Health Consultation

MIDDLE TWIN LAKE FISH TISSUE STUDY

JOSLYN MANUFACTURING AND SUPPLY COMPANY SITE
CITY OF BROOKLYN CENTER, HENNEPIN COUNTY, MINNESOTA

EPA FACILITY ID: MND044799856

JUNE 23, 2006

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Public Health Service
Agency for Toxic Substances and Disease Registry
Division of Health Assessment and Consultation
Atlanta, Georgia 30333

Health Consultation: A Note of Explanation

An ATSDR health consultation is a verbal or written response from ATSDR to a specific request for information about health risks related to a specific site, a chemical release, or the presence of hazardous material. In order to prevent or mitigate exposures, a consultation may lead to specific actions, such as restricting use of or replacing water supplies; intensifying environmental sampling; restricting site access; or removing the contaminated material.

In addition, consultations may recommend additional public health actions, such as conducting health surveillance activities to evaluate exposure or trends in adverse health outcomes; conducting biological indicators of exposure studies to assess exposure; and providing health education for health care providers and community members. This concludes the health consultation process for this site, unless additional information is obtained by ATSDR which, in the Agency's opinion, indicates a need to revise or append the conclusions previously issued.

HEALTH CONSULTATION

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Prepared by:

The Minnesota Department of Health
Under Cooperative Agreement with the
Agency for Toxic Substances and Disease Registry
U.S. Department of Health and Human Services

FOREWORD

This document summarizes public health concerns related to a hazardous waste site in Minnesota. It is based on a formal site evaluation prepared by the Minnesota Department of Health (MDH). For a formal site evaluation, a number of steps are necessary:

- *Evaluating exposure:* MDH scientists begin by reviewing available information about environmental conditions at the site. The first task is to find out how much contamination is present, where it is found on the site, and how people might be exposed to it. Usually, MDH does not collect its own environmental sampling data. Rather, MDH relies on information provided by the Minnesota Pollution Control Agency (MPCA), the US Environmental Protection Agency (EPA), and other government agencies, private businesses, and the general public.

- *Evaluating health effects:* If there is evidence that people are being exposed—or could be exposed—to hazardous substances, MDH scientists will take steps to determine whether that exposure could be harmful to human health. MDH's report focuses on public health— that is, the health impact on the community as a whole. The report is based on existing scientific information.

- *Developing recommendations:* In the evaluation report, MDH outlines its conclusions regarding any potential health threat posed by a site and offers recommendations for reducing or eliminating human exposure to pollutants. The role of MDH is primarily advisory. For that reason, the evaluation report will typically recommend actions to be taken by other agencies—including EPA and MPCA. If, however, an immediate health threat exists, MDH will issue a public health advisory to warn people of the danger and will work to resolve the problem.

- *Soliciting community input*: The evaluation process is interactive. MDH starts by soliciting and evaluating information from various government agencies, the individuals or organizations responsible for the site, and community members living near the site. Any conclusions about the site are shared with the individuals, groups, and organizations that provided the information. Once an evaluation report has been prepared, MDH seeks feedback from the public. *If you have questions or comments about this report, we encourage you to contact us.*

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On the web: http://www.health.state.mn.us/divs/eh/hazardous/index.html

Summary

Fish tissue samples collected from Middle Twin Lake show that of the contaminants of concern at the Joslyn Manufacturing and Supply Company site, only dioxins and furans appear to be present at elevated concentrations. Concentrations of dioxins and furans in fish tissue from Middle Twin Lake are between five and forty times the respective concentrations measured in reference lakes. The reference lakes were selected for the study due to their similarity to Middle Twin Lake. However, dioxin and furan concentrations for fish from Middle Twin Lake do not differ significantly from concentrations found by EPA in samples from 58 lakes in Minnesota. Mercury and PCBs were detected in the fish tissue samples, although there is no evidence that their presence is related to site activities. Mercury and PCBs are found in fish in many lakes in Minnesota and throughout the world. Existing fish consumption advice for mercury and PCBs for Middle Twin Lake is protective for dioxins and furans.

I. Site Background and History

The Joslyn Manufacturing and Supply Company site, West Area (the site), is located in the City of Brooklyn Center, Minnesota, just northeast of the intersection of France Avenue and State Highway 100. The site is bounded on the west by Middle Twin Lake, on the north by the Soo Line railroad tracks, open space, and commercial/industrial properties with a residential neighborhood beyond, on the south by a residential neighborhood, and on the east by the development portion of the Joslyn site, France Avenue and Highway 100. The location of the site is shown in Figure 1.

Wood-preserving operations were conducted at the Joslyn site from the 1920's until 1980. Soil, sediment, and groundwater at the site are contaminated with pentachlorophenol (PCP) and polynuclear aromatic hydrocarbons (PAHs). Polychlorinated dibenzo-p-dioxins and furans (dioxins and furans), common contaminants of PCP, have also been detected in soil, sediment, and groundwater at the Joslyn site, including the West Area. The entire site was listed on the National Priorities List (NPL) in 1983, but the majority of the Joslyn site (with the exception of the westernmost portion, a wooded/wetland area known as the “West Area” that occupies about 30% of the site) was de-listed from the Permanent List of Priorities (PLP), the state Superfund list, and from the NPL following cleanup and redevelopment. The ongoing investigation of the West Area remains under the oversight of the MPCA Superfund Program. The West Area is located on private property owned by Joslyn.

MDH has conducted several evaluations of the Joslyn site, most recently a Public Health Assessment focusing on the West Area (MDH 2002). That document contains detailed information on contamination found in the West Area, which is adjacent to Middle Twin Lake. The 2002 report also documents investigations conducted in Twin Lakes itself, including an investigation conducted in 1950 in response to a reported fish kill. Because contaminants from the Joslyn site and West Area may have reached Twin Lakes, one of the MDH recommendations in the 2002 Public Health Assessment for the West Area was as follows:

> "Representative samples of various fish species from Twin Lakes should be collected and analyzed for dioxins and furans to determine if concentrations of these contaminants in the fish population could pose an unacceptable health hazard. Samples from other urban lakes may be needed for comparison since dioxins are ubiquitous in the environment."

MDH staff were requested by MPCA Superfund Program staff to conduct a review of the results of a fish tissue study of Middle Twin Lake conducted by Joslyn in 2005, and to develop conclusions and recommendations regarding any public health concerns suggested by the results.

Middle Twin Lake

Middle Twin Lake lies adjacent and just west of the West Area of the Joslyn site (see Figure 1). It is also referred to as the middle bay or section of Twin Lakes. The lake has a surface area of approximately 70 acres, and a maximum depth of 45 feet (DNR 2005). The lake is used for recreation year-round, including swimming, boating, and fishing in the summer months and ice fishing, skiing, and snowmobiling in the winter months. A swimming beach is located in a city park on the southeast shore of Middle Twin Lake, as is a public water access point/boat landing (see Figure 3). Other public water access points are located in Upper and Lower Twin Lakes. Groundwater in the area flows from the lake to the east, towards the Joslyn site (Barr 2005). Stormwater from the Joslyn site indirectly discharges to Middle Twin Lake during heavy rainfall events.

According to a Minnesota Department of Natural Resources (DNR) lake survey conducted in 2002, black crappie is the most abundant panfish species in the lake, but tend to be small (DNR 2005). Bluegill and yellow perch are also common, and also are small. Northern pike were abundant, and reach a desirable size for sport fishing. In the 2002 lake survey, 56 northern pike were caught. The northern pike averaged 23.1 inches in length and 3.0 pounds in weight. The largest northern pike was 32.6 inches in length. No walleye and only one largemouth bass were caught in the 2002 DNR lake survey, indicating that northern pike are the dominant predator fish in the lake. Rough fish (dogfish, common carp, and bullhead) are also common in the lake. Carp averaged 3.5 pounds in weight and 18.6 inches in length.

Middle Twin Lake Fish Tissue Study

In April of 2004, the MPCA requested that Joslyn develop a workplan for collecting fish tissue samples from Middle Twin Lake for analysis for the site contaminants of concern: PCP, PAHs, and dioxins/furans. An initial workplan was submitted in September of 2004, and a final workplan incorporating MPCA and MDH comments on the proposed fish tissue study was submitted to the MPCA in January 2005 and approved by the MPCA in February 2005 (Barr 2005).

In the workplan, Barr, the consultant for Joslyn, stated that the purpose of the study was "to assess the potential human health risks associated with exposure to contaminants of potential concern (COPCs) in select fish species in Middle Twin Lake in comparison to reference lakes in the Minneapolis-St. Paul metropolitan area" (Barr 2005). Barr selected reference lakes for the study based on their similar characteristics to Middle Twin Lake using criteria they developed including water quality and geographic location in the metro area. The Barr workplan also included analysis of the fish tissue for mercury and polychlorinated biphenyls (PCBs), though neither has been considered contaminants of concern at the Joslyn site. These two contaminants are persistent, accumulate in fish tissues, and are found in lakes and rivers throughout North America as a result of human activities. The reference lakes and the Twin Cities suburbs they are located in were as follows:

- Medicine Lake, Plymouth
- Crystal Lake, Robbinsdale
- Snail Lake, Shoreview
- Eagle Lake, Maple Grove
- Lotus Lake, Chanhassen
- Long Lake, Long Lake

The locations of the reference lakes in relation to Middle Twin Lake are shown in Figure 2.

Fish samples were collected by the DNR from Middle Twin Lake and the six Twin Cities area reference lakes between May and July 2004 during routine lake survey operations (Barr 2005). A number of techniques were used, including electrofishing (which uses an electric charge to stun fish to the surface), gill nets, and trap nets. The locations in Middle Twin Lake where the fish were collected by the various methods are shown in Figure 3.

Per the MPCA approved workplan, individual fillets of 10 northern and 13 carp from Middle Twin Lake were prepared for analysis. For black crappie, composite fillet samples were prepared from five groups of 10 fish each yielding five separate composite samples. For each of the reference lakes, composite samples of northern pike, carp, and black crappie were prepared by species from single fillets from up to 10 individual fish. This was done to increase the number of available reference lake samples and reduce analytical costs (Barr 2005). The remaining fish fillets were retained by the laboratory for possible future analysis. To produce comparable results, fish that were not within approximately 75% to 100% of the size of the largest fish from Middle Twin Lake were not included in the reference lake composite samples. Some species were not found in some of the reference lakes. The numbers and size ranges of the various fish collected from Middle Twin Lake and the reference lakes are shown in the table below:

Lake	Fish Species	Number of Fish	Size Range, inches
Middle Twin	Northern Pike	10*	20 – 25
	Carp	13*	18 – 22
	Black Crappie	50#	4.5 – 8
Medicine Lake	Northern Pike	6	19.5 – 23.75
	Carp	3	17 – 20.25
	Black Crappie	8	5.75 – 8.25
Crystal Lake	Northern Pike	9	21 – 26
	Black Crappie	10	5.75 – 8.5
Snail Lake	Northern Pike	10	19 – 24
Eagle Lake	Northern Pike	5	20.25 – 23.25
	Carp	2	19 – 22.5
	Black Crappie	6	6.5 – 9
Lotus Lake	Northern Pike	1	25
	Carp	5	20.75 – 23
	Black Crappie	9	6.25 – 7.25
Long Lake	Northern Pike	9	19.5 – 25
	Carp	2	17 – 17.25
	Black Crappie	8	6 – 8.25

*Analyzed as individual fillets.
Analyzed as five composite samples of ten fish each.

