste piles also pose significant physical hazards. The Gypsum Pond Area discussed below is adjacent to and bordered to the west by these hazard areas.

The Gypsum Pond Area was formerly used for disposal of various wastes and by-products associated with mining, mineral extraction, and improvement of the grade of copper and other ores. Within the Gypsum Pond Area there are four prominent former disposal ponds that were flooded with water during the site remedial investigation process. These ponds contain some game fishes. Many species of wildlife are also present. There have been previous instances of recreational trespassing (fishing and hunting) in the Gypsum Pond Area. Additionally, five former disposal ponds in this area were capped (all or in large part). Cover material on each remains mostly intact. The four prominent former disposal ponds were flooded as part of the Cantrell Flats sludge disposal and are not capped. The four prominent ponds, the five capped ponds, and the lands immediately surrounding these features that were disturbed during previous disposal activities are referred to as the Waterfront Area (Figure 4). The area surrounding the Waterfront Area is designated the Perimeter Area (Figure 4). The Perimeter Area consists of large undeveloped tracts of land that were reportedly not disturbed by previous industrial or disposal activities. The Perimeter Area is also adjacent to and bordered to the west by the hazard areas described above.

The Gypsum Pond Area does not have improvements (BWSC 2008). However, an attractive nuisance does exist in the area such that there is recreational trespassing. There have been instances of fishing by site trespassers and there have been instances of other recreational trespassing (hunting) across the site. The current property owners are proposing to develop both the Waterfront and surrounding Perimeter Area into residential areas. If these properties are developed into residences, the general public will be living within these areas.

Human Health Risk Assessment

The HHRA report (BWSC 2008) evaluated soil data collected from both the Waterfront Area and the Perimeter Area in making health hazard determinations. The HHRA report is composed of completed parts of chapters of a larger Draft Remedial Investigation (RI) Report for Davis Mill Creek Surface Water. The RI report is a more comprehensive investigation of the waste materials from mining and processing activities that remain in the Davis Mill Watershed and contains additional information regarding human health risk assessment in areas adjacent to the Gypsum Areas. The Final RI should be available for public review in Spring 2010.

Overall, limited sampling was performed in the two areas. In some cases, individual samples represent the chemical quality of many acres, in the worst case, over 100 acres. Both soil/waste and sub-aqueous sediment samples were collected in January 2006, under the authorization of and oversight by EPA and TDEC (BWSC 2008). Based on the HHRA report, it is unknown how each sample was collected. However, the soil/waste and sub-aqueous sediment samples used in the HHRA were collected using a biased approach; using a judgment - or search-based sampling design rather than random allocation of samples. Such an approach would lead to worst case concentrations rather than average concentrations. Soil and waste sampling was aimed at characterizing specific materials or areas associated with past site operations. All data on which the HHRA is based were subjected to some degree of data quality assessment. The sampling data collected were reviewed in accordance with work plan quality assessment (BWSC 2008).

The HHRA identified a future resident of the Waterfront Area to an unacceptable risk to lead in soil. Additionally, both a future Perimeter Area and Waterfront Area resident would have unacceptable non-cancer and cancer health risks due to elevated concentrations of arsenic in soil and arsenic and polychlorinated biphenyls in fish (BWSC 2008). TDEC understands the hazards posed by these contaminants. TDEC requested the further evaluation of the health effects of the iron concentrations present to fully understand additional chemical contributions to risk.

Concentrations of iron in soil and sediment samples collected from the Waterfront Area and Perimeter Area are summarized in Tables 1 and 2.

Iron in the Perimeter Area

As shown in Table 1, iron concentrations in the Perimeter Area soils and waste ranged from a minimum detected concentration of 24,600 mg/kg to a maximum concentration of 55,400 mg/kg, with an arithmetic mean of 35,260 mg/kg. An EMEG/MRL for iron has not been established by ATSDR. In the absence of an MRL, EPA Region 3 Regional Screening Levels were reviewed. EPA has established a concentration of 55,000 mg/kg as an incidental ingestion screening level concentration for iron in residential soils. This concentration was calculated using a reference dose (RfD) of 0.7 milligrams per kilogram per day (mg/kg-day) for an ingestion exposure pathway.

In the HHRA (BWSC 2008), iron concentrations were compared to a human health screening value of 5,460 mg/kg. This value was established using the same methods as EPA, but using a hazard index of 0.1 in accordance with EPA Region IV guidance. In their calculations, BWSC used the reasonable maximum exposure (RME) concentration of iron, 117,633 mg/kg.

TABLE 1. Iron concentrations in soils and waste in Waterfront Area and Perimeter Area of the Gypsum Pond Area, Copper Basin, Polk County, TN (BWSC 2008). Values are in milligrams per kilogram. Health screening guidelines based on EPA Region 3 Regional Screening Table (EPA 2008).

Area	Soil / Waste		Background Value (BWSC 2008)	Health Screening Value (BWSC 2008)	EPA Region 3 RST Value (EPA 2008)
	Minimum Concentration Detected	Maximum Concentration Detected	mg/kg	mg/kg	mg/kg
Perimeter Area	24,600	55,400	100 – 100,000[1]	5,460	55,000
Waterfront Area	20,700	203,000	55,400	5,460	55,000

Notes:
[1] = background iron concentration in Perimeter Area soils compared to background iron concentrations in soils of the United States (from Dragun and Cherkiri 2005, Elements in North American Soils, Second Edition)
mg/kg = milligrams per kilogram

TABLE 2. Iron concentrations in sub-aqueous sediment in Waterfront Area of the Gypsum Pond Area, Copper Basin, Polk County, TN (BWSC 2008). Values reported in parts per million. Health screening guidelines based on EPA Region 3 Regional Screening Table (EPA 2008).

Area	Sub-Aqueous Sediment		Risk-Based Screening Value for Human Health Effects (BWSC 2008)	EPA Region 3 RST Value (EPA 2008)
	Minimum Concentration Detected	Maximum Concentration Detected	mg/kg	mg/kg
Waterfront Area	119,000	347,000	42,464	55,000

Notes:
mg/kg = milligrams per kilogram

Four out of 5 soil samples of the Perimeter Area soils and waste are below the EPA iron residential screening level concentration. Soil samples collected represent extensive areal distances, however. Each sample represents upwards of 100 acres. Data points, overall, are relatively scarce. One sample located within the area is slightly elevated with respect to its iron concentration (55,400 mg/kg) and therefore slightly above the EPA residential soil screening level concentration. EEP performed its own screening level calculation using the EPA RfD, a child's weight of 16 kilograms (kg), and ingestion of 100 milligrams (mg) of soil each day. Using these parameters, a screening level of 56,000 mg/kg was calculated. Therefore, the soil sample having an iron concentration of 55,400 mg/kg is about the same as EEP's calculated screening level.

Iron in Waterfront Area

Concentrations of iron in soils and waste in the Waterfront Area are considerably higher than those of the Perimeter Area. Concentrations of iron in Waterfront Area soil samples ranged from 26,800 to 193,000 mg/kg. Concentrations of iron in waste in the Waterfront Area ranged from 20,700 to 203,000 mg/kg. The arithmetic mean of iron concentrations in the Waterfront Area soil/waste samples was 75,768 mg/kg. As with the Perimeter Area, samples collected represented large areal extents (over 100 acres) and some samples collected in the Waterfront Area represented highly contaminated soils/waste. Of the 37 samples collected, 18 (49%) were above the 55,000 mg/kg EPA residential soil screening level for iron and above the background concentration of 55,400 mg/kg (highest Perimeter Area iron concentration) used in the HHRA.

As with iron concentrations in the Perimeter Area, iron concentrations in the Waterfront Area were compared to the remedial goal option human health screening value of 5,460 mg/kg calculated in the HHRA.

Iron in Sub-aqueous Sediment in Waterfront Area

Overall, metals concentrations were found to be the highest in sub-aqueous sediment along the margins of Ponds 2, 3, and 4 of the Waterfront Area. Iron concentrations ranged from 119,000 to 347,000 mg/kg, averaging 247,000 mg/kg. These concentrations are high and, as with soils/waste in the Waterfront Area, may result in a potential hazard to any recreational trespassers or residents of this area. The water in the ponds is shallow and would be easily accessed by recreational trespassers.

In the HHRA (BWSC 2008), iron concentrations in sub-aqueous sediment were compared to a human health screening value of 42,464 mg/kg. No reference for this calculation was found in the HHRA document to understand its origin.

Discussion

Introduction to Chemical Exposure

To determine whether persons have been or are likely to be exposed to chemicals, TDH EEP evaluates mechanisms that could lead to human exposure. An exposure pathway contains five parts:

- a source of contamination
- contaminant transport through an environmental medium
- a point of exposure
- a route of human exposure, and
- a receptor population.

