United States
Environmental Protection
Agency

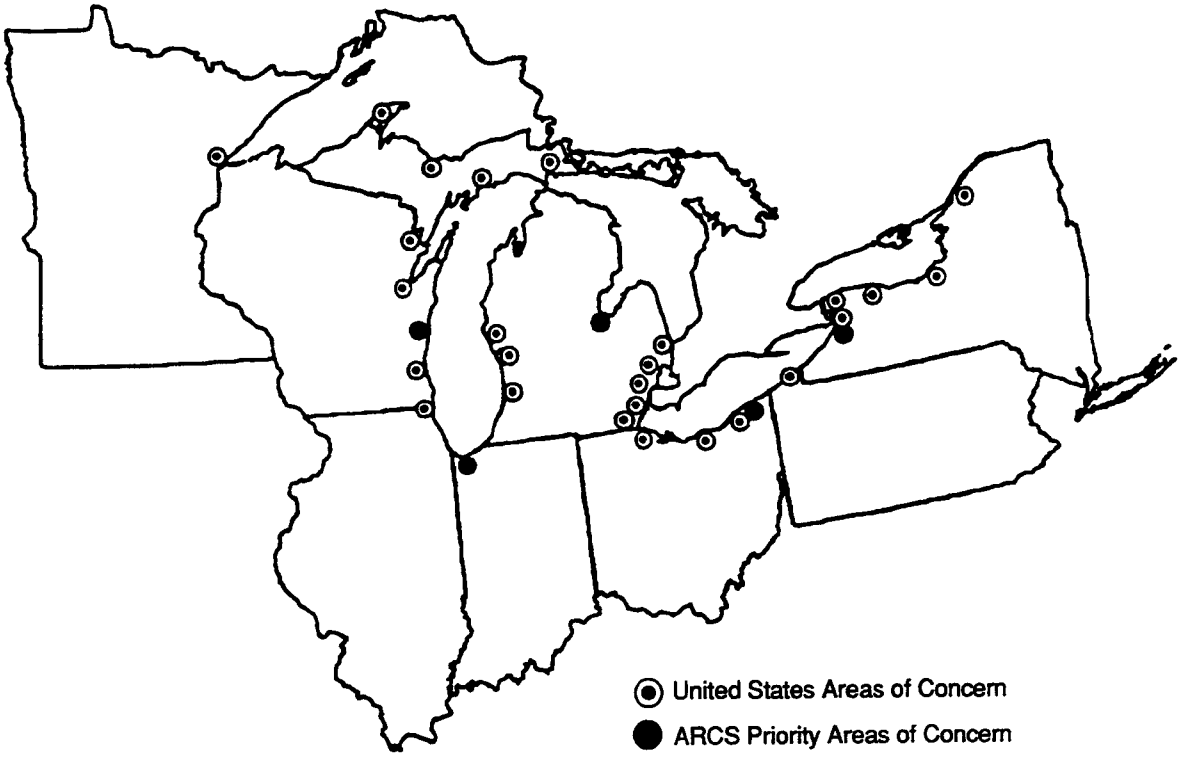
Great Lakes
National Program Office
77 West Jackson Boulevard
Chicago, Illinois 60604

EPA 905-R-93-001
FEBRUARY 1993

EPA

Assessment and Remediation Of Contaminated Sediments (ARCS) Program

BASELINE HUMAN HEALTH RISKS RESULTING FROM PCB CONTAMINATION AT THE SHEBOYGAN RIVER, WISCONSIN, AREA OF CONCERN



BASELINE ASSESSMENT OF HUMAN HEALTH RISKS RESULTING FROM PCB CONTAMINATION AT THE SHEBOYGAN RIVER, WISCONSIN, AREA OF CONCERN

by

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PREFACE

This risk assessment was prepared as part of the Assessment and Remediation of Contaminated Sediments (ARCS) program coordinated by the U.S. EPA Great Lakes National Program Office. The work by AScI Corporation was completed under contract no. 68-C1-0012 with the U.S. EPA Environmental Research Laboratory-Athens by Judy L. Crane, Ph.D. under the supervision of James L. Martin, Ph.D., P.E., AScI Site Manager. This work was performed through the U.S. EPA Center for Exposure Assessment Modeling, Mr. Robert Ambrose, Jr., P.E., Manager.

FOREWORD

Risk assessment has been defined as the characterization of the probability of adverse effects from human and ecological exposures to environmental hazards. Risk assessments are quantitative, chemical-oriented characterizations that can use statistical and biological models to calculate numerical estimates of risk to human health or the environment. The concept of risk assessment is a cornerstone on which the U.S. Environmental Protection Agency builds programs to confront pollution problems in air, water, and soil under the direction of Congressional mandates. One such mandate is the Clean Water Act, which includes a directive to the Agency to study the control and removal of toxic pollutants in the Great Lakes, with emphasis on removal of contaminants from bottom sediments. Charged with performing this study is EPA's Great Lakes National Program Office (GLNPO) located in Chicago, IL. GLNPO administers the Assessment and Remediation of Contaminated Sediments (ARCS) program to examine the problem of contaminated sediments using a multidisciplinary approach involving engineering, chemistry, toxicology, modeling, and risk assessment.