The fish were individually wrapped in foil and frozen as soon as possible after collection for storage prior to transfer to laboratories operated by Columbia Analytical Services for analysis for PAHs, PCP, PCBs, mercury, and dioxins/furans. The data from the laboratory was reviewed by Barr and appeared to meet the data quality objectives for the study, with a few minor exceptions.

MDH staff have reviewed the data from the Middle Twin Lake fish tissue study, as well as available reference data from the EPA National Study of Chemical Residues in Lake Fish Tissue (EPA 2005). A summary of the Middle Twin Lakes fish tissue study results is presented in the results and discussion section, and the data are presented in Tables 1-4 and Figures 4-6.

Site Visit

MDH staff have conducted numerous site visits to the Joslyn site and Twin Lakes area, as documented in the 2002 Public Health Assessment (MDH 2002). Since that report, MDH staff have also attended a meeting of the Twin Lakes area lake association to discuss contamination issues related to the Joslyn site.

II. Results and Discussion

The purpose of the Middle Twin Lake fish tissue study was to determine if site related contaminants were present in fish, and to evaluate the potential human health risks associated with consumption of the fish found in Middle Twin Lake. The main site related contaminants of concern in fish species are dioxins and furans, as PCP and PAHs do not bioaccumulate substantially under most environmental conditions (ATSDR 1994, 1995). The responsible parties for the Joslyn site also included analyses for mercury and PCBs to determine if the lake differs from other lakes with regards to these ubiquitous contaminants.

PAHs are produced by the incomplete combustion of organic materials, and as a result are ubiquitous in urban environments. They can be divided into two groups based on their toxicological properties: those that are carcinogens and those that are non-carcinogens. Carcinogenic PAHs have been found to cause cancer in animals at high doses, and one PAH (benzo(a)pyrene) is classified as a known human carcinogen. Exposure to high levels of PAH mixtures (such as direct exposure to creosote) has also been associated in animals with reproductive difficulties and adverse effects on the skin and immune system. Adverse effects on the liver and gastro-intestinal tract have also been noted. No carcinogenic PAHs were detected in any of the fish samples from Middle Twin Lake; carcinogenic PAHs were detected in one fish sample (a black crappie composite sample) from one of the reference lakes. Very low concentrations (in the 10-20 part per billion range) of some non-carcinogenic PAHs (primarily naphthalene) were consistently detected in the fish samples from Middle Twin Lake and from the six reference lakes.

PCP was widely used as a wood treatment chemical, and was used extensively at the Joslyn site. Soil and groundwater contaminated with PCP remains on the West Area of the Joslyn site (MDH 2002). Short-term exposure to high concentrations of PCP (as in direct contact with the pure chemical) is associated with adverse effects to the kidneys, blood, lungs, nervous system, immune system, and gastrointestinal tract (ATSDR 1994). Long-term exposure to low levels of PCP, such as what might be found at contaminated sites where PCP was used or disposed, can cause damage to the liver, kidneys, blood, and nervous system. PCP is considered a probable human carcinogen. Some of the adverse effects associated with exposure to PCP may be caused by impurities present in commercially produced PCP, such as dioxins and furans. In fish samples from Middle Twin Lake, PCP was not detected in many of the samples, and in those samples in which PCP was detected (nine northern pike fillets and two carp fillets) the concentration was within five times of the method blank sample result, so the results are considered estimates only. Similar results were seen in the reference lake samples, with all of the positive results flagged as estimated values because they were below the laboratory quantification limit.

PCBs are oily liquids or solids that were widely used as coolants and lubricants in transformers, capacitors, and other electrical equipment (ATSDR 1998b). In 1977, EPA banned the manufacture and use of PCBs in the United States because of evidence that PCBs build up in the environment and have harmful effects. PCBs are ubiquitous in the environment, and have been detected in fish tissue samples from lakes across the United States (EPA 2005). Individual PCBs are known as congeners, which vary mainly in chlorine content. Commercial mixtures of PCBs (known as aroclors), used as coolant in electrical equipment such as large transformers are generally described by the number of carbon atoms and the percent chlorine content of the mixture (ATSDR 1998b). For example, aroclor 1254 refers to a PCB mixture containing 12 carbon atoms in the biphenyl group and average chlorine content of 54%. Analysis for PCBs can be by individual congener, or by aroclor mixture. PCBs with higher chlorine content tend to be more stable and persistent in the environment. Exposure to PCBs is linked to development problems in children whose mothers were exposed to PCBs before becoming pregnant. PCBs also cause changes in human blood, liver, and immune functions of adults. In addition, PCBs cause cancer in laboratory animals and may cause cancer in humans (ATSDR 1998b).

PCBs (aroclors 1254 and 1260 only) were detected in all ten northern pike and 13 carp fillets from Middle Twin Lake, and in composite samples from five of the six northern pike and four of four carp from reference lakes. PCB concentrations in northern pike and carp from Middle Twin Lake were higher than PCBs in fish from the reference lakes. PCBs were detected in all five composite samples of black crappie from Middle Twin Lake, and in three of five composite reference lake samples. The concentrations of PCBs in Middle Twin Lake black crappie were slightly higher than that observed in fish from the reference lakes. Summary PCB data is presented in the table below.

Mercury is a naturally occurring metal that is also released to the environment from man-made sources such as coal-fired power generation and waste incineration (ATSDR 1999). In the environment, metallic mercury is converted to methylmercury by microorganisms. In lakes and streams, fish take up the methylmercury, and when these fish are eaten by larger fish methylmercury is transferred. In this way, predator fish may accumulate large amounts of methylmercury from the environment. Mercury may harm the human nervous system and other organs. Young children and developing fetuses are at most risk, because relatively small amounts of mercury can damage the brain during early stages of development. Exposure to too much mercury may affect a child’s behavior and lead to learning problems later in life. The first symptoms of adult mercury poisoning include lack of coordination and a burning or tingling sensation in the fingers and toes. As mercury levels increase in the body, vision, hearing, speech, and coordination may all be subtly affected.

Mercury was detected in all fish samples from Middle Twin Lake and the reference lakes. The mercury results for northern pike and carp from Middle Twin Lake were considered estimated low due to quality assurance issues. The average concentration of mercury was higher in carp and black crappie from Middle Twin Lake as compared to the reference lakes, and in northern pike it was about the same. Summary mercury data is presented in the table below.

In 1995 and 2002, as a part of the interagency Fish Contaminant Monitoring Program (a joint effort of the MPCA, DNR, and MDH), the Minnesota DNR collected fish samples from Middle Twin Lake for analysis for PCBs and mercury. Northern pike, carp, and black crappie were collected for analysis of fillets for mercury, and carp fillets were also analyzed for PCBs. The mean results for the 2002 DNR samples, along with the 2005 Barr study results from Middle Twin Lake and the reference lakes are shown in the table below:

Fish Species	No. of Samples	Mean Mercury, mg/kg (ppm)	Mean PCBs, mg/kg (ppm)
Northern Pike:			
DNR, 2002	5	0.275	Not analyzed
Barr, 2005	10	1.00	0.125
Ref. Lakes, Barr 2005	6*	1.048	.0495[@]
Carp:			
DNR, 2002	4	0.057	0.070
Barr, 2005	13	0.288	0.417
Ref. Lakes, Barr 2005	4*	0.168	0.036
Black Crappie:			
DNR, 2002	12	0.115	Not analyzed
Barr, 2005	5*	0.440	0.041
Ref. Lakes, Barr 2005	5*	0.268	0.029[#]

*Composite samples
[@]PCBs detected in 5 of 6 composite samples only
[#]PCBs detected in 3 of 5 composite samples only

The 2002 DNR mercury and PCB results for Middle Twin Lake are clearly lower than the 2005 Barr fish study results. This is somewhat surprising given that the 2002 DNR fish were in general somewhat larger than the 2005 Barr study fish. The reason for the differences is not entirely clear, but could include differences in sample preparation or laboratory analytical methods. In addition, the 2005 Barr data for PCBs represents the sum of the aroclor mixtures, while the 2002 DNR data, which is also reported using aroclors, includes a factor to account for the overlap in individual PCB congeners between aroclor mixtures. This would tend to make the Barr data biased high as compared to the DNR data.

Dioxins and furans are a family of 210 similar compounds, or congeners, of which 17 are suspected to be toxic because they contain chlorine atoms in the 2,3,7,8 substituted positions and are therefore thought to act through a similar toxicological mechanism. One dioxin congener (2,3,7,8 tetrachloro dibenzo-p-dioxin (TCDD)) is thought to be the most toxic and has been studied extensively. TCDD is classified by the EPA as a known human carcinogen, while mixtures of dioxins commonly found in the environment are considered likely human carcinogens. Penta- and hexachloro-dioxins with chlorine atoms in the 2, 3, 7 and 8 positions appear to have similar toxicities, while other dioxins that do not have chlorine atoms in those positions are relatively less toxic (ASTDR 1998a; Van den Berg et al 1998). Exposure to high levels of dioxins is associated with chloracne, a severe skin disease, as well as other skin disorders. Such skin diseases usually result only from exposure to high concentrations for an extended time period, such as in the workplace or from an industrial accident. Studies in animals have shown that long-term exposure to lower levels of dioxins can affect the liver, and may cause reproductive, developmental, and immune system effects in addition to cancer.

To assess the toxicity of mixtures of the 17 dioxins and furans of concern, toxic equivalency factors (TEFs) have been developed by the World Health Organization (WHO) that use the toxicity of 2,3,7,8 as the reference compound for comparison (Van den Berg et al 1998). This allows for the calculation of a single total estimated dioxin concentration for a given sample based on the application of the TEFs to each of the 17 individual 2,3,7,8-substituted congeners. The sum of the individual TEF values are often referred to as "TCDD equivalents."

Dioxins and furans are also ubiquitous in the environment (generally at part per trillion levels) as a result of natural and man-made processes such as waste combustion. They are persistent, and fish have been shown to accumulate dioxins and furans from water, sediments, and through the aquatic foodchain. They also become concentrated in the tissues of larger animals, especially in the fatty tissue. (ATSDR 1998a).

Dioxins and furans are also common contaminants of PCP. During PCP production, a variety of different congeners were typically formed, with dioxins and furans containing six, seven, and eight chlorine atoms making up by far the highest proportion of the congeners produced and dioxins being present in much greater proportion than furans (EPA 2000a; Fries et al 2002). The proportion of dioxin congener groups found in soil samples at the Joslyn site closely follows the typical congener profile for PCP (MDH 2002; EPA 2000a).

Dioxin and furan results are shown in Tables 1-4, and displayed graphically in Figures 4-6. In the tables, both individual dioxin and furan congener concentrations as well as total TCDD equivalents are listed for individual fish and composite samples. Figures 4-6 show the mean (colored column) and mean plus one standard deviation (error bar) for each of the 17 individual dioxin and furan congeners of interest by fish species for Middle Twin Lake and the reference lakes. All data qualified as "estimated values" were used; other data qualifiers were ignored, and all detections of dioxin and furans were included in the analysis. Summary statistics for TCDD equivalents are presented in the table below:

Fish Species	**No. of Samples w/Detects**	**Mean TCDD Equivalents, ppt**	**Range of TCDD Equivalents, ppt**
Northern Pike:			
Middle Twin	10	0.0228	0.00002 – 0.0338
Reference Lakes	2	0.00427	0.000327 – 0.00821
Carp:			
Middle Twin	13	0.555	0.00022 – 1.98775
Reference Lakes	3	0.0137	0.0001 – 0.0248
Black Crappie:			
Middle Twin	5	0.000786	0.00003 – 0.00295
Reference Lakes	1	0.000062	0.000062

Dioxins and furans were detected in all ten northern pike fillets collected from Middle Twin Lake, with multiple congeners detected in nine of the ten fish. Assuming congeners not found above laboratory detection limits were not present in a sample (a standard assumption that will be used in this report) the mean TCDD equivalents for the ten fish was 0.0228 parts per trillion (ppt). Fourteen of the 17 congeners were detected. Larger fish tended to have higher TCDD equivalents. In the reference lakes, dioxins and furans were detected in northern pike composite fillet samples from two of the six lakes, and only four congeners were detected. The mean TCDD equivalent for the two reference lake composite fillet samples was 0.00427 ppt. The mean concentration of dioxins and furans in TCDD equivalents in northern pike from Middle Twin Lake was approximately five times that of the reference lakes.