An exposure pathway is considered complete if there is evidence that all five of these elements are, have been, or will be present at the site. A pathway is considered potential if there is a lower probability of exposure. If there is no evidence that at least one of the five elements listed is, has been, or will be present at the site, then it is considered an incomplete exposure pathway. For this site, there is a potential exposure pathway for the incidental ingestion of soils containing metals, especially if the areas being reviewed are developed into residential properties. There is also a potential dermal contact exposure pathway if there is trespassing in the four ponds.

Physical contact alone with a potentially harmful chemical in the environment by itself does not necessarily mean that a person will develop adverse health effects. A chemical's ability to affect public health is controlled by a number of other factors, including:

- the amount of the chemical that a person is exposed to (dose)
- the length of time that a person is exposed to the chemical (duration)
- the number of times a person is exposed to the chemical (frequency)
- the person's age and health status, and
- the person's diet and nutritional habits.

The purpose of this public health consultation is to examine any potential health hazards from iron present in high concentrations in soils and sub-aqueous sediment in the Waterfront Area and in low to moderately high iron concentrations in soils in the Perimeter Area. The health consultation will also evaluate the physical hazards in the Gypsum Ponds Area.

The Gypsum Ponds Area is a large expanse of undeveloped property containing large ponds, wooded, and open areas being considered for potential development as residential properties. The responsible party is considering dividing the Perimeter and Waterfront Areas into residential home building sites. An airstrip exists on private property east of the Perimeter and Waterfront Areas. The airstrip could be one means by which private citizens could access the areas. New roads and utility corridors would be developed as part of any planned residential development for these two areas. As stated previously in the background section, TDEC is concerned about the effects of iron concentrations in the Perimeter and Waterfront Areas on potential future residents and recreational trespassers who would live and use these areas on a daily basis. Along with this health evaluation TDEC is also reviewing the need for institutional controls such as land use restrictions, groundwater use restrictions, installation of barriers to prevent use of certain areas, etc. to protect the public from potentially harmful areas within the Gypsum Pond Area if any residential development is allowed to occur.

Comparison Process Explanation

To evaluate exposure to a hazardous substance, health assessors often use health guidance values. If the chemical concentrations are below the guidance value, then health assessors can be reasonably certain that no adverse health effects will occur in people who are exposed. If concentrations are above the guidance values (ATSDR 2007a, 2008) for a particular chemical, then further site evaluation is needed.

The Agency for Toxic Substances and Disease Registry (ATSDR) environmental media evaluation guidelines (EMEGs) and minimum risk levels (MRLs) are based on conservative assumptions about chemical exposure. EMEGs and MRLs consider non-cancer adverse health effects. Exposure durations are defined as acute (14 days or less), intermediate (15–364 days), and chronic (365 days or more) exposures. For cancer effects, ATDSR uses U.S. Environmental Protection Agency (EPA) information to set their cancer risk evaluation guidelines (CREGs) for lifetime exposure.

The iron concentrations obtained from soil samples collected in both the Waterfront Area and Perimeter Area will be evaluated by comparison to published screening levels. In addition, a hazard evaluation of iron concentrations in both the Waterfront and Perimeter Areas within the Gypsum Pond Area will be carried out using a dose calculation based on the average and maximum iron concentrations for soils and sediment.

Hazard Evaluation

Iron is an abundant natural element found in soil and bedrock around the world. Naturally-occurring concentrations of iron in soils of the eastern United States range from 100 to 100,000 milligrams per kilogram (mg/kg). Pure metallic iron is rarely encountered due to its chemical activity and rapid corrosion. In the Copper Basin Mining District much of the iron was present in the form of sulfide minerals. Iron has a variety of uses, such as the production of steel and many other alloyed metals (BWSC 2008). Iron is a vital constituent of plant and animal life and is present in hemoglobin. Humans can suffer ill effects from the intake of too much iron or too little. The average iron content in a person’s body is approximately 4 milligrams. Exposure to excess iron may cause harmful gastrointestinal, blood, and liver effects (IronToxicity.com 2008a). Iron is distributed throughout a person’s body as shown in Table 3.

The National Institutes for Health has published Daily Reference Intakes (DRIs) for iron for the various life stages of a human. DRIs are the general term for a set of reference values used for planning and assessing nutrient intake for healthy people. DRIs for iron are shown in Table 4.

TABLE 3. Distribution of iron in a human body. Distribution reported in percent.

Area/System	Percentage of Iron
Red blood cells	45
Liver	25
RE cells	15
Bone marrow	7.5
Muscles	7.5
Circulatory system	0.075

Source: IronToxicity.com

Table 4. Daily Reference Intakes (DRI) for iron for the various life stages of a human (National Institutes for Health 2008). Iron intake reported in milligrams per day.

Life Stage		Iron Intake (mg/day)
Infants	0 to 6 months	0.27
	7 to 12 months	11
Children	1 to 3 years	7
	4 to 8 years	10
Males	9 to 13 years	8
	14 to 18 years	11
	19 to ≥ 70 years	8
Females	9 to 13 years	8
	14 to 18 years	15
	19 to 50 years	18
	51 to ≥ 70 years	8
Pregnancy	≤ 18 to 50 years	27
Lactation	≤ 18 years	10
	19 to 50 years	9

Notes:
mg = milligrams

Potentially Exposed Populations and Exposure Pathways

Potentially exposed populations and future populations include both site workers and future residents. If homes were built in both the Waterfront Area and Perimeter Area, construction workers leveling residential lots, utility workers installing site utilities, and construction workers building the homes could be a potentially exposed population. A second potentially exposed population would be adults and sensitive populations such as pregnant women, the elderly, and children who would live in a home built either in the Waterfront Area or the Perimeter Area. Children exhibiting pica behavior would be an especially sensitive population. Pica behavior is discussed further in the Child Health Considerations section of this document. Those having homes in the Perimeter Area presumably would also have access to the Waterfront Area as recreational trespassers and be a third potentially exposed population.

A completed exposure pathway would exist from the contaminated sediments within the Waterfront Area for residents and recreational trespassers. Iron present in the sediments on the margins of the Gypsum Ponds could potentially be a dermal contact and ingestion hazard if the area was developed for future residential properties.

Iron Toxicity

Since iron absorption efficiency decreases with increasing dosage, iron toxicity from consumption of food sources is rare. Iron supplements may be fatal for adults when taken in doses of 200-250 mg/kg from body weight. Iron poisoning may also occur in children who take adult supplements even at low doses. Individuals who receive repeated blood transfusions are most at risk of iron toxicity (Northwestern University 2008).

The upper limit of safety for iron established by the Food and Nutrition Board of the Institute of Medicine is approximately 45 milligrams per day (mg/day) for adults and 40 mg/day for infants and children up to 13 years of age (Table 5). These upper limits (ULs) are the maximum daily intake unlikely to result in adverse health effects (National Institutes for Health 2008). The ULs for iron are not defined as screening values but they are relevant given that iron is an essential nutrient for humans. There is considerable potential for iron toxicity because very little iron is excreted from the body. Iron can accumulate in body tissues and organs when normal storage sites are full. There have been instances of death occurring in children from ingesting 200 mg of iron.

The early symptoms of acute iron overload are vomiting, diarrhea, abdominal pain, and gastrointestinal bleeding. Later effects include circulatory shock and liver failure (Chang 1996). Chronic iron overload usually affects the liver first, although chronic iron overload can also effect the pancreas, the joints, and the heart (Harrison’s 2001). One iron overload disease is homochromatosis. Individuals with homochromatosis absorb up to 30 percent of iron. Over time, they absorb and retain between five and twenty times more iron than the body needs. The extra iron builds up in the body’s organs and damages them. Without treatment, the disease can lead to an increased risk of failure of the organs listed above.

Table 5. Tolerable upper intake levels for iron for infants 7 to 12 months, children and adults (National Institutes for Health 2008). Iron intake reported in milligrams per day.

Life Stage		Upper Iron Intake (mg/day)
Infants - males and females	7 to 12 months	40
Children - males and females	1 to 13 years	40
Males	14 to 18 years	45
	19+ years	45
Females	14 to 18 years	45
	19+ years	45
Pregnancy	14 to 18 years	45
	19+ years	45
Lactation	14 to 18 years	45
	19+ years	45

Notes:

mg = milligrams

Dose Calculation

The limited number of soil samples within the Waterfront and Perimeter Areas are a concern. Soil samples collected and analyzed, in some cases, represent the chemical quality of many acres, in the worst case, over 100 acres. EEP evaluated exposure doses based on the data provided from TDEC DoR. To evaluate if exposure to the iron in the soil of the Perimeter Area and the soil/waste and sediment in the Waterfront Area would cause an adverse health effect through dermal contact or ingestion, EEP evaluated different scenarios. EEP calculated exposure doses for six iron adult dermal exposure scenarios and for iron adult ingestion exposure scenarios. The same number and type of scenarios were also evaluated for a child. The exposure scenarios were specifically evaluated for children age 1 to 13 years and for individuals aged 14 to 19-plus years.

