HEALTH CONSULTATION

PUBLIC COMMENT RELEASE

Little Black Creek Sediments
Muskegon County, Michigan

July 29, 2005

Comment Period End Date: September 12, 2005

Prepared by

The Michigan Department of Community Health
Under a Cooperative Agreement With the
U.S. Department of Health and Human Services
Agency for Toxic Substances and Disease Registry

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The conclusions and recommendations presented in this health consultation are the result of site-specific analyses and are not to be cited or quoted for other evaluations or health consultations.

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Acronyms and Abbreviations

µg	microgram
AE_d	dermal absorption efficiency
AE_i	ingestion absorption frequency
AF	soil adherence factor
AT	averaging time
ATSDR	Agency for Toxic Substances and Disease Registry
AWRI	Annis Water Resources Institute
CF	conversion factor
DCC	Direct Contact Criteria
DF	age-adjusted soil dermal factor
EF_d	dermal exposure frequency
EF_i	ingestion exposure frequency
EPA	U.S. Environmental Protection Agency
GSI	Groundwater Surface Water Interface Criteria
GSIPC	Groundwater Surface Water Interface Protection Criteria
IEUBK	Integrated Exposure Update Biokinetic Model for Lead in Children
IF	age-adjusted soil ingestion factor
kg	kilogram
MDCH	Michigan Department of Community Health
MDEQ	Michigan Department of Environmental Quality
MDNR	Michigan Department of Natural Resources
mg	milligram
MRL	Minimal Risk Level
PAH	polynuclear aromatic hydrocarbon
PCB	polychlorinated biphenyl
PEC	Probable Effect Concentration
ppb	parts per billion
ppm	parts per million
RCRA	Resource Conservation and Recovery Act
RfD	reference dose
RSC	relative source contribution
SF	oral cancer slope factor
THQ	target hazard quotient
TMDL	Total Maximum Daily Load
TR	target cancer risk
VOC	volatile organic compound
WWTP	wastewater treatment plant

Summary

Little Black Creek in Muskegon County, Michigan, flows into Mona Lake, which empties into Lake Michigan. The creek's sediments contain elevated levels of metals, polycyclic aromatics hydrocarbons (PAHs), volatile organic compounds (VOCs), and polychlorinated biphenyls (PCBs). Although the concentrations of the contaminants exceed the state's generic clean-up criteria for residential soils, only several samples for cadmium exceeded exposure-adjusted screening levels for the creek's sediments. The most elevated levels of cadmium occur where the creek passes the Peerless Plating Superfund site. This area of the creek does not appear attractive to play in or otherwise use, due to surrounding dense brush, poor access, and nearby traffic. It is likely that there is little or no exposure to the creek and its sediments in this area. Therefore, ***exposure to the cadmium in the sediments in Little Black Creek poses no apparent current or future public health hazard***.

Several concentrations found for lead in the creek sediments exceed the state's generic clean-up criteria for residential soils. An exposure-adjusted screening level for lead, to determine the health risk of exposure to lead in the sediments, cannot be determined. However, the areas of the creek in which the most elevated levels of lead were found are likely to have little, if any, access: dense brush, steep banks, and neighboring industrial facilities all serve to restrict access to these areas. There is likely little or no exposure to the creek and its sediments in these areas. Therefore, ***exposure to the lead in the sediments in Little Black Creek poses no apparent current or future public health hazard***.

Because the concentrations of other contaminants do not exceed their respective screening levels, ***exposure to other contaminants in the sediments in Little Black Creek poses no apparent current or future public health hazard.***

Mercury levels detected in the sediments of Little Black Creek pose an indeterminate public health hazard. Dermal or oral exposure to the mercury as it exists in the sediment poses no apparent public health. However, the mercury may become methylated and enter the food chain, ending up in fish or other aquatic wildlife in the creek or in Mona Lake. Economically disadvantaged populations who supplement their diets with fish, muskrat, or turtles might be exposed levels of methylmercury that would be harmful in the long term.

Exposure to contaminants deposited from Little Black Creek to floodplain soils during flood events poses an indeterminate public health hazard. There are no data for surficial soils in floodplain areas. This information should be acquired to determine if a health threat exists.

Groundwater contaminated with petroleum products is venting to Little Black Creek near the creek's headwaters. Some contamination has been detected in the creek sediments in this area. Neighbors and passersby frequently detect noxious odors associated with the petroleum contamination. There are no data regarding concentrations of VOCs in the air

near this area. Until contaminant concentrations in the air are known, ***chemicals present during odor events pose an indeterminate public health hazard***.

Purpose and Health Issues

In the fall of 2004, the Muskegon County Health Department requested assistance from the Michigan Department of Community Health (MDCH) in evaluating the public health implications of exposure to sediments in two Muskegon-area creeks, Ryerson Creek and Little Black Creek.

The purpose of this document is to discuss whether the contaminated sediments in Little Black Creek, which flows primarily through the city of Muskegon Heights in Muskegon County (Figure 1), pose a health threat to recreational users of the creek and the surrounding area. (Ryerson Creek is discussed in a separate health consultation.)

Background

Little Black Creek is part of the Mona Lake watershed in Muskegon County, Michigan (Figure 1). MDCH, under a cooperative agreement with the federal Agency for Toxic Substances and Disease Registry (ATSDR) previously evaluated the public health implications of contamination in the creek near the Peerless Plating Superfund (Peerless) site (Figure 2; ATSDR 1992, 1996). The U.S. Environmental Protection Agency (EPA) and the Michigan Department of Environmental Quality (MDEQ) have addressed most of the contamination at the Peerless site. However, environmental groups and local residents and officials are concerned that the contamination remaining near the Peerless site as well as pollutants from other sources to the creek may pose a public health threat. Along with several residential areas, there are two public parks along Little Black Creek: Johnny O. Harris Park, which connects to a trail following the creek downstream, and Mona Lake Park (Figure 2).

On February 14, 2005, MDCH met with approximately 30 people representing local health, government, and neighborhood associations at the Grand Valley State University Annis Water Resources Institute (AWRI) in Muskegon, Michigan. The purpose of the meeting was for MDCH to inform the attendants regarding the process of public health consultations, for AWRI to share research findings regarding Little Black Creek and Ryerson Creek (another contaminated creek which is addressed in a separate health consultation), and for the attendants to voice concerns about the contamination. Contact with contaminated sediments was the main concern at this meeting; however, there was also interest in contaminated groundwater.

On April 7, 2005, MDCH accompanied MDEQ field staff in a site visit for both creeks. This allowed MDCH to gain first-hand information about the characteristics of the creeks and their surrounding environments.

On June 14, 2005, MDCH and MDEQ attended a community-input meeting, hosted by the Mona Lake Watershed Council and the Great Lakes Alliance, regarding Little Black Creek. The purpose of the meeting was for MDCH to update stakeholders on the progress of the health consultation and hear community concerns, for MDEQ to discuss its upcoming sampling program for the creek, and for the community to provide information to both agencies regarding historical use of the creek and potential areas for sampling. MDCH and MDEQ conducted another site visit at sections of Little Black Creek before arriving at the meeting.

Discussion

Sources of Contamination to Little Black Creek

There are several known sources of contamination to Little Black Creek (Figure 2). Near the headwaters of the creek is the defunct Marathon Petroleum refinery. Downstream, the Keating Avenue storm sewer discharges to the creek slightly upstream from the Peerless site. The sewer receives non-contact cooling water discharges from several area industries (R. Fountain, City of Muskegon, personal communication, 2005). Downstream from the Keating Avenue storm sewer discharge is the Peerless site, then the municipal sanitary/industrial wastewater pump station, the Webb Chemical Company, and a closed municipal landfill. Further downstream is the City of Muskegon Heights' former wastewater treatment plant (WWTP), which has gone through several acquisitions, and the Merriam Street storm sewer. Each of these known sources of contamination to Little Black Creek is discussed individually below. Comparison of contaminant levels to state screening levels is discussed in the "Environmental Contamination" section of this document.

