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April 23, 2021

Patrick Peckham, Alderman
City of Wausau

Subject: Phase II data review of soil and groundwater contaminants at 1300 Cleveland Ave in Wausau, WI

Dear Alderman Peckham,

Thank you for contacting the Wisconsin Department of Health Services with your concern about thallium and other contaminants on the 1300 Cleveland Avenue site. I am writing to provide you with our public health conclusions regarding the onsite contaminants and neighboring residential areas based on soil and groundwater samples taken in October 2020. To summarize our findings, the results indicate the following:

- **There could be a public health hazard present if very young children are consistently on site due to thallium levels found in soil onsite.** Taking steps to minimize trespassing would be protective against these exposures as well as physical hazards expected at an industrial property.
- **The potential for offsite impacts to the neighboring residential areas represents an indeterminate public health hazard due to the lack of sampling data in those areas.** Following standard gardening practices for urban areas is expected to be protective against any possible chemical exposure.

Background

The 1300 Cleveland Ave. site is currently developed with a storage building that is being leased by a sewer and water utility contractor, loading docks that were associated with a former larger industrial building that was razed and removed in 2019, and areas of concrete and asphalt pavement associated with the former industrial building. The City uses a portion of the site for log and wood chip storage and the utility contractor uses a portion of the site for staging of sewer and water piping. Historically, the site was associated with a larger area of land and had been developed for manufacturing and/or commercial purposes since the 1950's.[1] As part of the Phase II investigation, 44 soil samples of varying depths were taken from 22 soil borings and were analyzed for a variety of contaminants, including for metals and polycyclic aromatic hydrocarbons (PAHs) (see Appendix Figure 1). Groundwater samples were taken at three locations at depths ranging from 25 to 33 feet below the surface.

Exposure Assessment

An evaluation of exposure pathways is performed to determine if an exposure or potential exposure to the contaminants were possible (Appendix Table 1). In order for any contaminant to be a health concern, a completed exposure pathway must exist and the contaminant must be at a

[1] Phase 2 Subsurface Assessment, City of Wausau, Marathon County, WI. GEI Consulting Engineers and Scientists, January 22, 2021

high enough concentration to cause potential harm to people. In order for a completed pathway to be present, all of the following elements must exist: a source of contamination, media for the contaminant to travel, a point of exposure where people actually come into contact with a contaminated material, a route of exposure allowing the contaminants to enter or contact the body, and a receptor population or people who are exposed or potentially exposed to the contaminants.[2]

Site Barriers to Soil/Sediment Access

Only the top four feet of soil is considered to be accessible since deeper soil would require excavation to access to cause a dermal or ingestion exposure. Therefore, values representing the maximum levels of thallium or PAHs in the top four feet of soil for our evaluation. During winter, the ground is frozen and/or covered with snow or ice making the soil inaccessible for the season. Where ground coverage such as vegetation or asphalt/concrete are present, the soil isn't considered to be readily accessible. The site is elevated and partially surrounded by fencing and dense vegetation.

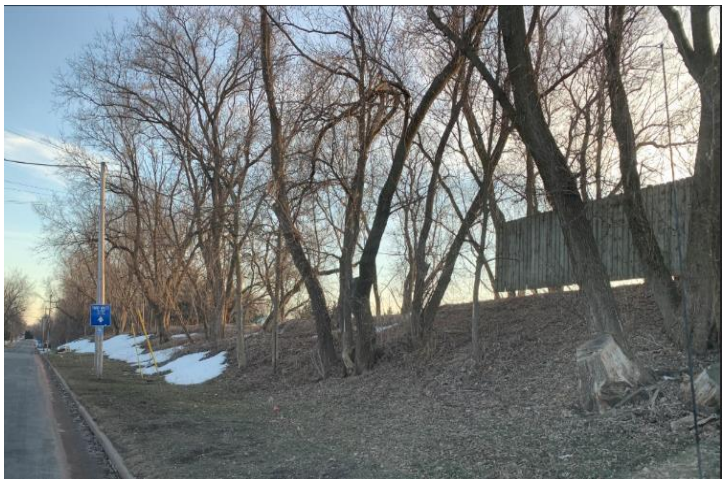

Image 1. Gap in fencing along Cleveland Avenue.