The dermal exposure dose was calculated using both the average and the maximum soil iron concentrations in each area for an adult resident living in a home 350 days out of a year for 30 years with default assumptions for skin surface area available for contact, soil to skin adherence factor, and absorption factors. For a child, the dose was calculated using both the average and maximum soil iron concentrations for a child resident living in a home 350 days each year for 12 years with default assumptions for skin surface area available for contact, soil to skin adherence factor, and absorption factors.

For an adult ingestion dose, the average and maximum soil iron concentrations were used as were default assumptions for ingestion rate and fraction ingested. Similar calculations were completed using a child's ingestion rate and fraction ingested. The oral exposure doses included the intake from food and supplements. These intakes were approximated using the DRI in Table 5. For children, an intake was assumed to be 10 milligrams per day (mg/day). For adults, the intake was assumed to be 18 mg/day. These intakes were simply added to the calculated exposure doses.

To obtain an iron intake amount, the calculated dose was multiplied by the body weight (adults – 70 kilograms [kg], and children – 30 kg). The iron intake was compared to the ULs listed in Table 6.

Although the ULs are not screening values they are relevant as they are guidelines defining how much iron intake per day is considered too high in a person. Once the dermal contact and ingestion doses and daily intakes were calculated, they were compared to the ULs for adults and children. The dose calculation results are presented in Tables 6 through 9. The equations and specific factors used in the equations are detailed in the Appendix. Iron concentrations evaluated include the average and the maximum soil iron concentrations in both the Perimeter Area and the Waterfront Area. Additionally, average and maximum sub-aqueous sediment iron concentrations were evaluated for the Waterfront Area.

Perimeter and Waterfront Areas Resident Scenario

The resident scenario for the Perimeter Area would also be similar to that of the Waterfront Area. An adult resident would be someone living in a home constructed in that area and having access to iron-containing soils near their home. The age of an adult in this case would range from 14 to 19-plus years as the UL for iron intake is the same for these ages. A child resident would be assumed to be living in a Perimeter Area home with adults and be between the ages of 1 and 13.

An adult resident in the Waterfront Area would be someone living in a home constructed in that area and having access to sub-aqueous sediment along the shoreline of the existing ponds. Access to the sediment along the fringes of the ponds would be likely in times of drought and to children playing at the water's edge. The age of an adult in this case would range from 14 to 19-plus years as the UL for iron intake is the same for these ages. A child resident would be assumed to be living in a Waterfront Area home with adults and be between the ages of 1 and 13.

Resident Scenario — Dermal Contact

Equations shown in the Appendix were used to calculate an expected dose from having dermal contact with soils in the Perimeter and Waterfront Areas. For an adult having dermal contact with iron-bearing soils in either the Waterfront Area or the Perimeter Area, they would receive a dermal contact dose, converted into a daily intake, well below the daily UL of 45 milligrams (mg) using both the average (35,260 milligrams per kilogram [mg/kg]) and high (55,400 mg/kg) soil iron concentrations in the Perimeter Area (Table 6). There likely would only be a remote chance of transfer of iron from hands or skin surface to the mouth for an adult ingestion. The additional iron added to a normal adult diet from a site-related adult dermal contact dose, even when using the maximum reported Waterfront Area sub-aqueous sediment sample concentration (347,000 mg/kg), would not cause any adverse health effects (Table 6).

A child resident would receive a dermal contact dose, converted to a daily intake, well below the recommended daily UL of 40 mg for children 1 to 13 years old using the average iron concentration in the Perimeter Area soils (Table 6). A child would also receive a low dermal contact dose using the average and the maximum iron concentration found in Waterfront Area soils of 75,768 mg/kg and 203,000 mg/kg, respectively. A child resident would also receive a low dermal contact dose using the average and highest sub-aqueous sediment iron concentration of 347,000 mg/kg in the Waterfront Area (Table 6).

The dermal exposure for both adults and children to iron-containing soils in the Perimeter Area and Waterfront Area, as shown in Table 6, will not create additional health concerns and will not result in a cumulative effect. The amount of dermal contact is small. Iron is an inorganic metal and will not be easily absorbed through the skin of an adult or child.

Table 6. Reasonable Maximum Exposure Dose and Iron Intake Calculations for Adult and Child Residents – Dermal Contact with Iron in Soil (includes iron from food and vitamin intake)

	Resident	Iron Dose (mg/kg-day)	Iron Intake (mg/day)
Perimeter Area Soils			
Average Soil Iron Concentration of 35,260 mg/kg	Adult	0.016	19.1
	Child	0.059	11.8
Maximum Soil Iron Concentration of 55,400 mg/kg	Adult	0.025	19.7
	Child	0.093	12.8
Waterfront Area Soils/Waste			
Average Soil/Waste Iron Concentration of 75,768 mg/kg	Adult	0.034	20.4
	Child	0.127	13.8
Maximum Soil/Waste Iron Concentration of 203,000 mg/kg	Adult	0.090	24.4
	Child	0.341	20.2
Waterfront Area Sub-Aqueous Sediment			
Average Sub-Aqueous Sediment Iron Concentration of 247,000 mg/kg	Adult	0.110	25.7
	Child	0.415	22.4
Maximum Sub-Aqueous Sediment Iron Concentration of 347,000 mg/kg	Adult	0.155	28.9
	Child	0.58	27.5

Notes:

mg/kg = milligrams per kilogram

Adult dose calculation variable assumptions are in accordance with EPA Human Health Risk Assessment Bulletins – Update to RAGS Region 4 Superfund (EPA 2008) and EPA Risk Assessment Guidance for Superfund Human Health Evaluation Manual (EPA 1989) and are listed in the Appendix.

Child dose calculation variable assumptions are in accordance with EPA Human Health Risk Assessment Bulletins – Update to RAGS Region 4 Superfund (EPA 2008) and EPA Risk Assessment Guidance for Superfund Human Health Evaluation Manual (EPA 1989) and are also listed in the Appendix.

Resident Scenario — Ingestion

If an adult ingested iron-bearing soils in either the Perimeter Area they would receive a dose, converted to a daily intake, below the UL of 45 mg using both the average (35,260 mg/kg) soil iron concentration and the highest iron concentration (55,400 mg/kg) in the Perimeter Area (Table 7). There likely would only be a remote chance of transfer of the iron from hands or skin surface to the mouth for ingestion for an adult as adults are more aware of hand washing and other measures to eliminate transfer of contaminants from their skin. Ingestion by an adult of soils/waste or sediment from the Waterfront Area would result in a calculated dose, converted to a daily intake, less than the adult daily UL for iron (Table 7).

Ingesting the average iron and high concentration in the Perimeter Area soils, a child resident would not receive a dose greater than the daily recommended UL of 40 mg for children 1 to 13 years old (Table 7). Ingesting the average iron concentration found in Waterfront Area soils of 75,768 mg/kg would result in a child receiving a dose less than the recommended daily UL. If the child ingested the maximum iron concentration found in Waterfront Area soils of 203,000 mg/kg, the child would receive a dose greater than the UL. A child ingesting the average sub-aqueous sediment concentration of 246,875 mg/kg and highest sub-aqueous sediment iron concentration of 347,000 mg/kg in the Waterfront Area would create doses greater than the daily UL (Table 7). The potential excess iron ingestion from the Waterfront Area would not be recommended for a child.

Consideration should also be given to a child exhibiting pica (dirt-eating) behavior residing in the Perimeter Area. For a pica child, a dose was calculated using two ingestion amounts: one for ingestion of 1,000 mg/day and a second ingestion rate of 5,000 mg/day. A pica child ingesting 1,000 mg/kg of iron containing soil having the average iron concentration for soils in the Perimeter Area would ingest less than the UL. However if an ingestion rate of 5,000 mg/day were used with the average Perimeter Area iron concentration, the resulting intake of 179 mg would exceed the child's daily UL intake of 40 mg by nearly 4.5 times. More importantly, if an ingestion rate of 3,000 mg/day is used, the resulting intake would be slightly above the child's daily UL. Therefore, pica behavior in the medium range of an estimated ingestion rate would be above the UL for a child. All other iron concentrations from the Waterfront Area are higher than those of the Perimeter Area. Therefore, pica children residing in the Waterfront Area could potentially ingest much higher amounts of iron into their bodies than the recommended iron intake UL of 40 mg.