In support of the GLNPO, the Environmental Research Laboratory-Athens began a series of studies under the ARCS program that will culminate in a baseline risk assessment for each of five Great Lakes Areas of Concern (AOC)--Buffalo River, NY, Grand Calumet River/Indiana Harbor Canal, IN, Saginaw River, MI, Ashtabula River, OH, and Sheboygan River, WI. This report describes a baseline human health risk assessment for the population within the Grand Calumet River/Indiana Harbor Canal AOC. The assessment, which is based on available environmental data, is designed to provide a conservative estimate of carcinogenic and noncarcinogenic risks to human health under the baseline, no-action alternative.

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ABSTRACT

The Assessment and Remediation of Contaminated Sediments (ARCS) program, a 5-year study and demonstration project relating to the control and removal of contaminated sediments from the Great Lakes, is being coordinated and conducted by the U.S. Environmental Protection Agency's (EPA) Great Lakes National Program Office (GLNPO). As part of the ARCS program, baseline human health risk assessments are being performed at five Areas of Concern (AOCs) in the Great Lakes region. The Sheboygan River, located in eastern Wisconsin, is one of these AOCs.

In this report, exposure and risk assessment guidelines, developed for the EPA Superfund program, have been applied to determine the baseline human health risks associated with direct and indirect exposures to sediment-derived contaminants in the Sheboygan River AOC. These risks were estimated for carcinogenic effects (i.e., probability of an individual developing cancer over a lifetime).

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

This risk assessment was performed in cooperation with Bonnie Eleder, Remedial Project Manager for the Sheboygan River/Harbor Superfund site, of the Office of Superfund, U.S. EPA Region V. Helpful information about the Hmong population in Sheboygan was obtained from Kim Bro (Wisconsin Department of Health and Social Services) and Jim Amrhein (Wisconsin Department of Natural Resources). This document was reviewed by the ARCS Risk Assessment and Modeling Work Group and by the U.S. EPA Environmental Research Laboratory-Athens.

INTRODUCTION

The Assessment and Remediation of Contaminated Sediments (ARCS) program, a 5-year study and demonstration project relating to the control and removal of contaminated sediments from the Great Lakes, is being coordinated and conducted by the U.S. Environmental Protection Agency's (EPA) Great Lakes National Program Office (GLNPO). As part of the ARCS program, baseline human health risk assessments are being performed at five Areas of Concern (AOCs): Ashtabula River, OH; Buffalo River, NY; Grand Calumet River/Indiana Harbor Canal, IN; Saginaw River, MI; Sheboygan River, WI. This risk assessment will focus on the baseline human health risks resulting from exposure to sediment-derived contaminants at the Sheboygan River.

The Sheboygan River/Harbor AOC includes approximately 22.5 km of the Sheboygan River and the entire Sheboygan Harbor (47.5 hectare) (Figure 1). This area was designated as a Superfund site in 1985 due to widespread contamination of the sediments and fish by PCBs. In addition, the sediments have been contaminated with several heavy metals (e.g., cadmium, chromium, lead, mercury, nickel, and zinc). Due to the level of PCB contamination in the fish, a "do not eat" fish advisory has been issued by the Wisconsin Department of Natural Resources (DNR) and the Wisconsin Division of Health for all resident fish species, including smallmouth bass, walleye, and panfish as well as for migratory species such as chinook salmon and steelhead trout. Despite these fish advisories, some people continue to consume fish from the Sheboygan River and Harbor.

The extent of contamination at the AOC has been described in detail in the Remedial Investigation/Enhanced Screening (RI/ES) report for the Sheboygan River and Harbor (Blasland and Bouck Engineers, 1990). A human health endangerment assessment, conducted as part of the RI/ES report, indicated that three long-term exposure scenarios resulted in "unacceptable" carcinogenic risks (i.e., cancer risks greater than the 10^{-4} to 10^{-7} range):

- Dermal exposure to river sediments containing the maximum observed PCB concentrations
- Ingestion of certain fish species that contained PCB concentrations greater than the FDA limit (i.e., 2.0 mg/kg)
- Ingestion of certain waterfowl species contained PCB concentrations greater than 4 mg/kg in edible portions

The most highly contaminated sediments in the Sheboygan River were dredged between 1989 and 1991 under two phases. Under the first phase, dredged sediments were placed in a Pilot Confined Treatment Facility (CTF) (Eleder, 1991); the CTF is being used to study the effectiveness of enhanced natural biodegradation for