Contaminants of concern

Data collected onsite by the responsible party's contractor was reviewed and contaminants with completed exposure pathways underwent a screening process to identify contaminants of concern (COC). During the screening process, the maximum concentration of each contaminant[3] in the top four feet of sediment was selected and compared to a health-based comparison or screening value that is protective of human health risk (Appendix Table 2). When exceeded, further investigation was warranted into the COC, but it did not necessarily indicate a cleanup was needed or that an increased risk to human health had occurred.[4]

Discussion

Thallium contamination offsite and impacts to gardening

No sampling has occurred off the 1300 Cleveland Ave site; therefore, it is unknown what thallium levels might be offsite and, therefore, thallium is an indeterminate public health hazard.

Thallium contamination and access to 1300 Cleveland Avenue by children and residents

As previously discussed, this industrial property is located within a residential community. The site is accessible due to insufficient fencing, lack of gates, or damaged fencing and no signage is

[2] https://www.atsdr.cdc.gov/training/toxmanual/pdf/module-2.pdf
[3] Maximum concentration of a contaminant only included values that were above limits of detections (LOD) since those values could be applied as either estimates or accurate values of exposure.
[4] https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide

present. Based on the 1.5 mg/kg thallium estimate and a trespassing scenario exposure of 175 days per year (5 days/week for 35 weeks a year[5]), a weighted average exposure of 0.0000018 mg/kg-day is well below the EPA's Provisional Peer-Reviewed Toxicity Value (PPRTV)[6] for thallium of 0.00001 mg/kg-day[7]. The risk for non-cancer related health exposures to small amounts (150 to 200 mg/day) of thallium is highest from birth to 2 years old (Table 1) and this age group should have minimal exposure to exposed soil on the 1300 Cleveland Ave. site.

Table 1. Trespassing Scenario of maximum onsite thallium concentrations in top 4' of soil.

Exposure Group	Chronic Dose (mg/kg/day) RME[a]	HQ[b] RME	HQ>1?[c]	Cancer Rate[d]
Birth to <1 year	1.4E-05	1.4	Yes	N/A
1 to <2 years	1.3E-05	1.3	Yes	N/A
2 to <6 years	8.5E-06	0.85	No	N/A
6 to <11 years	4.7E-06	0.47	No	N/A
11 to < 16 years	1.4E-06	0.14	No	N/A
16 to <21 years	1.1E-06	0.11	No	N/A
Adult	9.4E-07	0.094	No	N/A

[a] RME= reasonable maximum exposure; chronic dose (combined oral and dermal exposures) is based on a thallium value of 1.5 mg/kg which was considered an estimate [J-tagged] and an exposure of 5 days per week for 35 weeks a year (175 days total) which is an onsite trespassing scenario.

[b] HQ=hazard quotient is the combined dermal and oral dose divided by EPA's provisional peer-reviewed toxicity value of 0.00001 mg/kg-day.

[c] If the value is greater than 1, there is the potential for an increased risk for non-cancer health effects. When/if the exposure is discontinued, the risk for non-cancer health effects decreases.

[d] It is unknown if thallium causes cancer and the EPA has not calculated a cancer slope factor value for thallium which is necessary to calculate any potential increased cancer risk.

PAHs contamination levels Human Health Risk Assessment

After taking the maximum concentrations of PAHs from 1300 Cleveland Ave, seven PAH were converted to Benzo(a)pyrene equivalents using a relative potency factor (RPF) calculation (see Appendix Table 3). The seven compounds listed in Appendix Table 3 may cause similar types of cancer, but they have different levels of strength. The RPF approach is a way we can assess how the compounds contribute to cancer risk altogether. This is done by assessing the cancer risk contributed by each substance after adjusting them relative to Benzo(a)pyrene, the compound in the set with the strongest carcinogenicity. After using the RPF approach, risk assessment was performed and it was determined that there was not an increased risk for non-cancer related risk to health effects (Table 2).[8] The potential risk of cancer-related health effects was determined to

[5] Exposure used was 5 days a week for 35 weeks per year or 175 days based on a trespassing scenario