Table 7. Reasonable Maximum Exposure Dose and Iron Intake Calculations for Adult and Child Residents – Ingestion of Site Soils (includes iron from food and vitamin intake)			
	Resident	Iron Dose (mg/kg-day)	Iron Intake (mg/day)
Perimeter Area Soils			
Average Soil Iron Concentration of 35,260 mg/kg	Adult	0.048	21.4
	Child	0.225	16.8
Maximum Soil Iron Concentration of 55,400 mg/kg	Adult	0.076	23.3
	Child	0.354	20.6
Waterfront Area Soils/Waste			
Average Soil/Waste Iron Concentration of 75,768 mg/kg	Adult	0.105	25.4
	Child	0.485	24.6
Maximum Soil/Waste Iron Concentration of 203,000 mg/kg	Adult	0.278	37.5
	Child	1.30	49.0
Waterfront Area Sub-Aqueous Sediment			
Average Sub-Aqueous Sediment Iron Concentration of 246,875 mg/kg	Adult	0.338	41.7
	Child	1.58	57.4
Maximum Sub-Aqueous Sediment Iron Concentration of 347,000 mg/kg	Adult	0.476	51.3
	Child	2.22	76.6

Notes:

mg/kg = milligrams per kilogram

Adult dose calculation variable assumptions are in accordance with EPA Human Health Risk Assessment Bulletins – Update to RAGS Region 4 Superfund (EPA 2008) and EPA Risk Assessment Guidance for Superfund Human Health Evaluation Manual (EPA 1989) and are listed in the Appendix.

Child dose calculation variable assumptions are in accordance with EPA Human Health Risk Assessment Bulletins – Update to RAGS Region 4 Superfund (EPA 2008) and EPA Risk Assessment Guidance for Superfund Human Health Evaluation Manual (EPA 1989) and are also listed in the Appendix.

Waterfront Area Recreational Trespasser Scenario

Recreational trespassers would include those individuals who would hunt or fish in the Waterfront Area, use the area for common sports activities (baseball, football, golf), or would likely use the area for open space activities (walking, picnicking, observing nature). The exposure to these trespassers is evaluated in the following paragraphs.

Recreational Trespasser Scenario - Dermal Contact

To evaluate if exposure to the iron in the soil/waste and sediment in the Waterfront Area would cause an adverse health effect to recreational trespassers through dermal contact or ingestion, EEP evaluated different scenarios. The exposure scenarios were specifically evaluated for children age 1 to 13 years and for adults aged 14 to 19-plus years.

The dermal exposure dose was calculated using both the average and the maximum soil iron concentrations in each area for an adult recreational trespasser using the Waterfront Area for 108 days per year for 10 years with default assumptions for skin surface area available for contact, soil to skin adherence factor, and absorption factors. For a child trespasser, the dose was calculated using both the average and maximum soil iron concentrations for a child using the Waterfront Area 108 days each year for 10 years with default assumptions for skin surface area available for contact, soil to skin adherence factor, and absorption factors.

For an adult ingestion dose, the average and maximum soil iron concentrations were used as were an ingestion rate and fraction ingested. Similar calculations were completed using a child's ingestion rate and fraction ingested.

To obtain an iron intake amount, the calculated dose was multiplied by the body weight (adults – 70 kilograms [kg], and children – 30 kg). The iron intake was compared to the ULs listed in Table 6.

An adult male trespasser spending 108 days in the Waterfront Area would receive a dermal contact absorbed dose below the UL of 45 mg using the average soils/waste iron concentration (75,768 mg/kg) in the Waterfront Area (Table 8). This also holds true using the maximum soil/waste iron concentration of 203,000 mg/kg. If an adult received a dermal exposure dose of using the average iron concentration from the Waterfront Area sub-aqueous sediment, it would be below the UL. Even using the maximum sub-aqueous sediment iron concentration of 347,000 mg/kg, the dose would be below the adult iron UL (Table 8). There likely would only be a remote chance of transfer of the iron from hands or skin surface to the mouth for ingestion for an adult.

Similar to the adult recreational trespasser scenario, a child recreational trespasser spending 108 days each year in the Waterfront Area would also receive a dermal contact dose below the recommended UL of 40 mg using the average and maximum Waterfront Area soils/waste iron concentration (Table 8). A child recreational trespasser would also receive a dermal contact absorbed dose below the recommended UL of 40 mg using both the average and maximum Waterfront Area sub-aqueous sediment concentrations (Table 8), a worse-case scenario.

Table 8. Reasonable Maximum Exposure Dose Calculation for Adult and Child Trespassers – Dermal Contact with Iron in Soil (includes iron from food and vitamin intake)

	Resident	Iron Dose (mg/kg-day)	Iron Intake (mg/day)
Waterfront Area Soils/Waste			
Average Soil/Waste Iron Concentration of 75,768 mg/kg	Adult	0.010	18.74
	Child	0.039	11.19
Maximum Soil/Waste Iron Concentration of 203,000 mg/kg	Adult	0.028	19.98
	Child	0.011	13.19
Waterfront Area Sub-Aqueous Sediment			
Average Sub-Aqueous Sediment Iron Concentration of 246,875 mg/kg	Adult	0.034	20.41
	Child	0.13	13.88
Maximum Sub-Aqueous Sediment Iron Concentration of 347,000 mg/kg	Adult	0.048	21.39
	Child	0.18	15.46

Notes:

mg/kg = milligrams per kilogram

Adult dose calculation variable assumptions are in accordance with EPA Human Health Risk Assessment Bulletins – Update to RAGS Region 4 Superfund (EPA 2008) and EPA Risk Assessment Guidance for Superfund Human Health Evaluation Manual (EPA 1989) and are listed in the Appendix.

Child dose calculation variable assumptions are in accordance with EPA Human Health Risk Assessment Bulletins – Update to RAGS Region 4 Superfund (EPA 2008) and EPA Risk Assessment Guidance for Superfund Human Health Evaluation Manual (EPA 1989) and are also listed in the Appendix.

Waterfront Area Recreational Trespasser Scenario – Ingestion

This section evaluates the ingestion exposure to recreational trespassers who would hunt, fish, or generally use the area as open space. The ingestion dose for an adult recreational trespasser would be under the recommended daily reference intake using the average Waterfront Area soil/waste iron concentration of 75,768 mg/kg. Using the maximum soil/waste iron concentration of 203,000, the resulting iron dose would be above the adult UL. When using the average sediment sample concentration and calculating a dose, the adult iron intake would still be less than the UL. Even using the maximum reported Waterfront Area sediment sample concentration (347,000 mg/kg) a daily dose 4 times less than the UL would be expected (Table 9).

Using the average soil/waste iron concentration, an expected child ingestion dose would be approximately 3 times less than the UL. Using the maximum Waterfront Area sub-aqueous sediment iron concentration the resultant calculated dose would be half the UL for a child.

Table 9. Reasonable Maximum Exposure Dose Calculation for Male Adult and Child Trespassers – Ingestion of Iron in Soil (includes iron from food and vitamin intake)

	Resident	Iron Dose (mg/kg-day)	Iron Intake (mg/day)
Waterfront Area Soils/Waste			
Average Soil/Waste Iron Concentration of 75,768 mg/kg	Adult	0.033	20.3
	Child	0.153	14.6
Maximum Soil/Waste Iron Concentration of 203,000 mg/kg	Adult	0.087	24.2
	Child	0.406	22.2
Waterfront Area Sub-Aqueous Sediment			
Average Sub-Aqueous Sediment Iron Concentration of 246,875 mg/kg	Adult	0.106	25.4
	Child	0.494	24.8
Maximum Sub-Aqueous Sediment Iron Concentration of 347,000 mg/kg	Adult	0.149	28.4
	Child	0.694	30.8

Notes:

mg/kg = milligrams per kilogram

Adult dose calculation variable assumptions are in accordance with EPA Human Health Risk Assessment Bulletins – Update to RAGS Region 4 Superfund (EPA 2008) and EPA Risk Assessment Guidance for Superfund Human Health Evaluation Manual (EPA 1989) and are listed in the Appendix.

Child dose calculation variable assumptions are in accordance with EPA Human Health Risk Assessment Bulletins – Update to RAGS Region 4 Superfund (EPA 2008) and EPA Risk Assessment Guidance for Superfund Human Health Evaluation Manual (EPA 1989) and are also listed in the Appendix.

Again, consideration should also be given to a child exhibiting pica (dirt-eating) behavior being a recreational trespasser in the Waterfront Perimeter Area. For the pica child recreational trespasser scenario, a dose was calculated again using two ingestion amounts: one for ingestion of 1,000 mg/day and a second ingestion rate of 5,000 mg/day. A recreational trespasser pica child ingesting 1,000 mg/kg of iron-containing soil/waste having the average iron concentration for soils/waste in the Waterfront Area would ingest less than the UL, a total of 32.4 mg. If an ingestion rate of 5,000 mg/day were used with the average Waterfront Area iron concentration, the resulting intake of 122 mg would exceed the child's daily UL intake of 40 mg by 3 times. Average sub-aqueous sediment Waterfront Area iron concentrations are 247,000 mg. A pica child ingesting 1,000 mg or 5,000 mg of sediment would result in iron intakes of approximately 84 mg and 380 mg, respectively. These values are above the child iron UL of 40 mg.