Dioxins and furans were detected in all thirteen carp fillets collected from Middle Twin Lake, with multiple congeners (up to 15 of 17) detected in all but one of the thirteen fish. Carp from Middle Twin Lake were the only fish in which TCDD, the most toxic dioxin congener, were detected. The mean TCDD equivalent for the thirteen fish was 0.555 ppt. The highest total TCDD equivalent detected in carp (1.98 ppt) was from the largest carp caught, which was 22 inches in length. In the reference lakes, dioxins and furans were detected in carp composite fillet samples from three of the four lakes where carp were caught. Three congeners were detected. The mean TCDD equivalent for the three reference lake composite fillet samples was 0.0137 ppt. The mean concentration of dioxins and furans in TCDD equivalents in carp from Middle Twin Lake was approximately forty times that of the reference lakes.

Dioxins and furans were detected in all five composite black crappie samples collected from Middle Twin Lake, with multiple congeners detected in two of the five samples. The mean TCDD equivalent for the five composite samples was much lower than that found in northern pike or carp, 0.000786 ppt. In the reference lakes, only one dioxin congener, octachloro dioxin, was detected in one composite sample from one of the five lakes. The TCDD equivalent for the composite sample was 0.000062 ppt. The mean concentration of dioxins and furans in TCDD equivalents in black crappie from Middle Twin Lake was approximately twelve times that of the reference lakes. Black crappie are a smaller, shorter-lived species that feed lower on the foodchain, and this may account for the much lower overall dioxin and furan concentrations detected.

<u>Dioxins in Minnesota Fish: EPA National Fish Tissue Study</u>
EPA has conducted a four-year national freshwater fish contamination survey to estimate the distribution of selected persistent, bioaccumulative and toxic chemicals in fish tissue (EPA 2005). The purpose of the study is to generate the first national estimates of mean concentrations for these chemicals in lake fish, define a national fish contamination baseline to track progress of pollution control activities, and identify areas where contaminant levels are high enough to warrant further investigation. The data are not intended for the generation of fish consumption advice.

EPA worked with partner agencies (including MDH and DNR) over a four-year period (2000-2003) to collect fish from 500 lakes and reservoirs selected randomly from the estimated 147,000 target lakes and reservoirs in the lower 48 states. The study included 57 lakes in Minnesota, plus “Lake Pepin,” which is actually part of the Mississippi River. A large majority of the lakes were located outside of the Twin Cities metropolitan area.

Sampling teams applied consistent methods nationwide to collect composites of one predator species and one bottom-dwelling species from each lake selected for the study. Composites consist of five adult fish of similar size that are large enough to provide 20 ounces of tissue for analysis of fillets for predators and whole bodies for bottom dwellers. Each composite sample was analyzed for 268 chemicals, including mercury, PCBs, PCP, dioxins and furans, and PAHs.

The EPA study has generated the first comprehensive and consistent set of data on levels of dioxins and furans in fish tissue in Minnesota. The data include multiple samples for northern pike and carp, but no black crappie were collected. The table below contains the summary data for 58 Minnesota lakes, including Lake Pepin which is part of the Mississippi River. Data for bluegill, a smaller panfish species, are included to provide a panfish analog for black crappie samples collected by Barr. Also included for reference are PCB and mercury data. The EPA PCB data represent the sum of individual PCB congeners and not aroclor mixtures as was reported in the Barr analysis, so the results are not directly comparable. Note that PCP and PAHs were usually not found above detection limits in the EPA study fish, although the laboratory analytical detection limits were higher than those used in the Middle Twin Lake fish tissue study.

Fish Species	**No. of Samples**	**Type of Sample**	**Mean TCDD Equivalents, ppt**	**Mean PCBs, ppm**	**Mean Mercury, ppm**
Northern Pike	25	Fillets	0.0265	0.003472	0.2705
Carp	7	Whole Fish	0.633	0.049114	0.0555
Bluegill	5	Fillets	0.0004	0.0005204	0.0579
All Predators	61	Fillets	0.0335	0.011421	0.2551
All Bottom Feeders	57	Whole Fish	0.271	0.025274	0.0652

The concentrations of dioxins and furans in fish samples collected for the EPA study are similar to those found in Middle Twin Lake by Barr, while the Barr reference lake fish samples generally contained lower concentrations of dioxins and furans. The EPA data for PCBs and mercury are also comparable to the 2002 DNR data for Middle Twin Lake. The Barr PCB data may be biased high due to methodological and analytical differences as discussed above.

<u>Dioxins in the Diet and Human Exposure</u>

As described previously, dioxins are found nearly everywhere in the environment. Dioxins have been found in the fat tissue of humans across the U.S., even in those who have no known exposure to dioxins. This indicates that human exposure is widespread, with the most common exposure being through the food supply. The current estimate of the mean daily exposure in the general U.S. population to dioxins and furans is approximately one picogram per kilogram of body weight per day (1 pg/kg/day) in TCDD equivalents (EPA 2000a). A picogram is one-trillionth of a gram (0.000000001 gram).

Certain sub-populations who eat a particularly fatty diet, such as subsistence fishermen and nursing infants may have a higher daily intake. Dioxins may also be passed from mother to infant through breast milk, which is high in fat. Studies have shown, however that levels of dioxins and furans measured in human body fat samples have declined from the early 1980s to the present as a result of the increased regulation of emission sources and the subsequent decrease in levels of dioxins measured in the environment (EPA 2000a). Several studies have estimated the percentage of dioxin/furan intake through the food supply by measuring dioxins and furans in a wide variety of food products. Studies consistently show that foods containing animal fat, such as meat and dairy products, are the most common dietary sources. The following table is a summary from one recent study (South et al 2004) of dioxin/furan levels in various food products; other recent studies have shown similar results.

Food Category	**Percentage of Total Dietary Intake of Dioxins/Furans***
Meat	43.7%
Other foods	14.8%
Dairy foods	14.5%
Fruits and vegetables	9.5%
Fish	8.6%
Poultry	4.7%
Eggs	2.6%
Fats and oils	1.6%

* For all age/sex groups, with non-detections equal to zero (from South et al 2004).

Based on these data, fish represent a smaller source of dioxins and furans in the diet of the average American, especially compared to other common sources of protein such as meat and dairy products.

<u>Existing Fish Consumption Advice for Middle Twin Lake</u>

Fish consumption advice for lakes and rivers in Minnesota is based on measured concentrations of PCBs and mercury in fish tissues. Based on analysis for mercury and PCBs of the 2002 DNR fish samples from Twin Lakes, MDH has developed fish consumption advice for the lake for the most common species typically consumed by people (DNR 2005). Because they may be more vulnerable to adverse health effects as a result of exposure to mercury, more conservative meal advice is given for pregnant women, women who may become pregnant, and children under age 15 than for the general population. The current MDH fish consumption advice for Twin Lakes is as follows:

Pregnant Women, Women who may become Pregnant, and
Children under Age 15:

Species	**Size Range**	**Meal Advice**	**Basis**
Black Crappie	< 15”	1 meal per week	Mercury
Carp	15” – 25”	1 meal per month	PCBs
Northern Pike	15” – 25”	1 meal per week	Mercury
	25” +	1 meal per month	Mercury

General Population:

Species	Size Range	Meal Advice	Basis
Black Crappie	< 15”	Unlimited	Mercury
Carp	15” – 25”	1 meal per month	PCBs
Northern Pike	15” – 20”	Unlimited	Mercury
	20” +	1 meal per week	Mercury

PCBs and dioxins build up in the body over time. It may take months or years of exposure, such as through regularly eating contaminated fish, however, to accumulate levels of health concern. At consumption rates specified in the fish advisory, the amount of methylmercury taken into the body is safely eliminated between meals. The consumption advice given by the MDH is intended to keep the mercury below levels that damage the human nervous system, and PCBs below levels intended to protect children from developmental problems. The MDH does not specifically factor in carcinogenicity of PCBs for fish consumption advice.

Currently, cancer will affect about one in every two people in Minnesota over their lifetimes, primarily due to smoking, diet, and hereditary risk factors (MDH 2005). In following the Minnesota fish consumption advisory over a lifetime, using Environmental Protection Agency methods to calculate risk from a lifetime of eating contaminated fish, it is estimated that approximately one additional cancer case may develop in 10,000 people eating fish contaminated with PCBs at levels commonly found in Minnesota fish (EPA 2000b). The added cancer risk from dioxins and furans in Minnesota fish based on data from the EPA study is about the same or less. Eating fewer meals of contaminated fish will further decrease the estimated cancer risk from fish.

Fish absorb fat-soluble chemicals like PCBs and dioxins from water, suspended sediments, and food. Larger, older fish and fish which eat other fish accumulate more contaminants than smaller, younger fish which eat less contaminated prey. PCBs and dioxins concentrate in the fat of fish, and especially in fatty fish such as carp and catfish. Cleaning and cooking a fish to remove fat will lower the amount of PCBs and dioxins in a fish meal. A recent study showed that grilling of fish removed an average of 41% of dioxins and 24% of furans present in the fish (Hori et al 2005). EPA states that higher reductions from cooking and cleaning may occur for some persistent contaminants in other fish species including an up to 80% reduction of TCDD observed in white bass from the Great Lakes (EPA 2000b). In developing fish consumption advice for PCB-contaminated fish, MDH assumes a 50% reduction factor due to cleaning and cooking, a factor proposed in a 1993 report by the Great Lakes Sport Fish Advisory Task Force (Anderson et al 1993). The states in the Task Force agreed to the use of a 50% reduction factor for most species after review of a number of documents related to contaminant reduction through various preparation methods. The Task Force recognized that there may be inter-species variability in contaminant reduction, but felt that by following the suggested guidelines, the 50% reduction factor provided a good estimate for the various species encountered by consumers of sport fish.

Fish can be part of a healthy, balanced diet. Fish are generally low in fat and high in protein. Fish contain a number of vitamins and minerals, and are the primary food source for long-chain omega-3 fatty acids. Studies suggest that omega-3 fatty acids are important during fetal brain and eye development, and may help to prevent heart disease in adults. Health and nutrition experts recommend that regular consumption of fish be included as part of a healthy diet.

Based on an analysis of the dioxin/furan concentrations in Middle Twin Lake fish tissue and the EPA study data for Minnesota, MDH staff have concluded that dioxin levels are approximately equal in the two sets of data. Fish represent only one source of dioxin in the diet, and the intake of dioxin might even be higher if fish consumption was decreased. Because consuming fish can have clear health benefits, MDH has made a risk policy decision not to issue separate fish consumption advice for dioxins in fish in Middle Twin Lake. MDH has determined that to warrant more stringent fish consumption advice than already exists for Middle Twin Lake, the dioxin data would need to be a clearly higher than the EPA data for other Minnesota lakes.