[6] Due to study and data quality limitations as stated in the IRIS Toxicological Review, a reference dose was not derived but a screening subchronic and chronic p-reference dose could be derived with the available dose-response data (see https://cfpub.epa.gov/ncea/pprtv/documents/ThalliumCarbonate.pdf)

[7] Screening Chronic p-RfD for soluble Thallium based on the critical effect of atrophy of hair follicles

[8] After converting the appropriate PAHs to benzo(a)pyrene equivalents and calculating a mg/kg/day exposure value, the hazard quotient (HQ) is calculated by taking the benzo(a)pyrene equivalents divided by the EPA reference dose for benzo(a)pyrene (0.0003 mg/kg-day). A HQ greater than 1 indicates a potential increased risk for non-cancer health effects.

be 2.4 people in every 100,000 people over a lifetime exposure (78 years) for total PAHs in soil based on exposure of 175 days each year (trespassing scenario; 5 days per week for 35 weeks per year).

Table 2. Trespassing Scenario based on cumulative assessment of maximum PAH concentrations in top 4' of soil onsite.

Exposure Group	Chronic Dose (mg/kg/day) RME[a]	HQ RME[b]	HQ>1?[c]	Exposure Duration (years)	Cancer Rate RME
Birth to <1 year	4.6E-05	0.15	No	1	2.10E-05
1 to <2 years	4.2E-05	0.14	No	1	
2 to <6 years	2.8E-05	0.093	No	4	
6 to <11 years	1.7E-05	0.057	No	5	
11 to < 16 years	7.8E-06	0.026	No	5	
16 to <21 years	6.6E-06	0.022	No	5	
Adult	3.5E-06	0.012	No	57	2.60E-06
			Total	78	2.36E-05

[a] RME= reasonable maximum exposure; chronic dose is based on a 3.8 mg/kg benzo(a)pyrene which is the maximum values of each PAH converted to benzo(a)pyrene equivalents and summed (see Appendix table "PAH relative potency factor adjustments" for details). Exposure is based on a trespassing scenario of 5 days per week for 35 weeks a year (175 days total).

[b] HQ=hazard quotient is the combined dermal and oral dose divided by EPA's reference dose of 0.0003 mg/kg/day.

[c] If the value is greater than 1, there is the potential for an increased risk for non-cancer health effects. When/if the exposure is discontinued, the risk for non-cancer health effects decreases.

Cancer risk interpretation

Since PAHs are found as mixtures, the cancer risk was assessed cumulatively. The cumulative cancer risk calculated based on maximum PAH levels at the 1300 Cleveland site (2.4×10^{-5}) slightly exceeds the acceptable cumulative cancer risk threshold of 1×10^{-5} outlined in Ch. NR720, Wis. Admin. Code. However, there are several factors that suggest exposures do not represent a public health concern:

- The cumulative values of the seven PAHs found on site are within ranges reported for other sites including residential and industrial sites (See table in Appendix Table 4).
- The exposure assumptions are conservative as they are reflect frequent exposures to PAHs through ingestion and dermal contact while trespassing on the property 175 days per year over long periods of time (78 years). Actual on-site exposures among trespassing individuals are likely lower because many people are not expected to be on site this frequently and for such a long time.
- The assessment is based on maximum PAH contamination values found primarily in one soil boring (SB-14) found on site.[9]
- PAH concentrations were lower in the other 19 soil borings collected from the top 4 feet of soil on site. Cancer risk estimates calculated based on these concentrations were lower as well, and were consistently below the cumulative acceptable cancer risk listed in Ch. NR720, Wis. Admin. Code.

[9] https://www.itrcweb.org/GuidanceDocuments/Risk_Docs/RISK2.pdf

Physical Hazards
Hazards on the industrial property are expected to include physical hazards such as trains, railroad tracks, heavy machinery, vehicles including trucks and cars, and other equipment that may be used on site that would create a potentially hazardous environment for a child. Children should not be trespassing onsite alone and, if on site, should be with an adult and under their supervision.