Individuals with iron-overload diseases such as homochromatosis or other iron-overload disease could also be affected by the iron concentrations in the Waterfront Area. Individuals with homochromatosis absorb up to 30 percent of iron. Over time, they absorb and retain between five and twenty times more iron than the body needs. The extra iron builds up in the body's organs and damages them. Without treatment, the disease can lead to an increased risk of failure of the liver, heart, and pancreas. If the individual with this disease ingests soils/waste from the Waterfront Area of the Gypsum Pond Area, the potential for health effects increases.

Physical Hazards in the Waterfront Area

Physical hazards within the Waterfront Area are more prevalent than in the Perimeter Area. The Waterfront Area includes the Gypsum Ponds themselves and the area immediately surrounding these ponds. The area contains high levels of iron and should not be considered a pristine area for recreation. The area also includes previously closed and capped ponds and exposed soil and sediment areas. Therefore the physical hazards of the Waterfront and Perimeter Areas vary.

TDEC communicated to EEP that the closed ponds' surface material is hummocky and the stability of the caps on all closed ponds is questionable. Thus, there is concern about recreational trespassing across the closed ponds and whether the ground surface is stable in select areas.

TDEC also had concerns about the accessibility of the Gypsum Ponds themselves. These large ponds are reportedly shallow and have unknown materials and sediment containing unknown concentrations of metals (except for iron) in them. The stability of the sediment in the bottoms of individual ponds is unknown. Dams are constructed between each pond creating separate impoundments for water and sediment to accumulate. Dam stability is also in question. There is concern about recreational trespassing in and around the ponds. Potential problems could arise if a recreational trespasser accidentally falls into one of the ponds. It is unknown whether the chemical concentrations of unknown substances in the bottom sediment could cause harm or if the stability and depth of sediment has the potential to engulf the trespasser.

Child Health Considerations

In communities faced with air, water, soil, or food contamination, the many physical differences between children and adults demand special emphasis. Children could be at greater risk than adults from certain kinds of exposure to hazardous substances (ATSDR 1997, 1998). Children have lower body weights than adults. Although children's lungs are usually smaller than adults, children breathe a greater relative volume of air compared to adults. If toxic exposure levels are high enough during critical growth stages, the developing body systems of children can sustain permanent damage. Finally, children are dependent on adults for access to housing, for access to medical care, and for risk identification. Thus, adults need as much information as possible to make informed decisions regarding their children's health.

In preparation of this health document, the health of children was thoughtfully considered. No children access the Gypsum Pond Area at the moment. This would change in the future if the Waterfront and Perimeter Areas of the Gypsum Pond Area were redeveloped into residential lots for the construction of single family homes, multifamily apartments, duplexes, or condominiums. In addition, many physical hazards are present in the Waterfront Area. Physical threats include uneven surface topography, subsidence, drowning, and engulfment in sediment. These health threats are in part unique to children because children are much shorter than adults and have a natural curiosity to explore various open areas.

Children can only tolerate low amounts of iron in their bodies. A dietary threshold of 1 milligram of iron given to a child can cause gastrointestinal problems. Acute iron intoxication most commonly occurs in children who consume their mothers' iron tablets. Depending on the amount ingested, circulatory arrest may ensue. Iron poisoning is a leading cause of death from accidental ingestion in children under the age of five (IronToxicity.com). Chronic iron poisoning most often results from prolonged exposure to excessive dietary iron, as may happen from cooking with iron implements. Children with pica (dirt eating) behavior in the Waterfront Area could ingest higher concentrations of iron by eating soil/waste and sub-aqueous sediment from this area. Based on the average Waterfront Area sub-aqueous sediment concentration, a dose of more than 3 times the UL of iron intake could result from a child ingesting the sediment. Using the maximum iron concentration in sub-aqueous sediment from the Waterfront Area, an iron dose above the UL of iron intake would result. The Waterfront Area should be avoided by children who exhibit certain types of behavior, such as pica.

Pica is defined as the reoccurring ingestion of unusually high amounts of soil. Soil ingestion is typical among children as is soil-pica behavior. Typical groups at risk of soil-pica behavior include children aged 6 years and younger and individuals who are developmentally delayed (ATSDR 2000). Even with a definition of soil-pica, it is difficult to determine the prevalence of this behavior. Soil-pica clearly exists, but the prevalence at a given soil ingestion rate has not been adequately characterized (ATSDR 2000). Experts believe that soil-pica among adults is probably rare.

There are many theories about what causes pica. One is that a nutritional deficiency, such as iron deficiency, can trigger specific cravings. Evidence supports that at least some pica cases are a response to dietary deficiency — nutritional deficiencies often are associated with pica and their correction often improves symptoms. Some children enjoy the taste and texture of dirt or clay, and eat it as part of a daily habit. And some psychological theories explain pica as a behavioral response to stress or an indication that the individual has an oral fixation (is comforted by having things in his or her mouth) (KidsHealth.org). Cases have been presented in which an ingestion rate of 5,000 mg of soil was found (ATSDR, 2005).

Future Considerations Regarding Residential Exposure to Iron

Consideration has been given to redeveloping the Waterfront Area and the surrounding Perimeter Area into residential building lots for single family homes. The high iron concentrations in the soil/waste and sediment samples collected from the Waterfront Area and the physical hazards of this area make it unsafe for permanent residence. Doses to children resulting from ingestion of iron-containing soil/waste or sediment indicate the need to restrict development of the Waterfront Area.

Institutional controls should be implemented if the soils/waste and sediment in the Waterfront Area are allowed to remain in place. Signs should be posted warning anyone entering the area that it contains certain chemicals above health standards. Institutional controls should also be implemented to restrict access to the Waterfront Area sediments and the ponds themselves.

Conclusions

EEP reached four important conclusions in this health consultation:

EEP concludes that walking on former ponds, and walking into, wading, or swimming in existing ponds in the Waterfront Area could harm people's health. The unknown stability of the caps on the former ponds and the thickness and consistency of sediment within the existing ponds could cause long-term exposure and a chronic physical hazard. Undulating and potentially unstable caps are present over former ponds which would be a hazard to recreational trespassers, potential homeowners, and children of those homeowners. Dams of unknown stability are also present. Potential hazards specific to children are present if they wander into the large ponds that are present in the Waterfront Area. The sediment thickness in the ponds is unknown and likely poses a danger of trapping and/or engulfing children and adults or causing them to lose their footing and balance. If they are engulfed or lose their balance then drowning is possible.

EEP concludes that a child, especially a child exhibiting pica behavior (dirt-eating) would be harmed if the child ate soils/waste and exposed sediment in the Waterfront Area of the Gypsum Pond Area. If the Waterfront Area were developed to include residential home sites, an increased health risk to children would be likely. EEP believes the concentrations of iron present may lead to increased risk of adverse health effects in children, especially pica (dirt-eating) children. The area is impacted with high iron concentrations and for this reason the health impact of this area should not be overlooked. For children and adults who do not exhibit pica behavior, dermal exposure and ingestion exposure intakes are lower than recommended daily iron upper limits. Chronic iron overload may cause adverse health effects to the liver, pancreas, and heart.

EEP could not conclude whether iron in soils in the Perimeter Area of the Gypsum Pond Area in the Copper Basin Mining District would cause harm to future adult and children residents of this area. The limited number of samples comprising the database represents a very large areal extent and may not reflect an accurate representation of the iron distribution in the area.

EEP concludes that individuals with iron-overload diseases such as homochromatosis or other iron-overload disease may also be affected by the iron concentrations in the Waterfront Area. Individuals with homochromatosis absorb up to 30 percent of iron. Over time, they absorb and retain between five and twenty times more iron than the body needs. The extra iron builds up in the body's organs and damages them. Without treatment, the disease can lead to an increased risk of failure of the liver, heart, and pancreas. If the individual with this disease ingests soils/waste from the Waterfront Area of the Gypsum Pond Area, the potential for health effects increases.

Recommendations

The major focus of this health consultation is to determine if the soils within the Waterfront and Perimeter Areas of the Davis Mill Surface Water, Gypsum Ponds Area are safe to be touched or inadvertently eaten. Based on EEPs review of the data presented in the Human Health Risk Assessment prepared by Barge Waggoner Sumner & Cannon, Inc., if any development of this area is considered or permitted to occur, the following actions should be considered to protect public health:

- Iron concentrations in soil/waste and sediment and physical hazards in the Waterfront Area are such that EEP recommends this area not be made available for development. Without the removal of the Waterfront Area soils/waste and sediments, measures to protect public health should be instituted.