Defunct Marathon Petroleum Refinery

The Marathon Petroleum Company formerly operated a refinery near the headwaters of Little Black Creek. In 1977, MDEQ (then the Michigan Department of Natural Resources [MDNR]) conducted several biological and water quality surveys of the creek. Surface water of the creek near Evanston Road had high concentrations of aluminum, chromium, lead, and zinc. The findings were attributed to either groundwater contamination or a waste hauler illegally dumping (MDNR 1977). (During the April 7, 2005 site visit by MDCH, a local citizen living near the defunct refinery claimed that garbage trucks would dump waste in the area during the 1950s and 1960s.) No sediment sampling occurred during the 1977 surveys.

In 1985, MDEQ sampled sediments in Little Black Creek at two locations near groundwater seeps containing suspected petroleum contaminated groundwater from Marathon's property. The samples contained concentrations of lead that were greater than the Michigan background concentration for this metal, as well as polycyclic aromatic hydrocarbons (PAHs) and oil/grease, indicating that petroleum-contaminated seepage was entering Little Black Creek along the west side of Marathon's property (MDNR 1985). Marathon conducted dredging of the creek in 1993 under an agreement with the Muskegon County Drain Commissioner, to meet discharge-permit requirements (Tolbert 1993). Post-dredging sampling, as well as the 1985 MDEQ sampling, indicated that the concentrations of lead found do not exceed the current Michigan clean-up criteria that address skin contact with or incidental ingestion (swallowing) of dry soil. (There are no generic clean-up criteria in Michigan for sediments.)

It should be noted that local residents still detect petrochemical odors regularly in the air around the Marathon site (MDEQ 2003). MDCH and MDEQ staff readily detected odors in this area during the April 7, 2005 site visit. At the very least, these odors are nuisances and decrease the quality of life for these residents. Further study, specifically ambient air sampling for volatile organic compounds (VOCs) associated with petroleum products (e.g., benzene, toluene, ethylbenzene, xylenes, and phenols), would provide information regarding the identity and concentration of the airborne compounds and help determine if a health threat is posed by these odors.

Keating Avenue Storm Sewer

The Keating Avenue storm sewer formerly received industrial discharges from several businesses along Keating Avenue. The largest contributor of wastewater during dry weather into the sewer was the Kersman Company, now called Coil Anodizers, which anodizes coiled aluminum (MDNR 1970, Newell 1970a-c). Local companies (Coil Anodizers, American Coil and Spring, Johnson Products, American Porcelain, and Sealed Power) now discharge their process wastewater to the sanitary sewer system and reportedly release only non-contact cooling water, which is considered innocuous, and storm water to the Keating Avenue storm sewer (MDNR 1979; R. Fountain, City of Muskegon, personal communication, 2005).

In 1977, the MDEQ (then the MDNR) conducted several biological and water quality surveys of Little Black Creek. Sediments below the Keating outfall had concentrations of cadmium, lead, nickel, and zinc greater than the Michigan background concentrations for these metals (MDNR 1977), but the concentrations do not exceed the current state criteria addressing skin contact with or incidental ingestion of dry soil.

Peerless Plating Superfund Site

The Peerless Plating Company was an abandoned electroplating facility proposed for listing as a National Priorities List (NPL or "Superfund") site in 1988. MDCH has been involved in public health activities at the site since 1983 and has written a Preliminary Health Assessment and a Site Review and Update document discussing the health hazards found there (ATSDR 1992, 1996). Remedial activities taken by the U.S. EPA include removing chemicals and wastes remaining on-site after the facility closed, treating and removing contaminated soil, and pumping and treating groundwater from under the site (EPA 2004). The groundwater treatment system has been operating since the summer of 2002. The discharge limit is set at 12 micrograms per liter (ug/L) for cadmium (EPA 2002). Currently, the treated groundwater is released to Little Black Creek but will be discharged to the Muskegon County Wastewater Management System by the end of 2005 (Alexander 2005a).

During construction of the groundwater treatment system, previously unidentified soil contamination was discovered and found to be widespread in the subsurface both vertically and horizontally. Because of the difficulties and expense of excavating soil below the water table and underneath a building addition of a neighboring business, contaminated soil was only excavated to the water table and/or left under the building addition. The Peerless property has been limited to industrial/commercial use with no groundwater consumption or construction activities that could potentially expose contaminated soils left in place (EPA 2002).

Ongoing sampling indicates that sediment cadmium concentrations remain high in this area (see the “Environmental Contamination” section of this document). It is not clear whether the contamination in the sediment is from unaddressed historic deposition, erosion of contaminated soils into the creek, or uncaptured contaminated groundwater venting to the creek (or a combination of the three).

Municipal Sanitary/Industrial Wastewater Pump Station (Getty Street)

The Getty Street sewage pump station has failed at least twice in the past 11 years, allowing raw sewage, industrial wastewater, and domestic debris to bypass the station and enter the creek directly (MDEQ 2003). There are no environmental data for this portion of Little Black Creek. However, contamination attributed to one of the failures was detected further downstream in the vicinity of the Merriam Street storm sewer (discussed later in this section).

Webb Chemical Company

The Webb Chemical Company has been remediating contaminated groundwater at its property since 1992, using a pump-and-treat remedy, then releasing the wastewater to Little Black Creek (MDEQ 2003). The contaminants are chlorinated solvents, and their breakdown products, and PAHs. There were no environmental data regarding soil or sediments available to review for this document.

Defunct Municipal Landfill

MDEQ has documented evidence of debris eroding into Little Black Creek from the former landfill. During the 1977 biological and water quality surveys of the creek, MDEQ noticed an increase in the levels of oils, phosphorus, lead, and aluminum in the sediments in this stretch of the creek, either from the landfill or an unknown source (MDNR 1977). No other environmental data were available for review.

Former Wastewater Treatment Plant

The former WWTP is a former Resource Conservation and Recovery Act (RCRA) site and is now part of EPA’s RCRA Brownfield Prevention Pilot. The plant was built in 1917 and used by the City of Muskegon Heights until 1974. It was leased to Systech in 1975 and used for treatment of wastes from metal finishing operations. Documented environmental releases (two groundwater pressure relief valve leaks) and permit violations started during Systech’s ownership. Tricil acquired the plant in 1983, followed by Laidlaw in 1990, who performed closure (environmental clean-up) activities. Safety-Kleen purchased the property in the early 1990s. The City of Muskegon Heights is the current owner (Williams & Beck 2004).

The City is investigating the possibility of developing this property into residential housing and hired an environmental consultant to identify remaining environmental issues. Groundwater and soils were tested but creek sediments were not. (The area of the property where the operations had taken place is set back from Little Black Creek.) The consultants found some increased contaminant concentrations in groundwater down-gradient of the site and some residual contamination in on-site soils but not at levels of public health concern. If any groundwater is venting to Little Black Creek, it is likely not significantly affecting the creek (Williams & Beck 2004).

Merriam Street Storm Sewer and Vicinity

MDEQ conducted several biological and water quality surveys of Little Black Creek in 1977, 1991, and 1996 that included the area of the creek around the Merriam Street storm sewer. The earlier sampling indicated that the storm sewer appeared to have little measurable effect on the creek (MDNR 1977). In 1992 and 1996, the specific sampling site for this area was at Airline Highway. Sediments had increased levels of aluminum, barium, chromium, copper, lead, titanium, and zinc, but this was attributed to a failure at the municipal sanitary/industrial wastewater pump station upstream 10 days earlier (see discussion for the pump station above), which had released 80,000 gallons of untreated wastewater to Little Black Creek in a 24-hour period (MDNR 1992). The concentrations had decreased by the 1996 sampling. According to MDEQ, there are no industrial sources of pollutants to the creek in this area, and increased concentrations may be more reflective of sediment transport and deposition patterns (Walker 2000).