Child Health Considerations

ATSDR and MDH recognize that the unique vulnerabilities of infants and children make them of special concern to communities faced with contamination of their water, soil, air, or food. Children are at greater risk than adults from certain kinds of exposures to hazardous substances. They are more likely to be exposed because they play outdoors and they often bring food into contaminated areas. They are smaller than adults, which means they breathe dust, soil, and heavy vapors close to the ground. Children also weigh less, resulting in higher doses of chemical exposure per body weight. The developing body systems of children can sustain permanent damage if toxic exposures occur during critical growth stages. Most importantly, children depend completely on adults for risk identification and management decisions, housing decisions, and access to medical care.

Children who consume fish from Middle Twin Lake may be exposed to site related contaminants such as dioxins and furans. By following existing fish consumption advice, however, these exposures should be of minimal concern.

III. Conclusions

Fish tissue samples collected from Middle Twin Lake show that of the contaminants of concern at the Joslyn site, only dioxins and furans appear to be present at elevated concentrations. Concentrations of dioxins and furans in fish tissue from Middle Twin Lake are between five and forty times the respective concentrations measured in reference lakes selected for the study due to their similarity to Middle Twin Lake. However, dioxin and furan concentrations for fish from Middle Twin Lake do not differ significantly from concentrations found by EPA in samples from 58 lakes in Minnesota. Mercury and PCBs were also detected at higher levels than in fish samples from reference lakes although there is no evidence that their presence is related to site activities. Mercury and PCB levels in Middle Twin Lake fish were considerably lower in samples collected by the DNR in 2002. Analytical problems and differences may be responsible for the discrepancies. MDH considers dioxins and furans in fish in Middle Twin Lake to represent no apparent public health hazard at this time if people follow existing fish consumption advice.

IV. Recommendations

1. People who consume fish from Twin Lakes should follow the existing MDH fish consumption advice.
2. The interagency Fish Contaminant Monitoring Program should review the 2005 Barr data on mercury and PCBs in Middle Twin Lake fish and collect new fish samples from Middle Twin Lake for analysis for mercury and PCBs.
3. Representative sediment samples should be collected from Middle Twin Lake to determine if there is a human health risk from direct exposure to the sediments and to determine if there is a future risk to fish if the sediments are disturbed.
4. The responsible party for the Joslyn site should continue working towards cleanup of the West Area to prevent future releases of site related contaminants to Middle Twin Lake.

V. Public Health Action Plan

MDH's Public Health Action Plan for the site consists of continued consultation with MPCA, DNR, and City of Brooklyn Center staff on site activities, communication of the results of this report to neighborhood residents near the site, and participation in any planned public outreach activities.

VI. References

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CERTIFICATION

This Joslyn Manufacturing and Supply Company, Middle Twin Lake Fish Tissue Study Health Consultation was prepared by the Minnesota Department of Health under a cooperative agreement with the Agency for Toxic Substances and Disease Registry (ATSDR). It is in accordance with approved methodology and procedures existing at the time the health consultation was begun. Editorial review was completed by the Cooperative Agreement partner.

Alan Parham
Technical Project Officer, SPS, SSAB, DHAC
ATSDR

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

Alan Yarbrough
Chief, State Program Section, SSAB, DHAC, ATSDR

Figure 1: Joslyn Site and Middle Twin Lake Location

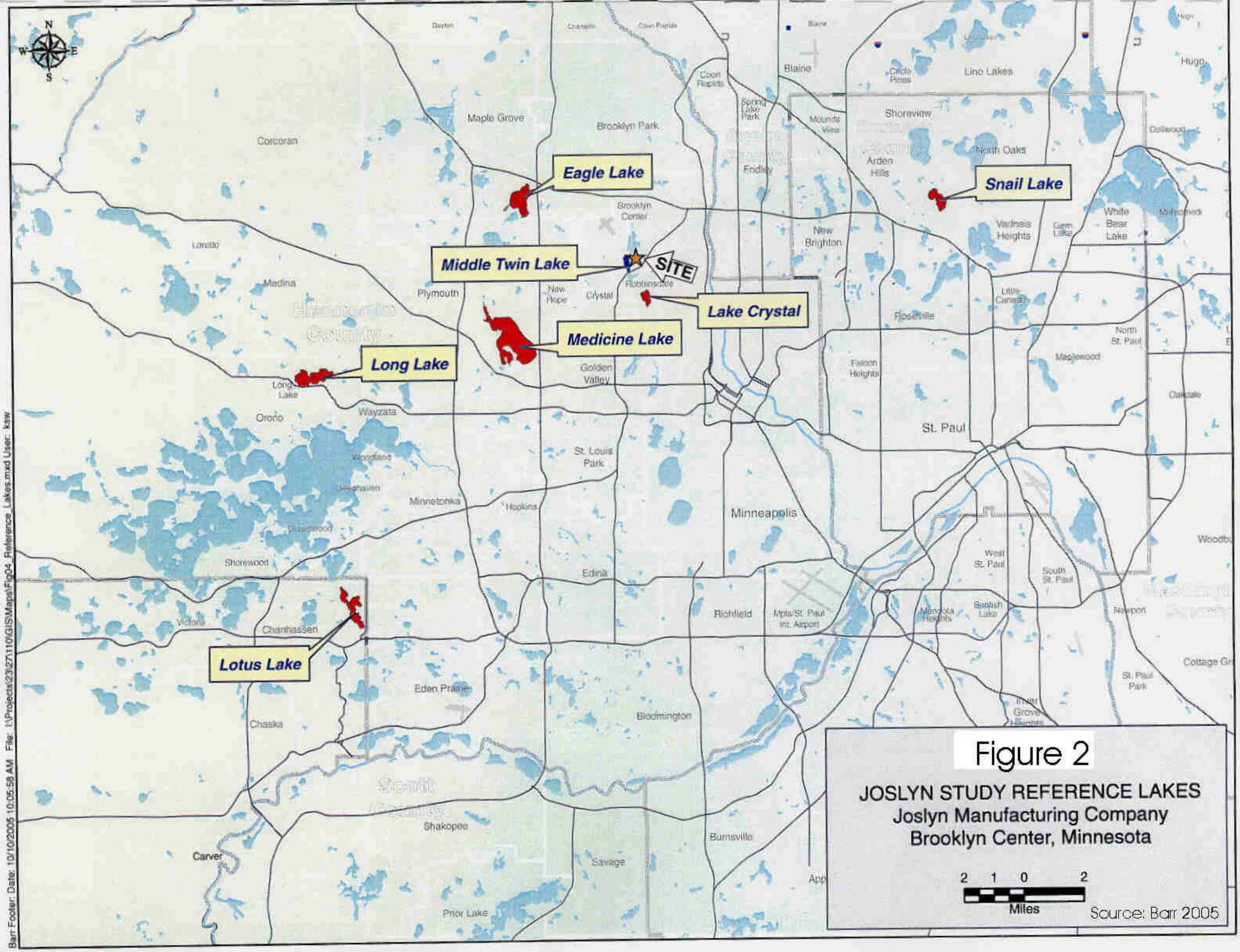
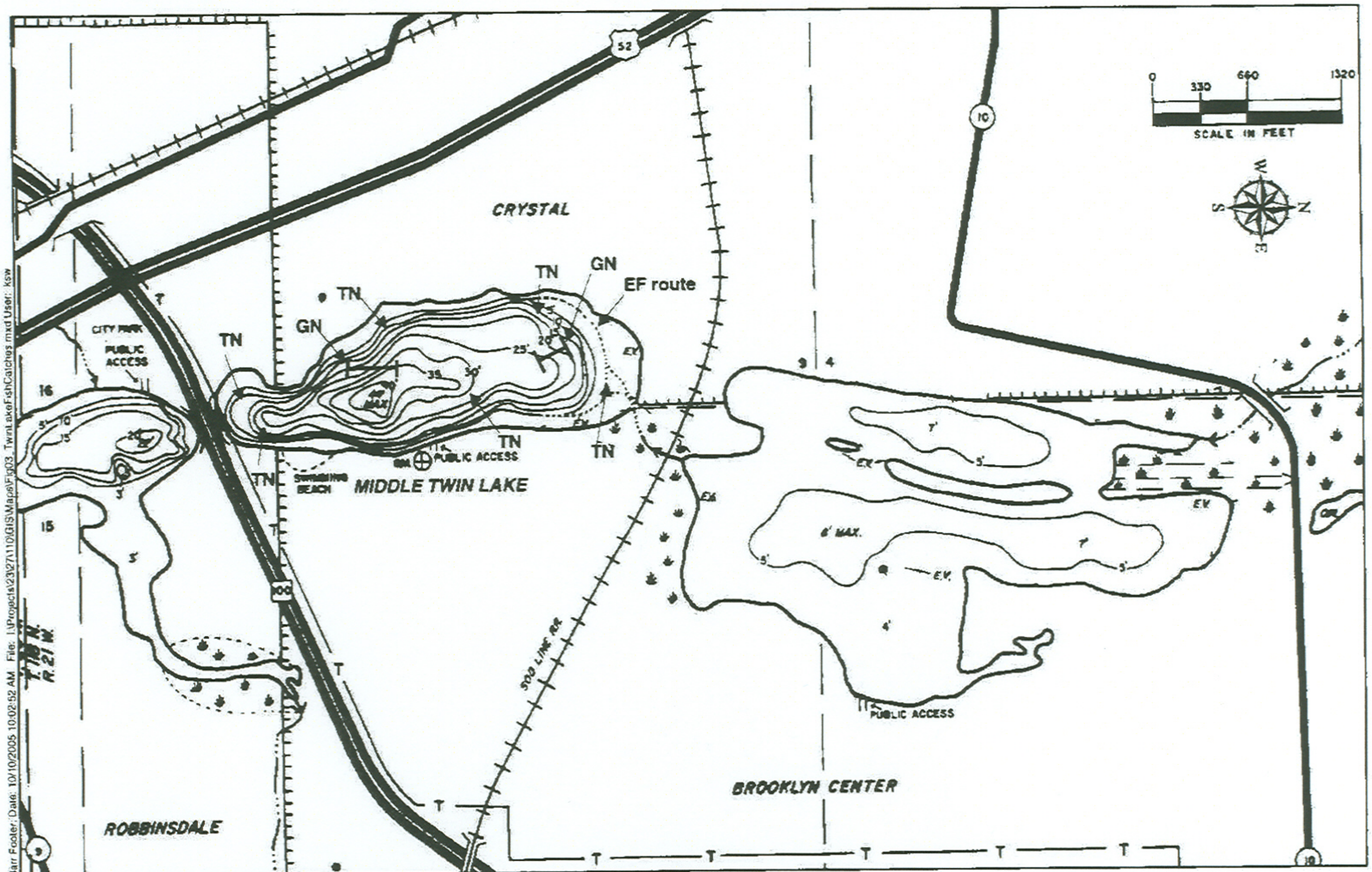


Figure 2

JOSLYN STUDY REFERENCE LAKES
Joslyn Manufacturing Company
Brooklyn Center, Minnesota



MN DNR Lake Map

EF = Electrofishing (Carp)

GN = Gill Net

TN = Trap Net (Northern Pike and Black Crappie)

Source: Barr 2005

Figure 3

LOCATIONS OF FISH CATCHES AT MIDDLE TWIN LAKE

Joslyn Manufacturing Company

Brooklyn Center, Minnesota

Figure 4: Northern Pike Dioxin/Furan Congener Concentration Profile, Reference Lakes vs. Middle Twin Lake