- Due to the limited number of samples EEP could not conclude whether iron in soils in the Perimeter Area of the Gypsum Pond Area in the Copper Basin Mining District would cause harm to future adult and children residents of this area. Any future development of the Perimeter Area into residential building lots should not be undertaken without further investigation of the area. Any future development of the Perimeter Area into residential building lots should not be undertaken without consideration for human health hazards in the adjacent Davis Mill Watershed areas. Any future development of the Perimeter Area should also be tied to institutional controls which would prevent residents or recreational trespassers from entering the Waterfront Area of the Gypsum Ponds Area.

- Implemented institutional controls by the responsible party and TDEC should allow for adequate distance between the potential future residential portion of the Perimeter Area and the undeveloped Waterfront Area.

Public Health Action Plan

The public health action plan for the Gypsum Pond Area contains a list of actions that have been or will be taken by EEP and other agencies. The purpose of the public health action plan is to ensure that this health consultation identifies public health hazards and offers a plan of action designed to mitigate and prevent harmful health effects that result from breathing, eating, drinking, or touching hazardous substances in the environment. Included is a commitment on the part of EEP to follow up on this plan to ensure that it is implemented.

Public health actions that have been taken by TDH’s EEP include:

- Review of the HHRA provided by TDEC DoR.

- Preparing/publishing this health consultation

Public health actions that will be taken include:

- This report and any needed explanation will be provided to the TDEC DoR. Upon request, this report will also be provided to federal, and local government, academia, environmental groups, community groups, the property owner, or a future lessee should the Perimeter Area be redeveloped.

- Evaluation of other metals present in the soil of the Perimeter Area, and in the soil and sediment in the Waterfront Area will be performed by EEP upon TDEC's request.

- Should the Perimeter Area be allowed to be developed, TDEC should require any future residents to be informed of physical hazards present in the Waterfront Area as well as adjacent Davis Mill Watershed Areas. In addition TDEC should place institutional controls on the Waterfront Area property warning residents of the physical hazards and potential chemical hazards associated with entering the Waterfront Area.

- TDH EEP will maintain dialogue with ATSDR, TDEC, EPA and other interested stakeholders to safeguard public health and to prevent people from future exposure to chemicals related to the Davis Mill Surface Water Gypsum Pond Area.

- TDH EEP will be available to review any newly collected or additional environmental data, as requested by TDEC such as the Final Remedial Investigation (RI) Report for Davis Mill Creek Surface Water in order to assess additional human health hazards in the adjacent Davis Mill Watershed Areas. TDH EEP will provide TDEC with interpretation of the data, as requested.

Preparer of Report

Joseph P. George, PG, MS
Environmental Epidemiologist

Tennessee Department of Health (TDH)
Communicable and Environmental Disease Services (CEDS)
Environmental Epidemiology (EEP)
1st Floor, Cordell Hull Building
425 5th Avenue North
Nashville TN 37243

Reviewers of Report

Bonnie S. Bashor, MS
Environmental Epidemiology Director
Tennessee Department of Health

David M. Borowski, MS
Environmental Epidemiology Assistant Director
Tennessee Department of Health

Lofton Carr, Remedial Project Manager
U.S.EPA, Region 4, Site Remediation and Site Evaluation Branch
Site Remediation Section

Andy Shivas, Project Manager
Division of Remediation
Tennessee Department of Environment and Conservation

ATSDR Technical Project Officer

Trent LeCoultre, MSEH, REHS, CMDR Public Health Service
Cooperative Agreement and Program Evaluation Branch (CAPEB)

References

[ATSDR] Agency for Toxic Substances and Disease Registry. 2008. Soil comparison values. Atlanta, GA: US Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2005. Public Health Assessment Guidance Manual (Update), January 2005. Atlanta, GA: US Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 2000. Summary Report for the ATSDR Soil-Pica Workshop. Atlanta, GA: US Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 1998. Promoting children's health, progress report of the Child Health Workgroup, Board of Scientific Counselors. Atlanta, GA: US Department of Health and Human Services.

[ATSDR] Agency for Toxic Substances and Disease Registry. 1997. Healthy children - toxic environments. Report of the Child Health Workgroup presented to the Board of Scientific Counselors. Atlanta, GA: US Department of Health and Human Services.

[BWSC] Barge Waggoner Sumner & Cannon, Inc. 2008. Davis Mill Surface Water Remedial Investigation, Sub OU 1-D Gypsum Pond Area, Human Health Risk Assessment, Davis Mill, Copperhill, Tennessee. Nashville, TN. 30 p.

Chang, L.W., Editor. 1996. Toxicology of metals. Lewis Publishers, an imprint of CRC press. New York, NY. 1232 p.

Dragun, J. and Cherkiri, K. 2005. Elements in North American Soils, 2nd Edition. Amherst, MA. Amherst Scientific Publishers. 270 p.

[EPA] U.S. Environmental Protection Agency. 2005. Copper Basin Mining District Case Study. July 2005. Available at: http://www.epa.gov/aml/tech/copperbasin.pdf

[EPA] U.S. Environmental Protection Agency. 2008. Regional Screening Levels Tables. September 2008. Website last accessed on February 2, 2009 and available at http://www.epa.gov/region4/waste/ots/index.htm

[EPA] U.S. Environmental Protection Agency. 2009. Contaminated media, human health, and environmental effects. February 2008. Website last accessed on August 21, 2009 and available at http://epa.gov/region4/waste/ots/healtbul.htm

[Harrison's] 2001. Harrison's Principles' of Internal Medicine, 15th Edition. McGraw-Hill, Medical Publishing Division. 2629 p.

KidsHealth.org Pica. Website last accessed on January 27, 2009 and available at: http://kidshealth.org/parent/emotions/behavior/pica.html

National Institutes for Public Health. 2008. Dietary supplement fact sheet for iron. Website last accessed on January 28, 2009 and available at: http://ods.od.nih.gov/factsheets/Iron_pf.asp

Figure 1. Copper Basin Mining District, Copperhill, Polk County, Tennessee
Source: EPA Copper Basin Mining District Case Study
(Area of Interest Outlined in Orange)