<u>Environmental Contamination</u>

As an initial screening tool, MDCH compared the concentrations of chemicals found in Little Black Creek sediments to the MDEQ Part 201 Generic Residential and Commercial I Direct Contact Criteria (DCC) to select chemicals requiring further investigation. The residential DCC identifies a soil concentration that is protective against adverse health effects (cancer or noncancer) due to long-term dermal exposure to and incidental ingestion of contaminated soil (MDEQ 2001). The criteria are not applicable to the evaluation of contaminated sediments in streams. However, inputs to the algorithm used to calculate the DCC can be adjusted to assist in determining public health implications of exposure to contaminated sediments (Appendix A). This results in an informal, adjusted screening level.

The chemicals found in Little Black Creek sediments following sampling events dating back to the 1970s are listed in Table 1. Those chemicals in bold print exceeded the Part 201 residential DCC.

Table 1. Chemicals detected in Little Black Creek sediments, Muskegon County, Michigan. (Sampling events occurred between 1977 and 2004.)

Metals	*Organics*
Aluminum	Acenaphthene
Arsenic	Anthracene
Barium	Benzo(a)anthracene
Beryllium	**Benzo(a)pyrene**
Cadmium	Benzo(b)fluoranthene
Calcium[1]	Benzo(g,h,i)perylene
Chromium[2]	Benzo(k)fluoranthene
Cobalt	Carbon disulfide
Cyanide	Chrysene
Iron	Dibenz(a,h)anthracene

Metals	Organics
Lead	1,2-Dichloroethene (total)[3]
Magnesium	Fluoranthene
Manganese	Fluorene
Mercury	Indeno(1,2,3-cd)pyrene
Nickel	Naphthalene
Potassium[1]	**PCBs (as Aroclor 1254)**[4]
Selenium	Phenanthrene
Silver	Pyrene
Sodium	Tetrachloroethene
Thallium	Toluene
Vanadium	1,1,1-Trichloroethane
Zinc	Trichloroethene
	Vinyl chloride

Notes:

1. There are no Part 201 criteria for calcium and potassium. These elements are macronutrients. Any incremental exposure from the creek's sediments should not cause adverse health effects.
2. Total chromium concentrations were compared to the more-protective criteria for hexavalent chromium.
3. Total 1,2-dichloroethene concentrations were compared to the more-protective criteria for cis-1,2-dichloroethene.
4. PCBs = polychlorinated biphenyls

References: MDEQ 2004a, Rediske 2005 (unpublished data)

Arsenic, cadmium, lead, benzo(a)pyrene, and PCBs exceeded their respective Part 201 residential DCC. MDCH adjusted the screening levels for arsenic, cadmium, benzo(a)pyrene, and PCBs to consider the less frequent exposure expected with sediments (Appendix A). Table 2 shows these chemicals, along with the concentrations found, the residential DCC for each chemical, and the adjusted DCC for each chemical.

Table 2. Concentrations of selected chemicals in sediments of Little Black Creek, Muskegon County, Michigan, and comparison to screening levels. (Samples taken between 1977 and 2004. All concentrations in parts per million [ppm].)

Chemical	No. detections / No. samples	Concentration Range	Residential DCC[1] (No. exceedances)[2]	Adjusted DCC[1] (No. exceedances)[2]
Arsenic	29 / 29	0.63 – 20	7.6 (10)	21 (0)
Cadmium	36 / 42	0.5 – 4,260	550 (6)	**1,600 (3)**
Lead	42 / 42	7.9 – 2,100	400 (7)	See text
Benzo(a)pyrene	5 / 8	0.5 – 5.1	2 (3)	5 (0)
PCBs	5 / 8	0.42 - 3	1 (1)	10 (0)

Notes:

1. DCC = Direct Contact Criteria
2. Comparisons made after rounding criteria and concentrations to least number of significant digits.

References: MDEQ 2004a, Rediske 2005 (unpublished data)

Arsenic, benzo(a)pyrene, and PCBs do not exceed their respective adjusted DCC. Therefore, documented levels of these chemicals in the sediments of Little Black Creek are not a public health concern.

The three samples that exceeded even the adjusted DCC for **cadmium** were located in the stretch of Little Black Creek next to Peerless. Concentrations ranged from 2,300 to 4,260 parts per million (ppm). These samples are retained for further evaluation under the "Exposure Pathways" and "Toxicological Evaluation" section of this document.

Some sediment concentrations of **lead** exceeded its residential DCC addressing dry soils. These samples were located primarily around the defunct municipal landfill and the Merriam Street storm sewer outfall area. There was one sample each at the Keating Street storm sewer outfall and Peerless that also exceeded the criterion, however higher concentrations were found at the downstream sites. The DCC for lead is determined using the IEUBK model (Integrated Exposure Uptake Biokinetic Model for Lead in Children), which considers other environmental lead sources along with contaminated soil (EPA 2004). Due to the complexity of the model, it is difficult to adjust the DCC for lead in sediments. Therefore, samples containing elevated concentrations of lead are evaluated further in the "Human Exposure Pathways" and "Toxicological Evaluation" sections of this document.

Although sediment **mercury** concentrations did not exceed the generic DCC for residential soils, 10 samples (out of 22 analyzed for the metal) exceeded the MDEQ Groundwater Surface Water Interface Protection Criterion (GSIPC) of 0.1 ppm. The GSIPC identifies a soil concentration of a chemical that is not expected to leach and contaminate groundwater at levels greater than the corresponding GSI criterion. The GSI is a groundwater concentration that is protective of a receiving surface water (MDEQ 1999). The GSI for mercury, a bioaccumulative compound, is based on the protection of fish for human consumption.

When mercury enters surface water, microorganisms change it to methylmercury, a highly toxic form that builds up in fish and, subsequently, in animals that eat fish, including humans. (Fish can also take up the methylmercury directly from the water column but to a much smaller degree when compared to that from the food chain [ATSDR 1999c].) Currently, there is a fish-consumption advisory for certain Mona Lake fish species (carp, smallmouth bass, and walleye); however, the advisory was triggered due to PCB concentrations in these species. When there are no lake-specific data regarding concentrations of mercury in fish tissue, MDCH provides a general advisory to the public, suggesting that people limit their meals of large fish from these lakes (MDCH 2004).

Groundwater and surface water analyses of Little Black Creek have either not tested for mercury or not detected mercury. However, the reported detection limits (ranging from 0.2 to 0.5 parts per billion [ppb]) are greater than the GSI for the metal (0.0013 ppb; MDEQ 2004b). It is possible that levels of mercury detected historically in Little Black Creek exceeded the GSI and impacted concentrations in fish.

Some areas along Little Black Creek may be prone to flooding during winter thaws and heavy rains. There is no information available regarding possible contamination of floodplain areas.

AWRI researchers have compared concentrations of contaminants in Little Black Creek sediments to the chemicals' respective Probable Effect Concentrations (PECs). A PEC is a consensus-based sediment quality guideline that represents the levels at which adverse ecological effects are likely (Steinman et al. 2003). While adverse impacts on aquatic organisms are expected, these comparisons are not directly applicable to the evaluation of public health implications.

Exposure Pathways Analysis

To determine whether persons are, have been, or are likely to be exposed to contaminants, MDCH evaluates the environmental and human components that could lead to human exposure. An exposure pathway contains five elements: (1) a source of contamination, (2) contaminant transport through an environmental medium, (3) a point of exposure, (4) a route of human exposure, and (5) a receptor population. An exposure pathway is considered complete if there is evidence, or a high probability, that all five of these elements are, have been, or will be present at a site. It is considered either a potential or an incomplete pathway if there is no evidence that at least one of the elements above are, have been, or will be present, or that there is a lower probability of exposure. The exposure pathway elements for this site are shown in Table 3:

Table 3. Pathways of human exposure to contaminants found in sediments in Little Black Creek, Muskegon County, Michigan.