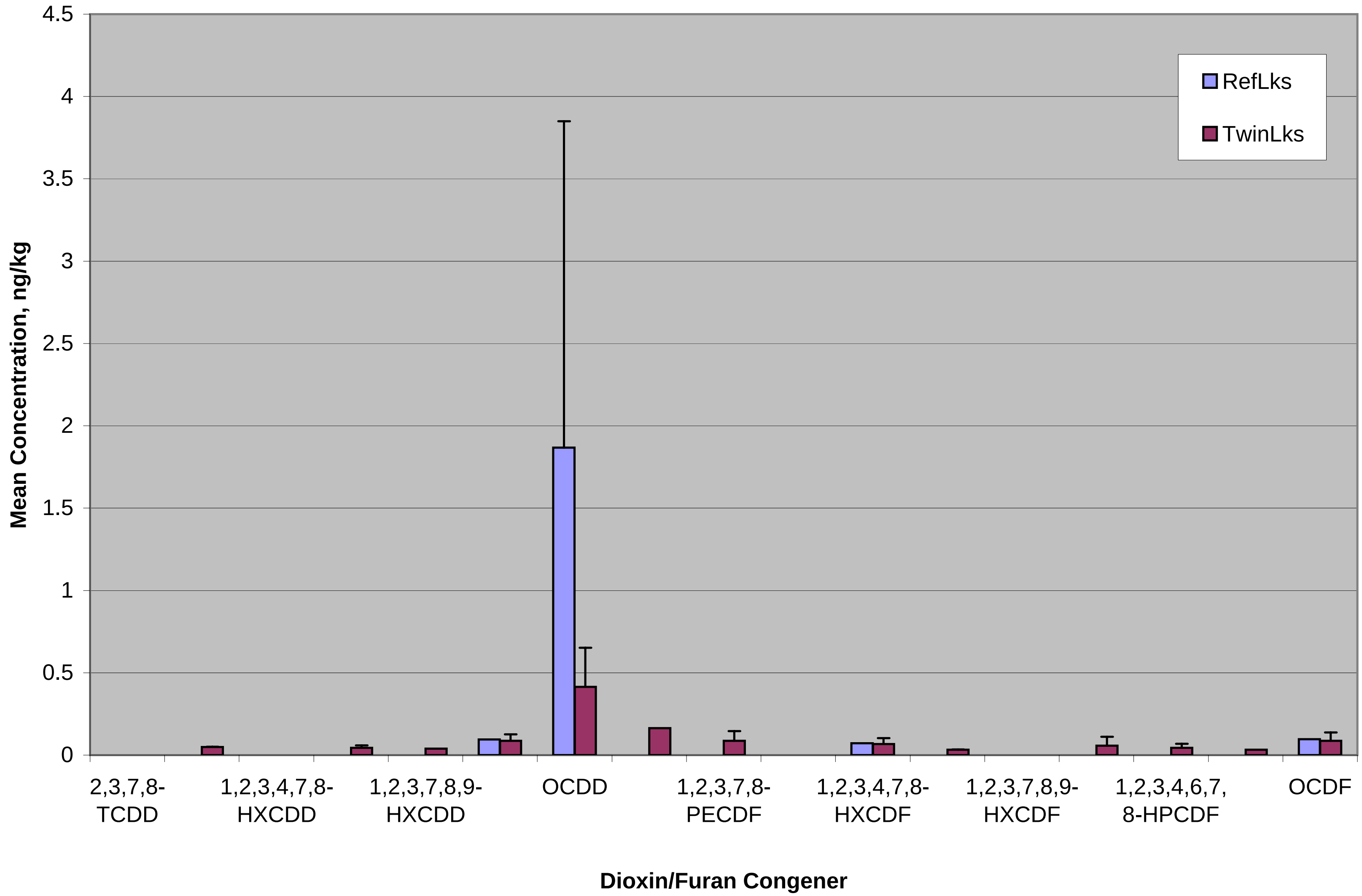


Figure 5: Carp Dioxin/Furan Congener Concentration Profile, Reference Lakes vs. Middle Twin Lake

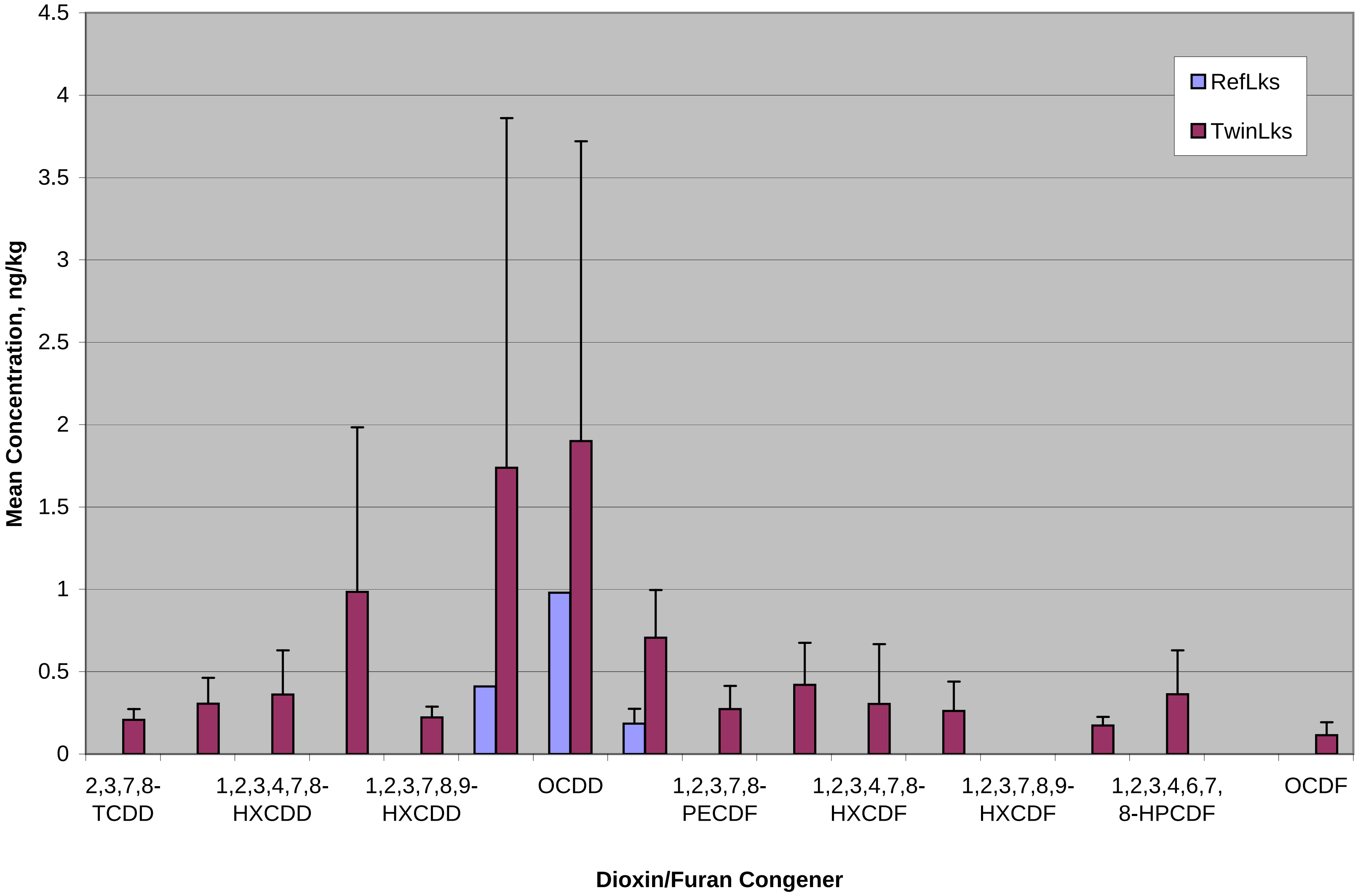


Figure 6: Black Crappie Dioxin/Furan Congener Concentration Profile, Reference Lakes vs. Middle Twin Lake

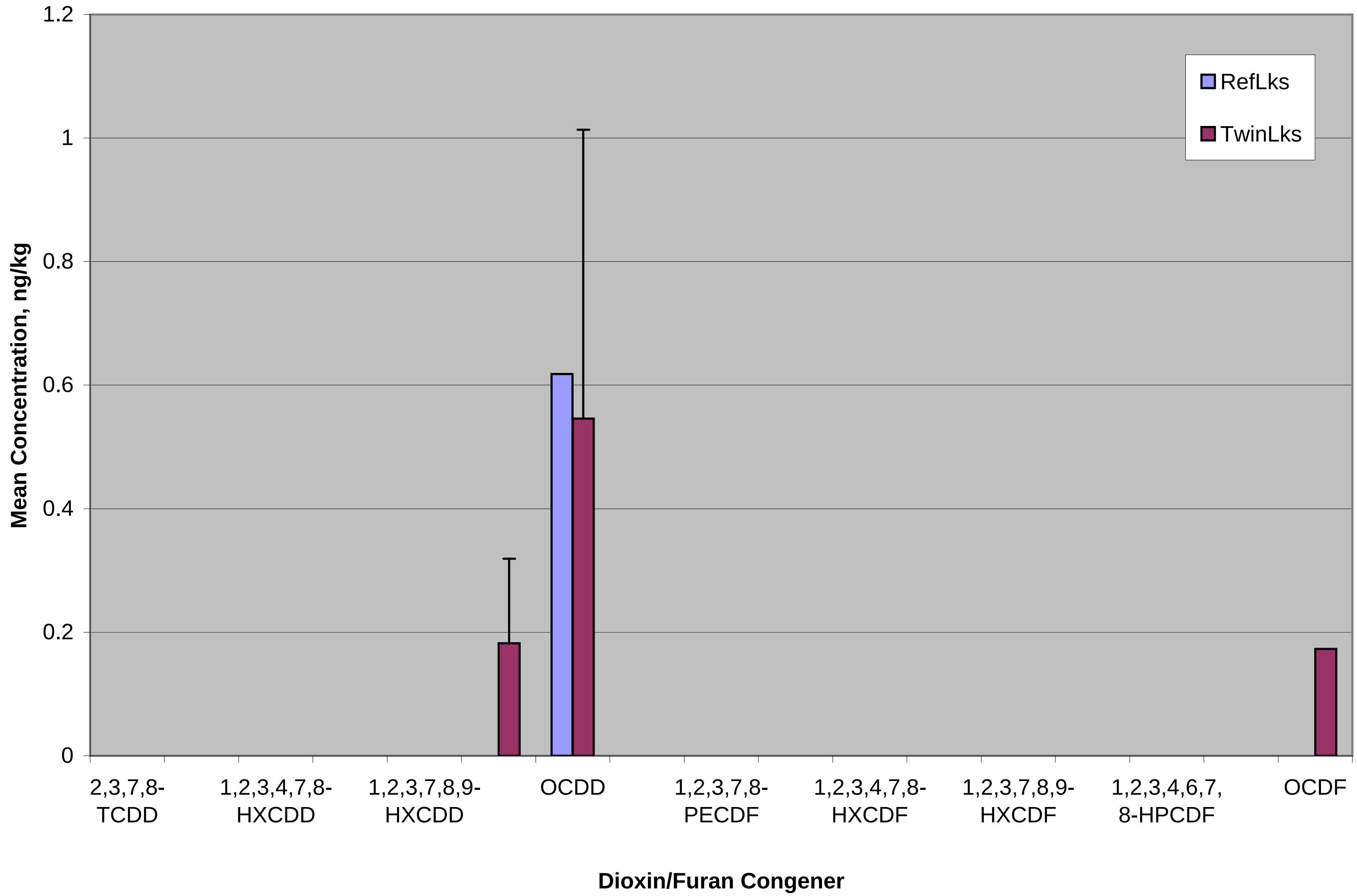


Table 1
Northern Pike
(concentrations as noted)