Limitations
- All detectable thallium values were considered to be estimates.
- Soil data is only available for the 1300 Cleveland Ave. site
- It is unknown if or to what extent trespassing is occurring onto the site

Conclusions
Based on the assessment described above, DHS concludes that:
- Exposure to PAHs among individuals trespassing on site does not constitute a public health hazard.
- Thallium levels potentially pose a public health hazard only for very young children that consistently trespass onsite (175 days per year).
- Site-related chemical contamination of the neighboring residential area represents an indeterminate public health hazard since no samples have been taken offsite.

Recommendations
- Steps should be considered to ensure children cannot access the site to minimize potential exposures to any physical hazards and elevated levels of thallium present.
- PAH and thallium levels off-site in the residential neighborhood are unknown. However, implementing appropriate urban gardening practices[10] will reduce exposure to any soil contaminants present. Gardeners should:
    - Create a raised bed garden with store-bought soil, topsoil, or clean fill from 'certified soil sources',[11]
    - wear gloves while gardening or handling soil,
    - wash hands to prevent hand-to-mouth exposure,
    - wash produce thoroughly before eating,
    - peel vegetables, especially, root vegetables,
    - remove outer leaves of leafy vegetables,
    - avoid tracking soil into the home,
    - and supervise children when in the garden to make sure they are also using proper gardening techniques.
- Any residents that are concerned that they've been exposed to thallium or any other contaminant that may be impacting their health should consult with their medical provider.

[10] https://www.epa.gov/sites/production/files/2014-03/documents/urban_gardening_fina_fact_sheet.pdf
[11] https://cdn.shopify.com/s/files/1/0145/8808/4272/files/A3905-04.pdf and https://www.epa.gov/sites/production/files/2015-09/documents/bf_urban_ag.pdf?_sm_au_=iVVSPFr17j4T15VsBLQtvK7BJGKjp

Additional information on thallium and PAHs and human health effects are available at https://www.atsdr.cdc.gov/toxfaqs/tfacts54.pdf and https://www.atsdr.cdc.gov/toxfaqs/tfacts69.pdf, respectively. If you have any questions regarding the information contained in this letter, please contact me at the email address below.

Sincerely,

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Enclosures
1. Exposure pathways
2. Contaminant of concern screening
3. PAH relative potency factor adjustments
4. Background level comparison of PAHs
5. Risk assessment calculations, assumptions, and variables
6. Toxicity information and glossary
7. Map of sampled parcel

cc: Matthew Thompson, Hydrogeologist Program Coordinator, Department of Natural Resources
Dale Grosskurth, Environmental Health and Safety Director, Marathon County Health Department
Eric Lindman, Director of Public Works & Utilities, City of Wausau

Appendix Table 1. Exposure pathways at 1300 Cleveland Ave.

Pathway Name	Exposure Pathway Elements					Time Frame	Pathway status
	Source	Environmental Medium	Point of Exposure	Potentially Exposed Population	Route of Exposure		
Soil	PAHs	Soil	Top 4' of soil onsite	Local residents, visitors	Ingestion, Dermal contact	Past, present, future	Completed Pathway
Soil	Metals	Soil	Top 4' of soil onsite	Local residents, visitors	Ingestion, Dermal contact	Past, present, future	Completed Pathway
Biota (plants)	PAHs	Garden plants	Gardens offsite	Local residents, visitors	Ingestion, Dermal contact	Past, present, future	Potential Pathway
Biota (Plants)	Metals	Garden plants	Gardens offsite	Local residents, visitors	Ingestion, Dermal contact	Past, present, future	Potential Pathway
Ground-water	PAHs, Metals	Groundwater	None; not a drinking water source	None; not a drinking water source	Ingestion, Dermal contact	Past, present, future	Incomplete Pathway

Groundwater

Groundwater samples were taken at a depth of 25 to 33 feet below the surface which indicated that the pathway was incomplete and that people are unlikely to come into contact with contaminated groundwater located at that depth. The residential area is supplied with municipal water and is unlikely to come in contact with the contaminants in drinking water since municipal wells are routinely monitored for contamination. Therefore, the exposure pathway through groundwater was considered incomplete and was not evaluated further.

Appendix Table 2. Contaminants detected above the limit of detection in top 4 feet of sediment at 1300 Cleveland Ave.