Source	Environ-mental Transport and Media	Chemicals of Concern	Exposure Point	Exposure Route	Exposed Population	Time Frame	Status
Little Black Creek sediments (various polluters)	Sediment	Metals, PAHs[1], PCBs[2], VOCs[3]	Creek sediment	Dermal contact, incidental ingestion	Recreational users of Little Black Creek	Past	Potential
						Present	Potential
						Future	Potential
	Fish and other aquatic wildlife	Mercury, cadmium	Little Black Creek, Mona Lake	Ingestion	Consumers of fish and other aquatic species	Past	Complete
						Present	Potential
						Future	Potential
	Sediment	Metals, PAHs[1], PCBs[2], VOCs[3]	Flood-plain soils	Dermal contact, incidental ingestion, inhalation	Persons living along or using the creek's floodplain	Past	Potential
						Present	Potential
						Future	Potential
Little Black Creek (Marathon Petro-leum)	Ambient air	VOCs[3]	Air around headwaters of creek	Inhalation	Persons living near the creek's headwaters, passersby	Past	Complete
						Present	Complete
						Future	Potential

Notes:

1. PAHs = polynuclear aromatic hydrocarbons
2. PCBs = polychlorinated biphenyls
3. VOCs = volatile organic compounds

Sediments

Persons wading or playing in the creek could be exposed to the contaminated sediments. As discussed in the "Environmental Contamination" section of this document, the only chemicals that remain of concern when considering intermittent contact with the sediments are cadmium and lead.

The **cadmium** exceedances occurred adjacent to the Peerless site, which does not appear attractive for playing in or near because of surrounding dense brush, poor access, and nearby traffic. However, this area of the creek is not completely inaccessible (see Figures 3 and 4), though if access does occur, it is likely less than the 90 days/year assumed when adjusting the screening level (Appendix A). Also, it is possible that the reservoir of contaminated sediments near the Peerless site can be mobilized during a moderate rain event and transported downstream (MDEQ 2004b, Steinman et al. 2003). If sediments are transferred to areas more heavily used by children, such as the Johnny O. Harris park, children might be exposed to unacceptable and potentially harmful levels of cadmium. The Peerless Plating Company operated from 1937 to 1983 (EPA 2004). It is not known when the cadmium first appeared in the sediments. However, the evidence suggests that significant amounts of cadmium have *not* been transported downstream. If the trend continues, significant amounts of cadmium will not be transported downstream in the future. It is not likely that harmful exposures to cadmium in the sediments of Little Black Creek will occur.

Figure 3. Little Black Creek behind Peerless Plating Superfund Site (looking east), April 7, 2005, Muskegon County, Michigan.

Figure 4. Little Black Creek behind Peerless Plating Superfund Site (looking west), April 7, 2005, Muskegon County, Michigan.

The **lead** exceedances occurred primarily downstream of the Peerless site, near the defunct municipal landfill and the Merriam Street storm sewer outfall. During its June 14 site visit, MDCH noted that the areas where the lead exceedances occurred are difficult to access. The Keating outfall and Peerless areas have industrial facilities on one side of the creek and dense brush on the other. The creek banks by the closed landfill are steep and overgrown and both sides of the creek are occupied by private businesses. The Merriam outfall area also has dense brush, impeding any access. Therefore, the likelihood of exposure to lead-contaminated sediments in Little Black Creek is minimal. Any exposure that might occur should not result in adverse health effects.

Some local schools' science classes have used the creek for ecological and environmental lessons (GLOBE 2005). According to the MDEQ staff person who oversaw recent testing conducted by one such class, few children entered the creek (at Johnny O. Harris Park) and those that did wore rubber boots (D. Wierzbicki, MDEQ Remediation and Redevelopment Division – Grand Rapids Office, personal communication, 2005). However, one area resident has reported anecdotally that this has not always been the case and that school children used to enter the creek without any protective measures. Nonetheless, it is likely that any exposure that occurred was brief and would not result in adverse health effects.

The Muskegon County Health Department, with assistance from the Mona Lake Watershed Council, has erected signs in public areas near Little Black Creek that ask people not to enter the creek. This action likely has helped reduce exposure to the sediments.

Fish and Other Aquatic Wildlife

The **mercury** in the sediments in Little Black Creek might be entering the water column as methylmercury and accumulating in fish in the creek or Mona Lake. Painted turtles and muskrat, though primarily herbivorous, occasionally eat fish (National Wildlife Federation 2005) and may bioaccumulate methylmercury. Snapping turtles eat both aquatic plants and animals (National Wildlife Federation 2005) and would likely bioaccumulate methylmercury. (There are wetlands that could support these species near the headwaters of the creek, in Johnny O. Harris Park, and downstream of the WWTP.) Although there is a general inland lake mercury advisory, which would apply to Mona Lake and its watershed, economically disadvantaged persons might ignore it and eat fish or other aquatic wildlife from the lake or the creek to supplement their diet, potentially exposing themselves to mercury in these species. There is information available for mercury levels in fish sampled from Mona Lake (MDEQ 2005). However, there is no information regarding mercury levels in fish or other aquatic wildlife from Little Black Creek, to what extent local persons may eat muskrat or turtles, or the population of muskrat and turtles in the creek.

Cadmium can be taken up by water plants such as cattails and marsh grass (ATSDR 1999a), some of which were evident in Johnny O. Harris Park and are food sources for muskrat and turtles (National Wildlife Federation 2005). Cadmium also can be taken up by fish and generally is found in higher concentrations in older animals (ATSDR 1999a). Economically disadvantaged populations might supplement their diet by catching and eating fish, muskrat, or turtles from Little Black Creek and could be exposed to cadmium in these animals. However, there is no information regarding cadmium levels in these species, to what extent local persons may eat muskrat or turtles, or the population of muskrat and turtles in the creek.

Floodplain Soils

Little Black Creek can overflow its banks during the spring thaw and heavy rains. Contaminated sediments might be transferred to soil during these overflows. If flooding occurs in areas normally used by the public, the likelihood and frequency of exposure would increase. There are no data available regarding levels of contaminants in floodplain soils. If contamination were found in floodplain soils in residential areas, the generic residential DCC would apply.

Ambient Air near Headwaters

People living near or passing by the headwaters of Little Black Creek, near the defunct Marathon refinery, have complained about petroleum-like odors. As stated earlier, there are no data regarding ambient air concentrations of VOCs during odor events.

Toxicological Evaluation

Cadmium

Cadmium is a naturally occurring element and is usually found in zinc, lead, and copper ores. It has been used in electroplating and coating, metal alloys, batteries, pigments, and stabilizers for plastics. Cadmium is a component of tobacco and tobacco smoke (ATSDR 1999a).

Harmful effects as a result of dermal (skin) exposure to cadmium are not likely to occur (ATSDR 1999a).

The primary target for oral cadmium toxicity is the kidney. The kidneys remove waste and toxins from the bloodstream, so any decreased function can have severe health consequences. Toxic effects caused by long-term oral cadmium exposure include renal tubular dysfunction, decreased glomerular filtration, and increased calcium excretion, which can lead to decreased vitamin D metabolism and bone disorders. Cadmium also interferes with gastrointestinal uptake of iron, which can lead to anemia (ATSDR 1999a).

ATSDR has set the chronic oral Minimal Risk Level (MRL) of cadmium at 0.0002 milligrams per kilogram body weight per day (mg/kg/day) (ATSDR 1999a). An MRL is defined as "an 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" (ATSDR 2005). If a 10-kg child (a default weight assumption) were to eat 200 mg/day (2E-4 kg, another default assumption, which is less than 1/8 teaspoon) of the most contaminated sediment in Little Black Creek *every day*, the daily dose of cadmium would be 0.0852 mg/kg/day.

$$\frac{2E-4kg_{Se\,dim\,ent}/day}{10kg_{BW}} \times \frac{4{,}260mg_{Cadmium}}{1kg_{Se\,dim\,ent}} = 0.0852mg_{Cadmium}/kg_{BW}/day$$

MDCH assumed that exposure would be limited to 90 days per year (about ¼ of the year). Therefore, the child's averaged daily dose for 90 days' exposure would be 0.0213 mg/kg/day (0.0852 / 4), which rounds to 0.02 mg/kg/day, 100 times greater than the MRL. An adult would eat less soil per day (100 mg/day) and weigh more (70 kg) than a child, resulting in a lower dose (0.006 mg/kg/day) and lower averaged dose (0.006 / 4 = 0.0015 mg/kg/day), but still a rate greater than the MRL. These doses, 0.02 mg/kg/day for a child and 0.0015 mg/kg/day for an adult, would increase the risk of harmful effects that could occur upon oral exposure to the sediments in Little Black Creek. However, as discussed earlier, a person is not likely to be exposed to the highest concentrations of cadmium found, near Peerless, due to the inaccessibility of the site. More accessible areas of the creek have concentrations of cadmium below the exposure-adjusted screening level. Exposure to these concentrations should not result in adverse health effects.