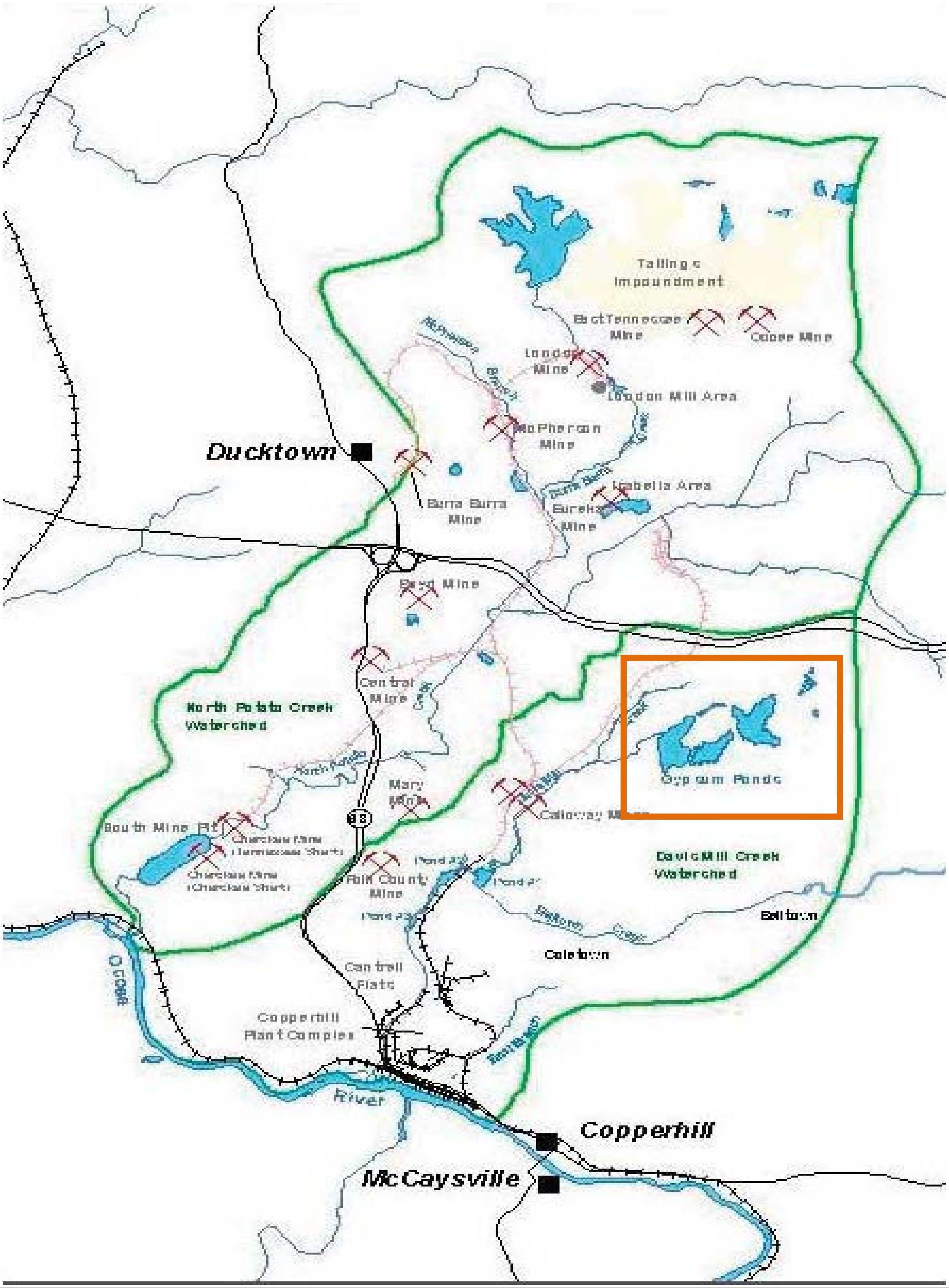

Figure 2. 1957 Aerial View of the Manufacturing Area of the Copper Basin Mining District. Source: EPA Copper Basin Mining District Case Study

Figure 3. 2005 Comparative Aerial View of the Manufacturing Area of the Copper Basin Mining District. Source: Lofton Carr, USEPA

APPENDIX

Resident Calculations – Dermal Exposure

Adult Resident Dermal Exposure Dose and Intake Calculation (for Table 7 in Discussion)

This exposure scenario was examined to compare the potential dose and iron intake of an adult resident who would receive an exposure from dermal contact of iron-containing soil from the Perimeter Area and the Waterfront Area. Iron concentrations used for the Perimeter area included the average and maximum concentrations of iron in site soils, as shown in Table 6. For the Waterfront Area soils the average and maximum soil/waste iron concentration and the average and maximum sediment iron concentrations were used, also shown in Table 6. An exposure dose was also calculated for dermal contact of iron-containing soil from the Perimeter area and iron containing soil/waste and sediment from the Waterfront Area.

The doses are calculated using utilizing the standard ATSDR and EPA default values for adults (ATSDR 2005, EPA 1989, and EPA 2008). Iron intake is the product of the dose and body weight, and is reported in milligrams (mg). The iron dose an adult would get through food and taking supplements is then added to the calculated dose above. For an adult, this additional dose of iron is calculated to be 18 milligrams per day (mg/day).

The excess iron intake for each scenario is then compared to the upper limit of daily iron intake recommended for an adult, also reported in mg.

The default values used for a resident adult for this scenario are:

- Average and maximum iron concentrations from samples collected in the Perimeter Area.
- Average and maximum soil/waste iron concentrations from samples collected from the Waterfront Area.
- Average and maximum sediment iron concentrations from samples collected from the Waterfront Area.
- An adult is assumed to weigh 70 kilograms (kg) equivalent to 154 pounds.
- A conversion factor of 1×10^{-6} kg/mg is used.
- Skin surface area available for contact is assumed to be 0.07 square centimeter for an adult.
- Soil to skin adherence factor is assumed to be 0.1 mg/cm^2 for an adult.
- An absorption factor is assumed to be 1.0 for an adult.
- The exposure frequency is assumed to be 350 days per year for an adult.
- Time a person lives a one residence is 30 years.
- There are 365 days in a year.
- The result of the dose calculation is then multiplied by 70 kg to obtain an iron intake in milligrams per day.

The equations used for determining the adult resident exposure dose and the iron intake are as follows:

Adult resident exposure doses from dermal contact with chemicals in soil can be calculated as follows:

$$D = \frac{C \times CF \times SA \times AF \times ABS \times EF \times ED}{BW \times AT}$$

Where

D = exposure dose (mg/kg·day)
C = contaminant concentration (mg/kg)
CF = conversion factor (10^{-6} kg/mg)
SA = skin surface area available for contact (cm^2/event)
AF = soil to skin adherence factor (mg/cm^2)
ABS = absorption factor (unitless)
EF = exposure frequency (events/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = period over which exposure is averaged (days)

The Exposure Factor can be calculated as follows:

$$EF = (F \times ED) / AT$$

Where:

F = Frequency of exposure (days/year)
ED = Exposure Duration (years)
AT = Averaging Time (ED x 365 days/year)

The iron Intake can be calculated as follows:

$$Intake = Dose \times Body\ Weight$$

$$I = D \times BW$$

Where

I = Intake
D = Dose
BW = Body Weight

Child Resident Dermal Exposure Dose Calculation (for Table 7 in Discussion)

This exposure scenario was examined to compare the potential dose and iron intake of a child resident who would receive an exposure from dermal contact of iron containing soil from the Perimeter Area and the Waterfront Area. Iron concentrations used for the Perimeter area included the average and maximum concentrations of iron in site soils, as shown in Table 7. For the Waterfront Area soils the average and maximum soil/waste iron concentration and the average and maximum sediment iron concentrations were used, also shown in Table 7. An exposure dose was also calculated for dermal contact of iron-containing soil from the Perimeter area and iron containing soil/waste and sediment from the Waterfront Area.

Dose results are reported in milligrams per kilogram per day (mg/kg/day). The doses are calculated utilizing the standard ATSDR and EPA default values for adults (ATSDR 2005, EPA 1989, and EPA 2008). Daily iron intakes are the product of the dose and body weight. The iron dose a child would get through food and taking supplements is then added to the calculated dose above. For a child, the calculated additional dose of iron would be 10 milligrams per day (mg/day).

The excess iron intake for each scenario is then compared to the upper limit of daily iron intake recommended for a child, also reported in mg.

The default values used for a resident child for this scenario are:

- Average and maximum iron concentrations from samples collected in the Perimeter Area.
- Average and maximum soil/waste iron concentrations from samples collected from the Waterfront Area.
- Average and maximum sediment iron concentrations from samples collected from the Waterfront Area.
- A child is assumed to weigh 30 kilograms (kg) equivalent to 66 pounds.
- Skin surface area available for contact is assumed to be 0.2 square centimeters for a child.
- Soil to skin adherence factor is assumed to be 0.1 mg/cm^2 for a child.
- An absorption factor is assumed to be 1.0 for a child.
- The exposure frequency is assumed to be 350 days per year for a child.
- Time a child lives in one residence is 10 years (age 3 to 13).
- There are 365 days in a year.
- The result of the dose calculation is then multiplied by 30 kg to obtain an iron intake in milligrams per day.

These values are used in the dermal contact equation shown above and an iron dose is calculated.

Adult Resident Ingestion Exposure Dose Calculations (for Table 8 in Discussion)

This exposure scenario was examined to compare the potential dose and iron intake of an adult resident who would receive an exposure from ingesting iron-containing soil from the Perimeter Area and the Waterfront Area. Iron concentrations used for the Perimeter area included the average and maximum concentrations of iron in site soils, as shown in Table 8. For the Waterfront Area soils the average and maximum soil/waste iron concentration and the average and maximum sediment iron concentrations were used, also shown in Table 8. An exposure dose was also calculated for the ingestion of iron-containing soil from the Perimeter area and iron containing soil/waste and sediment from the Waterfront Area.

The doses are calculated using utilizing the standard ATSDR and EPA default values for adults (ATSDR 2005, EPA 1989, and EPA 2008). Iron intake is the product of the dose and body weight, and is reported in milligrams (mg). The iron dose an adult would get through food and taking supplements is then added to the calculated dose above. For an adult, this additional dose of iron is calculated to be 18 milligrams per day (mg/day).

The excess iron intake for each scenario is then compared to the upper limit of daily iron intake recommended for an adult, also reported in mg.

The default values used are:

- Average and maximum iron concentrations from samples collected in the Perimeter Area.
- Average and maximum soil/waste iron concentrations from samples collected from the Waterfront Area.
- Average and maximum sediment iron concentrations from samples collected from the Waterfront Area.
- An adult is assumed to weigh 70 kilograms (kg) equivalent to 154 pounds.
- An ingestion rate is assumed to be 100 mg soil per day.
- A conversion factor of 1 x 10^{-6} kg/mg is used.
- A fraction ingested is assumed to be 1.0 for an adult.
- The exposure frequency is assumed to be 350 days per year for an adult.
- Time a person lives a one residence is 30 years.
- There are 365 days in a year.
- The result of the dose calculation is then multiplied by 70 kg to obtain an iron intake in milligrams per day.