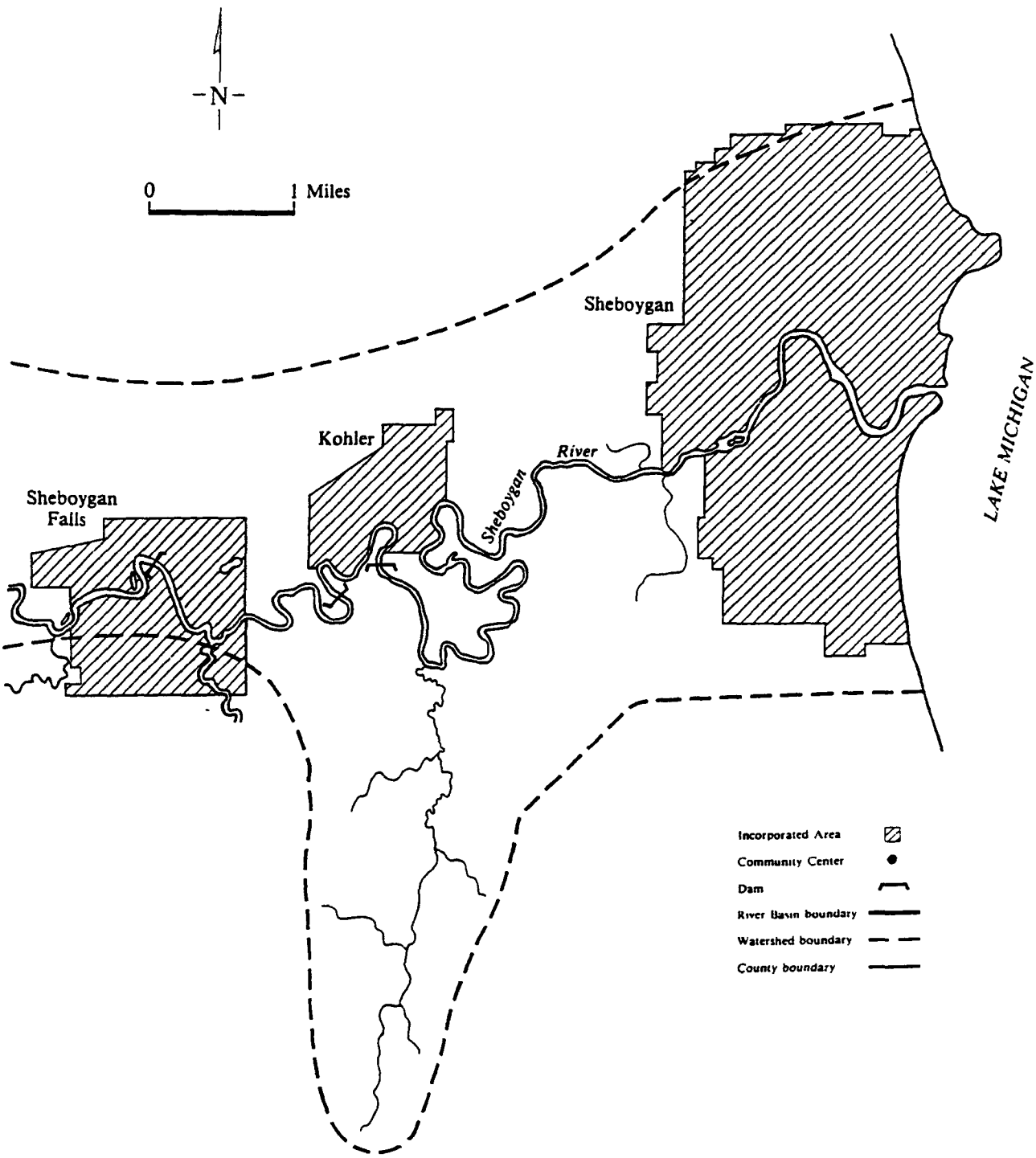

Figure 1. Sheboygan River AOC boundaries.

treatment of PCBs. The second phase was implemented under a Removal Action; these sediments have been stored temporarily in a tank until a decision can be made in the Record of Decision as to their final disposal. In addition, less contaminated sediments have been armored in place. A monitoring program has been designed and implemented to assess the effectiveness of the removal, armoring, and biodegradation of sediments. A fish monitoring program was begun in 1989 and continues today. As part of the monitoring program, data were collected during 1991 to determine total PCB levels in floodplain soils and in four species of fish.

Rather than duplicate the effort of the RI/ES endangerment assessment, this baseline risk assessment for the ARCS program sought to update the endangerment assessment with new data. Exposure and risk assessment guidelines, developed for the EPA Superfund program, were used to estimate the carcinogenic risk from exposure to sediment-derived contaminants (i.e., PCBs).

EXPOSURE ASSESSMENT

Exposure Pathways

Residents of Sheboygan and the surrounding area may be exposed to sediment-derived contaminants through two complete exposure pathways: 1) consumption of contaminated fish (e.g, river steelhead, chinook salmon, smallmouth bass, and river carp) and 2) dermal exposure to floodplain soils. These pathways were selected because recent data were available and because other exposure pathways had previously been evaluated for the RI/ES endangerment assessment. There was no evidence that children would be ingesting floodplain soils (i.e., pica behavior) in the AOC; thus, this exposure scenario was not determined to be complete. People may inadvertently ingest some dust from the soil if they do not wash their hands before eating. However, much more soil is dermally contacted than is ingested during normal exposure scenarios, and dermal contact usually poses a greater threat than soil ingestion. Thus, the ingestion of dust from the hands was not evaluated here.