Cadmium is considered a probable human carcinogen when inhaled (EPA 1992, ATSDR 1999a). There is insufficient evidence to determine whether the metal is carcinogenic when exposure occurs orally. Recent studies suggest that cadmium may be an endocrine disruptor and play a role in prostate and breast cancer (Stoica et al. 2000, Achanzar et al. 2001, Johnson et al. 2003, Saturag and Moore 2004). These preliminary findings indicate the need for further study into the toxicity and carcinogenicity of cadmium.

Lead

Like cadmium, lead is a naturally occurring element. It is used in a number of occupational settings and by hobbyists. Sources for lead exposure include battery manufacture and repair, plumbing, pipe fitting, jewelry and pottery making, stained glass making, emissions from foundries and smelters, and some imported or folk remedies. Lead was used in residential paint before its use was discontinued in 1978 (ATSDR 1999b).

Lead is well-known for its neurotoxic effects, causing learning and behavioral difficulties in children. Nervous system effects in adults include decreased reaction times, weakness in the hands and ankles, and impaired memory. It can also damage the kidneys, the reproductive system, and cause anemia. Rather than an external dose in mg/kg/day, the level of lead in the body, usually expressed as blood levels, is used to determine the potential for adverse health effects. This approach is used because exposure can occur from several different sources including air, food, water, and soil contamination. Models that account for multiple exposures to lead often are used to assess potential effects from exposure to lead in the environment (ATSDR 1999b). As discussed earlier in the "Environmental Contamination" section of this document, the criterion for lead in soil is based on the IEUBK model. All potential sources of lead must be evaluated to determine if the contribution from contaminated sediment or soil is significant. Most often, lead-based paint in older homes is the most important source of lead in a person's environment. In the City of Muskegon Heights, 59 percent of the homes were constructed before the 1950s, when the lead in paint was at its highest concentration, and 96 percent of the homes were constructed before the 1980s (GeoLytics 2002), before lead use in residential paint was discontinued. Due to the level of poverty in the City of Muskegon Heights (30 percent of the population lives below the poverty level [GeoLytics 2002]), it is likely that many of these homes have not had the paint removed or sealed.

The National Toxicology Program recently reported that lead and lead compounds may be "reasonably anticipated to be a human carcinogen" (NTP 2004). This determination was based on limited evidence in human studies and sufficient evidence in animal studies. The human studies investigated occupational settings in which workers primarily were exposed via inhalation (NTP 2004). Exposure to the lead in Little Black Creek sediments and nearby soils would likely occur primarily through ingestion. It is unknown whether oral exposure has as great a cancer risk as inhalation exposure.

Mercury

Mercury is a naturally occurring metal. In its elemental form, it is used in thermometers, barometers, and some electrical equipment (cathode ray tubes, switches). Mercury compounds are emitted to the air from coal-fired electrical plants and some manufacturing plants. Methylmercury, an organic mercury compound, is formed by bacteria in soil or water where airborne mercury compounds have deposited. Methylmercury builds up in the aquatic food chain, with higher concentrations being found in predator fish (ATSDR 1999c).

Exposure to high levels of mercury can permanently damage the brain, kidneys, and developing fetus. Effects on brain functioning may result in irritability, shyness, tremors, changes in vision or hearing, and memory problems. Methylmercury exposure can have adverse cardiovascular effects for adults, resulting in elevated blood pressure and incidence of heart attack (ATSDR 1999c).

Dermal exposure to and unintentional ingestion of the mercury-containing sediments of Little Black Creek should not result in any harm. It is not likely that the mercury could volatilize (enter the air) and be inhaled. The exposure pathway of concern for mercury in the Little Black Creek sediments is that of ingesting contaminated fish. As discussed earlier in the "Environmental Contamination" section of this document, Little Black Creek empties into Mona Lake, which is under a fish-consumption advisory for PCBs in several species (carp, smallmouth bass, walleye) (MDCH 2004). Persons eating fish from either the lake or Little Black Creek might be at risk of methylmercury toxicity. It is likely that toxic effects would not manifest themselves immediately but build up over time and appear insidiously. However, as discussed earlier in this document, it is not known whether mercury in the creek sediments have entered the creek itself.

Children's Health Considerations

Children may be at greater risk than adults from exposure to hazardous substances at sites of environmental contamination. Children engage in activities such as playing outdoors and hand-to-mouth behaviors that could increase their intake of hazardous substances. They are shorter than most adults, and therefore breathe dust, soil, and vapors found closer to the ground. Their lower body weight and higher intake rate results in a greater dose of hazardous substance per unit of body weight. The developing body systems of children can sustain permanent damage if toxic exposures are high enough during critical growth stages. Even before birth, children are forming the body organs they need to last a lifetime. Injury during key periods of growth and development could lead to malformation of organs (teratogenesis), disruption of function, and premature death. Exposure of the mother could lead to exposure of the fetus, via the placenta, or affect the fetus because of injury or illness sustained by the mother (ATSDR 1998). The obvious implication for environmental health is that children can experience substantially greater exposures to toxicants in soil, water, or air than adults can.

It is not known if children are more susceptible to the effects of cadmium exposure than adults are. As discussed in the "Toxicological Evaluation" section of this document, children playing in the creek near the Peerless site could be exposed to harmful concentrations of cadmium, as could adults but to a lesser degree. It is likely, however, that this section of Little Black Creek is not attractive for playing in or near because of surrounding dense brush, poor access, and nearby traffic (Figures 4 and 5). It is possible that the reservoir of contaminated sediments near the Peerless site can be mobilized during a moderate rain event and transported downstream (MDEQ 2004b, Steinman et al. 2003). If sufficient quantities of sediments were transferred to areas more heavily used by children, such as the Johnny O. Harris Park (Figure 2), children might be exposed to unacceptable and potentially harmful levels of cadmium. However, as discussed earlier, sediment transfer is not expected to occur.

Young children, especially those from urbanized, low-income populations, are at the greatest risk for experiencing lead-induced health effects. Children under 5 years old absorb lead from the gastrointestinal tract more efficiently than do adults (about 50% versus 15% relative absorption, respectively). Thumb-sucking and pica behavior (consuming large quantities of non-food items) can increase the amount of lead-contaminated dust and dirt being transferred to the gastrointestinal tract. Deficits in some nutrients, including calcium, iron, and zinc, can exacerbate the toxic effects of lead. Lead can pass through the placenta to a developing fetus and can be secreted through breast milk (ATSDR 1999b). When considering the effects that lead in the sediments of Little Black Creek might have on children's health, one should also consider and address other sources of lead so that overall exposure is minimized.

Very young children are more sensitive to mercury than are adults. Mercury in the mother's body passes to the fetus and may accumulate there. It can also pass to a nursing infant through breast milk. Children poisoned by mercury may develop problems of their nervous and digestive systems, and kidney damage (ATSDR 1999c). Mercury levels in the sediments of Little Black Creek might be contributing to elevated mercury in Mona Lake fish.