Location	Crystal NP Composite	Eagle NP Composite	Lotus NP-3	Long NP Composite	Med. NP Composite	Snail NP Composite	TNP-1	TNP-2	TNP-3	TNP-4	TNP-5	TNP-6	TNP-7	TNP-8	TNP-9	TNP-10
Date	3/28/2005	3/28/2005	2/8/2005	3/28/2005	3/28/2005	3/28/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005
Dioxins/Furans, ng/kg																
2,3,7,8-TCDD	<0.221	<0.051	<0.028	<0.040	<0.046	<0.062	<0.034	<0.044	<0.034	<0.040	<0.131	<0.039	<0.032	<0.047	<0.042	<0.059
1,2,3,7,8-Dioxin penta	<0.222	<0.060	<0.021	<0.050	<0.042	<0.062	<0.027	<0.023	<0.018	<0.023	<0.143	0.048 jk	0.050 jk	<0.030	<0.022	<0.041
1,2,3,4,7,8-Dioxin, hexa	<0.289	<0.080	<0.016	<0.103	<0.074	<0.101	<0.014	<0.022	<0.020	<0.021	<0.215	<0.024	<0.019	<0.019	<0.026	<0.035
1,2,3,6,7,8-Dioxin, hexa	<0.235	<0.068	<0.016	<0.087	<0.062	<0.085	<0.011	<0.019	<0.017	<0.017	<0.144	<0.020	0.055 j	0.034 jk	<0.022	<0.030
1,2,3,7,8,9-Dioxin, hexa	<0.261	<0.068	<0.016	<0.087	<0.063	<0.086	<0.013	<0.021	<0.019	<0.020	<0.178	<0.022	<0.018	0.039 jk	<0.025	<0.033
1,2,3,4,6,7,8-Dioxin, hepta	<0.561	<0.157	0.095 bj	<0.129	<0.101	<0.170	<0.020	0.036 bj	0.083 bj	0.049 bj	<0.375	0.067 bj	0.118 bj	0.146 bj	0.109 bj	<0.029
Dioxin octa	<1.415	<0.286	0.466 bj	<0.241	<0.159	3.269 j	0.308 bj	0.209 bjk	0.276 bj	0.285 bj	<1.200	0.287 bj	0.649 bj	0.892 bj	0.590 bj	0.228 bjk
2,3,7,8-TCDF	<0.192	<0.046	<0.044	<0.039	<0.027	<0.055	<0.054	<0.058	<0.049	<0.052	<0.117	<0.058	0.163 j	<0.054	<0.061	<0.066
1,2,3,7,8-Dibenzofuran, penta	<0.179	<0.055	<0.018	<0.048	<0.034	<0.065	<0.020	<0.018	<0.015	<0.017	0.129 j	0.045 jk	<0.014	<0.018	<0.022	<0.028
2,3,4,7,8-Dibenzofuran, penta	<0.178	<0.054	<0.017	<0.047	<0.033	<0.063	<0.019	<0.017	<0.014	<0.017	<0.094	<0.019	<0.013	<0.017	<0.022	<0.027
1,2,3,4,7,8-Dibenzofuran, hexa	<0.141	<0.042	0.072 bj	<0.042	<0.040	<0.059	0.060 j	0.034 jk	0.053 j	0.040 jk	0.154 j	0.082 j	0.065 jk	0.066 j	0.053 jk	<0.022
1,2,3,6,7,8-Dibenzofuran, hexa	<0.135	<0.041	<0.015	<0.041	<0.040	<0.059	<0.014	<0.014	<0.010	<0.011	<0.087	0.034 jk	<0.015	0.032 j	<0.020	<0.021
1,2,3,7,8,9-Dibenzofuran, hexa	<0.189	<0.050	<0.018	<0.051	<0.049	<0.071	<0.019	<0.019	<0.013	<0.015	<0.144	<0.017	<0.020	<0.023	<0.027	<0.029
2,3,4,6,7,8-Dibenzofuran, hexa	<0.157	<0.045	<0.016	<0.045	<0.044	<0.064	<0.015	<0.016	<0.011	<0.012	0.119 j	<0.014	0.026 jk	0.029 jk	<0.022	<0.024
1,2,3,4,6,7,8-Dibenzofuran, hepta	<0.340	<0.124	<0.026	<0.119	<0.078	<0.123	<0.019	<0.022	<0.023	<0.024	<0.145	<0.034	0.026 bjk	0.061 bjk	<0.027	<0.031
1,2,3,4,7,8,9-Dibenzofuran, hepta	<0.548	<0.169	<0.036	<0.161	<0.107	<0.168	<0.025	<0.027	<0.029	<0.030	<0.249	<0.043	<0.023	0.032 jk*	<0.034	<0.039
Dibenzofuran octa	<1.483	<0.332	0.097 bj	<0.249	<0.191	<0.346	<0.037	<0.042	<0.040	0.050 jk	<1.241	<0.054	0.067 j	0.144 j	<0.044	<0.059
Dibenzofuran penta, Total	<0.178	<0.054	<0.017	<0.047	<0.033	<0.063	<0.019	<0.017	<0.014	<0.017	0.129	<0.019	<0.013	<0.017	<0.022	<0.027
Dibenzofuran tetra, Total	<0.192	<0.046	<0.044	<0.039	<0.027	<0.055	<0.054	<0.058	<0.049	<0.052	<0.117	<0.058	0.163	<0.054	<0.061	<0.066
Dibenzofuran, hepta, Total	<0.340	<0.124	<0.026	<0.119	<0.078	<0.123	<0.019	<0.022	<0.023	<0.024	<0.145	<0.034	<0.018	<0.021	<0.027	<0.031
Dibenzofuran, hexa, Total	<0.135	<0.041	0.072	<0.041	<0.040	<0.059	0.060	<0.014	0.053	<0.011	0.273	0.082	0.025	0.097	<0.020	<0.021
Dioxin penta, Total	<0.222	<0.060	<0.021	<0.050	<0.042	<0.062	<0.027	<0.023	<0.018	<0.023	<0.143	<0.031	<0.017	<0.030	<0.022	<0.041
Dioxin tetra, Total	<0.221	<0.051	<0.028	<0.040	<0.046	<0.062	<0.034	<0.044	<0.034	<0.040	<0.131	<0.039	<0.032	<0.047	<0.042	<0.059
Dioxin, hepta, Total	<0.561	<0.157	0.158	<0.129	<0.101	<0.170	<0.020	0.036	0.083	0.107	<0.375	0.067	0.186	0.231	0.109	<0.029
Dioxin, hexa, Total	<0.235	<0.068	<0.016	<0.087	<0.062	<0.085	<0.011	<0.019	<0.017	<0.017	<0.144	<0.020	0.055	<0.016	<0.022	<0.030
TCDD Equivalent, reporting limit at 0, [2]	ND	ND	0.00821	ND	ND	0.0003269	0.006	0.0038	0.0053	0.0045	0.0338	0.0322	0.02181	0.00981	0.00645	0.00002
TCDD Equivalent, reporting limit at 1/2, [2]	0.3578149	0.0946559	0.04066	0.0847695	0.0744975	0.1110242	0.049087	0.04879	0.04282	0.04611	0.242467	0.06776	0.07542	0.06415	0.05173	0.070959
Metals, mg/kg																
Mercury	1.64	0.94	0.228 *	0.54	0.55	2.39	1.330 *	0.852 *	1.830 *	0.803 *	0.835 *	0.796 *	1.730 *	0.731 *	0.346 *	0.743 *
PCBs, mg/kg																
PCB-1016	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043
PCB-1221	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024
PCB-1232	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
PCB-1242	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014
PCB-1248	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026
PCB-1254	0.084	0.0077 j	0.0041 j	0.0045 jP	0.0069 jP	<0.00082	0.017	0.10	0.069	0.026	0.016	0.062	0.091	0.054	0.077	0.045
PCB-1260	0.087	0.025 P	0.0054 j	0.0088 jP	0.014 P	<0.0031	0.019	0.12	0.090	0.032	0.020	0.072	0.13	0.071	0.087	0.050
Sum of PCBs, ND at 0, [2]	0.171	0.0327	0.0095	0.0133	0.0209	ND	0.036	0.22	0.159	0.058	0.036	0.134	0.221	0.125	0.164	0.095
Sum of PCBs, ND at 1/2, [2]	0.17785	0.03955	0.01635	0.02015	0.02775	0.00881	0.04285	0.22685	0.16585	0.06485	0.04285	0.14085	0.22785	0.13185	0.17085	0.10185
PAHs, mg/kg																
2-Chloronaphthalene	<0.0050	<0.0050	<0.0050 *	<0.0050	<0.0050	<0.0050	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *
2-Methylnaphthalene	<0.0050	<0.0050	<0.0050	0.0023 j	<0.0050	<0.0050	<0.0050	0.0044 j	<0.0050	0.0024 j	0.0020 j	0.0035 j	0.0040 j	0.0044 j	0.0050	0.0035 j
Acenaphthene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0010 j	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.00099 j	0.0011 j	<0.0050
Acenaphthylene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Anthracene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(a)anthracene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(a)pyrene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b)fluoranthene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(g,h,i)perylene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(k)fluoranthene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Chrysene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Dibenz(a,h)anthracene	<0.0050	<0.0050	<0.0050 *	<0.0050	<0.0050	<0.0050	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *
Fluoranthene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Fluorene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Indeno(1,2,3-cd)pyrene	<0.0050	<0.0050	<0.0050 *	<0.0050	<0.0050	<0.0050	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *
Naphthalene	0.012	0.014	0.013	13	0.013	0.013	0.0038 j	0.012	0.0058	0.0061	0.0059	0.0041 j	0.0040 j	0.013	0.0041 j	0.014
Pentachlorophenol	<0.031	<0.031	<0.031	0.12 j	0.12 j	<0.031	<0.031	0.13 jb*	0.12 jb*	0.12 jb*	0.12 jb*	0.13 jb*	0.12 jb*	0.27 jb*	0.14 jb*	0.16 jb*
Phenanthrene	0.0019 j	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0025 j	<0.0050	<0.0050	<0.0050	0.0021 j	<0.0050	0.0027 j	0.0025 j	<0.0050
Pyrene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Sum of 7 cPAHs, ND at 0, [2]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sum of 7 cPAHs, ND at 1/2, [2]	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175
BaP equivalent, ND at 0, [1]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BaP equivalent, ND at 1/2, [1]	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925
General Parameter																
Lipid Content, %	0.73	0.51	0.40	0.55	0.51	0.32	0.30	1.1	0.51	0.59	0.43	0.75	0.95	0.95	1.0	0.70
Solids, total, %	23.1	21.8	20.7	21.3	21.1	22.0	18.5	20.5	21.4	21.4	19.8	20.8	20.8	18.3	19.3	21.3

Source: Barr 2005.