Chemical Intakes

The intake of PCBs into the body was determined by normalizing the exposures for time and body weight. The general equation for calculating chemical intake is given in Table 1. Several variables were used to determine intake based on specific information about the exposed population and the period over which the exposure was averaged. Using EPA Superfund guidance, typical (i.e., average) exposures were assumed to occur over a period of 9 years; reasonable maximum (i.e., the maximum exposure that is reasonably expected to occur at a site) and subsistence exposures were assumed to occur over a period of 30 years (USEPA, 1989a). The subsistence pathway only applied to a subpopulation of anglers and their families. The exposure durations were extrapolated over a period of 70 years for estimating

TABLE 1. GENERIC EQUATION FOR CALCULATING CHEMICAL INTAKES (USEPA, 1989a)

$$I = \frac{C \times CR \times EFD}{BW \times AT}$$

where:	
I	Intake = the amount of chemical at the exchange boundary (mg/kg body weight-day)
	Chemical-Related Variables
C	Chemical Concentration = the average concentration contacted over the exposure period (e.g., mg/L)
	Variables that Describe the Exposed Population
CR	Contact Rate = the amount of contaminated medium contacted per unit time or event (e.g., L/day)
EFD	Exposure Frequency and Duration = how long and how often exposure occurs. Often calculated using two terms, EF*ED, where EF = exposure frequency (days/year) ED = exposure duration (years)
BW	Body Weight = the average body weight over the exposure period (kg)
	Assessment-Determined Variables
AT	Averaging Time = period over which exposure is averaged (days)

carcinogenic risks. Exposures were added across pathways (i.e., consumption of fish and dermal exposure to floodplain soils) for typical and reasonable maximum exposures.

Exposure Through Fish Consumption

An unknown number of anglers and their families may be consuming fish from the Sheboygan River and Harbor. Although some anglers may fish for recreation, others may rely on fish from the AOC to supplement their diet. In particular, the southeastern Asian community of Hmong may constitute a subsistence

group of anglers. Approximately 2100 Southeast Asians (about 400 families) live in the city of Sheboygan (Xa Xov Newsletter, 1991). The Hmong make up a significant minority population in Sheboygan; there are about 100 families in the local Hmong Association. Approximately 15% of this population may consume fish as much as three times a week, although the amount of fish consumed from local sources is unknown (J. Amrhein, Wisconsin DNR, personal communication, 1992). The Hmong prefer to fish at Lake Winnebago, the largest inland lake in Wisconsin, because they can catch species of fish (e.g., white bass) that are similar to those in their original homeland. However, an unknown number of Hmong may fish out of the Sheboygan River. The Hmong are not familiar with identifying Wisconsin fish and may be consuming the more-contaminated, benthic species like carp. Consequently, the Wisconsin DNR has developed a public education program to inform the Hmong about fish advisories and to provide visual graphics identifying common fish species. A workshop has been held in Sheboygan to teach the Hmong where the fish are safe to eat and how to prepare the fish to reduce the contaminant burden.

As part of the monitoring program for Superfund, fish collection activities are being carried out by Blasland and Bouck Engineers for Tecumseh Products Co. Four species of fish were collected from the Sheboygan River during 1991. The fish were measured, weighed, and analyzed for total PCBs and lipid content; no other contaminants were analyzed in the fish. Table 2 contains the mean PCB concentrations, standard deviations (SD), and number of fish analyzed for each of the sites where river steelhead, chinook salmon, smallmouth bass, and river carp were collected. The PCB concentrations for river steelhead were based on fillets, whereas the other fish were analyzed as whole fish. Since PCBs preferentially accumulate in the fat of fish, the removal of fat during filleting will result in a lower concentration of PCBs in the fish relative to whole fish. Control spikes and matrix spikes were run with each set of samples. Little QA/QC information was supplied with the data sheets containing the analytical results. Nevertheless, the data were determined to be of adequate quality for use in this risk assessment because the collection and analysis of data had to conform to Superfund QA/QC protocols.

Of the four species of fish collected from the Sheboygan River, carp were the most contaminated with PCBs (Table 2). Carp are a good indicator of contamination problems because they are primarily benthic feeders and generally reside in a local area. In addition, carp may readily accumulate contaminants in their lipids through the ingestion and assimilation of contaminated food and possibly through the consumption of sediment while feeding. Unlike the carp, river steelhead and chinook salmon are migratory fish that spend most of the year in Lake Michigan; these fish are no longer stocked in the river, and the migrations of salmon and trout back to the Sheboygan River have almost ended (B. Eleder, USEPA Region V, personal communication, 1992). Smallmouth bass may also travel within the Sheboygan River and between the river and nearshore Lake Michigan area; as seen in Table 2, these fish accumulated a greater burden of PCBs than the steelhead and salmon.