Community Health Concerns

During the February 14 and June 14 community meetings, a local resident expressed concern that several school science classes would enter Little Black Creek (at Johnny O. Harris Park) as part of the lessons regarding environmental and ecological systems. According to an MDEQ staff person who oversaw environmental sampling conducted by the 5th-grade science class from the Martin Luther King, Jr. Elementary School (GLOBE 2005), few children entered the creek and those that did were wearing rubber boots (D. Wierzbicki, MDEQ Remediation and Redevelopment Division – Grand Rapids Office, personal communication, 2005). It is likely that any exposure that occurred was brief and would not result in adverse health effects.

MDCH received a phone call from the Mona Lake Watershed Council regarding a perceived high rate of cancers along Little Black Creek. MDCH discussed the caller's concerns and instructed her in gathering information so that MDCH can determine whether a cancer cluster investigation is indicated.

Recently, sampling events of surface waters in Mona Lake revealed that a previously unseen blue-green algae was in the lake (Alexander 2005b). This specific algae genus, *Cylindrospermopsis*, can release several different toxins when its cells are destroyed, such as when lake managers apply a copper sulfate algicide. There is concern around Mona Lake regarding how to control algal blooms without causing a toxic event in the lake. MDCH alerted MDEQ to the findings so that an aquatic biologist could answer any questions from the public regarding algal blooms. *Cylindrospermopsis* species are usually found in eutrophic (enriched, typically by runoff) water bodies. Little Black Creek provides sediments and nutrients to Mona Lake. MDEQ has developed a Total Maximum Daily Load (TMDL) for the creek. A TMDL proposes a sediment loading that, if achieved, would reduce the impacts to biota caused by excessive sediments entering a watershed (such as through runoff). The primary goal of the TMDL for Little Black Creek is to reestablish all designated uses of the creek. The secondary goal of the TMDL is to reduce the load of suspended solids in the stream by 15 percent. A full watershed management plan to prevent sediment loading to Mona Lake has yet to be developed (MDEQ 2003)

Conclusions

For a description of the ATSDR Health Hazard Categories, please see Appendix B.

Exposure to the cadmium in the sediments in Little Black Creek poses no apparent current or future public health hazard. The only area of the creek that exceeds the exposure-adjusted screening level for cadmium is next to Peerless. It is not likely that this area of the creek receives much, if any, access. Concentrations downstream of Peerless are below the exposure-adjusted screening level for cadmium. It does not appear that there is significant movement of the sediments downstream.

Exposure to the lead in the sediments in Little Black Creek poses no apparent current or future public health hazard. The areas of the creek where sediment lead concentrations exceeded the MDEQ generic DCC for residential soils are difficult to access due to the presence of dense brush, steep banks, and private businesses abutting the creek. More accessible areas of the creek have lead concentrations below the DCC.

Exposure to other contaminants, other than mercury, in the sediments of Little Black Creek poses no apparent current or future public health hazard. The concentrations of the other chemicals in the creek's sediments are below the screening values.

Exposure to contaminants deposited during flood events from Little Black Creek to floodplain soils poses an indeterminate public health hazard. There are no data for surficial soils in floodplain areas.

Mercury levels detected in the sediments of Little Black Creek pose an indeterminate public health hazard. Dermal or oral exposure to the mercury as it exists in the sediment poses no apparent public health. However, the mercury may become methylated and enter the food chain, ending up in fish or other aquatic wildlife in the creek or in Mona Lake. Economically disadvantaged populations who supplement their diets with fish, muskrat, or turtles might be exposed levels of methylmercury that would be harmful in the long term.

Concentrations of VOCs volatilizing from Little Black Creek's headwaters near the defunct Marathon Petroleum property pose an indeterminate public health hazard. The identities and concentrations of chemicals in the air during odor events are not known.

Recommendations

1. Continue monitoring concentrations of cadmium in the creek's sediments at and downstream of the Peerless site to confirm that significant amounts of cadmium are not being transported downstream.
2. Educate local residents, particularly in neighborhoods with older houses and young children, about sources of lead and how to prevent exposure.
3. Maintain the current general inland lake mercury advisory.
4. Characterize floodplain soils and address any contamination found.
5. Characterize ambient air during odor events near the creek's headwaters and address findings as necessary.

Public Health Action Plan

1. The EPA and the MDEQ Remediation and Redevelopment Division's (RRD's) Superfund Section are responsible for overseeing regulatory action at the Peerless site. Other entities (AWRI researchers, environmental consultants for responsible parties) will provide their findings to these agencies.
2. The Muskegon County Health Department, with assistance from MDCH, will provide information to local residents regarding lead exposure.
3. MDCH will maintain, and update as necessary, the fish consumption advisory, based on fish data collected by the MDEQ Fish Contaminant Monitoring Program.
4. MDEQ-RRD Superfund Section is scheduled to perform environmental sampling this summer (2005). MDCH will request that MDEQ field staff take several samples from floodplain soils in areas that receive high public use.
5. MDCH will request that the Muskegon County Health Department and the MDEQ Air Quality Division develop an air sampling plan for the area around Little Black Creek's headwaters.

MDCH will remain available as needed for future consultation at this site.

If any citizen has additional information or health concerns regarding this health consultation, please contact MDCH's Division of Environmental and Occupational Epidemiology at 1-800-648-6942.

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Little Black Creek and Muskegon Heights Area, Muskegon County

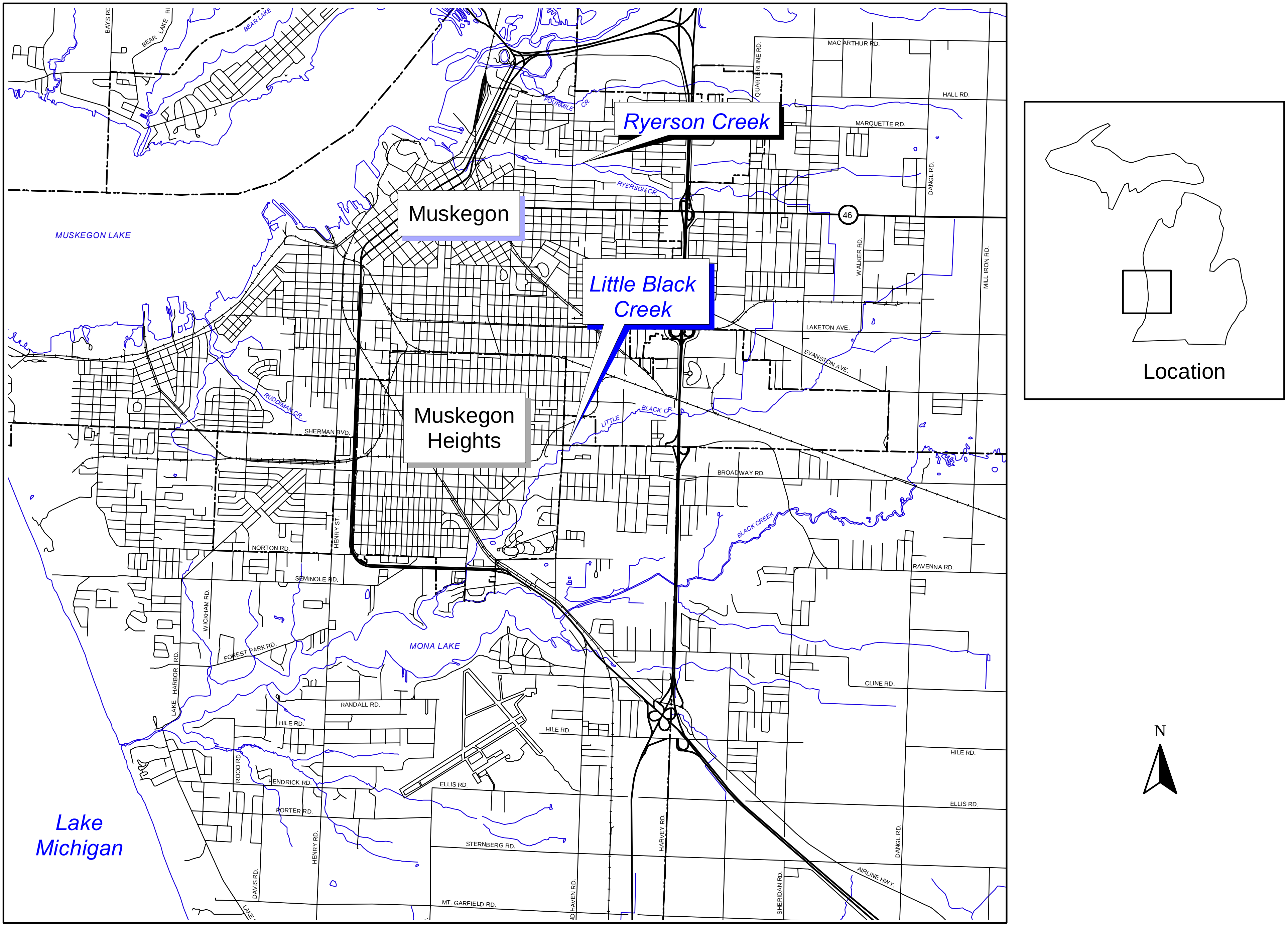

Figure 1.