The equations used for determining an adult resident ingestion dose and the iron intake are as follows:

Adult resident exposure dose from ingesting soil with site iron concentrations can be calculated as follows:

$$D = \frac{C \times IR \times CF \times FI \times EF \times ED}{BW \times AT}$$

D = exposure dose (mg/kg·day)
C = contaminant concentration (mg/kg)
IR = ingestion rate (mg soil/day)
CF = conversion factor (10^{-6} kg/mg)
FI = fraction ingested from contaminated source (unitless)
EF = exposure frequency (events/year)
ED = exposure duration (years)
BW = body weight (kg)
AT = period over which exposure is averaged (days)

The Exposure Factor can be calculated as follows:

$$EF = (F \times ED) / AT$$

Where:

F = Frequency of exposure (days/year)
ED = Exposure Duration (years)
AT = Averaging Time (ED x 365 days/year)

The iron Intake can be calculated as follows:

$$Intake = Dose \times Body\ Weight$$

$$I = D \times BW$$

Where:

I = Intake
D = Dose
BW = Body Weight

Child Resident Ingestion Exposure Dose Calculations (for Table 8 in Discussion)

This exposure scenario was examined to compare the potential dose and iron intake of a child resident who would receive an exposure from dermal contact of iron containing soil from the Perimeter Area and the Waterfront Area. Iron concentrations used for the Perimeter area included the average and maximum concentrations of iron in site soils, as shown in Table 8. For the Waterfront Area soils the average and maximum soil/waste iron concentration and the average and maximum sediment iron concentrations were used, also shown in Table 8. An exposure dose was also calculated for dermal contact of iron-containing soil from the Perimeter area and iron containing soil/waste and sediment from the Waterfront Area.

Dose results are reported in milligrams per kilogram per day (mg/kg/day). The doses are calculated utilizing the standard ATSDR and EPA default values for adults (ATSDR 2005, EPA 1989, and EPA 2008). Daily iron intakes are the product of the dose and body weight. The iron dose a child would get through food and taking supplements is then added to the calculated dose above. For a child, the calculated additional dose of iron would be 10 milligrams per day (mg/day).

The excess iron intake for each scenario is then compared to the upper limit of daily iron intake recommended for a child, also reported in mg.

The default values used for a resident child for this scenario are:

- Average and maximum iron concentrations from samples collected in the Perimeter Area.
- Average and maximum soil/waste iron concentrations from samples collected from the Waterfront Area.
- Average and maximum sediment iron concentrations from samples collected from the Waterfront Area.
- A child is assumed to weigh 30 kilograms (kg) equivalent to 66 pounds.
- An ingestion rate is assumed to be 200 mg soil per day.
- A conversion factor of 1 x 10^{-6} kg/mg is used.
- A fraction ingested is assumed to be 1.0 for a child.
- The exposure frequency is assumed to be 350 days per year for an adult.
- Time a child living in a residence is 10 years.
- There are 365 days in a year.
- The result of the dose calculation is then multiplied by 30 kg to obtain an iron intake in milligrams per day.

These values are used in the ingestion equation shown above and an iron dose is calculated.

Adult Recreational Trespasser Dermal Exposure Dose Calculations (for Table 9 in Discussion)

For this exposure scenario, the dermal contact dose from iron-containing soil for an adult recreational trespasser who would trespass in the Waterfront Area is evaluated. The equation used for the adult resident dermal exposure dose calculation above is used and the individual default parameter values are changed to those below. The iron dose an adult would get through food and taking supplements is then added to the calculated dose. For an adult, this additional dose of iron is calculated to be 18 milligrams per day (mg/day).

The default values used for this scenario are:

- Average and maximum iron concentrations from samples collected in the Perimeter Area.
- Average and maximum soil/waste iron concentrations from samples collected from the Waterfront Area.
- Average and maximum sediment iron concentrations from samples collected from the Waterfront Area.
- An adult is assumed to weigh 70 kilograms (kg) equivalent to 154 pounds.
- A conversion factor of 1 x 10^{-6} kg/mg is used.
- Skin surface area available for contact is assumed to be 0.07 square centimeters for an adult.
- Soil to skin adherence factor is assumed to be 0.1 mg/cm^2 for an adult.
- An absorption factor is assumed to be 1.0 for an adult.
- The exposure frequency is assumed to be 108 days per year for an adult.
- Time a person would trespass is 10 years.
- There are 365 days in a year.
- The result of the dose calculation is then multiplied by 70 kg to obtain an iron intake in milligrams per day.

Child Recreational Trespasser Dermal Exposure Dose Calculations (for Table 9 in Discussion)

For this exposure scenario, the dermal contact dose from iron-containing soil for an adult recreational trespasser who would trespass in the Waterfront Area is evaluated. The equation used for the adult resident dermal exposure dose calculation above is used and the individual default parameter values are changed. The iron dose a child would get through food and taking supplements is then added to the calculated dose. For a child, the calculated additional dose of iron would be 10 milligrams per day (mg/day).

The default values used for this scenario are:

- Average and maximum iron concentrations from samples collected in the Perimeter Area.
- Average and maximum soil/waste iron concentrations from samples collected from the Waterfront Area.
- Average and maximum sediment iron concentrations from samples collected from the Waterfront Area.
- A child is assumed to weigh 30 kilograms (kg) equivalent to 66 pounds.
- Skin surface area available for contact is assumed to be 0.2 square centimeters for a child.
- Soil to skin adherence factor is assumed to be 0.1 mg/cm^2 for a child.

- An absorption factor is assumed to be 1.0 for a child.
- The exposure frequency is assumed to be 108 days per year for a child.
- Time a child would trespass is 10 years (age 4 to 13).
- There are 365 days in a year.
- The result of the dose calculation is then multiplied by 30 kg to obtain an iron intake in milligrams per day.

Adult Recreational Trespasser Ingestion Exposure Dose Calculations (for Table 10 in Discussion)

For this exposure scenario, the dermal contact dose from iron-containing soil for an adult recreational trespasser who would trespass in the Waterfront Area is evaluated. The equation used for the adult resident dermal exposure dose calculation above is used and the individual default parameter values are changed to those below. The iron dose an adult would get through food and taking supplements is then added to the calculated dose. For an adult, this additional dose of iron is calculated to be 18 milligrams per day (mg/day).

The default values used for this scenario are:

- Average and maximum iron concentrations from samples collected in the Perimeter Area.
- Average and maximum soil/waste iron concentrations from samples collected from the Waterfront Area.
- Average and maximum sediment iron concentrations from samples collected from the Waterfront Area.
- An adult is assumed to weigh 70 kilograms (kg) equivalent to 154 pounds.
- An ingestion rate is assumed to be 100 mg soil per day.
- A conversion factor of 1 x 10^{-6} kg/mg is used.
- A fraction ingested is assumed to be 1.0 for an adult.
- The exposure frequency is assumed to be 108 days per year for an adult.
- Time a person would trespass is 10 years.
- There are 365 days in a year.
- The result of the dose calculation is then multiplied by 70 kg to obtain an iron intake in milligrams per day.

Child Recreational Trespasser Ingestion Exposure Dose Calculations (for Table 10 in Discussion)

For this exposure scenario, the ingestion dose from iron-containing soil for a child recreational trespasser who would trespass in the Waterfront Area is evaluated. The equation used for the child resident dermal exposure dose calculation above is used and the individual default parameter values are changed. The iron dose a child would get through food and taking supplements is then added to the calculated dose. For a child, the calculated additional dose of iron would be 10 milligrams per day (mg/day).

The default values used for this scenario are:

- Average and maximum iron concentrations from samples collected in the Perimeter Area.
- Average and maximum soil/waste iron concentrations from samples collected from the Waterfront Area.
- Average and maximum sediment iron concentrations from samples collected from the Waterfront Area.
- A child is assumed to weigh 30 kilograms (kg) equivalent to 66 pounds.
- An ingestion rate is assumed to be 200 mg soil per day.
- A conversion factor of 1 x 10^{-6} kg/mg is used.

- A fraction ingested is assumed to be 1.0 for a child.
- The exposure frequency is assumed to be 108 days per year for a child.
- Time a child would trespass is 10 years (age 4 to 13).
- There are 365 days in a year.
- The result of the dose calculation is then multiplied by 30 kg to obtain an iron intake in milligrams per day.

Certification

This Public Health Consultation: *Davis Mill Surface Water – Sub OU 1-D Gypsum Pond Area, Copperhill, Polk County, Tennessee, CIRCLIS ID TN0001890839,* was prepared by the Tennessee Department of Health Environmental Epidemiology under a Cooperative Agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It was prepared in accordance with the approved methodology and procedures that existed at the time the health consultation was begun.

Technical Project Officer, CAT, SPAB, DHAC, ATSDR

The Division of Health Assessment and Consultation, ATSDR, has reviewed this public health assessment and concurs with the findings.

Team Leader, CAT, SPAB, DHAC, ATSDR