The equation used to estimate intake of PCBs due to the ingestion of

TABLE 2. MEAN PCB CONCENTRATIONS IN FOUR SPECIES OF FISH COLLECTED FROM THE SHEBOYGAN RIVER

Fish/Location/Collection Date	Mean PCB Conc. (mg/kg)	SD (mg/kg)	N
River Steelhead			
From 22nd St. to Esslinger Park (4-11-91 and 4-25-91)	0.97	0.44	11
Chinook Salmon			
Strawberry Creek (10-16-91)	2.97	1.0	42
Kiwanis Park (9-18-91)	3.2	1.1	40
Lower Harbor (9-18-91)	2.93	1.1	41
Smallmouth Bass			
Kiwanis Park (7-16-91)	3.7	1.1	9
Rochester Park (7-16-91)	9.7	4.5	8
Between Kohler Dams (7-17-91)	8.14	3.6	8
River Carp			
Kiwanis Park (7-16-91)	12.1	5.6	25
Rochester Park (7-16-91)	48.9	39.2	25
Between Kohler Dams (7-17-91)	41.9	16.7	24

contaminated fish is provided in Table 3. The parameter values used to estimate intakes are given in Table 4 for typical, reasonable maximum, and subsistence exposures. Parameter values were obtained from recommended EPA sources and published studies, whenever possible. In some cases, professional judgment was used to make conservative estimates. For instance, the fraction of fish assumed to be ingested from the Sheboygan River AOC was estimated due to a lack of information for this exposure parameter.

Exposure Through Dermal Contact with Floodplain Soils

Dermal exposure to contaminated floodplain soils may occur at Esslinger and Kiwanis Parks in the city of Sheboygan. People may be exposed to soils while playing softball at Kiwanis Park or while playing in any of the parks' areas where the soil has been exposed. The soil samples used in this exposure assessment were collected in the upper 7.5 cm of the soil profile and composited before analysis; the soil samples collected from both parks were overlain with grass cover. The exposure assessment for this pathway is probably very conservative because most of the soils in both parks appear to be covered by grass and other vegetation.

The equation used to estimate intakes of PCBs is given in Table 5 and the

TABLE 3. EQUATION USED TO ESTIMATE CONTAMINANT INTAKES DUE TO INGESTION OF FISH

$$Intake = \frac{C \; X \; IR \; X \; FI \; X \; EF \; X \; ED}{BW \; X \; AT}$$

where:	
Intake	Intake Rate (mg/kg-day)
C	Contaminant Concentration in Fish (mg/kg)
IR	Ingestion Rate (kg/day)
FI	Fraction Ingested from Contaminated Source (unitless)
EF	Exposure Frequency (days/yr)
ED	Exposure Duration (yr)
BW	Body Weight (kg)
AT	Averaging Time (days)

exposure parameters used in that equation are given in Table 6. This exposure pathway assumed that an individual wore a long sleeve shirt, pants, and shoes under a typical exposure scenario; thus, the exposed skin surface was limited to the head and hands (USEPA, 1989b). Under the reasonable maximum exposure scenario, an individual would wear a short sleeve shirt, shorts, and shoes; thus, the head, hands, forearms, and lower legs would be exposed (USEPA, 1989b). The surface area of the exposed skin was estimated by age group values given in the EPA's "Exposure Factors Handbook" (USEPA, 1989b). Children and teenagers were assumed to have dermal contact with the soils 5 days/week during June through August and 2 days/week during May and September (i.e., 83 days). Adults were assumed to have contact with the soils 2 days/week during June through August (i.e., 26 days). For the dermal adherence of soil, a range of values from 0.2 to 1.5 mg/cm^2 appear possible; a conservative central value of 1.0 mg/cm^2-event was used (USEPA, 1989a). The absorption of PCBs through the skin was assumed to be 6% (C. Braverman, USEPA Region V, personal communication, 1992). The exposure assessment was divided into three age groups: 2-6, 7-17, and 18-70 years. These age groups were selected because children are at an increased risk to dermal exposure to contaminants due to their greater surface-to-volume ratio. In addition, children are more likely

TABLE 4. PARAMETERS USED IN ESTIMATING CONTAMINANT INTAKES DUE TO INGESTION OF FISH FROM THE SHEBOYGAN RIVER

Var.	Units	Value Used	Reference
IR	kg/day	0.0192	Typical: West et al. (1989)
		0.054	Reasonable Maximum Exposure (RME): USEPA (1991a)
		0.13	Subsistence fishing: used the 95th percentile daily intakes averaged over 3 days for consumers of fin fish [Pao et al. (1982) cited in USEPA (1989a)]
FI	-	0.05	Typical: study assumption
		0.1	Reasonable Maximum Exposure: study assumption
		0.2	Subsistence fishing: study assumption
EF	day/yr	350	USEPA (1991)
ED	yrs	9	Typical: USEPA (1989a)
		30	Reasonable Maximum and Subsistence Exposures: USEPA (1989a)
BW	kg	70	50th percentile average for adult men and women (USEPA, 1989b)
AT:	days	25550	70 yrs x 365 days/yr

than adults to spend time playing outdoors. The typical exposure duration of 9 years and reasonable maximum exposure duration of 30 years during a 70-year lifetime were subdivided among the age groups (Table 6). Thus, the proportion of the age group exposure duration (X) divided by the entire exposure duration (i.e., 9 years for typical and 30 years for reasonable maximum exposures) was equivalent to the ratio of the age group range divided by 70 years. For example, the proportion of a typical 9 year exposure (i.e., X) that the 7-17 year old age group would experience would be calculated as follows:

$$\frac{X \text{ years}}{9 \text{ years}} = \frac{11 \text{ years}}{70 \text{ years}}$$

$$X = 1.4 \text{ years}$$

TABLE 5. EQUATION USED IN ESTIMATING THE ABSORBED DOSE OF PCBS DUE TO DERMAL CONTACT WITH FLOODPLAIN SOILS

$$AD = \sum_{i=1}^{3} \left[\frac{CS_j \; X \; SA_i \; X \; AF \; X \; ABS \; X \; EF_i \; X \; ED_i \; X \; CF}{BW_i \; X \; AT_i} \right]$$

where:	
AD	Absorbed Dose (mg/kg/day)
i	Age Group
j	Chemical
CS	Chemical Concentration in Soil (mg/kg)
SA_i	Age Group Specific Skin Surface Area Available for Contact (m^2)
AF	Soil to Skin Adherence Factor (mg/cm^2)
ABS	Absorption Factor (unitless)
EF_i	Age Group Specific Exposure Frequency (events/yr)
ED_i	Age Group Specific Exposure Duration (yr)
CF	Conversion Factor (10^{-6} kg/mg)
BW_i	Age Group Specific Body Weight (kg)
AT_i	Age Group and Pathway Specific Period of Exposure, Averaging Time (days)

RISK ASSESSMENT

Carcinogenic risks were estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to PCBs. The risk was computed by multiplying the exposure intake by the oral slope factor for PCBs (i.e., 7.7 $(mg/kg\text{-}day)^{-1}$). Since slope factors based on dermal exposure have not been derived, the oral slope factor was used. The resulting carcinogenic risk estimate for both exposure pathways would generally represent an upper-bound estimate; this is because slope factors are usually based on upper 95th percentile confidence limits. The EPA believes it is prudent public health policy to consider actions to mitigate or

TABLE 6. PARAMETER VALUES USED IN ESTIMATING THE ABSORBED DOSE DUE TO DERMAL CONTACT WITH FLOODPLAIN SOIL (NUMBERS IN PARENTHESES CORRESPOND TO REASONABLE MAXIMUM EXPOSURES)

Var.	Units	Age Class (years)	Value Used	Reference
AF	mg/cm^2	-	1.0	Study Assumption
ABS	-	-	0.06	Recommended Value (C. Braverman, Region V, personal communication, 1992)
CF	kg/mg		10^{-6}	
SA_i	cm^2 /event	2-6	1400	USEPA (1989b)
			(2500)	USEPA (1989b)
		7-17	2000	USEPA (1989b)
			(5100)	USEPA (1989b)
		18-70	2020	USEPA (1989b)
			(5200)	USEPA (1989b)
EF_i	events /yr	2-6	83	Study Assumption
		7-17	83	Study Assumption
		18-70	26	Study Assumption
BW_i	kg	2-6	17	USEPA (1989b)
		7-17	44	USEPA (1989b)
		18-70	70	USEPA (1989b)
AT	days		25550	70 yrs x 365 days/yr
ED_i	years	2-6	0.64	Proportion of 9 yr exposure
			(2.1)	Proportion of 30 yr exposure
		7-17	1.4	Proportion of 9 yr exposure
			(4.7)	Proportion of 30 yr exposure
		18-70	6.8	Proportion of 9 yr exposure
			(22.7)	Proportion of 30 yr exposure

minimize exposures to contaminants when estimated, upper-bound excess lifetime cancer risks exceed the 10^{-5} to 10^{-6} range, and when noncarcinogenic health risks are estimated to be significant (USEPA, 1988).

The carcinogenic risk from consuming either river steelhead, chinook salmon, smallmouth bass, or river carp was greater than 1 person in 100,000 contracting cancer during their lifetime for all exposure scenarios (Tables 7-9). The risk was about an order of magnitude less for the migratory species of river steelhead and chinook salmon than for smallmouth bass and river carp. As would be expected for a bottom feeding fish, carp accumulated the greatest PCB burden and resulted in the worst carcinogenic risk. The risk was slightly greater at Rochester Park and in between the Kohler Dams than at Kiwanis Park for carp and smallmouth bass. The cancer risk increased by at least an order of magnitude with each greater exposure scenario. The subsistence exposure scenario was of particular concern, especially for people who consumed carp.

The estimated carcinogenic risk due to dermal exposure to contaminated floodplain soils was on the order of 10^{-7} under typical exposures for all age groups (Table 10). The risk increased by about an order of magnitude for reasonable maximum exposures (Table 11). Under this latter exposure scenario, the carcinogenic risk was at a borderline level of concern.

The carcinogenic risk from consuming contaminated fish was several orders of magnitude greater than the lifetime risk of dermal exposure to floodplain soils. Thus, the additive risks for both exposure scenarios is essentially the same as the fish consumption risk.

The risk estimates derived for both exposure pathways may have been overestimated because the only available oral slope factor for PCBs was based on Aroclor 1260. Aroclor 1260 is not representative of the kinds of PCBs found in the Sheboygan River AOC. The primary Aroclor mixture used in the Sheboygan River area consisted of Aroclors 1248 and 1254; the most prominent congeners in this mixture have been detected in fish from the river (David, 1990). Since Aroclor 1260 contains more highly chlorinated congeners (as well as potentially toxic coplanar congeners) than Aroclors 1248 and 1254, these risk estimates may be overly conservative.