Little Black Creek, Muskegon County: Pollution Sources and Selected Features

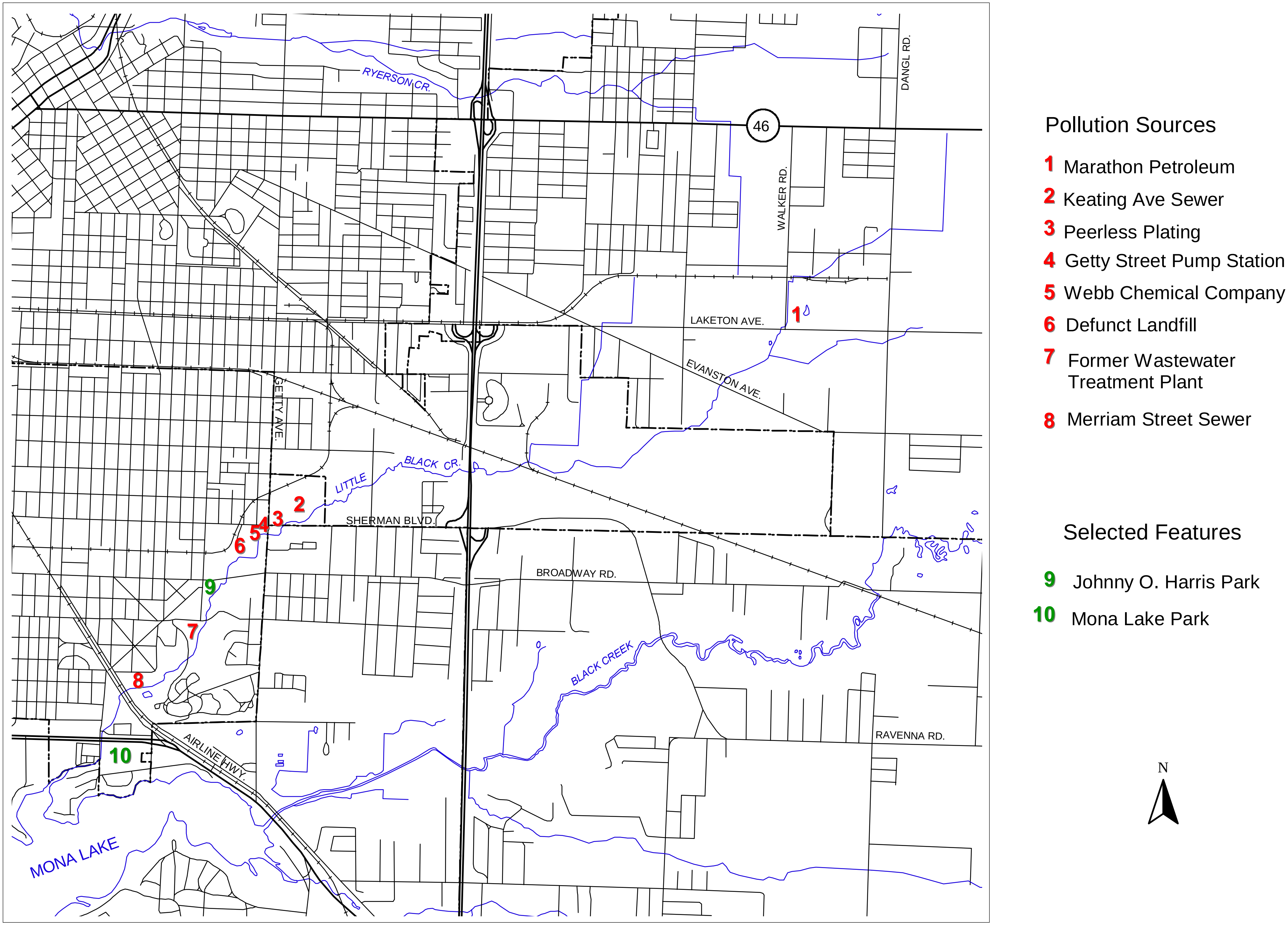

Figure 2.

Appendix A. Adjustment of MDEQ Residential Direct Contact Criteria to Address Contact with Contaminated Sediments in Little Black Creek

The purpose of the MDEQ Generic Residential and Commercial I Direct Contact Criteria (DCC) is to protect against adverse health effects due to long-term ingestion of and dermal exposure to contaminated soil. The generic DCC are only protective of chronic, not acute, effects and does not address inhalation of any volatile chemicals. The generic DCC may be adjusted to address the protection of persons who may come into contact with contaminated sediments, such as by wading or playing in Little Black Creek. The following discussion will demonstrate how the criteria were adjusted to account for a person standing in the creek. To be protective, MDCH assumed that a person would have exposure to the creek and its sediments from childhood through adulthood.

Arsenic is a known human carcinogen (EPA 1998). Benzo(a)pyrene is a probable human carcinogen (EPA 1994). Polychlorinated biphenyls (PCBs) also are probably human carcinogens (EPA 1997). Cadmium is a probable human carcinogen but only by inhalation (EPA 1992). Therefore the DCC for cadmium will be adjusted using the algorithm for noncarcinogens. The equation used to determine the Residential DCC of a known or probable carcinogen is below (MDEQ 2001):

$$ResidentialDCC_{carcinogen} = \frac{TR \times AT \times CF}{SF \times [(EF_i \times IF \times AE_i) + (EF_d \times DF \times AE_d)]}$$

TR is the target cancer risk, or the acceptable risk. An “acceptable” risk may range from 1 in 10,000 to 1 in 1,000,000, meaning that no more than one additional person in ten thousand (1E-4) or one million (1E-6) persons who are exposed to a specific carcinogen will die from cancer compared to a similar population not exposed to the carcinogen. The target risk in this exercise is set at 1 in 100,000 (**1E-5**).

AT is the averaging time factor, which, for carcinogens, is equivalent to the average human lifespan of 70 years, or **25,550 days**. When a chemical is found to be carcinogenic in laboratory animals, the research typically involves a high dose of the chemical given to the animal over a short period of time. Based on the assumption that a high dose of a carcinogen received over a short period of time is equivalent to a corresponding low dose spread over a lifetime, human exposures are calculated by prorating the total cumulative dose over an average person’s lifetime.

CF is the conversion factor used so that the appropriate units appear in the product of the equation. This factor is equal to 1,000,000,000 micrograms per kilogram (**1E+9 µg/kg**).

SF is the oral cancer slope factor, which is an estimate of the increased cancer risk from a lifetime exposure to a chemical. It is a probability estimate that is used only for comparative purposes. It is not a predictive tool. The SF for arsenic is 1.5 per milligram per kilogram-day [**1.5 (mg/kg-day)$^{-1}$**] (EPA 1998). The SF for benzo(a)pyrene is **4.1 (mg/kd-day)$^{-1}$** (EPA 1994). The SF for PCBs, focusing on sediment ingestion, ranges from 1.0 to 2.0 $(mg/kg\text{-}day)^{-1}$ (EPA 1997). For this exercise, MDCH chose to use the more protective SF of **2.0 $(mg/kg\text{-}day)^{-1}$**.