Compounds	Depth (feet)	Maximum concentration (ppm)	Recommended Comparison Value (ppm)	Comparison Value type[b]	COC?
Metals (mg/kg or ppm)					
Antimony	0-4	4.5	31.3	NID RCL[c]	No
Arsenic	0-4	9.3	16	Chronic EMEG child, RMEG Child	No
Beryllium	0-4	0.86 [a]	156	NID RCL	No
Cadmium	0-4	1.0	71	NID RCL	No
Total Chromium	0-4	40.9	100,000	NID RCL	No
Copper	0-4	75.8	3130	NID RCL	No
Lead	0-4	70.3	400	NID RCL	No
Nickel	0-4	14.9	1550	NID RCL	No
Selenium	0-4	2.5 [a]	391	NID RCL	No
Silver	0-4	0.36 [a]	391	NID RCL	No
Thallium	0-4	1.5[a]	0.782	NID RCL	**Yes**
Zinc	0-4	349	23500	NID RCL	No
Mercury	0-4	0.26	3.13	NID RCL	No
Semi-Volatile Organic Compounds					
Anthracene	0-4	0.56 [ae]	17900	NID RCL	No
Benzo(ghi)perylene	0-4	2.31[e]	Not established	No additional information	N/A
Fluoranthene	0-4	5.42[e]	2390	NID RCL	No
Fluorene	0-4	0.328 [a]	2390	NID RCL	No
Naphthalene	0-4	0.655 [a]	5.52	NID RCL	No
Phenanthrene	0-4	2.99	Not established	No additional information	N/A
Pyrene	0-4	4.03 [e]	1790	NID RCL	No
Per- and Polyfluoroalkyl substances (mg/kg or ppm)					
PFOS		0.001	1.26	NID RCL	No
PAHs (mg/kg or ppm)					
Chrysene	0-4	2.47 [e]	115	NID RCL	No
Benz(a)anthracene	0-4	2.39[e]	1.1	NID RCL	**Yes**
Benzo(a)pyrene	0-4	2.63[e]	0.11	NID RCL, CREG	**Yes**
Benzo(b)fluoranthene	0-4	3.55 [e]	1.1	NID RCL	**Yes**
Benzo(k)fluoranthene	0-4	1.37 [e]	11.5	NID RCL	No
Indeno(1,2,3-cd)pyrene	0-4	2.36 [e]	1.1	NID RCL	**Yes**
Dibenz(a,h)anthracene	0-4	0.335[ae]	0.115	NID RCL	**Yes**
PAH-sum[d]	0-4	3.8	0.11	CREG	**Yes**

[a] Value was between the limit of detection and limit of quantitation and is therefore considered to be an estimation of the actual concentration

[b] The type of comparison values indicated are the ones recommended by ATSDR for screening for each contaminants or are the Wisconsin RCL value.

[c] NID RCL is for "non-industrial direct contact residual contaminant level" which was used to indicate a threshold for a potential residential exposure. These values are the results from EPA's Regional Screening Level web calculator with NR 720 default parameters (https://dnr.wisconsin.gov/topic/Brownfields/soil.html).

[d] Polycyclic Aromatic Hydrocarbons that are similar in structure can be converted to benzo(a)pyrene, the most potent of the PAHs, using relative potency factors (RPF). This value includes benzo(a)athracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, Chrysene, dibenz(a,h,)anthracene, and indeno (1,2,3-cd) pyrene.[12]

[e] Value was from the top four feet of sediment in soil boring SB-14

PAH relative potency factor adjustments

Appendix Table 3. PAHs converted to benzo(a)pyrene equivalents and compared to health based comparison value for benzo(a)pyrene

Polycyclic aromatic hydrocarbons (PAHs)	Maximum concentration (ppm)	Relative Potency Factors[a]	Adjusted to relative potency of Benzo(a)pyrene[b] (ppm)	COC?
Chrysene	2.47	0.001	0.00247	
Benzo(a)anthracene	2.39	0.1	0.239	
Benzo(a)pyrene	2.63	1	2.63	
Benzo(b)fluoranthene	3.55	0.1	0.355	
Benzo(k)fluoranthene	1.37	0.01	0.0137	
Indeno(1,2,3-cd)pyrene	2.36	0.1	0.236	
Dibenz(a,h)anthracene	0.335	1	0.335	
Sum of PAHs			3.8	**Yes, exceeds benzo(a)pyrene value of 0.11 ppm[c]**