UNCERTAINTIES

People in the vicinity of Sheboygan, WI, may be at an increased risk of developing cancer during their lifetime if they consume fish from the Sheboygan River and Harbor. However, a number of assumptions and estimated values were used to develop this prediction. Most risk estimates derived from environmental data contain a large amount of uncertainty (i.e., on the range of at least an order of magnitude or greater) (USEPA, 1989a). This section will qualitatively identify the

TABLE 7. CARCINOGENIC RISK FROM CONSUMING SHEBOYGAN RIVER FISH, TYPICAL EXPOSURE, FI = 0.05

Fish/Location/Collection Date	Mean PCB Conc. (mg/kg)	Carcinogenic Intake (mg/kg-day)	Lifetime Cancer Risk
River Steelhead			
From 22nd St. to Esslinger Park (4-11-91 and 4-25-91)	0.97	1.64E-06	1.3E-05
Chinook Salmon			
Strawberry Creek (10-16-91)	2.97	5.02E-06	3.9E-05
Kiwanis Park (9-18-91)	3.2	5.41E-06	4.2E-05
Lower Harbor (9-18-91)	2.93	4.95E-06	3.8E-05
Smallmouth Bass			
Kiwanis Park (7-16-91)	3.7	6.26E-06	4.8E-05
Rochester Park (7-16-91)	9.7	1.64E-05	1.3E-04
Between Kohler Dams (7-17-91)	8.14	1.38E-05	1.1E-04
River Carp			
Kiwanis Park (7-16-91)	12.1	2.05E-05	1.6E-04
Rochester Park (7-16-91)	48.9	8.27E-05	6.4E-04
Between Kohler Dams (7-17-91)	41.9	7.08E-05	5.5E-04

site-related variables and assumptions that may contribute the greatest amount of uncertainty to the risk estimates. These uncertainties include the following assumptions and estimates:

- **A complete QA/QC review of the fish and floodplain soil data sheets could not be made because of a lack of information supplied with the data sheets.** However, since the data had to comply with Superfund QA/QC requirements, it was deemed acceptable for use in this risk update. The uncertainty associated with using this data is probably low.

- **Contaminant burdens in fish may decrease depending on how the fish is prepared and cooked. In addition, the use of whole fish data for chinook salmon, smallmouth bass, and river carp may be overly conservative.** Contaminant levels may be reduced 10-70% depending on how the fish is prepared and cooked (H. Humphrey, Michigan Department of Public Health, personal communication, 1989). Because of this wide range, the uncertainty associated with the resulting overestimation of risk is not well established.

TABLE 8. CARCINOGENIC RISK FROM CONSUMING SHEBOYGAN RIVER FISH, REASONABLE MAXIMUM EXPOSURE, FI = 0.1

Fish/Location/Collection Date	Mean PCB Conc. (mg/kg)	Carcinogenic Intake (mg/kg-day)	Lifetime Cancer Risk
River Steelhead			
From 22nd St. to Esslinger Park (4-11-91 and 4-25-91)	0.97	3.08E-05	2.4E-04
Chinook Salmon			
Strawberry Creek (10-16-91)	2.97	9.42E-05	7.2E-04
Kiwanis Park (9-18-91)	3.2	1.01E-04	7.8E-04
Lower Harbor (9-18-91)	2.93	9.29E-05	7.2E-04
Smallmouth Bass			
Kiwanis Park (7-16-91)	3.7	1.17E-04	9.0E-04
Rochester Park (7-16-91)	9.7	3.08E-04	2.4E-03
Between Kohler Dams (7-17-91)	8.14	2.58E-04	2.0E-03
River Carp			
Kiwanis Park (7-16-91)	12.1	3.84E-04	3.0E-03
Rochester Park (7-16-91)	48.9	1.55E-03	1.2E-02
Between Kohler Dams (7-17-91)	41.9	1.33E-03	1.0E-02

- **The assumptions made about exposure frequency and duration variables, body weight, life expectancy, and population characteristics** were appropriate. Many of these assumptions (e.g., body weight, life expectancy, exposure frequency) were based on EPA guidance (USEPA, 1989a,b; 1991) and probably have a low to moderate level of uncertainty associated with them. Professional judgment was used to determine the fraction of fish ingested from the Sheboygan River, and a moderate level of uncertainty was probably associated with this assumption.

- **The use of an oral slope factor for PCBs was appropriate for the dermal exposure pathway.** Since, a dermal slope factor was not available, the oral slope factor represented a "best estimate." A moderate amount of uncertainty is probably associated with this assumption.