Table 2
Carp
(concentrations as noted)

Location	Eagle Carp Composi	Long L. C Compos	Lotus L. Carp Compo	Med. Carp Composit	TC-1	TC-2	TC-3	TC-4	TC-5	TC-6	TC-7	TC-8	TC-9	TC-10	TC-11	TC-12	TC-13
Date	3/28/2005	3/28/2005	3/28/2005	3/28/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005	2/8/2005
Dioxins/Furans, ng/kg																	
2,3,7,8-TCDD	<0.047	<0.121	<0.053	<0.165	<0.217	<0.196	<0.185	0.280 j	0.155 jk	<0.184	<0.136	<0.208	<0.027	<0.191	<0.106	0.189 j	<0.025
1,2,3,7,8-Dioxin penta	<0.072	<0.131	<0.052	<0.141	<0.289	<0.274	0.321 j	0.590 j	0.402 j	0.236 j	0.311 j	0.252 j	0.034 j	<0.224	<0.123	0.296 j	<0.014
1,2,3,4,7,8-Dioxin, hexa	<0.092	<0.169	<0.085	<0.188	<0.306	<0.248	<0.296	0.668 j	0.240 jk	<0.239	<0.230	<0.284	<0.016	<0.271	<0.195	0.175 j	<0.011
1,2,3,6,7,8-Dioxin, hexa	<0.078	<0.142	<0.072	<0.169	0.497 j	0.510 j	<0.198	3.432	0.812 j	<0.160	0.683 j	0.529 j	<0.016	0.847 j	<0.130	0.569 j	<0.011
1,2,3,7,8,9-Dioxin, hexa	<0.078	<0.143	<0.072	<0.180	<0.253	<0.205	<0.244	0.291 j	0.215 j	<0.197	<0.190	<0.235	<0.015	<0.223	<0.161	0.163 j	<0.011
1,2,3,4,6,7,8-Dioxin, hepta	<0.157	<0.205	0.411 bjk	<0.344	1.647 j	0.789 j	1.075 j	7.788 b	2.224 bj	0.606 j	1.779 j	1.534 jk	0.068 bj	2.279	<0.349	1.511 bj	0.100 bjk
Dioxin octa	<0.259	<0.452	<0.211	0.979 bj	1.150 j	<1.180	<1.214	6.103 b	1.640 bj	<1.011	<1.255	<1.196	0.375 bj	2.002 j	2.182 j	1.315 bj	0.438 bj
2,3,7,8-TCDF	0.120 cj	<0.092	0.248 cj	<0.119	0.551 j	1.083	0.541 j	0.705 j	0.786 j	0.920	0.444 j	0.877 j	<0.031	1.199	<0.097	0.989 j	0.270 j
1,2,3,7,8-Dibenzofuran, penta	<0.052	<0.099	<0.044	<0.128	<0.171	<0.156	<0.165	0.469 j	0.248 j	<0.144	<0.122	0.303 j	<0.015	0.356 j	<0.098	0.208 j	0.056 j
2,3,4,7,8-Dibenzofuran, penta	<0.051	<0.096	<0.043	<0.129	0.212 j	0.266 j	0.302 j	1.049 j	0.457 j	0.276 j	<0.118	0.328 j	<0.014	0.528 j	<0.095	0.368 j	<0.017
1,2,3,4,7,8-Dibenzofuran, hexa	<0.051	<0.084	<0.040	<0.113	<0.119	<0.167	<0.137	1.039 bj	0.183 bjk	<0.101	<0.133	0.181 j	0.071 bj	0.191 j	<0.084	0.164 bj	0.070
1,2,3,6,7,8-Dibenzofuran, hexa	<0.050	<0.083	<0.039	<0.113	0.135 jk	<0.140	<0.115	0.602 j	0.232 j	<0.085	<0.112	0.145 j	<0.014	0.304 j	<0.070	0.152 jk	<0.012
1,2,3,7,8,9-Dibenzofuran, hexa	<0.061	<0.102	<0.048	<0.156	<0.164	<0.230	<0.189	<0.015	<0.018	<0.139	<0.183	<0.175	<0.018	<0.201	<0.116	<0.018	<0.015
2,3,4,6,7,8-Dibenzofuran, hexa	<0.055	<0.092	<0.043	<0.126	<0.124	<0.174	<0.143	0.210 jk	0.136 j	<0.105	<0.138	<0.133	<0.015	<0.152	<0.087	<0.016	<0.013
1,2,3,4,6,7,8-Dibenzofuran, hepta	<0.126	<0.117	<0.096	<0.211	<0.212	<0.230	<0.228	0.671 bj	0.224 bj	<0.163	<0.209	<0.270	<0.020	<0.192	<0.164	0.196 bjk	<0.015
1,2,3,4,7,8,9-Dibenzofuran, hepta	<0.171	<0.159	<0.131	<0.327	<0.366	<0.397	<0.393	<0.036	<0.029	<0.281	<0.360	<0.465	<0.028	<0.331	<0.282	<0.033	<0.022
Dibenzofuran octa	<0.278	<0.584	<0.255	<0.768	<1.438	<1.245	<1.399	0.199 bjk	0.044 bjk	<1.100	<1.532	<1.429	<0.029	<1.102	<1.185	<0.032	0.102 bj
Dibenzofuran penta, Total	<0.051	<0.096	<0.043	<0.129	0.212	0.266	0.302	1.750	0.930	0.276	<0.118	0.630	<0.014	1.332	<0.095	0.805	0.309
Dibenzofuran tetra, Total	0.120	<0.092	0.248	<0.119	1.332	1.213	0.919	0.705	0.936	1.116	0.628	0.877	<0.031	1.199	0.262	1.238	0.270
Dibenzofuran, hepta, Total	<0.126	<0.117	<0.096	<0.211	<0.212	<0.230	<0.228	1.005	0.224	<0.163	<0.209	<0.270	<0.020	<0.192	<0.164	0.049	<0.015
Dibenzofuran, hexa, Total	<0.050	<0.083	<0.039	<0.113	<0.100	<0.140	<0.115	1.851	0.525	<0.085	0.313	0.327	0.071	0.494	<0.070	0.280	<0.012
Dioxin penta, Total	<0.072	<0.131	<0.052	<0.141	<0.289	<0.274	0.321	0.590	0.402	0.236	0.311	0.252	0.034	<0.224	<0.123	0.296	<0.014
Dioxin tetra, Total	<0.047	<0.121	<0.053	<0.165	<0.217	<0.196	<0.185	0.280	<0.027	<0.184	<0.136	<0.208	<0.027	<0.191	<0.106	0.189	<0.025
Dioxin, hepta, Total	<0.157	<0.205	<0.171	<0.344	1.647	0.789	1.075	7.788	2.224	0.606	1.779	<0.434	0.068	2.279	<0.349	1.511	<0.012
Dioxin, hexa, Total	<0.078	<0.142	<0.072	<0.169	0.497	0.510	<0.198	4.392	1.027	<0.160	0.683	0.529	<0.016	0.847	<0.130	0.907	<0.011
TCDD Equivalent, reporting limit at 0, [2]	0.012	ND	0.0248	0.0001	0.22739	0.3002	0.5369	1.98775	0.861	0.4721	0.4415	0.6044	0.034	0.55889	0.00022	0.869	0.0368
TCDD Equivalent, reporting limit at 1/2, [2]	0.11109685	0.2002818	0.1123133	0.25114735	0.54267	0.600546	0.702811	2.09374	0.97302	0.621286	0.594324	0.761176	0.061775	0.81141	0.191952	0.89527	0.06491
Metals, mg/kg																	
Mercury	0.26	0.11	0.16	0.14	0.233 *	0.229 *	0.267 *	0.172 *	0.283 *	0.195 *	0.236 *	0.439 *	0.409 *	0.093 *	0.632 *	0.291 *	0.266 *
PCBs, mg/kg																	
PCB-1016	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043
PCB-1221	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024
PCB-1232	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
PCB-1242	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014
PCB-1248	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026
PCB-1254	<0.010 i	0.0063 jP	0.037	0.015 P	0.14	0.25	0.27 P	0.59	0.36	0.20	0.10 P	0.26	0.031	0.15	0.016	0.28	0.033
PCB-1260	0.011 P	0.011	0.043	0.020	0.17	0.21	0.34	0.60	0.35	0.21	0.13	0.22	0.025	0.14	0.015	0.31	0.027
Sum of PCBs, ND at 0, [2]	0.011	0.0173	0.080	0.035	0.31	0.46	0.61	1.19	0.71	0.41	0.23	0.48	0.056	0.29	0.031	0.59	0.06
Sum of PCBs, ND at 1/2, [2]	0.02285	0.02415	0.08685	0.04185	0.31685	0.46685	0.61685	1.19685	0.71685	0.41685	0.23685	0.48685	0.06285	0.29685	0.03785	0.59685	0.06685
PAHs, mg/kg																	
2-Chloronaphthalene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *
2-Methylnaphthalene	0.0073	0.013	0.0064	0.0036 j	0.019	0.042	0.032	0.018	0.033	0.022	0.011	0.017	0.0023 j	0.021	<0.0050	0.031	0.0044 j
Acenaphthene	<0.0050	<0.0050	<0.0050	<0.0050	0.0052	0.0059	0.0068	0.0029 j	0.0055	0.0021 j	0.0040 j	0.0037 j	<0.0050	0.0033 j	<0.0050	0.0032 j	<0.0050
Acenaphthylene	<0.0050	<0.0050	<0.0050	<0.0050	0.0016 j	0.0022 j	0.0020 j	<0.0050	0.0021 j	<0.0050	0.0011 j	0.0013 j	<0.0050	0.0014 j	<0.0050	0.0022 j	<0.0050
Anthracene	<0.0050	<0.0050	<0.0050	<0.0050	0.0011 j	0.0010 j	0.00097 j	0.0015 j	0.0010 j	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(a)anthracene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(a)pyrene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b)fluoranthene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(g,h,i)perylene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(k)fluoranthene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Chrysene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Dibenz(a,h)anthracene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *
Fluoranthene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	0.0040 j	0.0040 j	<0.0050	0.0039 j	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Fluorene	<0.0050	<0.0050	<0.0050	<0.0050	0.0049 j	0.0062	0.0061	0.0025 j	0.0056	0.0028 j	0.0030 j	0.0038 j	<0.0050	0.0033 j	<0.0050	0.0035 j	<0.0050
Indeno(1,2,3-cd)pyrene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *	<0.0050 *
Naphthalene	0.016	0.018	0.016	0.014	0.022	0.032	0.015	0.014	0.019	0.020	0.015	0.0085	0.014	0.019	0.013	0.025	0.0062 b
Pentachlorophenol	0.15 j	<0.031	0.13 j	<0.031	<0.031	0.12 jb*	<0.031	<0.031	<0.031	<0.031	<0.031	<0.031	<0.031	0.12 jb*	<0.031	<0.031	<0.031
Phenanthrene	<0.0050	<0.0050	<0.0050	<0.0050	0.010	0.0083	0.0091	0.0037 j	0.0095	0.0055	0.0060	0.0057	<0.0050	0.0049 j	0.0037 j	0.0068	<0.0050
Pyrene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Sum of 7 cPAHs, ND at 0, [2]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sum of 7 cPAHs, ND at 1/2, [2]	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175	0.0175
BaP equivalent, ND at 0, [1]	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
BaP equivalent, ND at 1/2, [1]	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925	0.004925
General Parameter																	
Lipid Content, %	2.1	3.6	6.5	2.4	5.4	11.5	9.2	4.2	8.1	4.6	4.4	5.5	2.5	5.9	1.8	8.2	5.1
Solids, total, %	22.6	21.9	25.4	24.2	24.6	27.1	27.9	25.5	28.3	25.1	25.8	24.3	23.1	28.6	21.6	29.0	24.6

Source: Barr 2005.