[a] Relative Potency Factors provided by the EPA https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide#thall and https://www.epa.gov/risk/regional-screening-levels-rsls-users-guide

[b] Adjusted values are calculated by taking the individual PAH compound and multiplying by the relative potency factor to equal the toxicity relative to benzo(a)pyrene which is the most potent of the PAHs

[c] After converting to benzo(a)pyrene potency, the compounds are compared to the screening value of 0.11 mg/kg which is both Wisconsin's non industrial regional screening level and ATSDR's recommended screening value for CREG.

[12] https://bcs-1.itrcweb.org/8-2-general-toxicity-of-pahs/#table_8_1 and https://nepis.epa.gov/Exe/ZyPDF.cgi/30002TUA.PDF?Dockey=30002TUA.PDF

Background Level Comparison of PAHs

Appendix Table 4. Background Benzo(a)pyrene levels in soil[a]

Location	N	Range (µg/kg)
Heavy Residential	142	2.0 – 7,920
Commercial	61	1.9 – 3,360
Light Industrial	32	2.7 – 4,740
Light Residential	27	2.0 – 2,220
Rural	13	4.9 – 1,360
Agricultural	6	3.3 - 135
Heavy Industrial	4	267 – 2,190
1300 Cleveland Ave. Benzo(a)pyrene equivalents	***20[b]***	***ND[c] –3,811***

[a]Data for exposure calculation compiled by Mauro et al. (2006)[13], with exposure calculations added.
[b]Includes only soil boring values in the top four feet of soil
[c]The lowest value was below the limit of detection and 11 soil borings had no detectable PAH levels.

[13] Mauro DM, DeClercq PJ, Siegener R, Coleman A. 2006. Survey of the distribution and sources of PAHs in urban surface soils. *Land Contamination and Reclamation, 14(2),* 513-21.

Calculations for Risk Assessment

Non-cancer Exposure Factor for Trespassing scenario

$$EFnc = \frac{5\ days}{7\ days\ per\ week} \times \frac{35\ weeks\ per\ year}{52.14\ weeks\ in\ a\ year} \times \frac{67\ years}{67\ years}$$

Cancer Exposure Factor

$$EFcancer = EF\ noncancer \times \frac{Age - Specific\ Exposure\ duration\ (years)}{78\ Years}$$

Exposure Dose Equation (ingestion)

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

D = Exposure Dose (mg/kg/day)
C = Contaminant Concentration (mg/kg)
IR = Intake Rate (mg/day)
EF = Exposure factor (unitless)
CF = Conversion Factor (10^{-6} kg/mg)
BW = Body Weight (kg)

Administered Dermal Dose equation

$$ADD = \frac{(C \times EF \times CF \times AF \times ABSd \times SA)}{BW \times ABSgi}$$

ADD = Administered Dermal Dose (mg/kg/day)
C = Contaminant Concentration (mg/kg)
EF = Exposure Factor (unitless)

- EF dermal: The dermal absorbed dose equation includes a 1 event/day EF parameter

CF = Conversion Factor (10^{-6} kg/mg)
AF = Adherence Factor to skin (mg/cm^2-event)
ABSd = Dermal Absorption Fraction to skin (unitless)
SA = Skin Surface Area Available for Contact (cm^2)
BW = Body Weight (kg)
ABSgi = Gastrointestinal Absorption Factor (unitless)

Hazard Quotient equation for determining risk of Non-cancer human health effects

$$HQ = \frac{D}{MRL\ or\ RfD}$$

HQ = Hazard Quotient
D = Exposure Dose (mg/kg/day)
MRL= Minimal Risk Level (mg/kg/day)
RfD = Reference Dose (mg/kg/day)
HQ>1=potential increase in the risk of human health effects.