EF_i is the ingestion exposure frequency. It is assumed in this exercise that a child or adult would be exposed to the sediment in the creek **90 days** (3 months) per year.

IF is the age-adjusted soil ingestion factor. It assumes that a child through the age of six years eats 200 mg of soil per day, and that an adult will eat 100 mg of soil per day for 24 years. Each ingestion total (years X amount eaten/year) is divided by the respective default body weight and the resulting quotients are summed. In this exercise, the ATSDR default child body weight of 10 kg was used rather than the EPA default of 15 kg, to provide greater protection. Therefore, IF in this exercise is equal to **154 mg-year/kg-day**.

AE_i is the ingestion absorption efficiency (a science-based estimate of what percentage of a chemical is absorbed through the gastrointestinal tract) and is chemical-specific. For arsenic, benzo(a)pyrene, and PCBs the AE_i is **0.5** (50 percent) (MDEQ 2003).

EF_d is the dermal exposure frequency. Similar to EF_i above, it is assumed that a person would be exposed to the sediment in the creek no more than **90 days** per year.

DF is the age-adjusted soil dermal factor. It considers exposed skin surface area, a soil adherence factor (AF), number of events per day, and the exposure duration and divides the product of those factors by the body weight. Respective subfactors are determined for a child and an adult and then summed. The default AF for children is 0.2 milligrams per square centimeter (mg/cm^2), meaning 0.2 mg of soil would adhere to each square centimeter of exposed skin (MDEQ 2001). The default AF is applicable to the 95^{th} percentile of children playing in *dry* soil (95 percent of children would have less soil adhering). In this case, however, the creek sediments would be wet and likely adhere more readily than dry soil. Conversely, a child or adult would likely rinse off the majority of the sediment when coming out of the creek. An AF value of 0.2 mg/cm^2 also applies to the *50^{th}* percentile of children playing in *wet* soil. This value affords some protection against adhered sediments, even though the majority, if not all, of the sediment would be washed off. Similar to the IF above, MDCH used the ATSDR default child body weight of 10 kg when calculating the DF. No adjustments were made for the adult subfactor. The DF in this exercise is equal to **459.6 mg-year/kg-day**.

AE_d is the dermal absorption efficiency (a science-based estimate of what percentage of a chemical is absorbed through the skin) and is chemical-specific. The value for arsenic is **0.03** (3 percent). The value for benzo(a)pyrene is **0.13** (13 percent). The values for PCBs is **0.14** (14 percent) (MDEQ 2003).

The adjusted Residential DCC for arsenic is calculated as follows:

$$Adjusted\ Residential DCC_{Arsenic} = \frac{1E-5 \times 25{,}550 \times 1E+9}{1.5[(90 \times 154 \times 0.5) + (90 \times 459.6 \times 0.03)]}$$

$$Adjusted\ ResidentialDCC_{Arsenic} = 20{,}846\,\mu g / kg = 21 mg / kg$$

The units mg/kg are equivalent to parts per million (ppm).

The adjusted Residential DCC for benzo(a)pyrene is calculated as follows:

$$Adjusted\ ResidentialDCC_{Benzo(a)pyrene} = \frac{1E-5 \times 25{,}550 \times 1E+9}{4.1[(90 \times 154 \times 0.5) + (90 \times 459.6 \times 0.13)]}$$

$$Adjusted\ ResidentialDCC_{Benzo(a)pyrene} = 5{,}063\,\mu g / kg = 5 mg / kg$$

The adjusted Residential DCC for PCBs is calculated as follows:

$$Adjusted\ ResidentialDCC_{PCBs} = \frac{1E-5 \times 25{,}550 \times 1E+9}{2[(90 \times 154 \times 0.5) + (90 \times 459.6 \times 0.14)]}$$

$$Adjusted\ ResidentialDCC_{PCBs} = 10{,}042\,\mu g / kg = 10 mg / kg$$

The equation used to determine the Residential DCC of a noncarcinogen is below (MDEQ 2001):

$$ResidentialDCC_{noncarcinogen} = \frac{THQ \times RfD \times AT \times CF \times RSC}{(EF_i \times IF \times AE_i) + (EF_d \times DF \times AE_d)}$$

THQ is the target hazard quotient. A hazard quotient is the relationship of an exposure dose to the Reference Dose (discussed below) of a chemical. If the quotient (exposure value divided by reference value) is less than or equal to 1, no adverse health effect would be expected. For this exercise, the THQ is **1**.

RfD is the Reference Dose, an estimated concentration of a chemical that a person can be exposed to orally for a lifetime without experiencing negative health effects. Although uncertainty exists in deriving the estimate, the agency deriving the value (usually EPA) strives to protect the most sensitive population. The RfD for cadmium is **1E-3 (0.001) mg/kg/day** (EPA 1992).

AT is the averaging time, which, for noncarcinogens, is equal to the exposure duration in years times 365 days/year. For this exercise, the exposure duration will be 30 years, from childhood through early adulthood. Therefore, AT is **10,950 days**.

CF is a conversion factor and is the same as that for carcinogens, **1E+9 µg/kg**.

RSC is the relative source contribution. There may be other exposures that the receptor population may face beside the exposure of immediate concern. For this exercise, it is assumes that all exposure to cadmium occurs via the sediments in Little Black Creek. Therefore the RSC is **1 (100 percent)**.

EF_i is the ingestion exposure frequency and, for this exercise, is the same as that used for carcinogens, **90 days/year**.

IF is the age-adjusted soil ingestion factor and, for this exercise, is the same as that used for carcinogens, **154 mg-year/kg-day**.

AE_i is the ingestion absorption efficiency, which, for cadmium is **0.5 (50 percent)** (MDEQ 2003).

EF_d is the dermal exposure frequency and, for this exercise, is the same as that used for carcinogens, **90 days/year**.

DF is the age-adjusted soil dermal factor and, for this exercise, is the same as that used for carcinogens, **459.6 mg-year/kg-day**.

AE_d is the dermal absorption efficiency, which, for cadmium is **0.001 (0.1 percent)** (MDEQ 2003).

The adjusted Residential DCC for cadmium is calculated as follows:

$$Adjusted\ ResidentialDCC_{Cadmium} = \frac{1 \times 0.001 \times 10{,}950 \times 1E+9 \times 1}{(90 \times 154 \times 0.5) + (90 \times 459.6 \times 0.001)}$$

$$Adjusted\ ResidentialDCC_{Cadmium} = 1{,}570{,}607\,\mu g / kg = 1{,}600 mg / kg$$

Appendix B. ATSDR Public Health Hazard Categories

Depending on the specific properties of the contaminant, the exposure situations, and the health status of individuals, a public health hazard may occur. Using data from public health assesements, sites are classified using one of the following public health hazard categories:

Category 1: Urgent Public Health Hazard
Sites that pose a serious risk to the publics health as the result of short-term exposures to hazardous substances.

Category 2: Public Health Hazard
Sites that pose a public health hazard as the result of long-term exposures to hazardous substances.

Category 3: Potential/Indeterminate Public Health Hazard
Sites for which no conclusions about public health hazard can be made because data are lacking.

Category 4: No Apparent Public Health Hazard
Sites where human exposure to contaminated media is occurring or has occurred in the past, but the exposure is below a level of health hazard.

Category 5: No Public Health Hazard
Sites for which data indicate no current or past exposure or no potential for exposure and therefore no health hazard.

(Information taken from the ATSDR website:
http://www.atsdr.cdc.gov/COM/hazcat.html)

Certification

This **Little Black Creek Sediments** Health Consultation was prepared by the Michigan Department of Community Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures. Editorial review was completed by the cooperative agreement partner.

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

Team Leader, CAT, SPAB, DHAC, ATSDR