Table 3
Black Crappie
(concentrations as noted)

Location Date Dup	Crystal BC Composite 3/28/2005	Eagle BC Composite 3/28/2005	Long BC Composite 3/28/2005	Lotus BC Composite 3/28/2005	Medicine BC Compos 3/28/2005	TBC Composite 1 3/28/2005	TBC Composite 2 3/28/2005	TBC Composite 3 3/28/2005	TBC Composite 4 3/28/2005	TBC Composite 5 3/28/2005
Dioxins/Furans, ng/kg										
2,3,7,8-TCDD	<0.079	<0.052	<0.042	<0.048	<0.133	<0.019	<0.032	<0.021	<0.019	<0.019
1,2,3,7,8-Dioxin penta	<0.082	<0.057	<0.065	<0.067	<0.131	<0.028	<0.025	<0.027	<0.024	<0.023
1,2,3,4,7,8-Dioxin, hexa	<0.093	<0.089	<0.071	<0.074	<0.176	<0.022	<0.024	<0.031	<0.028	<0.026
1,2,3,6,7,8-Dioxin, hexa	<0.078	<0.075	<0.059	<0.062	<0.158	<0.021	<0.023	<0.029	<0.027	<0.025
1,2,3,7,8,9-Dioxin, hexa	<0.079	<0.075	<0.060	<0.063	<0.169	<0.021	<0.022	<0.029	<0.027	<0.024
1,2,3,4,6,7,8-Dioxin, hepta	<0.155	<0.126	<0.113	<0.116	<0.250	<0.020	<0.013	**0.279 bj**	**0.085 bj**	<0.019
Dioxin octa	<0.244	<0.195	<0.216	<0.140	**0.618 bj**	**0.310 bj**	**0.318 bj**	**1.378 bj**	**0.422 bj**	**0.302 bj**
2,3,7,8-TCDF	<0.061	<0.039	<0.039	<0.034	<0.096	<0.039	<0.037	<0.041	<0.043	<0.038
1,2,3,7,8-Dibenzofuran, penta	<0.058	<0.050	<0.052	<0.050	<0.109	<0.017	<0.019	<0.017	<0.020	<0.020
2,3,4,7,8-Dibenzofuran, penta	<0.056	<0.049	<0.051	<0.049	<0.109	<0.017	<0.018	<0.017	<0.019	<0.020
1,2,3,4,7,8-Dibenzofuran, hexa	<0.044	<0.039	<0.039	<0.044	<0.082	<0.016	<0.017	<0.016	<0.013	<0.015
1,2,3,6,7,8-Dibenzofuran, hexa	<0.044	<0.038	<0.039	<0.043	<0.081	<0.017	<0.018	<0.017	<0.013	<0.016
1,2,3,7,8,9-Dibenzofuran, hexa	<0.053	<0.047	<0.048	<0.053	<0.113	<0.021	<0.022	<0.020	<0.016	<0.019
2,3,4,6,7,8-Dibenzofuran, hexa	<0.048	<0.042	<0.043	<0.047	<0.091	<0.018	<0.020	<0.018	<0.014	<0.017
1,2,3,4,6,7,8-Dibenzofuran, hepta	<0.120	<0.080	<0.084	<0.091	<0.200	<0.023	<0.016	<0.029	<0.024	<0.027
1,2,3,4,7,8,9-Dibenzofuran, hepta	<0.163	<0.109	<0.115	<0.124	<0.310	<0.032	<0.023	<0.041	<0.033	<0.037
Dibenzofuran octa	<0.239	<0.229	<0.236	<0.221	<0.665	<0.032	<0.027	**0.173 jk**	<0.038	<0.043
Dibenzofuran penta, Total	<0.056	<0.049	<0.051	<0.049	<0.109	<0.017	<0.018	<0.017	<0.019	<0.020
Dibenzofuran tetra, Total	<0.061	<0.039	<0.039	<0.034	<0.096	<0.039	<0.037	<0.041	<0.043	<0.038
Dibenzofuran, hepta, Total	<0.120	<0.080	<0.084	<0.091	<0.200	<0.023	<0.016	<0.029	<0.024	<0.027
Dibenzofuran, hexa, Total	<0.044	<0.038	<0.039	<0.043	<0.081	<0.016	<0.017	<0.016	<0.013	<0.015
Dioxin penta, Total	<0.082	<0.057	<0.065	<0.067	<0.131	<0.028	<0.025	<0.027	<0.024	<0.023
Dioxin tetra, Total	<0.079	<0.052	<0.042	<0.048	<0.133	<0.019	<0.032	<0.021	<0.019	<0.019
Dioxin, hepta, Total	<0.155	<0.126	<0.113	<0.116	<0.250	<0.020	<0.013	**0.609**	**0.085**	<0.019
Dioxin, hexa, Total	<0.078	<0.075	<0.059	<0.062	<0.158	<0.021	<0.023	<0.029	<0.027	<0.025
TCDD Equivalent, reporting limit at 0, [2]	ND	ND	ND	ND	**0.000062**	**0.000031**	**0.000032**	**0.00295**	**0.00089**	**0.00003**
TCDD Equivalent, reporting limit at 1/2, [2]	**0.12316415**	**0.0917962**	**0.0890326**	**0.09367305**	**0.21413915**	**0.0373171**	**0.04290225**	**0.04054755**	**0.036533**	**0.03593225**
Metals, mg/kg										
Mercury	**0.34**	**0.33**	**0.27**	**0.11**	**0.29**	**0.46**	**0.47**	**0.34**	**0.48**	**0.44**
PCBs, mg/kg										
PCB-1016	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043	<0.0043
PCB-1221	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024	<0.0024
PCB-1232	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030	<0.0030
PCB-1242	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014	<0.0014
PCB-1248	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026	<0.0026
PCB-1254	**0.040**	<0.0019 i	<0.00082	<0.00082	**0.0048 j**	**0.023 P**	**0.024 P**	**0.022**	**0.020**	**0.024**
PCB-1260	**0.027**	**0.0082 jP**	<0.0031	<0.0031	**0.0081 jP**	**0.018**	**0.021**	**0.016**	**0.017**	**0.022**
Sum of PCBs, ND at 0, [2]	**0.067**	**0.0082**	ND	ND	**0.0129**	**0.041**	**0.045**	**0.038**	**0.037**	**0.046**
Sum of PCBs, ND at 1/2, [2]	**0.07385**	**0.016**	**0.00881**	**0.00881**	**0.01975**	**0.04785**	**0.05185**	**0.04485**	**0.04385**	**0.05285**
PAHs, mg/kg										
2-Chloronaphthalene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
2-Methylnaphthalene	**0.0035 j**	<0.0050	**0.0042 j**	<0.0050	<0.0050	**0.0037 j**	**0.0039 j**	**0.0037 j**	**0.0043 j**	**0.0041 j**
Acenaphthene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	**0.0027 j**	<0.0050
Acenaphthylene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Anthracene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(a)anthracene	<0.0050	**0.0030 j**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(a)pyrene	<0.0050	**0.0035 j**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(b)fluoranthene	<0.0050	**0.0018 j**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(g,h,i)perylene	<0.0050	**0.0029 j**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Benzo(k)fluoranthene	<0.0050	**0.0030 j**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Chrysene	<0.0050	**0.0049 j**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Dibenz(a,h)anthracene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Fluoranthene	**0.0050**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Fluorene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Indeno(1,2,3-cd)pyrene	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Naphthalene	**0.013**	**0.013**	**0.013**	**13**	**0.013**	**0.013**	**0.013**	**0.014**	**0.015**	**0.013**
Pentachlorophenol	<0.031	**0.14 j**	**0.12 j**	**0.12 j**	<0.031	<0.031	<0.031	<0.031	<0.031	<0.031
Phenanthrene	**0.0058**	<0.0050	<0.0050	<0.0050	<0.0050	**0.0032 j**	**0.0032 j**	**0.0031 j**	**0.0034 j**	**0.0031 j**
Pyrene	<0.0050	**0.0028 j**	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050	<0.0050
Sum of 7 cPAHs, ND at 0, [2]	ND	**0.0162**	ND	ND	ND	ND	ND	ND	ND	ND
Sum of 7 cPAHs, ND at 1/2, [2]	**0.0175**	**0.0212**	**0.0175**	**0.0175**	**0.0175**	**0.0175**	**0.0175**	**0.0175**	**0.0175**	**0.0175**
BaP equivalent, ND at 0, [1]	ND	**0.004329**	ND	ND	ND	ND	ND	ND	ND	ND
BaP equivalent, ND at 1/2, [1]	**0.004925**	**0.005979**	**0.004925**	**0.004925**	**0.004925**	**0.004925**	**0.004925**	**0.004925**	**0.004925**	**0.004925**
General Parameter										
Lipid Content, %	**0.60**	**0.32**	**0.82**	**0.59**	**0.59**	**0.76**	**0.71**	**0.70**	**0.72**	**0.74**
Solids, total, %	**20.5**	**19.7**	**20.6**	**18.3**	**19.6**	**20.6**	**20.9**	**21.0**	**20.6**	**20.4**

Source: Barr 2005.

Table 4
Joslyn Manufacturing: Middle Twin Lake Fish Tissue Study
Footnotes

--	Not analyzed.
b	Potential false positive based on blank data validation procedure.
c	Coeluting compound.
i	Indeterminate value based on failure of blind duplicate data to meet quality assurance criteria.
j	Reported value is less than the stated laboratory quantitation limit and is considered an estimated value.
P	The GC or HPLC confirmation criteria was exceeded. The relative percent difference is greater than 40% between the
*	Estimated value, QA/QC criteria not met.
ND	Not detected.
	Detections are presented in bold.
1	Total BaP equivalents (2002) calculated using 0 for the detection limit on the non detected compounds.

	CAS No.	Site Conc. (mg/kg) dry weight	Relative Potency Factor	BaP Equivalent (mg/kg)
Benzo(a)anthracene	56553	0.000	0.1	0.000
Benzo(b)fluoranthene	205992	0.000	0.1	0.000
Benzo(k)fluoranthene	207089	0.000	0.1	0.000
Benzo(a)pyrene	50328	0.000	1	0.000
Chrysene	218019	0.000	0.01	0.000
Dibenz(a,h)anthracene	53703	0.000	0.56	0.000
Indeno(1,2,3-cd)pyrene	193395	0.000	0.1	0.000
		Total BaP equivalents = compare this value to the BaP SRV		0.000

2 Data values qualified with b and/or k qualifiers were considered non-detect at zero when calculating the TEQ's and Sums. Total TCDD equivalents calculated using 0 and 1/2 for the detection limit on the non detected compounds.

	Site Conc. (ng/kg) dry weight	Relative Potency Factor	TCDD Equivalent (ng/kg)
2,3,7,8-TCDD	0.000	1	0.000
1,2,3,7,8-Dioxin penta	0.000	1	0.000
1,2,3,4,7,8-Dioxin, hexa	0.000	0.1	0.000
1,2,3,6,7,8-Dioxin, hexa	0.000	0.1	0.000
1,2,3,7,8,9-Dioxin, hexa	0.000	0.1	0.000
1,2,3,4,6,7,8-Dioxin, hepta	0.000	0.01	0.000
Dioxin octa	0.000	0.0001	0.000
2,3,7,8-TCDF	0.000	0.1	0.000
1,2,3,7,8-Dibenzofuran, penta	0.000	0.05	0.000
2,3,4,7,8-Dibenzofuran, penta	0.000	0.5	0.000
1,2,3,4,7,8-Dibenzofuran, hexa	0.000	0.1	0.000
1,2,3,6,7,8-Dibenzofuran, hexa	0.000	0.1	0.000
2,3,4,6,7,8-Dibenzofuran, hexa	0.000	0.1	0.000
1,2,3,7,8,9-Dibenzofuran, hexa	0.000	0.1	0.000
1,2,3,4,6,7,8-Dibenzofuran, hepta	0.000	0.01	0.000
1,2,3,4,7,8,9-Dibenzofuran, hepta	0.000	0.01	0.000
Dibenzofuran octa	0.000	0.0001	0.000
	Total TCDD = equivalents		0.000

Source: Barr 2005.