Cancer Risk equation for determining risk of cancer-related health effects

$$CR = (D \times CSF) \times \frac{ED}{LY}$$

CR = Cancer Risk
D = Age-Specific Dose (mg/kg/day)
CSF = Cancer Slope Factor ((mg/kg/day)$^{-1}$)
ED = Age-Specific Exposure Duration (years)
LY = Lifetime in Years (78 years)

Variables used for risk assessment

Variables for all dermal and oral calculations

Exposure Group	Ingestion (mg/day)	body weight (kg)	Dermal Absorption Factor to Skin (mg/m^2-event)	Skin Surface Area Available for Contact (cm^2)	Exposure Duration (years)
Birth to < 1 year	150	7.8	0.2	1,772	1
1 to < 2 years	200	11.4	0.2	2,299	1
2 to < 6 years	200	17.4	0.2	2,592	4
6 to < 11 years	200	31.8	0.2	3,824	5
11 to < 16 years	100	56.8	0.2	5,454	5
16 to < 21 years	100	71.6	0.2	6,083	5
Combined Child					21
Adult	100	80	0.07	6,030	57
				Total Years	78

Contaminant specific variables

Contaminant	RfD (mg/kg/day)	Benzo(a)pyrene Cancer slope factor (mg/kg/day)$^{-1}$	Dermal Absorption Fraction to Skin (unitless)	Gastrointestinal Absorption Factor (unitless)	Conversion Factor (CF) in kg/mg
Benzo(a)pyrene	0.0003	1	0.13	1	10^{-6}
Thallium	0.00001	N/A	0.01	1	10^{-6}

Toxicity information

Thallium

Thallium is a metal that is found in trace amounts in the earth's crust and was a by-product of smelting other metals but has not been produced in the United States since 1984. Thallium is used mostly in manufacturing electronic devices, switches, and closures for the semiconductor industry. Thallium stays in the water and soil for a long time and is not broken down. It's absorbed by plants and enters the food chain. Touching, or for children, eating soil contaminated with thallium or living near hazardous waste sites containing thallium are ways people may be exposed.[14] Studies in people who ingested large amounts of thallium over a short time have reported vomiting, diarrhea, temporary hair loss, and effects on the nervous system, lungs, heart, liver, and kidneys. It has caused death. It is unknown what the effects are from ingesting low levels of thallium over a long time. The EPA has not classified thallium as to its ability to cause cancer to humans and it is unknown if it causes cancer.[11]

PAHS

Polycyclic Aromatic Hydrocarbons (PAHs) are a group of compounds that are formed during the incomplete burning of coal, oil and gas, garbage and other organic substances. Some PAH particles can readily evaporate into the air from soil or surface waters. PAHs can break down by reacting with sunlight and other chemicals in the air, over a period of days to weeks. Most PAHs do not dissolve easily in water. They stick to solid particles and settle to the bottoms of lakes and rivers and can break down in soil or water after a period of weeks to months by microorganisms. Exposure can occur when someone comes into contact with air, water, or soil near hazardous waste sites. Animal studies have shown that PAHs can cause harmful effects on the skin, body fluids, and ability to fight disease after both short- and long-term exposure. However, these effects have not been seen in people. Some people who have breathed or touched mixtures of PAHs and other chemicals for long periods of time have developed cancer.[15]

[14] https://www.atsdr.cdc.gov/toxfaqs/tfacts54.pdf
[15] https://www.atsdr.cdc.gov/toxfaqs/tfacts69.pdf