- **The assumption of 6% dermal absorption of PCBs was appropriate.** Major uncertainties exist concerning the extent to which a chemical is percutaneously absorbed and in the extent to which a chemical will partition from soil to skin. In addition, percutaneous absorption of a chemical in a soil matrix may depend on characteristics of the soil, such as particle size and organic carbon content. The EPA is considering

TABLE 9. CARCINOGENIC RISK FROM CONSUMING SHEBOYGAN RIVER FISH, SUBSISTENCE EXPOSURE, FI = 0.2

Fish/Location/Collection Date	Mean PCB Conc. (mg/kg)	Carcinogenic Intake (mg/kg-day)	Lifetime Cancer Risk
River Steelhead			
From 22nd St. to Esslinger Park (4-11-91 and 4-25-91)	0.97	1.50E-04	1.2E-03
Chinook Salmon			
Strawberry Creek (10-16-91)	2.97	4.60E-04	3.5E-03
Kiwanis Park (9-18-91)	3.2	4.96E-04	3.8E-03
Lower Harbor (9-18-91)	2.93	4.54E-04	3.5E-03
Smallmouth Bass			
Kiwanis Park (7-16-91)	3.7	5.73E-04	4.4E-03
Rochester Park (7-16-91)	9.7	1.50E-03	1.2E-02
Between Kohler Dams (7-17-91)	8.14	1.26E-03	9.7E-03
River Carp			
Kiwanis Park (7-16-91)	12.1	1.88E-03	1.4E-02
Rochester Park (7-16-91)	48.9	7.58E-03	5.8E-02
Between Kohler Dams (7-17-91)	41.9	6.49E-03	5.0E-02

using an absorption factor of 6% as a default value for PCBs; this value may change as additional data from laboratory studies becomes available. A moderate level of uncertainty is probably associated with this exposure parameter.

- **Current levels of exposure will remain constant over the duration time of the exposure (i.e., 9 or 30 years).** A moderate to high level of uncertainty is probably associated with this assumption. Due to the remediation efforts in the Sheboygan River, the contaminant concentrations in fish would be expected to decrease with time. Concentrations of PCBs in floodplain soils may also be altered with time through processes such as microbial degradation. In addition, the consumption of fish from the river could increase if fish are restocked in the Sheboygan River. The Wisconsin DNR released clipped steelhead trout in the Sheboygan River during the fall of 1990 to help assess cleanup plans for the river and harbor (Wisconsin DNR, 1990). The marked steelhead were stocked at 7.5 to 9 cm in size and were predicted to move out into Lake Michigan during the spring or summer of 1991. The study will be used to determine whether PCBs taken up by the young fish during this time contribute significantly to total PCB concentrations in returning adults.

- **Neglecting other chemicals, besides PCBs, may not be conservative.** No other chemicals, besides PCBs, were analyzed in the fish. Since PCBs are the primary organic contaminant in the Sheboygan River, the carcinogenic risk may be appropriate as calculated. Information on metals and other pesticides would have been necessary to estimate noncarcinogenic risks.

Overall, a moderate level of uncertainty appears to be associated with the carcinogenic risk estimates for people who consume fish from the Sheboygan River and have dermal contact with contaminated floodplain soils. These risk estimates will be most useful as a benchmark to compare against future risk estimates. In particular, the baseline carcinogenic risks presented in this report can be compared to the estimated risks resulting from different remediation scenarios.

CONCLUSIONS

The results of this baseline human health risk assessment indicate that fish consumption should be avoided from the Sheboygan River AOC. In addition, dermal exposure to floodplain soils appears to be of marginal concern under the reasonable maximum exposure scenario. The results of this risk assessment are not directly comparable to the human health endangerment assessment given in the RI/ES report because different exposure parameters were often used. However, some generalizations can be made between the two risk assessments.

- PCBs accounted for most (or all) of the carcinogenic risk.

- Concentrations of PCBs in fish tissue collected from the Sheboygan River have decreased over the past 10 years. Although the carcinogenic risk for the typical exposure scenario has decreased by one to two orders of magnitude compared to the RI/FS endangerment assessment, the estimated risk levels still warrant a fish advisory for the AOC.

- The RI/ES report indicated that the noncarcinogenic risk from either consuming fish or dermally exposing the feet to river bank soils was not significant. Likewise, if heavy metals had been measured in the fish and soil samples used in this risk assessment, the noncarcinogenic risks would probably have been below a level of concern.

TABLE 10. ESTIMATED CARCINOGENIC RISK DUE TO DERMAL EXPOSURE TO CONTAMINATED FLOODPLAIN SOILS, TYPICAL EXPOSURE SCENARIO

Site	PCB Conc. (mg/kg)	Age Group (years) 2-6	7-17	18-70	Lifetime
Esslinger Park	2.1	1.7E-07	2.0E-07	1.9E-07	6E-07
Kiwanis Park	1.5	1.2E-07	1.4E-07	1.4E-07	4E-07

TABLE 11. ESTIMATED CARCINOGENIC RISK DUE TO DERMAL EXPOSURE TO CONTAMINATED FLOODPLAIN SOILS, REASONABLE MAXIMUM EXPOSURE SCENARIO

Site	PCB Conc. (mg/kg)	Age Group (years) 2-6	7-17	18-70	Lifetime
Esslinger Park	2.1	9.7E-07	1.7E-06	1.7E-06	4E-06
Kiwanis Park	1.5	7.0E-07	1.2E-06	1.2E-06	3E-06

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*U.S. GOVERNMENT PRINTING OFFICE 1993-747-248