Glossary

Agency for Toxic Substances and Disease Registry (ATSDR)	The principal federal public health agency involved with hazardous waste issues, responsible for preventing or reducing the harmful effects of exposure to hazardous substances on human health and quality of life. ATSDR is part of the U.S. Department of Health and Human Services.
Cancer Risk	A theoretical risk for developing cancer if exposed to a substance every day for a lifetime. The true risk might be lower.
Cancer Risk Evaluation Guide (CREG)	The concentration of a chemical in air, soil or water that is expected to cause no more than one excess cancer in a million persons exposed over a lifetime. The CREG is a comparison value used to select contaminants of potential health concern and is based on the cancer slope factor (CSF).
Cancer Slope Factor	A number assigned to a cancer causing chemical that is used to estimate its ability to cause cancer in humans.
Carcinogen	Any substance that causes cancer.
Comparison Value (CV)	Calculated concentration of a substance in air, water, food, or soil that is unlikely to cause harmful (adverse) health effects in exposed people. The CV is used as a screening level during the public health assessment process. Substances found in amounts greater than their CVs might be selected for further evaluation in the public health assessment process.
Contaminant	A substance that is either present in an environment where it does not belong or is present at levels that might cause harmful (adverse) health effects.
Dermal Contact	Contact with (touching) the skin .
Dermal exposure	Dirt particles that can adhere to the skin may cause additional exposure to contaminants through dermal absorption. Although human skin is an effective barrier for many environmental contaminants, some chemicals can move easily through the skin.
Dose (for chemicals that are not radioactive)	The amount of a substance to which a person is exposed over some time period. Dose is a measurement of exposure. Dose is often expressed as milligram (amount) per kilogram (a measure of body weight) per day (a measure of time) when people eat or drink contaminated water, food, or soil. In general, the greater the dose, the greater the likelihood of an effect. An "exposure dose" is how much of a substance is encountered in the environment. An "absorbed dose" is the amount of a substance that actually got into the body through the eyes, skin, stomach, intestines, or lungs.
Environmental Media Evaluation Guide (EMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The EMEG is a comparison value used to select contaminants of potential health concern and is based on ATSDR's minimal risk level (MRL).
EPA	United States Environmental Protection Agency.

Exposure	Contact with a substance by swallowing, breathing, or touching the skin or eyes. Exposure may be short-term [acute exposure], of intermediate duration, or long-term [chronic exposure].
Groundwater	Water beneath the earth's surface in the spaces between soil particles and between rock surfaces [compare with surface water].
Hazard Quotient (HQ)	The ratio of the potential exposure to a substance and the level at which no adverse effects are expected (calculated as the exposure divided by the appropriate chronic or acute value). A hazard quotient of 1 or lower means adverse noncancer effects are unlikely, and thus can be considered to have negligible hazard. For HQs greater than 1, the potential for adverse effects increases, but we do not know by how much.
Ingestion	The act of swallowing something through eating, drinking, or mouthing objects. A hazardous substance can enter the body this way.
Ingestion exposure	Most people inadvertently swallow small amounts of sediments, soil and dust (and any contaminants they contain). Young children often put hands, toys, pacifiers, and other things in their mouths, and these may have dirt or dust on them that can be swallowed. Adults may ingest sediments, soil, and dust through activities such as gardening, mowing, construction work, dusting, and in this case, recreational activities.
Ingestion Rate	The amount of an environmental medium that could be ingested typically on a daily basis. Units for IR are usually liter/day for water, and mg/day for soil.
Inhalation	The act of breathing. A hazardous substance can enter the body this way.
Inhalation exposure	Although people can inhale suspended sediment, soil or dust, airborne sediment usually consists of relatively large particles that are trapped in the nose, mouth, and throat and are then swallowed, rather than breathed into the lungs.
Media	Soil, water, air, plants, animals, or any other part of the environment that can contain contaminants.
Minimal Risk Level (MRL)	An ATSDR estimate of daily human exposure to a hazardous substance at or below which that substance is unlikely to pose a measurable risk of harmful (adverse), noncancerous effects. MRLs are calculated for a route of exposure (inhalation or oral) over a specified time period (acute, intermediate, or chronic). MRLs should not be used as predictors of harmful (adverse) health effects [see reference dose].
Oral Reference Dose (RfD)	An amount of chemical ingested into the body (i.e., dose) below which health effects are not expected. RfDs are published by EPA.
Reference Dose Media Evaluation guide (RMEG)	A concentration in air, soil, or water below which adverse non-cancer health effects are not expected to occur. The RMEG is a comparison

	value used to select contaminants of potential health concern and is based on EPA's oral reference dose (RfD).
Wisconsin Residual Contaminant Level (RCL)	Wisconsin statute indicates that residual contaminant levels for soil be based on protection of human health from direct contact and shall be developed using a certain criteria also defined in Wisconsin Chapter NR 720.12.

Appendix Image 1. Phase II Investigation Report